B Towards a new digital era

This section describes the rise of digital technologies and identifies the technological forces that have helped propel their growth. It examines how digital technologies are changing the economy by giving rise to new markets, goods and services, and discusses some of the concerns that have arisen in parallel regarding privacy, market concentration, the impact on productivity and the digital divide. The section also discusses the methodological and data challenges involved in trying to measure the value of digital transactions and digital trade, and provides estimates culled from international organizations and national authorities, as well as financial reports from a number of well-known firms.

Contents

Some key facts and findings

- Digital technologies such as artificial intelligence, the Internet of Things, additive manufacturing (3D printing), and Blockchain have been made achievable by the exponential rise in computing power, bandwidth and digital information.
- Digital technologies are reshaping consumer habits by shifting purchases online through the widespread use of internet-enabled devices which provide consumers with direct access to online markets.
- It is estimated that, in 2016, the value of e-commerce transactions totalled US$ 27.7 trillion, of which US$ 23.9 trillion was business-to-business e-commerce transactions.
- On the supply side, digital technologies allow for easier entry and increased product diversity, making it easier for firms to produce, promote and distribute their products at a lower cost.
- The benefits of digital technologies notwithstanding, they are also giving rise to a number of concerns, including market concentration, loss of privacy and security threats, the digital divide, and the question of whether digital technologies have really increased productivity.

1. The rise of digital technologies

(a) What has made the digital revolution possible?

The shift from mechanical and analogue electronic technology to digital technologies, the rapid adoption of those technologies particularly in the information and communication sectors, and the sweeping economic and social changes that have accompanied this shift constitutes a revolution – a digital revolution. This technology-driven revolution has not yet run its course and continues to this day, transforming the way business are run, the way production is organized, the way countries and firms trade, and the way people work and communicate.

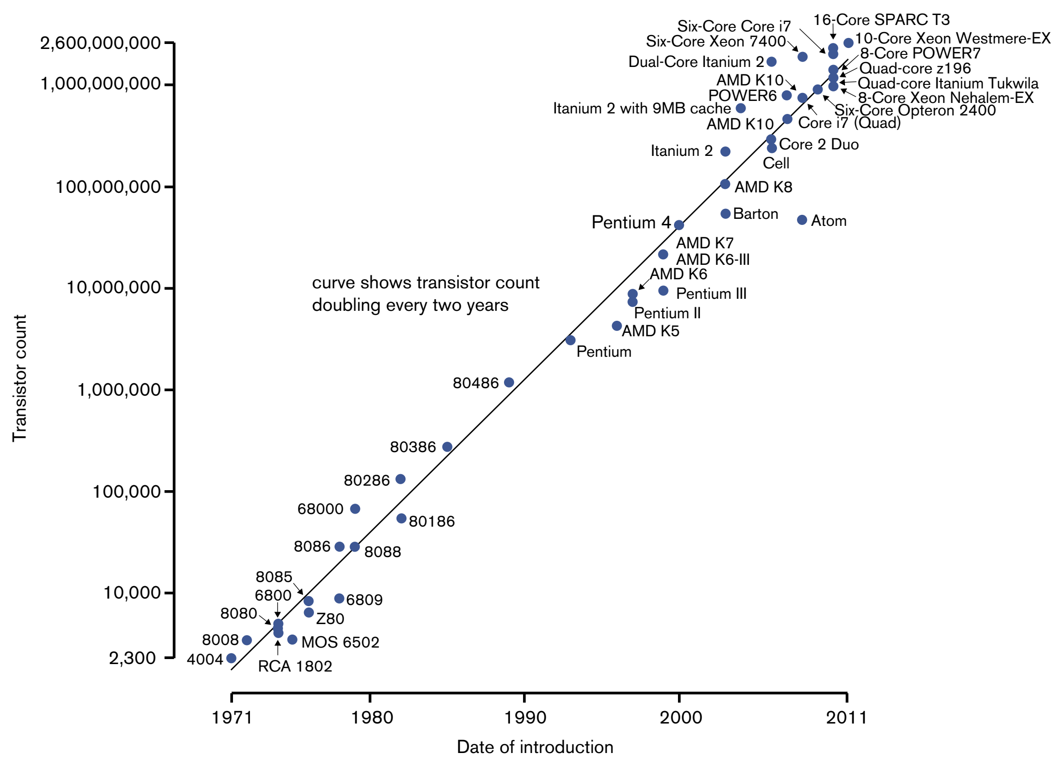
Technologies that underpin the digital revolution have benefitted from three powerful trends in computing, communications and information processing that have combined to enable the rapid technological advances we have observed. These three trends are Moore's Law, Gilder's Law and the digitalization of information, as explained below.

(i) Advances in computing power

Moore's law relates to the physics of transistors and integrated circuits that lie at the heart of modern computing. It is not a physical or natural law but a technological trend that has been remarkably long-lived. Originally formulated in 1965 at the dawn of the electronic age, the popular rendering of Moore's conjecture is that the number of components in an integrated circuit will double every year (Moore, 1965). This means in theory that the processing or computing capability of the integrated circuit doubles every year as well. This prediction was later revised by Moore to doubling every two years (other reformulations of the law state that the doubling occurs every 18 months). Figure B.1 gives a sense of the power of Moore's law. In the early 1970s, one could fit only 2,300 transistors into an Intel chip. Today, a single Intel quad core i7 chip contains about a billion transistors, and high-end chips used in workstations or servers (Xeon chips) can contain double that number.

As a result, the cost of computing power has fallen steadily over time (see Figure B.2). Over the period 1997-2015, the US consumer price index (CPI) for personal computers fell by nearly 95 per cent, while the corresponding index for all items purchased by consumers has risen by nearly 50 per cent. Naturally, computers have become widespread and are used for a wide variety of purposes beyond solving computationally difficult problems. In many Organisation for Economic

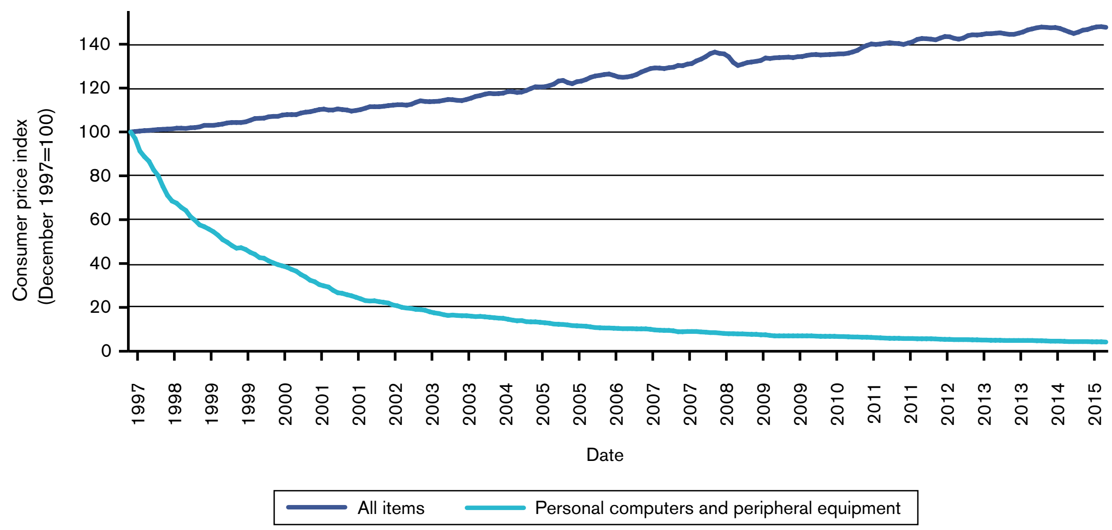
Figure B.1: Illustrating Moore's Law: microprocessor transistor counts 1971-2011



Source: Bloom et al (2017).

Co-operation and Development (OECD) countries and in some developing countries, between 70 per cent and 90 per cent of households have access to computers (see Figure B.3). Such access is, however, much less common in poorer countries, as discussed below in the section on the digital divide.

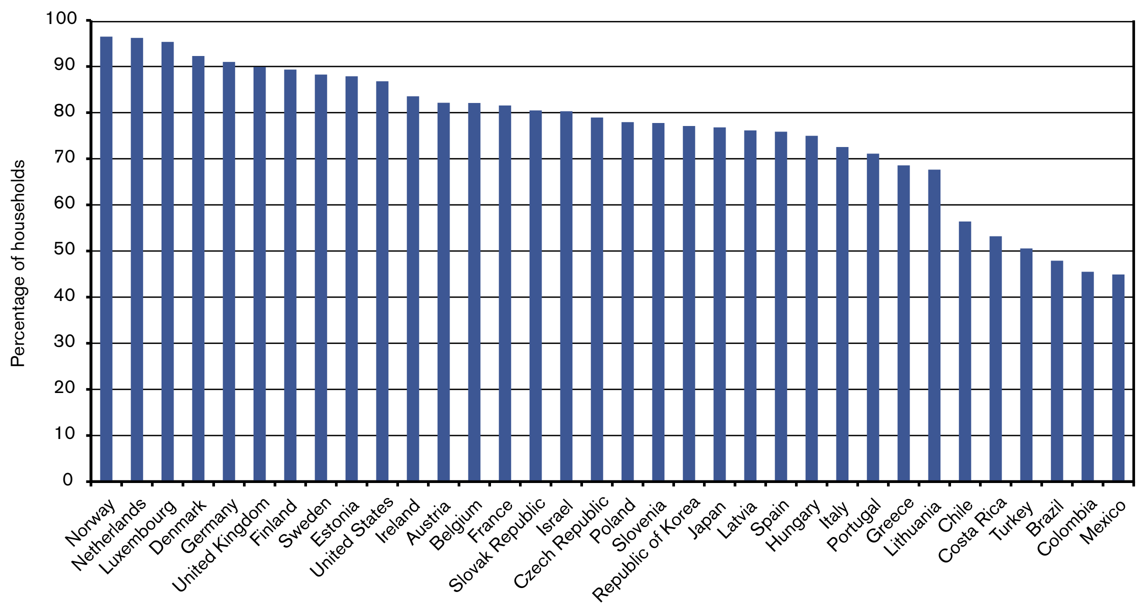
Figure B.2: The falling cost of computers, 1997-2015



Source: US Bureau of Labor Statistics.

Note: Figure shows consumer price indexes for all items and for computers, not seasonally adjusted.

Figure B.3: Access to computers from home, percentage of all households, 2015



Source: OECD and US Census Bureau.

Notes: Figure comes from US Census Bureau, Current Population Survey.

(ii) A communications revolution

The second technological trend to highlight is the massive improvement in the amount of information that can be carried by our modern communication networks. "Gilder's Law", a conjecture like Moore's Law, predicts that total bandwidth — a measure of the carrying capacity of a communication system — will grow at least three times faster than computing power (Gilder, 2000). Thus, if computing power doubles every 18 months, as projected by Moore's Law, then Gilder's Law predicts that bandwidth will double every six months.

This abundance of bandwidth means that large amounts of data can be transmitted instantaneously between any two nodes in a communication system. Figure B.4 shows the growth in average international internet bandwidth from 2000 to 2015 for a sample of 131 countries. In 2000, the average international bandwidth was a little less than 3,700 Mbits/sec. By 2015, this had increased to a little less than 1.2 million Mbits/sec, a more than 330-fold increase.

Like Moore's law, this increased bandwidth has led to a fall in the cost of communications and is an important catalyst in the rapid growth of the internet and mobile networks (see Box B.1 regarding the role of the telecommunications sector in the digital revolution).

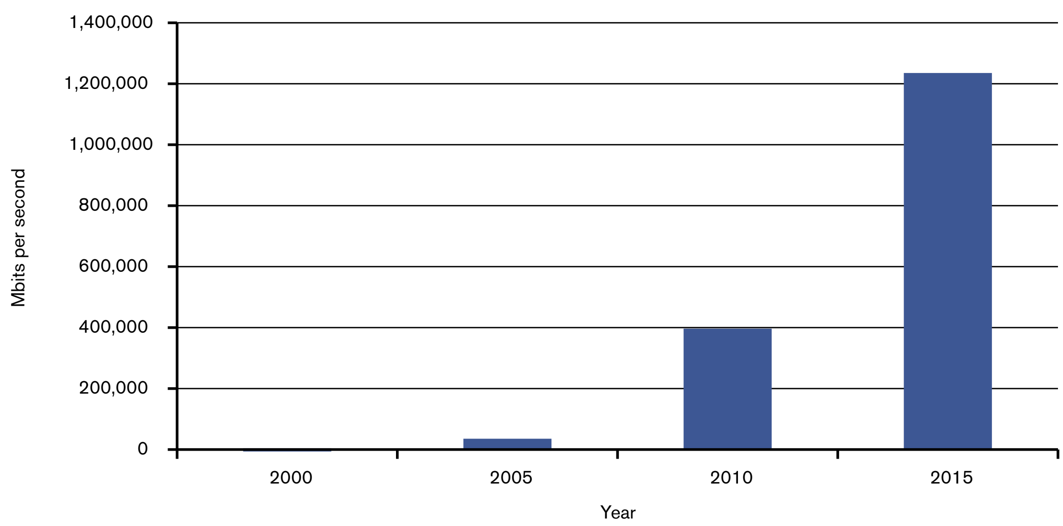
In 1990, less than 5 per cent of the world's population had access to the internet. Today nearly half of the world's population can access the internet, and it is far faster and more pervasive than the dial-up internet of the 1990s. Figure B.5 shows the volume of internet traffic since 1984 when it averaged about 15 gigabytes per month. In 2014, three decades later, the volume of internet traffic had increased by nearly 3 billion-fold to reach more than 42 billion gigabytes per month. In addition to increasing bandwidth, this increase reflects a variety of other causes, including growth in the number of users, greater sophistication and variety in the possible uses of the internet.

Reflecting on this communications revolution, Gilder boldly predicted a future when human communication will become "universal, instantaneous, unlimited in capacity and at the margins free" (Gilder, 2000).

(iii) Digitalization and the rise of big data

The third trend underlying the digital revolution is the ability to collect, store and turn many forms of information that existed in analogue form — music in vinyl tracks, images in nitrate film, words and numbers in documents — into digital information that can be processed by powerful computers and transmitted via fibre optic cables to a global audience. Nicholas Negroponte, founder and Chairman Emeritus of MIT's Media Lab, predicted that the world is inevitably

Figure B.4: Increase in international internet bandwidth in megabits/second
(Logarithmic scale)



Source: International Telecommunications Union.

Box B.1: The pivotal role of the telecommunications sector

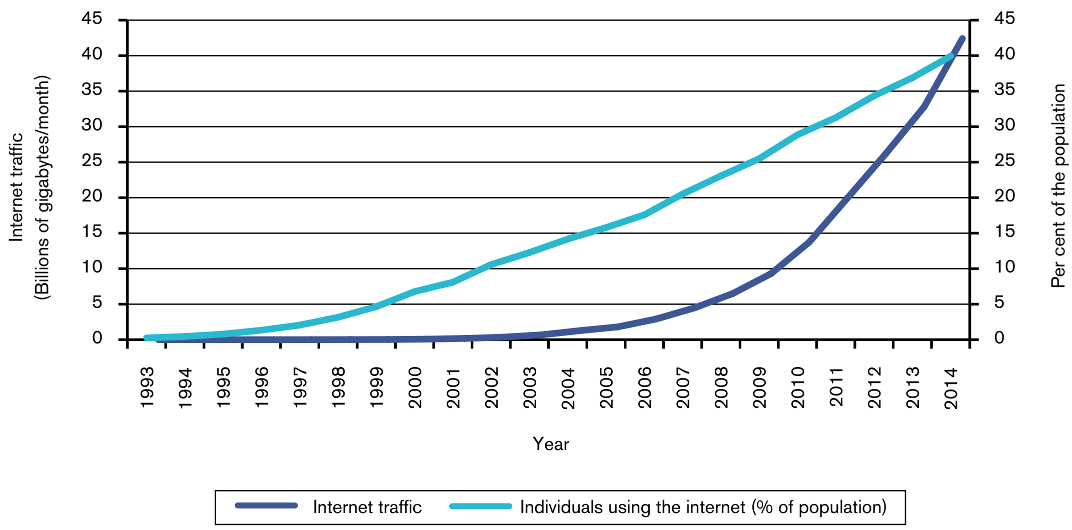
According to Roy (2017), telecommunication services, including internet, mobile telephony, and data transmission services, provide the basic infrastructure and transmission capacity that allow a range of other services to be provided digitally, and also permit goods and services to be offered and purchased through these networks. The technological developments described in Section B.1 have improved the quality, speed, carriage capacity and affordability of networks – including, for example, fixed and mobile broadband services – making it easier to supply products digitally and to connect producers, sellers and consumers across borders.

Telecommunication services also underpin data flows across borders which have skyrocketed in recent years. Cross-border data flows, boosted by basic and value-added telecommunication services, such as data processing and storage via high capacity (i.e. “cloud” storage), allow companies not only to sell their goods and services, but also to coordinate their logistics and the activities of their subsidiaries and partner offices across the globe (Tuthill, 2016). Nowadays, broadband access to the internet and other data networks offers the higher speeds that are required to exploit technologies such as cloud computing that allow a more widespread use or offering of services that require the transfer of large quantities of data (WTO, 2016c).

Telecommunication services, and more specifically the internet, are essential for the functioning of key pillars of e-commerce such as online retail and wholesale trade, whether cross-border or domestic. Indeed, without increased capacity and speed, and the lower communication costs brought about by improvements in telecommunication and computer services, the sale of goods online as it stands today, including inventory management, would not be possible.

Information and communication technology (ICT) services, in particular broadband network services, enable companies to develop new products and find innovative ways of reaching their consumers, connecting with other companies and managing their internal operations (e.g. cloud computing and data storage) without having to invest in servers or other costly equipment. Indeed, the internet is now one of the most important business platforms for companies, domestically and internationally.

Figure B.5: Individuals using the internet and volume of internet traffic



Source: Cisco Systems and World Development Indicators.

heading towards a future where everything that can, will be digitalized (Negroponte, 1995).

This third tend makes it possible to take full advantage of the massive leap in computing power and in the speed and expanding capacity of today's communication systems. It has enabled and motivated enterprises and governments to assemble large sets of data ("big data") which, through the use of advanced analytical methods, can be mined for patterns, relationships and insights. The term "big data" does not refer simply to the quantity of digital information, but to a qualitative leap in ability that collecting such large sets of digital information makes possible. Those capacities include "the ability to extract new insights or create new forms of value, in ways that change markets, organizations, the relationship between citizens and governments, and more" (Mayer-Schönberger and Cukier, 2013).

The use of big data helps a variety of stakeholders, from public health authorities which use Google Flu Trends to estimate influenza activity in real time, to technology giants such as Amazon and Netflix, which use "recommendations" from their big data algorithm to generate a significant portion of new sales. However, it has been argued that big data can also be the foundation of information asymmetry between firms with differing access to data, and between countries due to the digital divide (Ciuriak, 2018b). The qualitative leap that big data allows may not only be the basis for new benefits, but also the source of market failures that will characterize the data-driven economy.

As a result of this data explosion, the magnitude of digital information has grown rapidly. The total amount of digital information in 2012 was calculated to be 2.7 trillion gigabytes. By 2016, the amount of data created that year alone amounted to 16.1 trillion gigabytes (Reinsel et al., 2017), and it has been projected to increase tenfold to 163 trillion gigabytes by 2025. How this data is stored, accessed and processed has changed over time as well. To quote Reinsel et al.:

> "Before 1980, data resided almost exclusively in purpose-built datacentres. The data and processing ability remained centralized in mainframes. Between 1980 and 2000, the rise of the personal computer enabled a more democratic distribution of data and computing power. Data centres evolved from mere data containers to become centralized hubs that managed and distributed data across a network to end devices. From 2000 to the present, the growth of wireless broadband and fast networks encouraged data's movement into the cloud, decoupling data from specific physical devices (PCs, phones, wearables) and ushering in the era of accessing data from any screen. Datacentres expanded into cloud infrastructure".

The discussion has, for understandable reasons, emphasized the role of the technological drivers of the digital revolution. This may give a couple of false impressions: that technology is destiny and that everything digital is revolutionary. But as Tim Harford, Financial Times Columnist, suggests (see his opinion piece on page 29), neither is necessarily true. First, plenty of other things need to change if innovations are to become truly transformative. Second, not everything that glitters is gold.

(b) Digital innovations likely to shape the future

The digital innovations that are the focus of this report – 3D printing, the Internet of Things (IoT), artificial intelligence and Blockchain – and that are outlined below have been made achievable by the exponential rise in computing power, bandwidth and digital information. Without the aid of massive computing power to process and analyse data, the interconnectedness that the internet creates, and the bandwidth that makes the instantaneous and bulk transfer of information feasible, these innovations might not have arisen and certainly would not have the same potential that they do now.

In this section, we describe these technologies in more detail. Their market impact is discussed in Section B.1.(c), and a more detailed examination of their trade effects is made in Section C.

Internet of Things

The IoT can be defined as a "global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies".[1] More simply, the concept of the IoT is "that everyday objects can be equipped with identifying, sensing, networking and processing capabilities that will allow them to communicate with one another and with other devices and services over the internet to achieve some useful objective" (Whitmore et al., 2015). In some sense, the ideas underlying the IoT are not new – for example, technologies such as radio-frequency identification (RFID) have long been used by businesses for tracking items. RFID refers to any identification system wherein an electronic device that uses radio frequency or magnetic field variations to communicate is attached to an item (Glover and Bhatt, 2006). The

OPINION PIECE

What else needs to change?

By Tim Harford, Financial Times Columnist

Last year's *Blade Runner* sequel persuaded me to watch the 1982 original again – set in 2019. For all the amazing qualities of the film, it fails to provide a convincing vision of today's technology. And it fails in a particular way: when our hero Deckard falls for "Rachael", he already knows that Rachael is a highly intelligent organic robot, so sophisticated that she can hardly be distinguished from a human. Yet Deckard likes her and asks her out on a date – using a graffiti-scrawled public payphone.

That payphone is jarring, but in fairness to *Blade Runner,* we often make exactly the same mistakes when imagining new technologies. We wrongly assume that a technology like "Rachael" could somehow appear, yet little else would change. And we're hypnotized by the most sophisticated stuff, missing humble ideas that quietly change everything.

For example: when I embarked on my latest project – a book and BBC series about "Fifty Things That Made the Modern Economy" – everyone told me that I simply must include Gutenberg's movable type printing press. It was revolutionary of course, but when I came face-to-face with a 1450s Gutenberg bible, with its twin black columns of dense Latin text, I realised that there was another story to tell: the story of humble paper.

Without paper, the economics of printing simply do not work. Paper is nothing special, except that it is far cheaper than animal-skin parchment. It's so cheap that we now use it to wipe our backsides.

Other revolutionary cheap-as-toilet-paper inventions include: barbed wire, the cheap fencing material which allowed the colonisation of the American west; the lossy-yet-convenient MP3 music format; and the shipping container, a simple steel box that supercharged global trade.

Of course, some innovations truly are revolutionary, producing effects that would have seemed like sorcery to previous generations. The cell phone is one; the computer is another. Further back in time, one would include electricity and the internal combustion engine. Such inventions fit our instincts about what "new technology" should look like: unlike paper and shipping containers, they are mysterious and complex, like the organic robot Rachael.

Yet even here we think too much about the amazing technology, and too little about the workaday social and organizational changes needed to unlock its potential. Electricity should, by rights, have blossomed in US manufacturing in the 1890s, but in fact it wasn't until the 1920s that electric motors really delivered on their promise, and productivity surged.

The reason for the thirty-year delay? As the economic historian Paul David famously described it, the new electric motors only worked well when everything else changed too. The older, steam-powered factories had delivered power through awe-inspiring drive-shafts, secondary shafts, belts, belt towers, and thousands of drip-oilers. The first attempts to modernize simply replaced the single huge engine with a huge electric motor, changing little.

Electricity triumphed only when factories themselves were reconfigured. The drive-shafts were replaced by wires, the huge steam engine by dozens of small motors. Factories spread out; there was natural light, and room to use ceiling-slung cranes. Workers had responsibility for their own machines; they needed better training and better pay. The electric motor was a wonderful invention, once we changed all the everyday details that surrounded it.

I am as clueless about the future of technology as anyone – but I've learned three lessons by looking at its history. One: don't be dazzled by the fancy stuff. Two: humble inventions can change the world if they're cheap enough. Three: always ask, "To use this invention well, what else needs to change?"

two essential elements of an RFID system are the tag, which is the identification device attached to the item to be tracked, and the reader). Direct machine-to-machine communication is basic to the idea of the internet, in which clients, servers and routers communicate with each other (Whitmore et al., 2015). But advances made possible by massive computing power, the ability to process large amounts of real-time data, and communication through the internet have now given machine-to-machine communication a wider range of applications.

As a result, for businesses and consumers, the IoT is of growing interest. For consumers, the IoT can improve the quality of their lives by allowing them to track physical fitness and health or better manage their homes through smart appliances, such as connected or "smart" refrigerators. Meanwhile, the IoT can help businesses improve their operational efficiency through better preventive maintenance of machinery and products, as well as by providing them with opportunities to sell digital products and services (Accenture, 2015). More broadly, the IoT will allow companies to offer a better customer experience and better manage their organizations and complex systems (Fleisch, 2010).

Nevertheless, wider adoption of the technology faces some stiff challenges. They include security, connectivity, and compatibility and longevity (Banafa, 2017). The deployment of connected devices in the home or office, many of which were designed without much thought for security, can introduce dangerous vulnerabilities and will require the development of sufficient technical and perhaps regulatory safeguards. Connecting millions or billions of new devices to the internet can create serious bottlenecks in telecommunication systems requiring companies and governments to spend on new investments to upgrade these systems. Finally, as so many companies are competing to develop new connected devices for both business and consumer markets, compatibility issues are likely to arise and there will be a need to develop some standards to cope with this.

Artificial intelligence (AI)

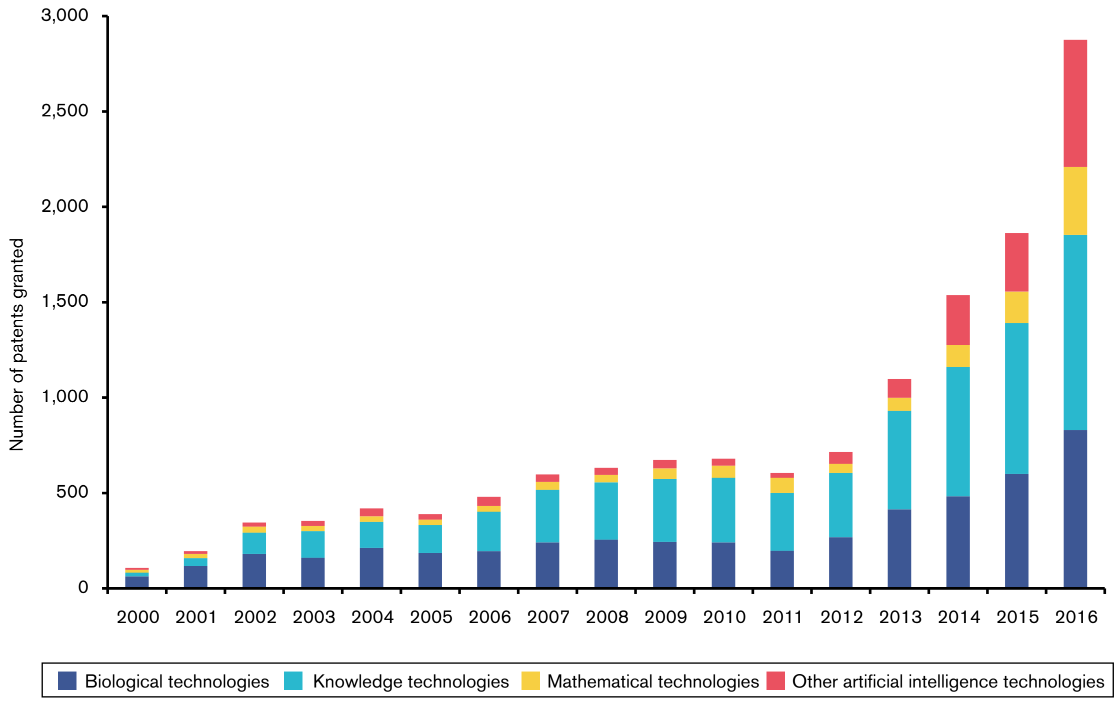
Artificial intelligence (AI) is "the ability of a digital computer or computer-controlled robot to perform tasks commonly associated with intelligent beings [...], such as the ability to reason, discover meaning, generalize or learn from past experience".[2] Much of today's AI is "narrow" or "weak", in that it is designed to perform a narrow task (e.g. facial recognition, playing chess). However, the long-term goal of many AI researchers is to create "general" or "strong" AI which may be characterized as the effort "to build a machine on the model of man, a robot that is to have its childhood, to learn language as a child does, to gain its knowledge of the world by sensing the world through its own organs, and ultimately to contemplate the whole domain of human thought" (Weizenbaum, 1976). According to the Future of Life Institute (2018), "While narrow AI may outperform humans at whatever its specific task is," [...] general AI "would outperform humans at nearly every cognitive task". In pursuit of this goal, important branches of AI, such as machine learning, rely on computing power to sift through big data to recognise patterns and make predictions without being explicitly programmed to do so.

AI was first used in the technology sector, but the non-technology sector is finding an increasing number of uses for it. One example is the growing adoption of AI by "traditional" car manufacturers, such as General Motors and Nissan, as they compete with technology companies, such as Alphabet (Google), Uber and Tesla, to develop autonomous vehicles (Future of Life Institute, 2018). Figure B.6 which shows the number of AI patents granted since 2000 in various fields (biological, knowledge, mathematical and other technologies) gives an indication of the rapid developments occurring in the AI field.

One way to look at AI is as the latest form of automation (Aghion et al., 2017). However, instead of substituting machine power for manual labour, as in the past, the use of AI involves substituting the computing ability of machines for human intelligence and expertise. Human abilities that were once thought to be out of the reach of machines, such as making a medical diagnosis, playing chess or navigating an automobile, are now either routine or well within reach. Two uses of AI – analogous to the weak AI and strong AI distinction – may be distinguished here, i.e. AI which aids the production of goods and services, and AI which helps to generate new ideas (Aghion et al., 2017; Cockburn et al., 2018). Examples of the former use of AI include guiding robots in warehouses, optimizing packing and delivery, and detecting whether loan applicants are being truthful. Examples of the latter use of AI are analysing data, solving mathematical problems, sequencing the human genome, and exploring chemical reactions and materials.

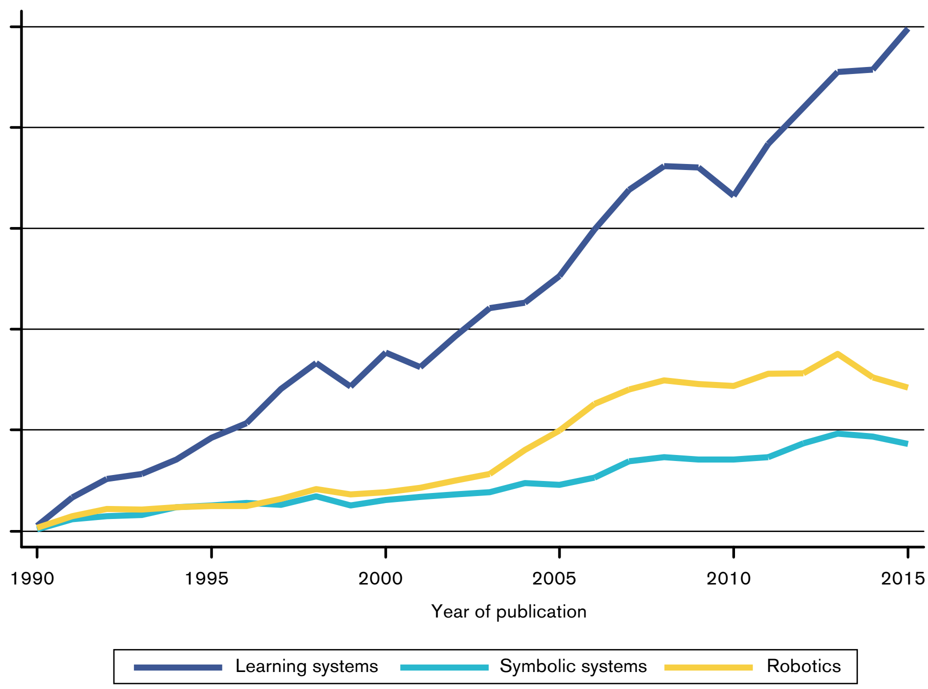
Cockburn et al. (2018) claim that AI is increasingly being used to generate ideas and as a general-purpose "method of invention" that is reshaping the nature of the innovation process. They find support for this hypothesis in the fact that one field of AI, namely learning systems, which involves the use of analytical programs modelled on neurologic systems to process data, has experienced much more rapid growth than other fields of AI (see Figure B.7).[3]

Figure B.6: Number of patents granted in artificial intelligence, 2000-16



Source: Fuji and Managi (2017) based on WIPO Patentscope database

Figure B.7: Scientific publications by AI field over time, 1990-2015



Source: Cockburn et al. (2018).

There is an important economic implication of this use of AI as a generator of new ideas. Aghion et al. (2017) argue that this use of AI can permanently increase the rate of economic growth. Their explanation for this is that the rate of economic growth depends on the expansion in the size of the research community and that the use of AI to generate new ideas is equivalent to making "effective" research grow faster than the growth in the size of the research community.

The successes achieved by AI should not cloud our perception of the technical challenges that still lie ahead of it. One frequent observation attributed to Donald Knuth[4] is that: "AI has succeeded in doing most everything that requires 'thinking' but has failed to do what people do without thinking". The things that people do without thinking but which are proving challenging for AI include perceiving and navigating our physical environment. In some of its proponents' most ambitious predictions,[5] AI sometimes has the feel of science fiction, which is not altogether surprising, given that it has been the subject of great literary imaginings since the 19th century.[6] And this enormous potential also offers the possibility of less positive changes, such as AI displacing human workers in the labour market (WTO, 2017d), being programmed to do something destructive, or developing a destructive method for achieving its goal even though that goal may be altogether beneficial. Some philosophers have even broached as a possibility the extinction of mankind from the rise of "superintelligent"[7] AI.

Still, the weight of expert opinion is on the side of the potential benefits of AI rather than the possible costs. Nevertheless, as a result of the recognition of the challenges associated with AI, some leading lights of the tech industry and the AI research community have collectively signed an open letter, calling for the focus of AI research to be on making it more robust and beneficial for humankind while mitigating its adverse effects, which could include increased inequality and unemployment.[8] The areas of research identified by the signatories for special focus include the labour market impacts of AI, law and ethics, and increasing the safety or robustness of AI systems (i.e. verification, validity, security and control).

Additive manufacturing (3D printing)

Additive manufacturing, more popularly known as 3D printing, "is a process of making a three-dimensional solid object of virtually any shape from a digital model [...] achieved using an additive process, where successive layers of material are laid down in different shapes [...] considered distinct from traditional machining techniques, which mostly rely on the removal of material by methods such as cutting or drilling (subtractive processes)".[9]

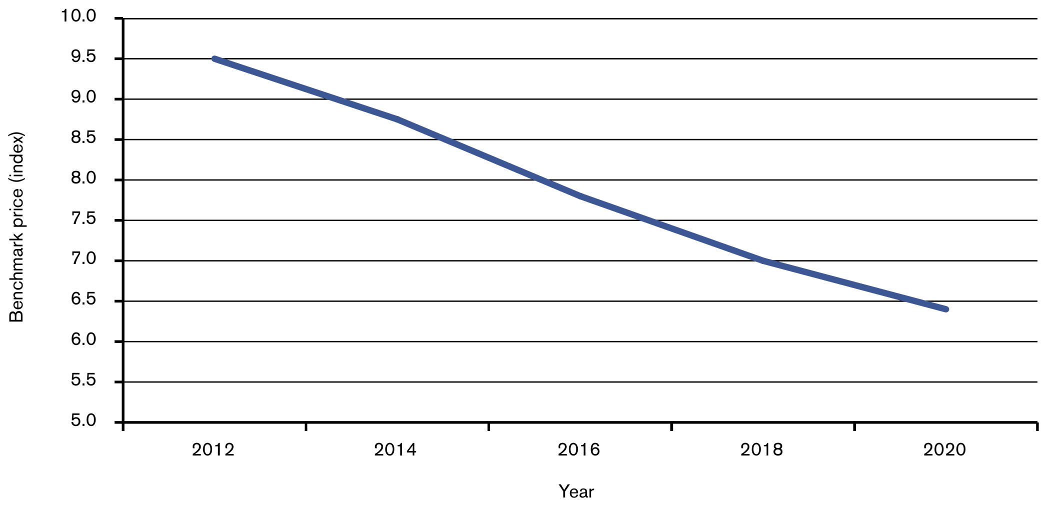
3D printing is currently used for a wide range of applications, from manufacturing parts for planes, trains and cars, to formulating fruit-based snacks (Garrett, 2014; Derossi et al., 2018). 3D printing makes customization much easier and less costly, as it involves a new design and a change in computer code rather than new production tools and moulds and costly modifications to factories. For instance, Shapeways, an e-commerce platform, enables designers to upload designs for products, use 3D printing to create the physical items, and manage logistics so that those items reach the end-consumers. The technology has been argued to be a boon for firms operating in low volume-markets and in customized and high-value production chains as aerospace and medical component manufacturing. Additive manufacturing is expected to lead to a shift towards more digital and localized supply chains and lower energy use, resource demands and related CO2 emissions over the product life cycle (Gebler et al., 2014).

In recent years, large-scale 3D printers intended for use in enterprises has developed from a promising technology to being at the cutting edge of technological change, signalling that mainstream adoption is starting to take off (DHL, 2016a). Recent years have also seen an increase in the sales of small-scale desktop printers, acquired mainly by educational institutions and creativity hubs. By 2025, McKinsey & Company (2013) estimates the potential economic impact of 3D printing to be between US$ 200 billion and US$ 600 billion.

The market for additive manufacturing is also growing rapidly. In a survey of nearly 1,000 stakeholders (mostly engineers and company CEOs) conducted by Sculpteo (2017), it was found that expenditure on 3D printing was expected to rise by 55 per cent in 2017. Estimates of the market for 3D-printing by 2020 vary quite a bit with De Backer and Flaig (2017) citing a range of figures between US$ 5.6 billion and US$ 22 billion.

Full realization of the potential of 3D printing depends on overcoming a number of obstacles. The necessary material technology is still nascent and building complex objects is slow. There are also regulatory issues that need to be addressed before 3D printing is to be more widely adopted in the consumer market. They include product warranties, liability attribution and questions about intellectual property. Finally, although it has declined in recent years (see Figure B.8), the cost of printers, materials and scans is still relatively high, especially for deployment in micro, small and medium-sized enterprises (MSMEs).

Figure B.8: 3D printer benchmark prices



Source: WTO Secretariat computations based on data from research by IBISWorld (benchmark prices).

Blockchain

A blockchain is a tamper-proof, decentralized and distributed digital record of transactions (distributed ledger). It is made of a continuously growing list of records, which are combined in "blocks" that are then "chained" to each other using cryptographic techniques – hence the term "blockchain". Once added to a blockchain, information is time-stamped and cannot be modified, so that attempted changes can easily be detected, and transactions are recorded, shared and verified on a peer-to-peer basis.

A key feature of Blockchain is that trust is shifted away from the centralized intermediaries who normally function to authenticate a transaction. With blockchain technology, authentication is achieved through cryptographic means. All participants have access to the same, up-to-date "version of the truth", but no single user can control it, which allows people who have no particular confidence in each other to collaborate without having to rely on trusted intermediaries. Blockchain is, as The Economist (2015) calls it, "a trust machine".

Another interesting characteristic of blockchain technology is that it offers the possibility of using smart contracts, i.e. computer programmes that self-execute when specific conditions are met, to automate certain processes such as payments of duties, and to guarantee to users the strict execution of transactions. Because of their distributed nature and the fact that they use various cryptographic techniques, blockchains are said to be highly resilient to cyber-attacks compared to normal databases. Hacking a blockchain network is economically inefficient and extremely hard in practice, but a 51 per cent attack – i.e. an attack by a group that controls more than 50 per cent of the network's computing power – is not impossible. In fact, the computing power capacity of the Bitcoin and Ethereum blockchains is increasingly aggregated. This potential vulnerability remains subject to debate in the information technology (IT) community. Furthermore, while blockchain technology itself is highly resilient, vulnerabilities can exist at the level of smart contracts and user interface (i.e. the mobile phones, tablets or computers used to access the internet). This is where most security flaws occur in the Blockchain ecosystem, as demonstrated by the 2016 DAO (i.e. Decentralized Autonomous Organization) attack in which millions of dollars' worth of assets were siphoned off.

Blockchains can be "permissionless", i.e. meaning that anyone can participate in the network, or "permissioned", i.e. meaning that restrictions can be imposed on who can read and/or write on the blockchain. Much of the excitement about blockchain technology has been centred on public permissionless blockchains used for cryptocurrencies. However, the potential use of blockchain technology extends to many other applications, from banking and finance to land registration, online voting, and even supply chain integration (see Section C) – with many such applications being permissioned blockchains. Figure B.9 shows the typical steps involved in a blockchain transaction.

Blockchain is the most well-known distributed ledger technology (DLT), but an increasing number of other models are being developed that, like Blockchain, are distributed and use various cryptographic techniques, but that are moving away from the concept of "blocks" – or even from both the concepts of "blocks" and "chains". One example of this is IOTA, a cryptocurrency[10] designed for machine-to-machine communication, in which each transaction is linked to two previous transactions as part of the validation process to form a "tangle" rather than a chain. Today, the term "blockchain" is commonly used to refer more generally to distributed ledger technology and to the phenomenon surrounding it. Like many other studies, this report will use the term "blockchain" in a generic way to refer to distributed ledger technologies.

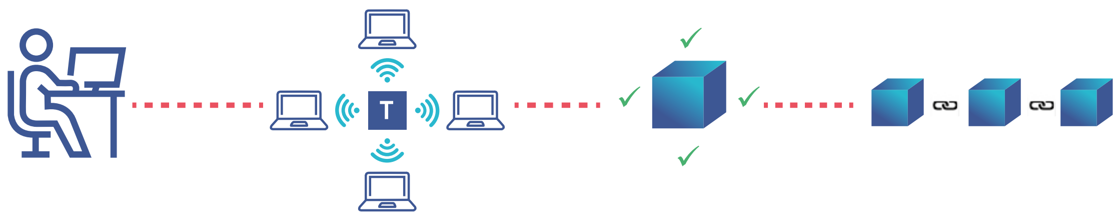
A technology that could "change our lives" for some (Boucher, 2017), a "pipe dream" and "the most overhyped technology" for others (Roubini and Preston, 2018), the real potential of Blockchain to truly transform the way business is done remains to be fully assessed. Indeed, the deployment of Blockchain currently hinges on various challenges.

Firstly, scalability of the main public blockchains remains limited due to the predetermined size of blocks and to the level of energy required to power the networks.[11] The Bitcoin platform, for example, handles about seven transactions per second on average[12] and the public blockchain Ethereum twice as many,[13] while Visa can process 2,000 transactions per second, with peaks of 56,000 transactions per second (Croman et al., 2016). However, permissioned blockchains – which are the most common types of platforms being tested when it comes to international trade – generally use computationally less expensive consensus protocols and can be more easily scaled up. The Hyperledger Fabric, for example, which is a distributed operation system for permissioned blockchains, can process 3,500 transactions per second for certain workloads (Androulaki et al., 2018).

Secondly, existing blockchain networks and platforms have their own technical specificities and do not "talk to each other". Organizations such as the International Organization for Standardization (ISO) and the International Chamber of Commerce (ICC) have started to look into issues of interoperability and standardization and various technical solutions are being developed by IT developers. However, solving the "digital island problem" is likely to take time.

Finally, the use of blockchain technology raises a number of legal issues, ranging from the legal status of Blockchain transactions (whether blockchain transactions are recognized legally) to applicable law (which law applies in the case of a blockchain spanning

Figure B.9: Typical steps involved in a blockchain transaction



1.
Transaction submitted or requested.
Can involve documents, contracts, cryptocurrency, etc.
The data are “hashed” and encrypted.
Possible to encrypt documents.

2.
The transaction data T are broadcast to the peer-to-peer network.

3.
Validation (by authorized nodes only in the case of permissioned blockchains).

Validating nodes take the transaction from the transaction pool and combine it with other transactions in a block.
Block validated based on the consensus protocol of the blockchain.

4.
Validated block added to the chain
and linked to the previous block in an permanent and unalterable way.

Source: Ganne (2018).

various jurisdictions), and liability issues (who has liability if something goes wrong and what resolution mechanism applies in case of conflict), not to mention possible compatibility issues with existing regulations.[14]

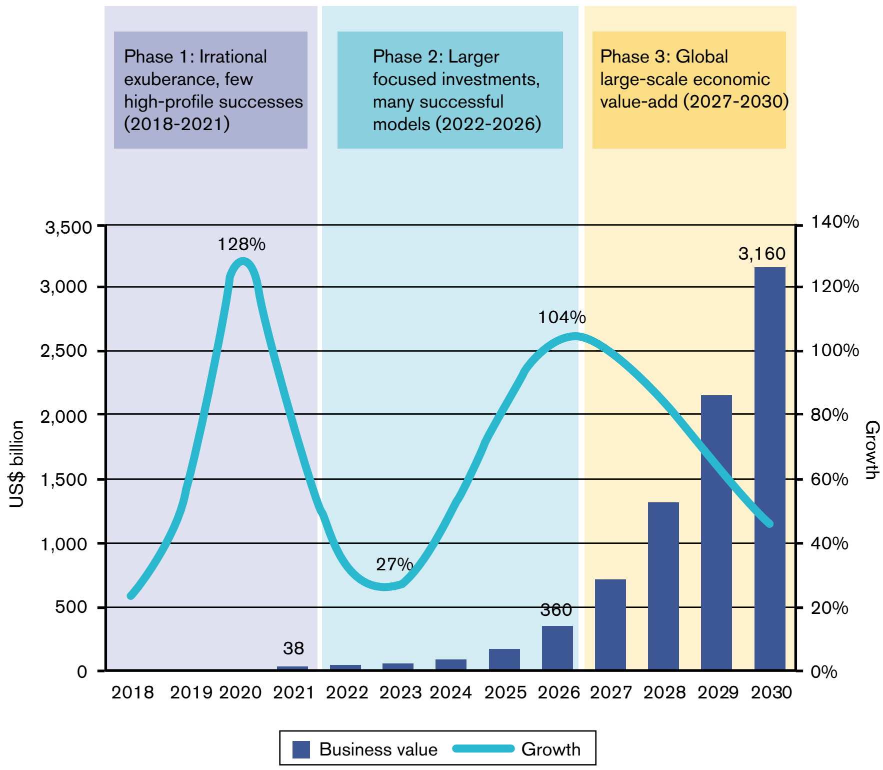
In spite of these challenges, which are the subject of active work to develop technical solutions, the promise of greater security, efficiency, integrity and traceability offered by Blockchain is leading an increasing number of companies to investigate the potential of the technology as a way to cut costs and improve their current business practices. The number of blockchain-related patent applications tripled in 2017, with China filing more than half of them, followed by the United States and Australia (Financial Times, 2018). A Gartner report on blockchain trends (Gartner, 2018) forecasts that the current phase of "irrational exuberance, few high-profile successes" will be followed between 2022 and 2026 by "larger focused investments, many successful models" (see Figure B.10), that after 2026, the technology will be a "global large-scale economic value-add", and that by 2030, blockchains could deliver US$ 3 trillion of value worldwide, through a combination of cost reduction and revenue gains (Gartner, 2018). Given the still early stages of the technology and existing challenges, whether such predictions will indeed become reality, remains to be seen.

(c) How digital technology is impacting the economy

(i) The birth of online markets

Digitalization has been reshaping consumer habits over the last decade, and there is every indication that more changes are still to come. A salient aspect of the adoption of digital technology by consumers at the global level is the worldwide trend towards buying goods and services online. Underlying this behavioural shift to online shopping is the widespread use of internet-enabled devices such as smartphones, tablets and laptops which provide consumers with direct access to online markets. These devices provide consumers with real-time information about a wide range of available goods and services and have revolutionized the way they identify, compare and pay for their selected products.

Figure B.10: Gartner's Blockchain business value forecast, 2018-2030



Source: Figure 3: Blockchain Business Value Forecast Highlights Three Phases of Development, in Gartner (2018).

As illustrated in Figure B.11, the share of US consumers who researched a product on a mobile device increased rapidly, from 22 per cent in 2013 to almost 30 per cent in 2015. In addition, the share of those who made an online purchase using their mobile phones almost doubled in the same period to 18 per cent in 2015.

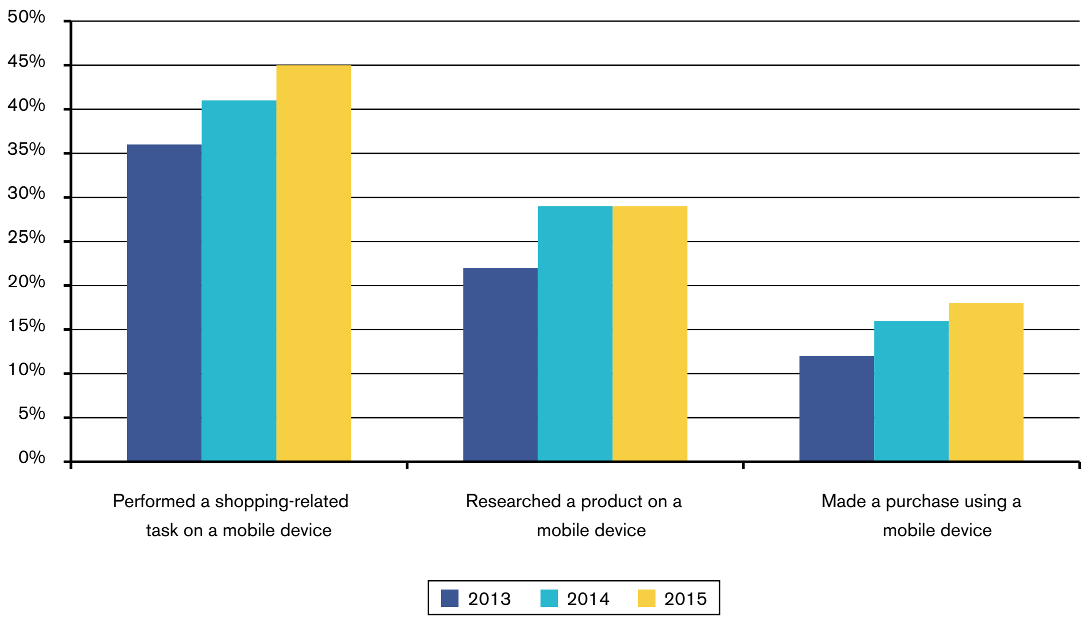
Importantly, the integration of these tools into the shopping experience has gone beyond the simple act of searching and buying items online. Indeed, the vast majority of consumers seek and share opinions and reviews on specialized forums such as Yelp and TripAdvisor and also refer to their peers' “likes” and testimonials on social networks before making a purchase online. As Deloitte (2015a) states, "Digital technology has already permeated the path to purchase, as today's consumers use websites, social media, and mobile apps not only to research products, compare prices, and make purchases, but also to provide feedback to peers and even companies". Notably, online reviews appear to be a significant driver of purchasing decisions for nearly 70 per cent of survey respondents (Ervin, 2016).[15]

Conscious of this change in consumer behaviour, companies have reacted fast by adapting their products and services accordingly. They have reinforced their online visibility and customized their content for a range of devices. An application, or app, may be tailored to the needs of mobile shoppers, but an interactive website must be made available in parallel in case it is the laptop that is used to make the purchase (EY, 2015). This type of customized online presence enabled eBay, for example, to generate over US$ 400M in sales from its iPhone app in the first full year (Accenture, 2014).

In order to attract this growing number of digital consumers and better meet their needs, firms are implementing new digital marketing techniques such as offering product comparison tools, designed to help consumers save time and make decisions based on tailored criteria (Deloitte, 2015a), proposing free shipping, or sending alerts to inform customers that a product is on sale (EY, 2015).

Digitalization has not only altered the way consumers and companies conclude transactions, but it has also altered the relationship between companies and

Figure B.11: Online shopping habits of US consumers between 2013 and 2015



Source: EY (2015).

Note: This study, conducted in March-April 2015, surveyed 5,516 Synchrony Bank cardholders and 1,209 random national shoppers. Respondents were aged 18+, participate in household financial decisions and had shopped with a major US retailer in the six months prior to the date of the survey. The data have been weighted to US census proportions. All references to consumer and shopper in this paper refer to survey respondents.

customers. For instance, social networks have enabled companies to promote their identities and to build new kinds of relationships with their customers. Almost half of survey respondents stated that they follow their favourite brands on social media (EY, 2015).

Certain companies have also begun to use AI techniques to deepen their understanding of consumer behaviour, identify customers' preferences and adapt their products and services accordingly. In the retail industry, companies now commonly use recommendation engines to better grasp consumers' shopping habits. This AI technique relies on machine-learning algorithms, which collect data points from each customer during their path to purchase, store every decision they make and continually adjust recommendations until the purchase is made. Amazon, one of the first to introduce this technology in the early 2000's, attributes 35 per cent of its sales to the engine.

Netflix offers another example of companies which leverage AI tools to achieve success. According to PWC (2015b), "What has made of Netflix a success story and set it apart from competitors is that Netflix closely analyses user demographics, viewing behaviour, and programming preferences. Its insights are used to create personalized content recommendations and to tailor the promotion of new shows to various audience segments".

(ii) What is being exchanged?

Media services

As digital technology led to the development of sophisticated devices, it has made it possible for consumers to use certain products online whenever and wherever they want, on condition that they are connected to the internet. One category of such products is audiovisual media and software, which are easier to digitalize than other types of digitalized products. For instance, movies and television series are now available via platforms such as Netflix, and may be watched on smartphones and tablets. E-books may be obtained from platforms such as Amazon and read via devices or apps, such as Amazon's Kindle reader and app. The market share for e-books is growing rapidly in developed countries; for example PWC (2015b) projected that the e-book market share in Germany would reach 17 per cent in 2017. And recorded music media were "physical" until the early 2000's, after which digital music sales increased rapidly, reaching 26 per cent of the recording industry's revenues in the European Union in 2015 (PWC, 2015b).

Other online services

Digitally-enabled services can be defined as a wide set of services that can be remotely delivered through ICT networks, for example the transportation services delivered by Uber or Lyft, which offer a personalized taxi service arranged via an app on the customer's mobile device (Accenture, 2015). Such digitally-enabled services are increasingly important nowadays. Other examples include consulting, legal and financial advice, teaching and coaching, which use interactive websites, e-mails and real-time communication tools such as Skype to offer knowledge-intensive services even across borders, allowing domestic firms and consumers to benefit from foreign talents. The United Nations Conference on Trade and Development (UNCTAD) (2017a), commenting on the increasing tradability of these remotely delivered services, states that "these platforms are enabling web designers, coders, translators, marketers, accountants and many other types of professionals to sell their services abroad. Annually, some 40 million users access these platforms looking for jobs or talent".

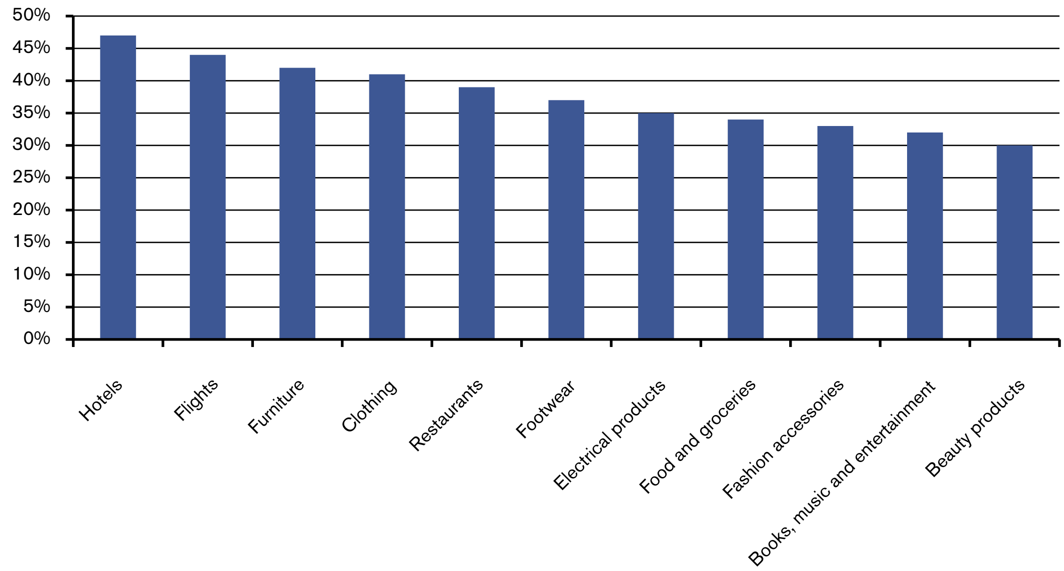
Another type of digitally-enabled service which has been experiencing a sharp increase in demand with the massive use of new devices such as tablets and smartphones is online gaming, and in the EU, for example, online gaming revenue increased ten-fold during the first decade of this century, rocketing from EUR 0.4 billion in 2003 to EUR 4 billion in 2013 (PWC, 2015b). Other services that can be delivered remotely, such as customer care, telehealth and remote surgery can generate substantial revenues for countries exporting those services. For example, India earned US$ 23 billion mainly from exporting such services in 2014 (UNCTAD, 2017a), and Chatterjee (2017) indicates that the medical tourism market in India is expected to reach US$ 7-8 billion by 2020.

Tourism offers further examples. Today, consumers can plan a trip online in only a few clicks, comparing flight prices on specialized websites such as Google Flights or Skyscanner, paying and checking in online and downloading their boarding passes to their mobile devices, while accommodation can be booked via mobile apps with companies such as Booking.com or Airbnb.

Customized and personalized goods and services

Consumers are becoming increasingly demanding and exhibiting a stronger taste for customized and personalized products tailored to their specific needs. For instance, almost one-fifth of consumers declare that they are willing to pay a 10 per cent premium to personalize products they purchase (Deloitte, 2015a). Another survey by Deloitte (2015b) revealed that almost half of survey-responding consumers are willing to wait longer for tailored goods and services.

Figure B.12: Consumers are interested in personalized goods and services



Source: Deloitte (2015b).

Figure B.12 suggests that the personalized services that interest consumers most, across all age groups, are related to holidays, hotels and flights.

Figure B.12 suggests that there is a growing interest in personalized goods as well as services. In response to this preference for customization, manufacturers have begun to embed online configuration options in their interactive websites. These features enable shoppers to configure the required goods or services using a range of available components or options.

Businesses too are adopting cutting-edge technologies such as product visualization techniques and 3D printing (EY, 2016). The use of this technology has been simplified by smart apps which can scan any product and turn it into a digital design file. The consumer can then visualize and configure it, before picking up the product, produced via 3D printing, at an indicated location (A.T. Kearney, 2015). The textile industry offers notable example of the rapid adoption of sophisticated 3D-scanning and modelling online platforms, which are enabling consumers to scan themselves, upload their own 3D models and order clothes tailored to their specific body shapes (Gandhi et al., 2013).

(iii) Easier entry and increased product diversity in the digital market

The growth of digital marketplaces and their success in complementing and sometimes substituting for traditional markets testifies to how digital, rather than physical, trade may allow for the sometimes substantial reduction of communication, search and matching costs (see also Section C.1). In fact, there is less and less need for companies to invest in brick-and-mortar shops for customers to spend their time looking for a given product or service given the attraction of shopping online (Singh, 2008).

A notable advantage of digitalization on the supply side is that it leads to a substantial decrease in the cost of entry, making it easier for firms to produce, promote and distribute media products such as music, films and television programmes in digital form at a lower cost. For instance, an artist can record a song using a basic microphone and inexpensive software, promote it on YouTube or Spotify and distribute it on iTunes for a relatively low price, while self-publishing platforms such as Kindle or Lulu offer an alternative to the traditional book publishing model. Since 2007, it has been possible for authors to upload their manuscripts directly to self-publishing platforms and thence to distribute their books worldwide without recourse to editors or publishers (Waldfogel, 2017). Self-published books accounted for 20 per cent of e-book sales in the UK in 2013 (PWC, 2015b).

Such reductions in the cost of launching products have not only facilitated the entry into markets of new artists and producers, but have also given incentives to existing ones to bring new products to market. For instance, the number of new US television series has more than doubled since early 2000's. In 2010, the number of releases available for streaming on Netflix and on the Amazon Instant service was roughly twice the number of movies that were available in cinemas (Waldfogel, 2017).

Importantly, this easier entry of firms on the supply side has benefitted consumers in the form of substantial variety gain on the demand side (e.g. see Box B.2 on the music industry). In other words, by removing barriers to entry and relaxing distribution constraints, digitalization has provided the consumer with a wider range of available varieties, such as a growing number of TV channels, an increasingly large music catalogue through streaming or downloading platforms, and global news providers across the world anytime and anywhere, provided the consumer has access to a suitable internet connection (PWC, 2015b). Accenture (2015) mention Spotify as an example, stating that, "Spotify is changing people's consumption of music by enabling users to access a vast pool of recordings wherever they are without the need for hardware storage". Another example is Scribd, on which, by 2015, only a few years after the launch of this online platform, a half million e-books were available (PWC, 2015b).

(d) Challenges posed by digital technologies

The benefits of digital technologies notwithstanding, these technologies are also giving rise to a number of concerns, including market concentration, loss of privacy and security threats, the digital divide, and the question of whether digital technologies have really increased productivity. This section discusses some of the difficult trade-offs that society needs to confront in seeking to balance the benefits that accrue from digital technologies and the costs that sometimes arise as a result of their deployment and use. The impact of these technologies on the labour market, and on employment and wages in particular, were covered in the 2017 *World Trade Report* and are therefore not included in the list of challenges.

(i) Privacy

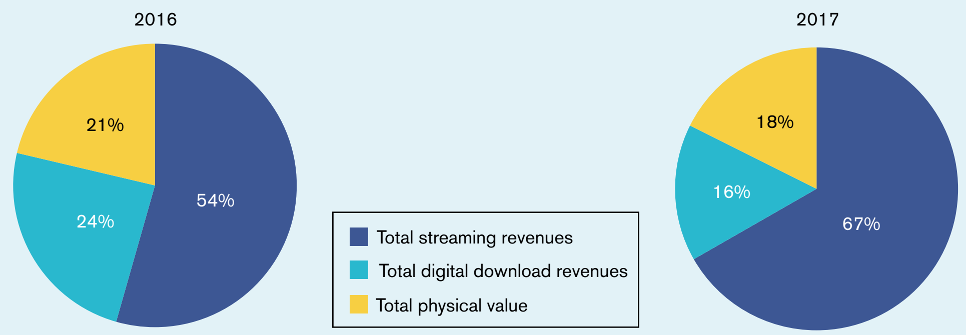
For the purposes of this section, privacy is defined as the right to have some control over how one's personal information, or data, is collected and used.[16]

Box B.2: Digitalization and the music industry

The advent of the internet was a game changer for the music industry. Innovations such as the Apple iTunes store shifted consumer demand from physical records to digital downloads. However, online music-sharing platforms such as Napster or YouTube made it difficult for those holding rights to music recordings to monetize them. Hence, global music industry revenue fell from US$ 23.8 billion in 1999 to US$ 14.3 billion in 2014 (IFPI, 2017). However, due to strong growth in subscription-based music-streaming services, the downward trend has recently reversed itself.

Digitalization primarily altered distribution in the music industry, now largely represented by music streaming, for which the number of subscriptions quadrupled between 2014 and 2017. Such subscriptions accounted for 67 per cent of total revenues of the US music industry in 2017 (see Figure B.13). However, digital technologies impacted upstream processes too by decreasing marginal costs and reducing search frictions.

Figure B.13: Music industry revenue in the United States in 2016 and 2017



Source: Friedlander (2018).

Notes: This figure shows the contributions of streaming, digital downloads and physical purchases of music to the total revenue of the music industry in the United States.

Box B.2: Digitalization and the music industry *(continued)*

The music industry has been transformed by digitalization in the following ways. First, increased demand for music over the internet changed the structure of the music supply chain. On the one hand, businesses concerned with the physical production and distribution of music records largely became obsolete and exited the market. On the other hand, new business models providing music digitally and as a service grew quickly and established themselves as important players in the industry. Despite what had been hoped for in the early days of the internet, digitalization did not increase the share of total music revenue that accrues to artists. In fact, asymmetries remain from the pre-internet era, giving the already-established major labels, as well as new aggregators (such as streaming services), great bargaining power (De León and Gupta, 2017).

Second, digitalization reduced the fixed costs of music production and drove the variable costs for copying and transportation down to near-zero. As physical printing and shipping became redundant, prices for albums fell. The reduction in music production costs increased the number of available products, improved the average quality of new products and thereby improved consumer satisfaction (Waldfogel, 2017). For instance, PWC (2015b) observes that entire music catalogues are available anytime and anywhere through streaming or downloading platforms such as Spotify and Napster (to name just a few), provided that a suitable internet connection is in place. The number of new songs added annually to Musicbrainz, a freely accessible United States-based music metadata encyclopaedia maintained by a community of users, rose sevenfold between 1988 and 2007 (Waldfogel, 2017). In 2014, 43 million licensed tracks were available online on more than 400 digital music services globally (IFPI, 2015).

Third, with only fixed costs left, economies of scale increased in the music business. As a result, revenue from highly successful products increases disproportionately, making revenues in the music business very volatile.

Fourth, the internet has reduced search costs for customers and costs for the promotion and distribution of artists. Consumers have an abundance of products to choose from and producers can leverage the size of the internet to make their music profitable. As most streaming services are based on monthly subscription fees, the effective marginal cost of listening to any song is zero for the consumer. Therefore, in principle, it should be easier for artists to be discovered by a wider audience, and indeed, curated playlists on streaming platforms are an important way of increasing audiences for artists.

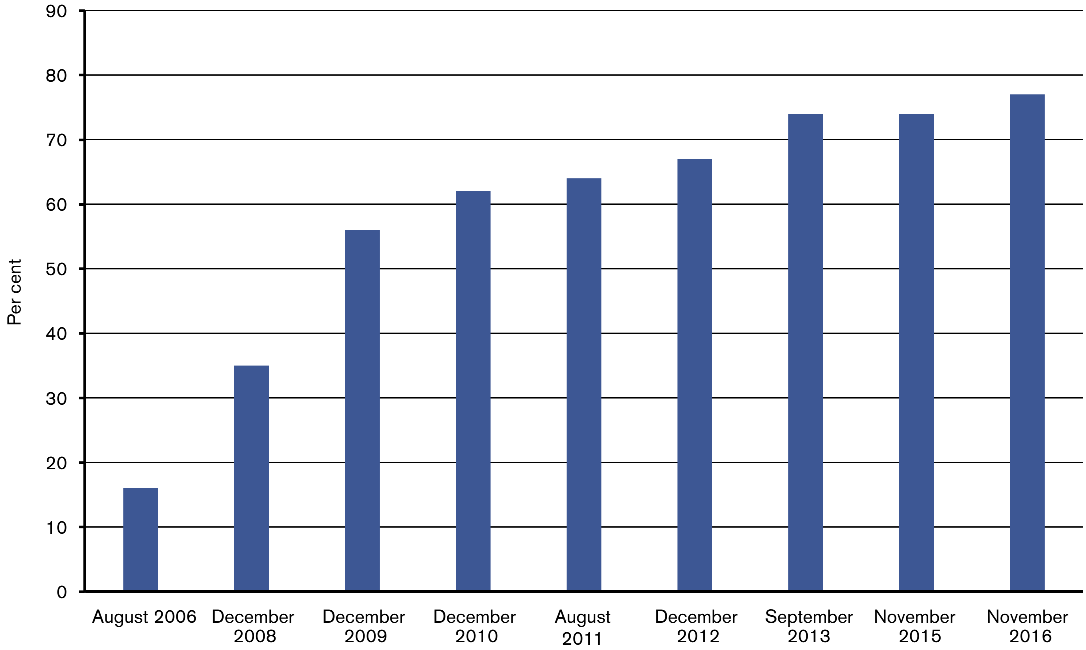
Digital technology will continue to affect the music industry. Analysing the potential of Blockchain for the music industry, De León and Gupta (2017) point out that new technologies may help to replace the complex and obscure royalty regimes by which the industry currently pays artists with simpler mechanisms that benefit both artists and consumers.

The consequences for international trade are two-fold. As physical shipment is costly, digitalization increases efficiency by replacing physical trade flows with digital cross-border data exchange. Therefore, it can be expected that physical trade in music records will shrink further and will eventually just comprise trade in physical records that have value beyond their audible content (such as sought-after vinyl antiquities). Furthermore, as digitalization reduces the distance between consumers and producers of music worldwide, specialization in music production and cross-border transactions are bound to increase.

Personal data include banking and other financial information, credit scores, medical records, biometric data, contact details, lists of friends and relatives, and one's location and itinerary.

Concerns about privacy have risen as digital technologies have made it easier to generate, collect and store personally identifiable data. The collection of personal data can occur when the individual voluntarily provides this information, such as when making an online purchase, subscribing to a free service (e.g. an email account or online storage), or becoming a member of a social network (see Figure B.14). However, personal information may also be collected when the individual has not given authorization, such as when one's image is captured by a surveillance camera, when data are hacked or stolen, when an individual's cell phone location is tracked, or when information scraped from the web is used to identify someone personally.

Figure B.14: Share of the US adult population that uses social media (Facebook, Twitter or Instagram), 2006-16



Source: Pew Research Center.

This collection of personal data has been accompanied by growing concerns that enterprises and governments are not taking data privacy more seriously. A 2016 survey by the Pew Research Center showed that more than half of the adult population in the United States did not trust the government and social media sites to protect their data (see Table B.1). This lack of trust also extends to a wider array of technology companies, including cell phone manufacturers, telecommunication companies and email providers. Partly as a result of this, a number of governments are tackling the privacy issue head-on and enacting legislation to better clarify what information about individuals enterprises can collect and retain and what they can do with this data (see Section D for a discussion of these measures).

It is important to compare these concerns to the benefits of collecting and analysing private data. This can be profitable for companies as it can help them better tailor their products and services to consumers, and this may also benefit consumers (see the discussion in Section B.1(d)). Online wish lists, grocery lists and registries can be used by firms to predict future demand, allowing them to manage their supply chains more effectively (Goldfarb and Tucker, 2012). In the area of health, electronic medical records make it easier for different health practitioners, located in different hospitals, to work together on a patient

Table B.1: Concerns about privacy
Percentage of adults in the United States confident in the ability of institutions to protect their privacy

Institutions	Not at all confident	Not too confident	Somewhat confident	Very confident
Their mobile phone manufacturers	13	13	43	27
Their credit card companies	15	15	42	27
Their mobile phone service providers	15	15	47	21
Their email providers	13	17	46	20
Companies/ retailers they do business with	15	21	46	14
The federal government	28	21	37	12
Social media sites they use	24	27	38	9

Source: Pew Research Center.
Notes: Survey conducted 30 March-3 May 2016.

because they can share information easily (Meingast et al., 2018). Advances in the area of sensor networks are making the idea of remote patient monitoring a reality. There is evidence that the combination of these various technologies is reducing medical costs and improving health outcomes (Goldfarb and Tucker, 2012).

Such examples suggest that there is a trade-off involved between securing the benefits created by the use of personal data and the need to safeguard personal information in the face of the possible harmful or illicit use of such data.

(ii) Market concentration

An important dimension of the debate concerning the role of digital technologies relates to their significance for competition. While digitalization can have important pro-competitive effects, it also brings with it the potential for limiting competition through exclusionary and/or collusive impacts.

More specifically, digitalization has eroded geographic market boundaries by facilitating the entry into markets and growth of internet-based suppliers and retailers. This, in turn, has contributed to increased competition in the provision of new types of services and goods (Organisation for Economic Co-operation and Development (OECD) and World Trade Organization (WTO), 2017).[17] Notwithstanding this, concerns have also arisen about potential anti-competitive effects in particular markets (see, for instance, The Wall Street Journal, 2018). The European Commission as well as the US Federal Trade Commission and competition agencies in other jurisdictions have investigated or are investigating the business practices of Google, Microsoft, eBay and other well-known internet-based companies.[18] (See Box D.3 for examples of competition enforcement activities).

Competition in digital markets is influenced by three significant forces that are largely absent in conventional markets, namely network effects, "scale without mass" and switching costs.[19] As discussed below, these tend to result in market concentration, first-mover advantages for incumbent firms and barriers to entry into the relevant markets.

Network effects in online platform markets consist in the increase in the value of the network to all participants that accrues from each additional user. This is the "direct network effect". Such effects often make large digital platforms an indispensable component to achieving an efficient utilization of the platform and thus lead to market concentration. "Indirect network effects" can also occur, whereby the increased size of the network attracts users on the other side of the market (potential buyers/suppliers).[20] These twin effects tend to result in winner-take-all outcomes, whereby a single network becomes dominant in each relevant market (Haucap and Heimeshoff, 2014).

In addition, the "scale without mass" feature of digital platforms allows companies to add new users vastly, rapidly and at virtually no cost, as they are not producing physical products, but simply reproducing and distributing digital bits (OECD and WTO, 2017).

High switching costs (i.e. the costs involved in moving to another platform) tend to produce customer lock-in, making it harder for new entrants to expand in a market: the more consumers use online services and provide their data to the service, the more costly and the harder it becomes for them to switch away and transfer their data (OECD and WTO, 2017). While switching costs may be not relevant to search engines as their users can switch away easily without major costs, they are relevant to social networks such as Facebook and auction platforms such as eBay (Haucap and Heimeshoff, 2014). Switching costs can be high in the case of auction platforms because a seller's reputation depends on the number of transactions that seller has already honestly completed on a given network; transferring a seller's reputation from one platform to another may be so difficult as to be almost impossible (Haucap and Heimeshoff, 2014). Switching would therefore require the seller to invest anew on building a reputation.

In addition, collusion (e.g. facilitating inter-firm coordination of supply and pricing) can also arise. Big data analytics, in particular, can result in reactive algorithmic pricing that produces effects similar to explicit coordination (i.e., reduced outputs and higher prices) without an actual agreement to collude (OECD and WTO 2017).

Overall, the nature of competition in digital markets is materially different from competition in traditional markets as it tends to be based on innovation rather than on pricing (see Wright, 2004 and Haucap and Heimeshoff, 2014). This is sometimes referred to as Schumpeterian competition, in which new players successfully replace incumbent firms through innovation or through the successful deployment of new technology (see OECD and WTO, 2017 and Haucap and Heimeshoff, 2014). Because of this, it is sometimes suggested that such anti-competitive effects as arise are unlikely to be long-lasting. However, significant welfare losses may come about as a result of anti-competitive effects before one platform or entrenched business model is replaced by another (Farrell and Katz, 2001).

(iii) Have digital technologies increased productivity?

Questions have been raised about how much the adoption of digital technologies, and specifically computers, has raised economic productivity. In 1987, Robert Solow famously said that "You can see the computer age everywhere but in the productivity statistics" (Solow, 1987). Measures of productivity in the United States suggest that there has been a significant slowdown since 2005 (Syverson, 2017). Other notable economists have argued that digital technologies will not have the same impact as innovations of the past, some of the reasons being that there are rapidly diminishing returns in the benefits derived from computing power, that some human tasks are resistant to replacement by computers, and that much of the investment in digital technologies is due to incumbents protecting their market share or substituting real products with virtual ones (Gordon, 2000). In the specific case of the United States, other factors that may be reducing the productivity gains from digital technologies are rising inequality, falling educational standards and the aging of the baby boomer generation (Gordon, 2016).

Several arguments have been made to counter this relatively negative view of the effects of digital technologies. The first one is related to the mismeasurement of inputs and particularly of outputs in the ICT sector, which obscures estimates of productivity, given that it is frequently estimated as the unexplained residual of input and output. Given that many online services are not paid for (e.g. Google searches or YouTube videos), the market is not able to fully capture gains in consumer surplus, which means that indicators like GDP understate the increase in society's well-being. Recent research appears to show large consumer surplus gains from digital technologies irrespective of whether the latter are free or paid for by consumers. These studies include Goolsbee and Klenow (2006), who looked at the value of the internet for consumers; Greenstein and McDevitt (2011) and Syverson (2017), who estimated the consumer surplus created when consumers switch from dialup to broadband; Nakamura and Soloveichik (2015), who estimated the value of free media; and Brynjolfsson et al. (2018a), who employed large-scale online choice experiments to measure the consumer surplus generated by a wide range of online services — email, search engines, maps, e-commerce, video, music, social media, and Instant Messaging. As a whole, the results from these papers appear to indicate that these services have created large gains in well-being that are missed by conventional measures of GDP and productivity.

Second, it may take time for technological revolutions to permeate throughout the whole economy. Technological change typically starts out in a small part of the economy (the ICT sector in the case of digital technologies, which was much smaller in the 1960s than it is now) and may require complementary innovations before it can have an impact on the economy as a whole (Brynjolfsson and McAfee, 2014).

A third explanation, already discussed earlier, is that digital technologies are increasing productivity, but only in certain sectors of the economy. However, these sectors with rapid productivity growth soon see their share of the economy decline, while those sectors with relatively slow productivity growth increase their share of the economy. As a result, the economy's aggregate productivity growth is weighed down by the larger share in the economy of the more stagnant sectors (Aghion et al., 2017). This explanation relies on the existence of Baumol's “cost disease”, which argues that productivity growth is difficult to achieve in some sectors such as health care and the arts (Baumol and Bowen, 1966; Baumol, 2012).

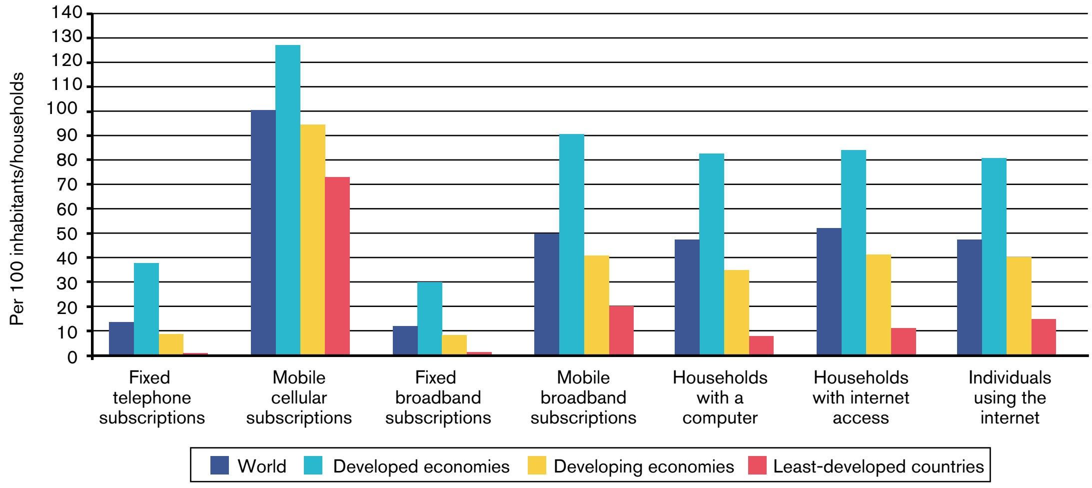
(iv) The many dimensions of the digital divide

There is evidence that digitalization is reshaping economic activity in every corner of the globe. However, this change is taking place at different speeds, depending on the degree of readiness of each country to participate in the digital economy and the extent to which each can benefit from it. This indicates that the digital divide between developed and developing countries can act as a barrier to more economic integration in the digital realm.

Access to ICT

Figure B.15 shows that developing countries, especially least-developed countries (LDCs), lag behind in all indicators of ICT development but especially so in access to broadband internet and mobile access. While access to mobile broadband hovers around 90 per cent of the population in advanced economies, it does not exceed 40 per cent in developing countries and stands at only 20 per cent in LDCs. The disadvantages in terms of internet access are magnified by other obstacles, including low download and upload speeds and relatively expensive broadband services compared to income levels in developing countries. These factors, in turn, make consumers in these countries less likely to use the internet for economic purposes (UNCTAD, 2017b).

Figure B.15: ICT by development levels

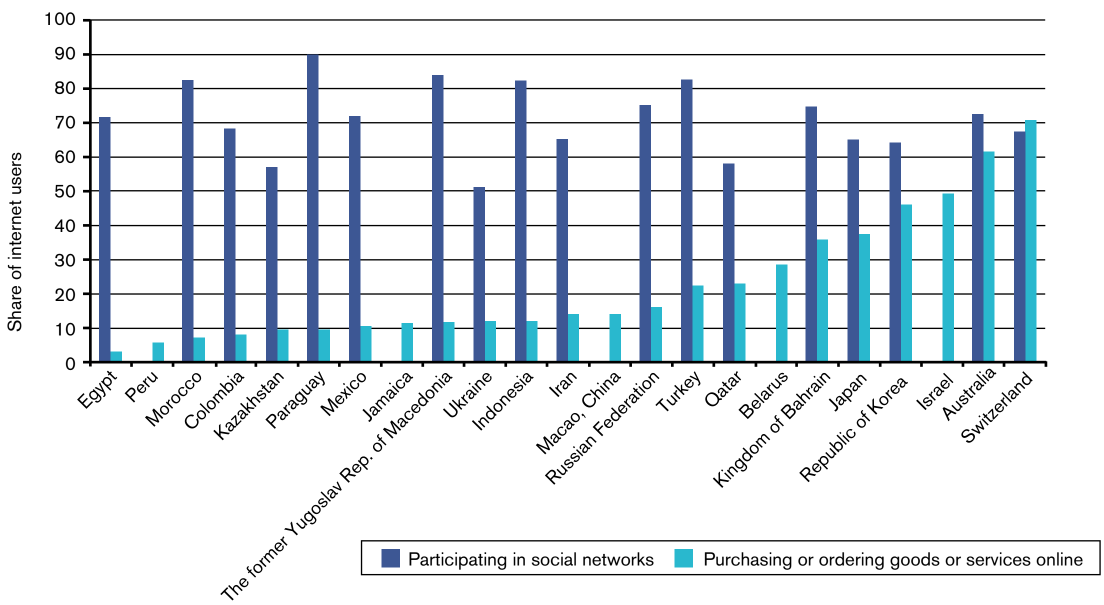


Sources: UNCTAD (2017b), based on ITU data.

This is reflected in Figure B.16, which shows that, for a group of developing countries included in the figure, the percentage of internet users that shop online is, on average, almost seven times lower than the rate of users active on social media. However, it is worth mentioning that limited access to broadband services is not the only reason why consumers in developing countries are reluctant to purchase goods and services online. Other barriers to online shopping prevail, including low purchasing power, undeveloped electronic payments systems, and outdated legal and regulatory frameworks, which considerably reduce consumers' trust in the digital market (see the subsection on the "Regulatory divide" below for more details).

Another major concern for developing countries is the difficulty for local companies to access e-commerce platforms. In a recent survey by the

Figure B.16: Share of internet users involved in online shopping and social media



Sources: UNCTAD (2017b), based on ITU data.

ITC (2017), responding businesses based in African countries pointed to the cost of membership in international e-commerce platforms as one of the most prominent challenges they face when they try to engage in digital trade. They also suffer from high commission rates on sales, which are charged by e-commerce platforms to mitigate risks and recover expected high operational costs. These commissions, when charged to developing country firms, may reach 40 per cent, almost three times the 15 per cent upper bound commissions in developed countries (ITC, 2017). Thus, the barriers to offline trade, including inadequate infrastructure and public services, are felt even in the digital realm and are magnified for developing countries. The picture is even more dismal for LDCs as long as companies based in these countries are not allowed to register as sellers on major international platforms such as Amazon (ITC, 2017).

Moreover, recent estimates by UNCTAD (2017a) show that only 4 per cent of the 3D printers available in the world are used in African and Latin American countries. This suggests that developing countries are ill-prepared to make use of digital technologies and that their participation in the digital economy is thereby hampered.

Companies from developing countries also suffer from relatively higher logistics costs compared to those in developed countries. Recent estimates by ITC (2017) show that the share of logistics costs compared to the final overall cost for companies in developing countries averaged 26 per cent in 2017, almost double that in developed economies. This is reflected in UNCTAD's (2017b) recent estimates, which suggest that global e-commerce is dominated by a group of 10 developed countries, excluding a developing country: China. In 2015, business-to-business (B2B) and business-to-consumer (B2C) online transactions in these countries totalled US$ 16.2 trillion, almost two-thirds of the overall global estimate.

But the digital divide is not destiny. As argued by Wim Naudé, Maastricht University, UNU-MERIT, and IZA Institute of Labor Economics (see his opinion piece on page 46), if developing countries can make the required investments in high-speed internet access, electricity expansion, skills development (particularly entrepreneurship and management skills) and "smart" cities, they will be able to harness the opportunities offered by digital technologies to close the gap with advanced countries.

Regulatory divide

A complete and well-established assessment of a country's readiness to participate in the digital economy should go beyond digital infrastructure and internet access to encompass a wider spectrum of determinants. In this respect, an updated legal system and a flexible regulatory regime are crucial requirements for making digital transactions safe and easy, as they provide the supportive business environment that gives both consumers and businesses the incentive to engage in buying and selling online.

According to OECD-WTO (2017), a favourable regulatory framework plays a crucial role in promoting consumer trust in the digital market by providing a set of laws and regulations for electronic documents and e-signatures, electronic payments, consumer protection from spam and other annoyances, the right of withdrawal (e.g. procedures for returning products acquired through e-commerce), online dispute resolution, cybersecurity, the legal responsibility of digital platforms and privacy and data protection. It is important to adopt regulatory policies which promote trust in the digital market and foster digital trade,[21] while avoiding overprotective regulation and government interference in online information-sharing, which reduce trust and inhibit trade (The Economist, 2014).

This regulatory challenge appears to be a difficult task for policy-makers, especially in developing countries. As depicted in Table B.2, many developing countries still lag behind in terms of the relevance of their e-commerce legislation. For instance, while almost 98 per cent of developed countries set clear rules governing digital transactions in their legal systems, only 52 per cent of African countries have implemented e-transaction laws. Table B.2 also shows that developing countries have been slow in updating their legal systems compared to the rapid pace at which the digital economy is evolving. Only one-third of African countries have adopted consumer protection laws, and the share of developing countries that have implemented privacy and data protection laws in their legislation ranges from around 38 per cent in Africa and Asia to 49 per cent in Latin America and the Caribbean. Outdated legal and regulatory frameworks reduce consumer trust in digital transactions and may be one of the main reasons why consumers in developing countries are active on social media and yet are reluctant to engage in online shopping (as highlighted in Figure B.16). Thus, inadequate legal systems and rigid regulatory regimes become major bottlenecks hampering the participation of developing countries in the digital economy.

OPINION PIECE

Emerging technologies and the future of African manufacturing

By Wim Naudé, Maastricht University, UNU-MERIT, and IZA Institute of Labor Economics

African countries have, largely unsuccessfully, tried many approaches over the past 50 years to develop manufacturing. Despite this, the ambition remains. However, new and emerging technologies associated with the "new industrial revolution" (Marsh, 2012) will have to be mastered. These technologies include advanced automation (robots); additive manufacturing (3D printing); the Internet of Things (IoT); and perhaps most significantly, artificial intelligence (AI).

One of the largest manufacturing sub-sectors in Africa is food and beverages. Companies in this sector include giants such as SABMiller, Tiger Brands, East African Breweries and Nestlé Nigeria. Trends such as population growth, urbanization and the rise of the middle class are increasing the demand for more, better quality and more diversified food products. It is a huge opportunity for manufacturing.

Emerging technologies such as AI and 3D-printing can play a catalysing role. AI applications being implemented elsewhere are already contributing to improving food production from the "farm to the fork", for instance, by helping farmers to monitor growing conditions and to identify crop diseases timeously, by tracking products along the entire supply chain, by improving food-sorting and equipment-cleaning, by monitoring hygiene in factories, and by helping entrepreneurs develop new products. Blockchain, a new digital technology that creates trust between parties and reduces the need for intermediaries, can help in this by improving the functioning of financial and land markets.

3D printing is contributing to the "mass customization" of new food products, for example in the 3D printing of food items (e.g. confectionery). It will not only drive customization of products to more closely meet consumer needs, but may also democratize production and innovation. An example is the 3D4AgDev project that uses 3D printing to provide female African smallholder farmers with the technology to design and develop their own labour-saving agricultural tools, whereby local tool manufacturers (artisans, blacksmiths) can copy plastic prototypes and develop their own modifications (see also Naudé, 2017).

Boosting African industrialization through food processing will require drought-proofing agriculture, given that the continent is one of those worst affected by climate change. This is an opportunity for "green" industrialization and promotion of the circular economy. Diamandis and Kotler (2012) recognised that "Africa has nine times the solar potential of Europe and an annual equivalent to one hundred million tons of oil". With such considerable potential energy resources, the costs of electricity, one of the most vital inputs into manufacturing, should drop significantly in Africa in years to come.

How do African countries harness these opportunities? Yes, there is a digital divide and yes, Africa lags behind in terms of many indicators of participation in the digital economy. Yes, there may not at present be enough science, technology, engineering and mathematics skills available in local labour markets. However, in the digital economy, leapfrogging is possible. Kenya is already a world leader in financial technology, or fintech (e.g. the mobile money transfer service M-Pesa). And new mobile technology is already being used to stream video lectures into African classrooms: there is nothing inevitable or permanent as far as the skills gap is concerned.

Africa needs to focus on four essential strategic areas: (i) high-speed internet access, (ii) electricity expansion, (iii) skills development, particularly entrepreneurship and management skills, and (iv) investing in smart cities. Cities are where manufacturing will grow. African cities should not lag behind the coming 5G mobile networks. The African Continental Free Trade Agreement (AfCTA) is important in all of the above to provide scale economies through regional coordination and integration.

It is wrong to argue that Africa should still be investing in traditional manufacturing sectors based on the idea that somehow this will give African countries the experience to "learn" how to industrialize. There is little opportunity in "old" industries where useful learning can occur in the age of disruptive digital manufacturing. In fact, it may only serve to lock certain countries into dead-end manufacturing sectors. What is far more sensible today is to invest in entrepreneurial ability. Africa has great entrepreneurs. Let's start now to build the start-up ecosystems that can generate the future giants of African (digital) manufacturing.

Table B.2: Relevance of e-commerce legislation by development level

Region	Number of economies	Share in e-transaction laws	Share in consumer protection laws	Share in privacy and data protection laws	Share in cybercrime laws
Developed	42	97.6	85.7	97.6	97.6
Developing					
Africa	54	51.9	33.3	38.9	50.0
Asia and Oceania	50	70.8	41.7	37.5	66.7
Latin America and the Caribbean	33	87.9	63.6	48.5	72.7
Transition economies	17	100.0	17.6	88.2	100.0
All economies	**196**	**77.0**	**50.0**	**57.1**	**71.9**

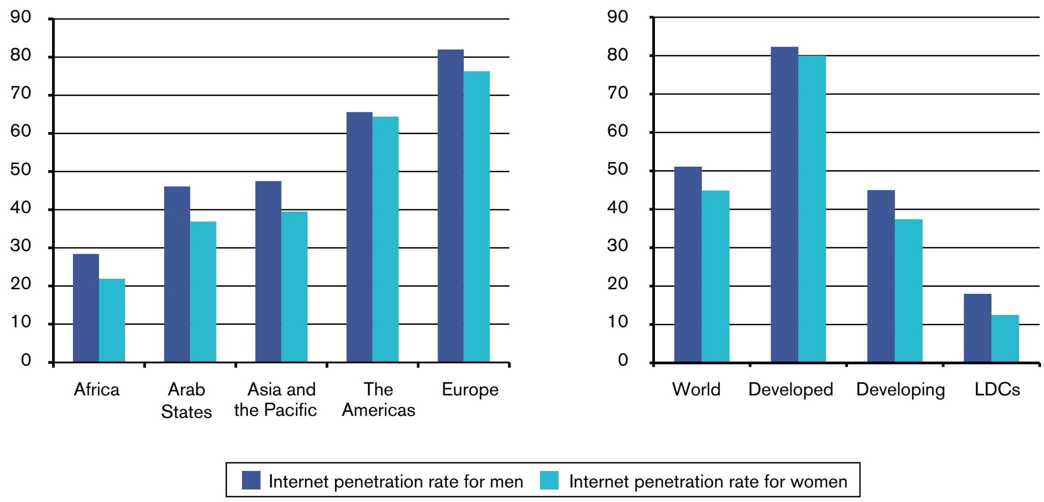
Source: UNCTAD (2018a).

Digital gender divide

As highlighted above, digital divides remain wide between developed and developing countries in terms of access to broadband services and e-commerce platforms, quality of infrastructure and legal framework. Similar divides exist within countries, particularly between men and women. Recent estimates by the ITU (2016) reveal that the digital gender gap is persistent and tends to get deeper over time. For instance, the internet user gender divide increased from 11 per cent in 2013 to 12 per cent 2016, with more than 250 million fewer women now online than men at the global level.

Figure B.17 illustrates the higher internet penetration rates for men than for women in all regions of the world in 2016. While this digital gender divide is prominent globally, its extent varies significantly across income categories, ranging from 2.3 per cent in developed countries to 7.6 per cent in developing countries. It is also worth mentioning that, while the rate of female online presence has reached 80 per cent in advanced economies, it stands below the world average in developing countries at 37.4 per cent, and LDCs lag even further behind with less than 13 per cent of women online. This suggests that the lack of women's online empowerment in these countries could further hamper their attempt to participate more actively in the digital economy.

Figure B.17: Internet penetration rates for men and women



Sources: ITU (2016).

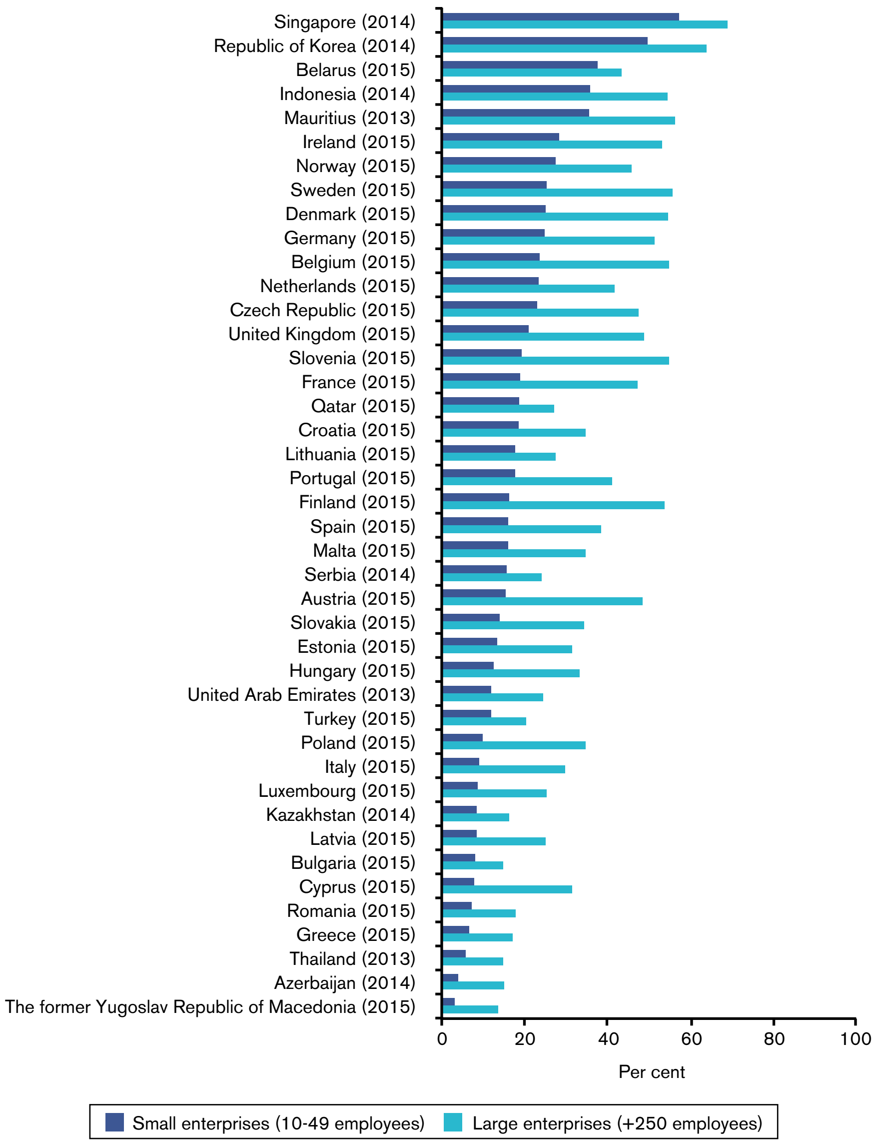
Notes: Penetration rates in this chart refer to the number of women and men that use the internet, as a percentage of the respective total female and male populations.

Furthermore, even in countries displaying high rates of a female presence online, the share of women employed in the ICT sector remains relatively low. For example, the proportion of women in the total number of ICT specialists in the European Union hovered around 16 per cent between 2011 and 2015. Similarly, in the United States, the share of women in computer-related employment did not exceed 25 per cent in 2015 (UNCTAD, 2017a).

Digital divide between small and big firms

Small firms lag behind in their readiness to engage in the digital economy. They are inadequately prepared to capture the many opportunities emerging as a result of digitalization, and may thereby miss opportunities to gain market share. As depicted in Figure B.18, the likelihood that a firm will participate in the digital economy increases with firm size. That is, the share of big firms selling online is always higher than that of small firms, and this stylized fact is observable in all countries reported in the figure. Such divides clearly indicate that digitalization is leading to increased polarization and widening market share gaps between firms, as only big firms seem to be adequately prepared to participate effectively in the digital economy and reap substantial gains from it.

Figure B.18: Proportion of small and big firms selling online, 2013-15



Sources: UNCTAD (2017a) based on World Bank data.

Divide between high- and low-skilled workers

The widespread use of digital technologies is also affecting labour markets by leading to the creation of new jobs and destruction of others, thereby altering skill requirements (UNCTAD, 2017a). The impact of this increased digitalization varies significantly across skill categories, increasing demand for high-skilled workers since they are complementary, while decreasing the demand for less-skilled workers if they are easily replaced by labour-saving technologies and automation (this subject was extensively covered in WTO, 2017d).

On the one hand, greater reliance on artificial intelligence, cloud computing and data analysis is likely to lead firms to hire more database administrators, network technicians, webmasters, planners and big data analysts qualified to handle new technology and to supply the expertise that is needed to interpret the data that new technology produces (European Parliament, 2015a). For instance, as documented by UNCTAD (2017a), the number of employees in e-commerce firms in the United States sharply increased from 130,000 to 210,000 between 2010 and 2014. Moreover, the number of unfilled cyber-security jobs worldwide is expected to reach 1.5 million by 2019 (UNCTAD, 2017a).

On the other hand, increased automation and services digitalization are leading to the gradual elimination of highly routinized jobs, such as those performed by manufacturing production workers, data-entry clerks, mail sorters, retail workers, administrative assistants and workers in book and music stores (European Parliament, 2015a). UNCTAD (2017a) estimates that more than 85 per cent of retail workers in Indonesia and the Philippines may be at high risk of losing their jobs due to automation, and that similar prospects are also conceivable for salaried workers in the textiles, clothing and footwear sectors in Cambodia and Viet Nam. Were such polarization in the labour market to materialize, income inequalities could be expected to widen rather than narrow, given the rapid pace at which the digital economy is evolving and the difficulty for low-skilled workers to upgrade their skills accordingly.

2. How much digitalization?

Section B.1 discussed how emerging digital technologies are changing the economy, by giving rise to new markets, goods and services. This section will go on to describe how digital technologies are affecting the economy at the industry or sectoral level, and to examine the measurement or statistical dimension to digital trade from "official" statistics and from private sector financial reports.

(a) Digitalization of industry

The increasing digitalization of the economy can be seen at the sectoral level, as measured by the digital intensity of firm-level usage of digital technologies, as well as in some selected estimates on the magnitude of digital trade at the industry, economy or global levels.

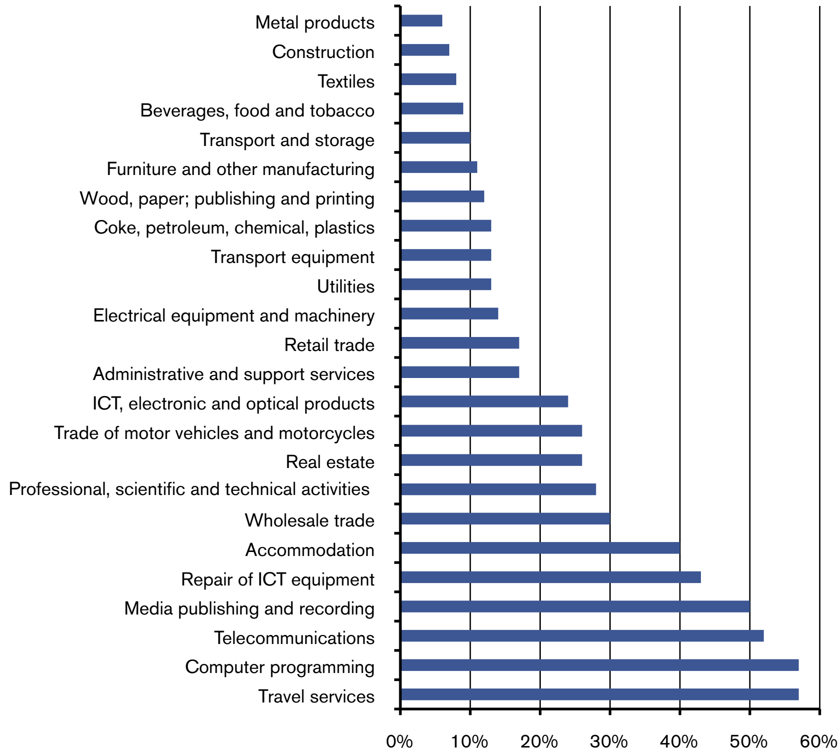
Broadly defined, the digital economy is the application of internet-based digital technologies to the production and trade of goods and services (UNCTAD, 2017c). The digital economy is not separate from the regular economy, as it impacts all industries and business types. Sectors become increasingly data-driven and change their economic structures, industry boundaries blur, and the basis of competition changes (Commonwealth of Australia, 2017).

Sectors differ significantly in their dependence on digital technologies. This allows a ranking of sectors based on their digital intensity.

In its 2017 *Digital Progress Report*, the European Commission (2017b) proposed a digital intensity ranking of sectors based on the share of enterprises in a given sector that uses at least seven out of 12 digital technologies (see Figure B.19).[22] It shows that, on average, services firms are more intensive users of digital technology than manufacturing firms, but this might be due to the specific way the index is calculated, focusing on sales rather than on production. A similar methodology was undertaken by the European Centre for International Political Economy (ECIPE), using data intensity as the ratio of software expenditure over labour usage, which yielded similar rankings (Ferracane and van der Marel, 2018).

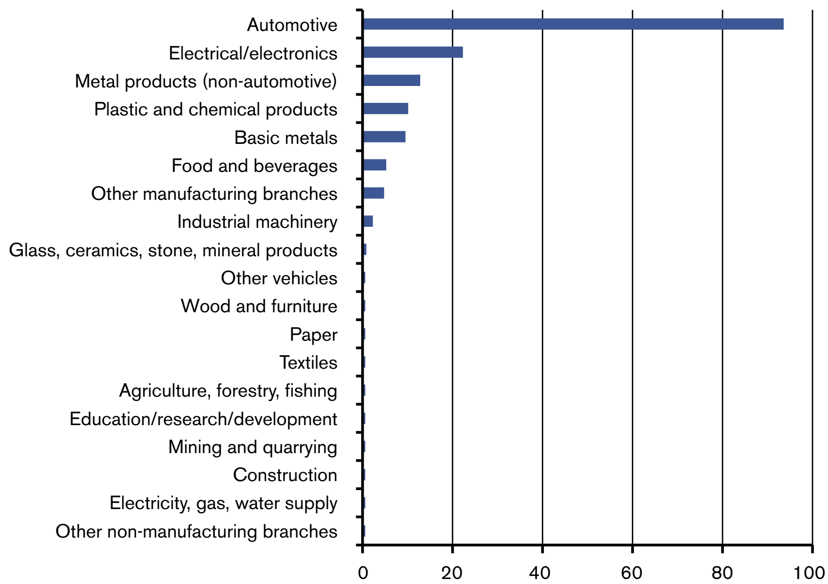
A widely accepted classification of digital-intensive sectors that takes into account both digital inputs in production and the use of digital technologies in sales is currently not available. To get a better idea of the production in manufacturing, one can look at the use of industrial robots per employed worker. Data from the International Federation of Robots in 2015 show that the automotive industry in particular uses a significant number of robots and is likely to benefit from progress in smart robotics. In contrast, at the current state of technology, robots are almost completely absent in sectors that require a high degree of dexterity or face-to-face interaction, such as in the textile industry or in services (see Figure B.20).

Figure B.19: Digital intensity of selected sectors



Sources: European Commission (2017b).

Figure B.20: Robot use by sector (number of robots per 1,000 employees)



Sources: Authors' calculation based on data by the International Federation of Robotics.

(b) Digitalization of trade

Digital transformation has resulted in the creation of new markets, products and business models. It adds further complexity to the issue of distinguishing between services and goods and may alter the manner of supplying services, thereby possibly influencing the relative importance of the supply of services.

(iv) Measuring "digitalization"

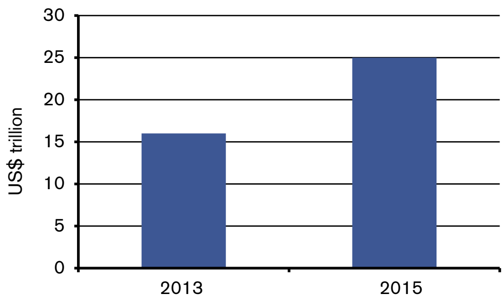
From a consumer's point of view, it is not always clear to what extent goods or services ordered online result in transactions produced and delivered purely domestically or across borders. This, and the ever-changing character and scope of digitalization, complicate the task of developing a comprehensive global account of the value and volume of digital transactions, which at the present moment is not yet possible. Data collection efforts remain in their infancy in many countries, particularly in developing economies and LDCs where smaller transaction volumes and lower levels of ICT penetration call into question the value of dedicating limited resources to developing or collecting the relevant statistics. Even in the most advanced economies, constant innovation and changing business models inevitably result in a number of gaps in data collection. Despite these challenges, a variety of statistical and anecdotal evidence is available that illustrates the current state of the digital economy and enables inferences about its likely future direction.

The magnitude of global e-commerce transactions is estimated with a range of methodologies. In the latest Information Economy Report, UNCTAD (2017a) estimates the total value of global e-commerce transactions, that is, domestic and cross-border, at US$ 25 trillion in 2015, up 56 per cent from US$ 16 trillion in 2013 (see Figure B.21).

For 2016, the United States International Trade Commission (USITC) estimates the magnitude of B2B e-commerce transactions, at US$ 23.9 trillion, as being six times larger than B2C e-commerce transactions ($3.8 trillion) (USITC, 2017). However, all these estimates do not break down transactions by origin. Thus, domestic and cross-border transactions are not separately identifiable.

UNCTAD assesses that e-commerce activity is dominated by a handful of large economies, with four countries (China, Japan, the Republic of Korea and the United States) making up half of the global total, and ten countries accounting for 64 per cent of it (see Figure B.22).

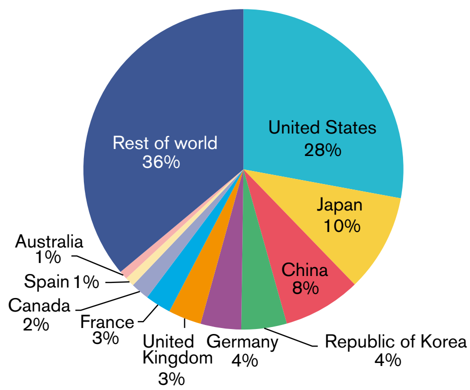
Figure B.21: Value of world e-commerce transactions, 2013 and 2015



Source: UNCTAD (2017a).
Note: Data cover both B2B and B2C transactions.

The availability of official data on e-commerce transactions is sparse and not comparable across economies but offers some evidence. For example, the US Bureau of Economic Analysis (BEA) estimates that digital goods and services account for 6.5 per cent of the US economy. From 2006 to 2016, the digital economy grew at an average annual rate of 5.6 per cent, outpacing overall US economic growth of 1.5 per cent per year (US BEA, 2018). In the European Union, one in five enterprises made e-commerce sales in 2016 (Eurostat, 2018). China is considered the world's largest e-commerce market with US$ 622 billion in online retail transactions in 2015, comprising over 40 per cent of total global

Figure B.22: Composition of world e-commerce transactions by value, 2015 (per cent)



Source: UNCTAD (2017a).
Note: Data cover both B2B and B2C transactions. Germany, France and Canada refer to 2014.

e-commerce spending. Domestic e-commerce sales in the Republic of Korea reached US$ 55.9 billion in 2016 (representing 17.9 per cent of the Republic of Korea's total retail industry), while cross-border online purchases reached US$ 1.6 billion in the same year. Online purchases from foreign retailers have been rapidly increasing because Koreans find it less expensive to buy from overseas websites, even after adding international shipping fees and import duties. The high penetration of digital access (90 per cent of the population has access to broadband and smartphones) is deemed to be the main factor driving market growth in e-commerce (US International Trade Administration (ITA), 2018).

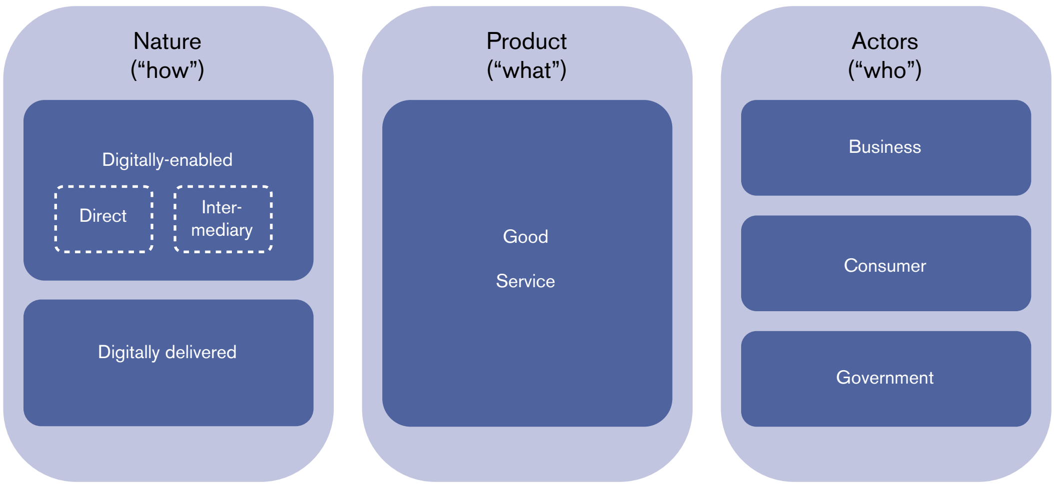
Broadening the discussion from e-commerce to digital trade, López-González and Jouanjean (2017) describe a possible typology. From this starting point the statistical community developed a tentative conceptual measurement framework to characterize digital transactions according to their nature ("how"), the good or service being traded ("what") and the actors involved ("who"). For the purposes of this report, this framework has been further revised ("revised framework") to avoid the implication that data flows are a category of trade separate from and unrelated to both trade in goods and trade in services (see Figure B.23):

- **Nature:** Under this "revised framework", digitally-enabled transactions would be defined as commercial transactions made by electronic means, either directly over computer networks or through an intermediary (e.g. "platform-enabled" cross-border trade such as that facilitated by companies like Airbnb, Alibaba, Amazon or Uber). Digitally-delivered transactions would include downloadable software, e-books and streamed video and data services. In principle, physical goods cannot be delivered digitally. The concept of digital delivery is consistent with what is described by UNCTAD (United Nations, 2018) as ICT-enabled services, namely, service products delivered remotely over ICT networks (OECD, 2017d).
- **Product:** The "revised framework" distinguishes between transactions involving goods and those involving services.
- **Actors:** The "revised framework" categorizes participants as businesses, consumers, or governments. Depending on analytical needs, data compilers could add additional dimensions such as firm size.

In late 2017, the international statistical community modified this framework to distinguish between transactions that are digitally-ordered and those that are platform-enabled (OECD, 2017d). E-commerce would encompass transactions for goods and services that are ordered digitally but delivered either digitally or physically.

The international statistical community's own framework remains a "work in progress" as it has some difficulty in categorizing certain kinds of transactions that involve cross-border data flows. For example, 3D-printed physical items are goods produced based on a design that is transmitted by

Figure B.23: "Revised framework" for measuring digital trade



Sources: WTO Secretariat, adapted from OECD (2017a).

electronic means as a service. Similarly, companies such as Facebook and Google provide seemingly "free" services in exchange for information about users. Moreover, the types of transactions that fit into this "revised framework" will evolve as technology continues to evolve. A few simple examples are provided in Table B.3.

(v) Digital products

To measure transactions in digital products, different approaches have been used. Cross-border digital transactions of digitizable goods can be inferred from the declining trade in corresponding physical goods such as books, newsprint, or recorded media, which comprised 2.7 per cent of global trade in 2000 but only 0.8 per cent in 2016. However, this methodology cannot trace all digitizable products, as codes for physical goods in statistical classifications change over time or are merged, and may even be deleted when trade volumes change or fall below a certain threshold. UNCTAD (2017a) defines the concept of ICT-enabled services, often denominated as digitally-enabled or digitally-delivered services. In addition, it defines the concept of potentially ICT-enabled services, which are services with outputs that could be delivered remotely over ICT networks (UNCTAD, 2015). Through the Central Product Classification (CPC)[23] these potentially ICT-enabled services can be linked to the Extended Balance of Payments Services Classification (EBOPS) 2010.[24]

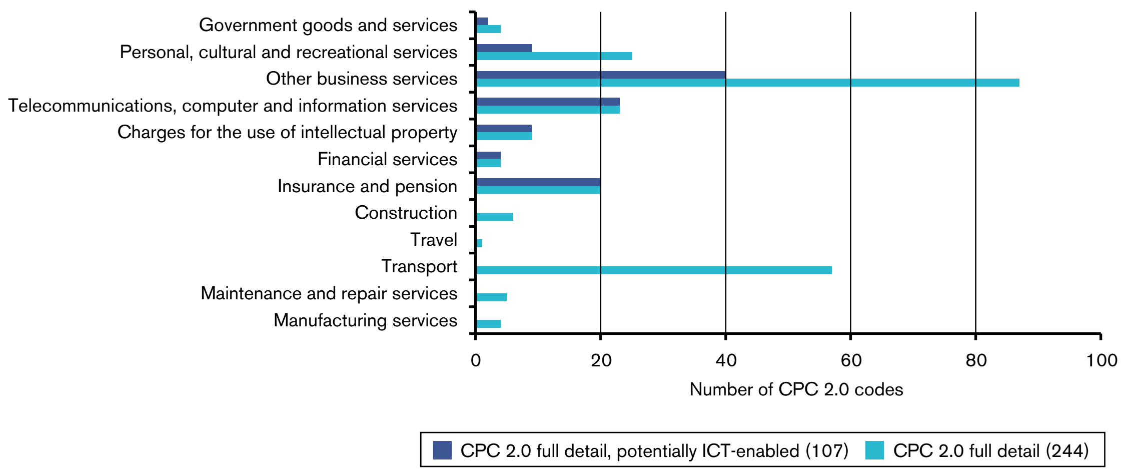
Figure B.24 shows possible EBOPS 2010 categories and counts the potentially ICT-enabled CPC codes. For other business services, the figure shows that

Table B.3: Examples of digital trade transactions

Digitally-enabled?	Digitally-delivered?	Who	Description
Y	N	B2B	An automotive company in country A orders car components from company B's supplier website.
Y	Y	B2B	A BPO in country A orders accounting software online from country B.
Y	N	B2C	A consumer in country A orders a ballerina tutu for his daughter through an intermediary (platform) in country B, which is delivered from country C after a week.
Y	Y	B2C	A consumer in country A orders an e-book from a platform in country B.
Y	N	B2B	A telecommunications firm in country A purchases ICT maintenance services online from country B, which are delivered physically.
Y	Y	B2B	A retail company in country A subscribes to financial services from a bank in country B.
Y	N	B2C	A tourist in country A reserves a hotel online for his holiday in country B.
Y	Y	B2C	A student studying abroad orders international insurance services online.

Source: Adapted from OECD (2017d).
Notes: Y – Yes; N – No; BPO – business process outsourcing

Figure B.24: Potentially ICT-enabled services



Sources: UNCTAD ICT4D Technical Note 3, derived from UNSD “Correspondence between the EBOPS 2010 and the Central Product Classification (CPC, version 2) – Detailed version”, cited in Korka (2018).

almost half of the codes can potentially be ICT-enabled (Korka, 2018).

However, this type of information is not captured in current statistical data-gathering frameworks. To address this, UNCTAD suggests a pilot questionnaire which asks respondents for the proportion of services delivered remotely, not on-site or in-person.

In 2016, the US BEA calculated the value of US ICT-enabled and potentially ICT-enabled services trade based on the definition developed by the "Partnership on Measuring ICT for Development" convened by UNCTAD. Exports of US ICT services and other potentially ICT-enabled services were US$ 66.1 billion and US$ 337.4 billion respectively (Figure B.25). They made up about 54 per cent of all US services exports. Imports of US ICT services and other potentially ICT-enabled services were US$ 41.9 billion and US$ 202.1 billion respectively. These accounted for 48 per cent of US imports of services.

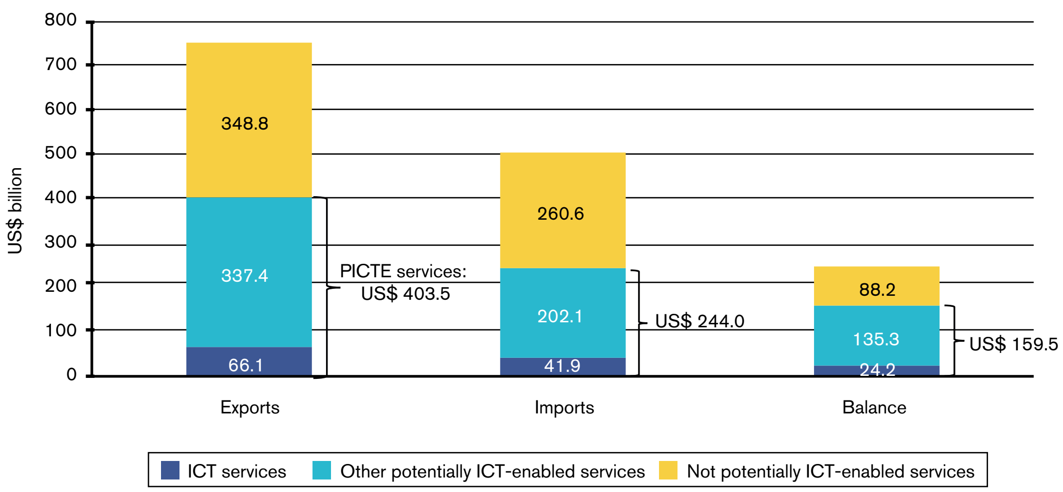
Costa Rica's pilot survey carried out in this context with the support of UNCTAD provides the first developing country perspective. Based on the sample surveyed, it calculates that around 984 of 1,196 resident service exporters in the country (96 per cent) make ICT services exports their primary activity, predominantly channelled through Mode 1 services (96 per cent). The study estimates that 38 per cent of all Costa Rican exports of services were ICT-enabled services in 2016, constituting around 5.8 per cent of the country's gross domestic product (GDP) and 5 per cent of total employment. These primarily represent administrative and auxiliary office services, computer and engineering services, and professional and management consulting services. Most of these ICT service exporters are large enterprises (88 per cent), representing exports from primarily US companies (61 per cent of all enterprises) to primarily US markets (60 per cent of all exports). More than three-quarters (76 per cent) of all ICT service exporting firms in Costa Rica are controlled by a foreign company, with around one-quarter (24 per cent) of these export sales occurring within the country's special Free Zone Regime (BCCR, 2018).

An upper bound of the size of potentially ICT-enabled services, as defined by UNCTAD (2017a), could be estimated by aggregating insurance and pension services, financial services, charges for the use of intellectual property, telecommunications, computer and information services, other business services, and personal, cultural and recreational services. The share of these services in world trade more than doubled between 2005-16 and represents around 90 per cent of the cross-border supply of Mode 1 services in General Agreement on Trade in Services (GATS) parlance (Figure B.26).

(vi) Firm-level data: case studies

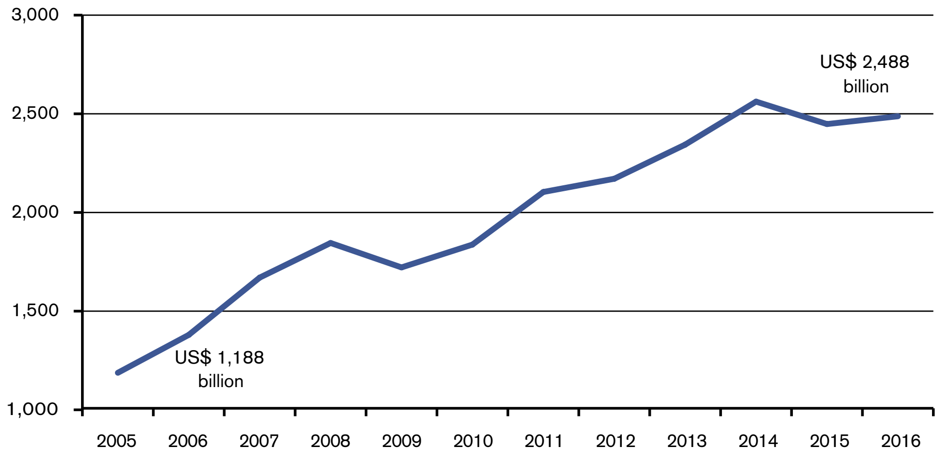
The financial reports of leading publicly traded digital firms (e.g. Alibaba, Alphabet, Amazon, Facebook, Microsoft, Netflix, Spotify, etc.) offer another source of information on the digitalization of trade. This information should be interpreted as a series of case studies rather than as a systematic description of industry developments, but it is no less valuable as a result. Taken together, this information demonstrates

Figure B.25: Trade in US ICT-enabled and potentially ICT-enabled services, 2016 (in US$ billion)



Sources: US Bureau of Economic Analysis (2018).

Figure B.26: Growth of potentially ICT-enabled services (upper bound), 2005-16



Sources: WTO-UNCTAD-ITC estimates, 2018.

Notes: The figure refers not to the actual value of these services, but to their upper bound – the value of these services if they were fully ICT-enabled.

not only the global reach of these firms, but also the fact they continue to have vast opportunities to grow their international operations.

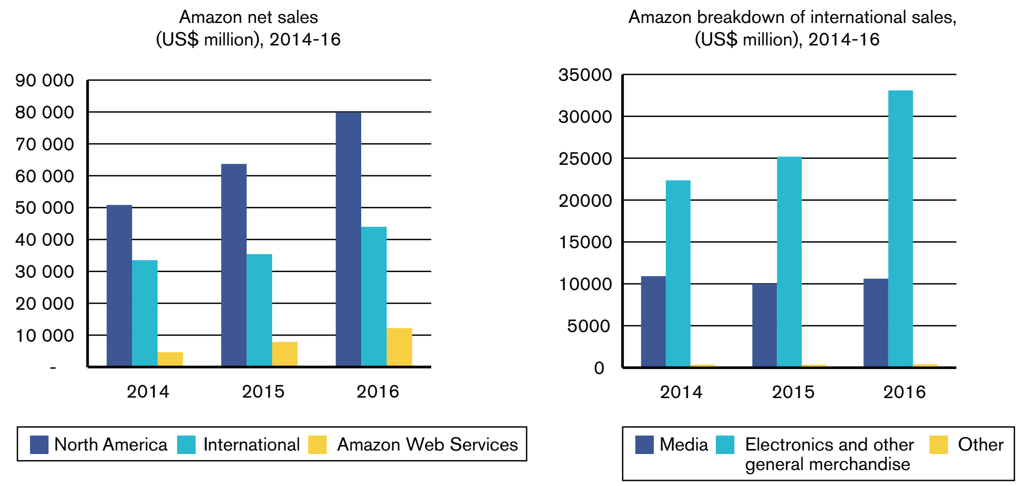
E-commerce platforms

Amazon

Amazon was one of the earliest internet retailers and has become one of the world's largest leading internet retailers and service providers. The company is based in the United States but, like many leading internet businesses, its activities and earnings are global. In addition to online sales of merchandise, Amazon has broadened its digital economy activities to include the manufacture and sale of digital devices, streaming of digital video and music, fulfilment, digital publishing, and the supply of IT services, including data storage and database management (US Securities and Exchange Commission (SEC), 2017b).

Nearly one-third (32 per cent) of Amazon's net sales are international (see Figure B.27). The North American segment consists of earnings from country-focused websites such as amazon.com, amazon.ca, and amazon.mx, including export sales from these websites. "International" sales consist of earnings through

Figure B.27: Breakdown of international sales of Amazon by region and product, 2014-16 (US$ million)



Sources: SEC (2017b).

B. TOWARDS A NEW DIGITAL ERA

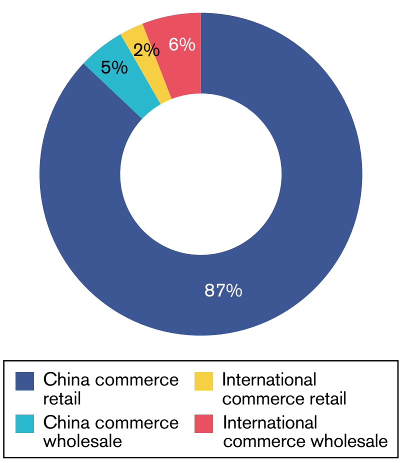
internationally-focused websites (e.g. amazon.de, amazon.fr, etc.), including export sales to customers in Canada, Mexico and the United States but excluding export sales from North American websites. Meanwhile, Amazon Web Services (AWS) include global sales of computing, storage, and database and other service offerings for start-ups, enterprises, government agencies and academic institutions. International export sales mostly consist of electronics and other merchandise goods (75 per cent), as opposed to digital media content (24 per cent). Surprisingly, 67 per cent of Amazon's international sales are exported to the United States, which is also its biggest "international" market (SEC, 2017b).

Alibaba

Alibaba, based in China, was the largest retail commerce company in the world in 2017 although it mostly serves its domestic market (see Figure B.28). Chinese market online retail activities earned the company US$ 547 billion in 2017. For its global retail activities, Alibaba operates AliExpress, which had 60 million customers in 2017, buying directly from manufacturers and distributors in China. In 2016, it acquired a controlling stake of Lazada, a company that operates e-commerce platforms in Indonesia, Malaysia, the Philippines, Singapore, Thailand and Viet Nam (SEC, 2018).

A majority (84 per cent) of Alibaba's revenues came from core commerce activities in 2017, of which 87 per cent was domestic Chinese commerce retail. Another 6 per cent was international commerce wholesale, 5 per cent was Chinese commerce wholesale, and 2 per cent was international commerce retail. Alibaba is

Figure B.28: Alibaba revenue by activity and region, 2016-17 (per cent)



Sources: SEC (2018).

notable for being a large e-commerce firm based in a developing rather than a developed economy. Given its strong domestic base, Alibaba has considerable scope to grow its cross-border activities (SEC, 2018).

MercadoLibre

MercadoLibre is an Argentinian e-commerce and payments platform listed on the Nasdaq stock exchange (MercadoLibre, 2018). The company claims to be the leading such platform in Latin America based on unique visitors and page views. Revenue and sales have grown steadily in recent years despite a sharp regional economic slowdown. Revenue rose to US$ 1,398.1 million in 2017 from US$ 472.6 million in 2013, while the number of confirmed registered users increased to 211.9 million from 99.5 million over the same period. The company can expect even stronger growth as regional economic growth picks up.

Online search

Alphabet/Google

Alphabet is the parent company of Google, of which the main internet products include its ubiquitous search engine, advertising, commerce, maps, video streaming through YouTube, and data storage through Google Cloud. Google also developed the Android operating system for electronic devices, the Chrome internet browser, and payment services, as well as a number of hardware products (SEC, 2017a).

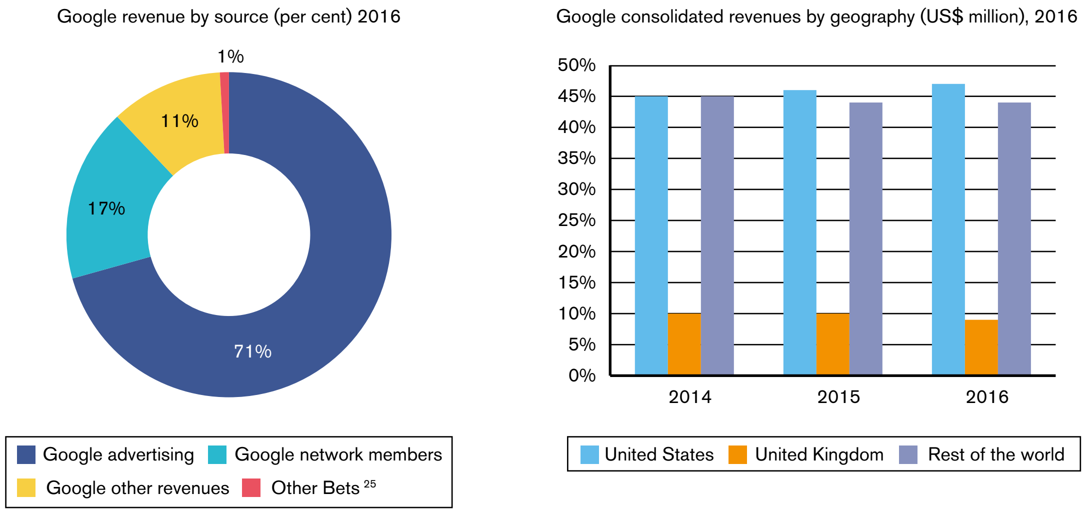
Alphabet/Google's revenue currently comes from Google Advertising (71 per cent); its affiliate Google Network Members (17 per cent), which are the third parties that use Google advertising programmes to deliver relevant advertisements on their websites; and other revenues (11 per cent), including sales from software, hardware, licensing and service fees for Google Cloud (see Figure B.29). As a percentage of consolidated revenues, determined based on the billing addresses of customers, the United States (47 per cent) and the United Kingdom (9 per cent) are the biggest customers geographically, with the rest of the world comprising the remainder (44 per cent) (SEC, 2017a).

Mobile payment services

M-Pesa

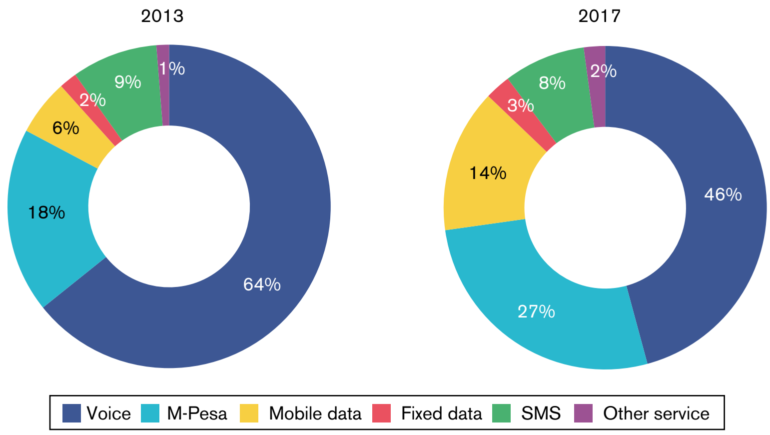
"Mobile"-Pesa (M-Pesa) is a mobile phone-based money transfer, financing and microfinancing service launched in 2007 by Vodafone for Safaricom and Vodacom, the largest mobile network operators in Kenya and Tanzania. It currently comprises 27 per cent of Safaricom's revenues, up from 18 per cent in 2013 (Figure B.30). It has since expanded to Albania, the Democratic Republic of the Congo,

Figure B.29: Breakdown of Alphabet/Google revenues by activity and region, 2014-16
(per cent and US$ million)



Sources: SEC (2017a).

Figure B.30: Breakdown of Safaricom revenues, 2013 and 2017



Sources: Safaricom (2018).

Egypt, Ghana, India, Kenya, Lesotho, Mozambique, Romania and Tanzania. In 2010, it became the most successful mobile-phone-based financial service in the developing world, and it has been lauded for giving millions of people access to the formal financial system and for reducing crime in cash-based societies (Monks, 2017).

Kenya's model has been successful because of several factors: the exceptionally high cost of sending money by other means; the dominant market position of Safaricom; the regulator's initial decision to allow the scheme to proceed on an experimental basis without formal approval; a clear and effective marketing campaign; and an efficient system to move cash around behind the scenes (The Economist, 2018b).

Pointepay

Nigerian Fintech startup SpacePointe has rolled out PointePay, a mobile application with multiple payment options such as cash, e-wallet, and debit or credit card. It is an affordable multi-point service system where online retailers can sell online via a marketplace, manage their business, and offer value added services such as the ability to sell wireless top-up and mobile wallet loads (Disrupt Africa, 2018).

Content streaming

Netflix

Netflix is the world's leading internet television network, with 90 million subscribers in 190 countries, enjoying 125 million hours of TV programmes and films daily. The network's core strategy is to grow its streaming membership business globally within the parameters of its profit margin targets.

Netflix has three market segments: domestic streaming revenues come from monthly membership fees for services consisting of streaming content to members in the United States; international streaming revenues come from members outside the United States; and domestic DVD revenues come from monthly membership fees for services of DVD by mail.

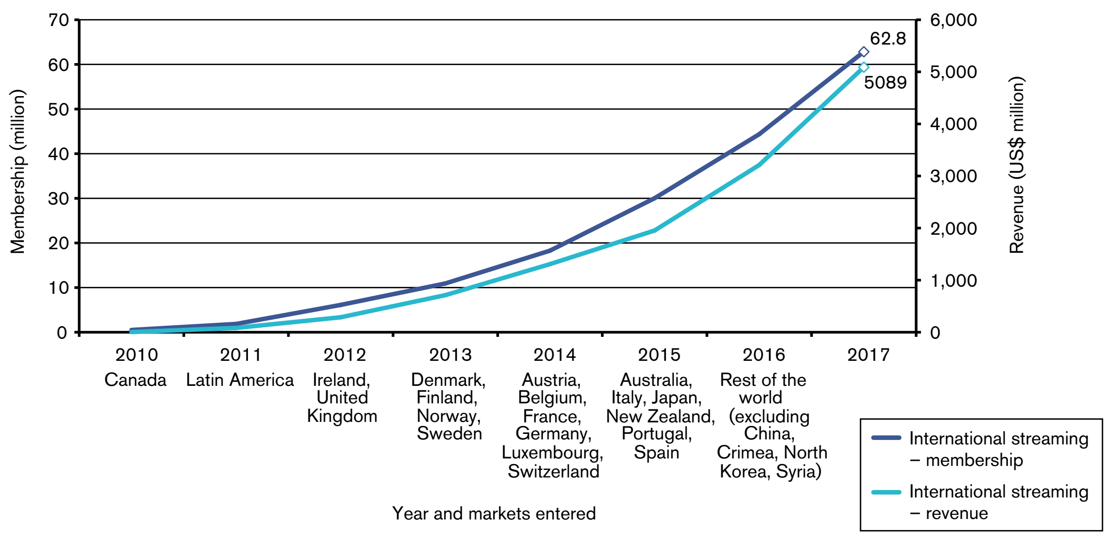
The trend of revenue growth from 2012-16 has been due to growth in the average number of paid streaming subscriptions globally, the majority of which was due to growth in international subscriptions, coupled with an increase in average monthly revenue per subscription resulting from price changes and plan mix. International streaming subscriptions increased nine-fold over this period, while international revenue increased nearly 18 times (see Figure B.31) (SEC, 2017c).

Spotify

The Swedish music streaming company Spotify is now worth US$ 25 billion and is the largest music company in the world. Spotify provides a digital music streaming service that gives on-demand access to songs on mobile devices, computers and home entertainment systems and allows users to discover music collections by friends, artists and celebrities, build personal playlists and share music on social media (Bloomberg LP, 2018). Streaming revenues grew 41.1 per cent year-on-year to US$ 6.6 billion in 2018, so that Spotify now accounts for 38.4 per cent of all recorded music revenue as the single biggest music source. As of 2018 Spotify has 170 million monthly active users (MAUs), up 30 per cent from the previous year. This is divided into 75 million premium subscribers (up 45 per cent from 2017) and 99 million advertisement-supported MAUs (up 21 per cent). Advertisement-supported MAUs continue to see strong growth in Asian markets, particularly in mainstream markets in Japan and newly launched markets such as Viet Nam and Thailand. Figure B.32 shows that 60 per cent of Spotify's monthly active users and its paying subscribers reside outside of Europe.

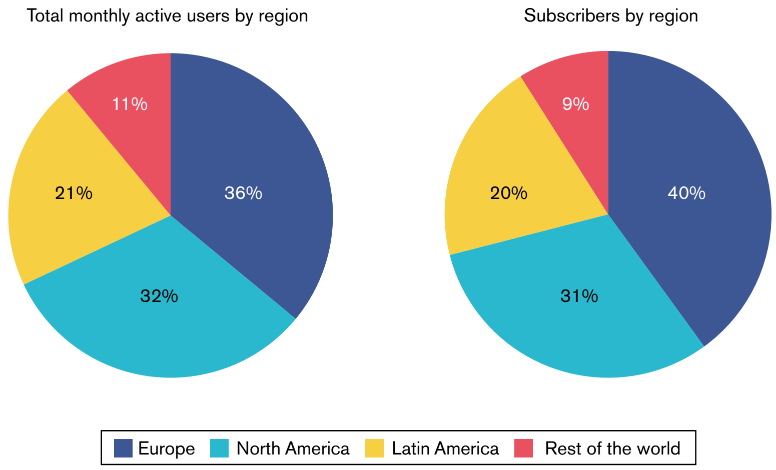
Revenue from paid subscriptions was Euros 1.037 billion in 2018, up 25 per cent from the previous year, with an average revenue per user of Euros 4.72 (down 14 per cent) being driven by growth in family and student plans, and a shift in the market to relatively lower average-revenue-per-user geographies like Latin America. Advertisement-supported revenue was Euros 102 million, up 38 per cent from the previous year (Spotify Technology S.A., 2018).

Figure B.31: Growth in international revenue of and subscriptions to Netflix, 2010-17



Sources: SEC (2017c).

Figure B.32: Total monthly active users and subscribers to Spotify in 2018



Sources: Spotify Technology S.A. (2018).

3. Conclusions

This section has described the exponential increase in computing power, bandwidth and the amount of digital information collected, and the role of these developments in enabling the rise of new digital technologies, such as additive manufacturing, the IoT, AI and Blockchain. These digital technologies are changing the global economy by giving rise to new online markets and products, resulting in considerable benefits for consumers and productivity gains for firms. At the same time, these new technologies have raised concerns about the loss of control over personal data, the concentration of market power in a few powerful companies, how much they are raising productivity, and the unbridged digital divide. A better understanding of the effects of digital technologies requires the ability to measure the economic transactions, including digital trade, that they are making possible. While noting the challenges involved in calculating the amount of these transactions, it provides a number of estimates culled from international organizations, national authorities and the financial reports of some prominent technology firms. These estimates show the remarkable effects that technological change is having on the magnitude of economic transactions both within and across national borders. In the next section, the report looks more closely at the trade impact of these digital technologies.

Endnotes

1 International Telecommunications Union (ITU, 2018b).

2 https://www.britannica.com/technology/artificial-intelligence

3 The other fields of AI are robotics and symbolic systems. Robotics includes approaches in which an AI system engages with and responds to environmental conditions. Symbolic systems attempt to represent complex concepts through the logical manipulation of symbolic representations.

4 Donald Knuth is a computer scientist at Stanford University, a past winner of the Turing Prize and the creator of the TeX computer typesetting system

5 On this matter, consider for instance Kurzweil (2005).

6. Samuel Butler's *Erehwon* is sometimes identified as the first literary work to allude to artificial intelligence. In the 20th century, authors such as Isaac Asimov and Arthur C. Clarke wrote compelling works of science fiction on the subject of AI.

7 Bostrom (2014) defines a superintelligent AI system as one which greatly exceeds the cognitive performance of humans in virtually all domains of interest.

8 The signatories include Nick Bostrom, Erik Brynjolfsson, Stephen Hawking, Elon Musk, and Steve Wozniak, among others. The open letter can be found at https://futureoflife.org/ai-open-letter/

9 See http://www.sme.org/additive-manufacturing-glossary/

10 Blockchain technology was first implemented in 2009 as the technology underpinning the digital currency known as Bitcoin.

11 In 2014, the annual electricity used to power the Bitcoin network alone was estimated to be as high as that of a country the size of Ireland (O´Dwyer and Malone, 2014).

12 See https://blockchain.info/de/charts/transactions-per-second?timespan=1year

13 See https://etherscan.io/chart/tx

14 The EU General Data Protection Regulation (GDPR) that entered into force on 25 May 2018 raises new issues in this regard. Because data stored on the blockchain, including personal data, cannot be deleted, the right to be forgotten that is included in the GDPR cannot be exercised. Blockchain may be "GDPR-incompatible", even though as Finck (2017) notes, blockchains in fact pursue the same goal of giving individuals more control over their personal data as the GDPR, but through mechanisms that are different to those laid down in the GDPR.

15 Seller feedback is mentioned as one of "Fifty Things that Made the Modern Economy" by Harford (2017).

16 This definition comes from the International Association of Privacy Professionals (IAPP), https://iapp.org/about/what-is-privacy

17 See also, for further discussion of how digitalization raises new challenges related to competition policy, Anderson et al. (2018b).

18 See Anderson et al. (2018a).

19 See Evans and Schamlensee (2008); Haucap and Heimeshoff (2014); OECD (2017c).

20 Taking eBay as an illustration, more potential buyers attract more sellers to offer goods on eBay as (a) the likelihood of selling their goods increases with the number of potential buyers; and (b) competition among buyers for the good will be more intense and, therefore, auction revenues are likely to be higher. A higher number of sellers and an increased variety of goods offered, in turn, make the trading platform more attractive for more potential buyers. See Haucap and Heimeshoff (2014).

21 While there is no agreed definition of digital trade, for the purposes of this report, digital trade encompasses digitally enabled transactions in trade in goods and services, which can be either digitally or physically delivered involving consumers, firms and governments (López-González and Jouanjean, 2017).

22 The 12 technologies considered in the study were: internet for at least 50 per cent of employed persons; recourse to ICT specialists; fast broadband (30 Mbps or above); mobile internet devices for at least 20 per cent of employed persons; a website; a website with sophisticated functions; social media; paying for advertising on the internet; the purchase of advanced cloud computing services; sending eInvoices; e-commerce turnover accounting for over 1 per cent of total turnover; and business-to-consumer (B2C) web sales of over 10 per cent of total web sales. The finance industry was excluded.

23 The Central Product Classification constitutes a complete product classification covering goods and services. It

serves as an international standard for assembling and tabulating all kinds of data requiring product detail, including industrial production, national accounts, service industries, domestic and foreign commodity trade, international trade in services, balance of payments, consumption and price statistics.

24 The Extended Balance of Payments Services Classification (EBOPS) 2010 is a classification system for services that allows for the production of statistical information at a level of detail that, among others, meets needs for information in the framework of the General Agreement on Trade in Services (GATS). It is primarily a product-based classification which may be described in terms of the Central Product Classification Version 2 (CPC Ver. 2), which is the standard international product classification. It has twelve main classification of services: manufacturing services on physical inputs owned by others; maintenance and repair services not included elsewhere; transport; travel; construction; insurance and pension services; financial services; charges for the use of intellectual property not included elsewhere; telecommunications, computer and information services; other business services; personal, cultural, and recreational services; and government goods and services not included elsewhere.

25 "Other Bets is a combination of multiple operating segments that are not individually material. Other Bets includes businesses such as Access, Calico, CapitalG, GV, Nest, VErily, Waymo, and X. Revenues from the Other Bets are derived primarily through the sales of internet and TV services through Google Fiber, sales of Nest products and services, and licensing and R&D services through Verily." (SEC, 2017a.)