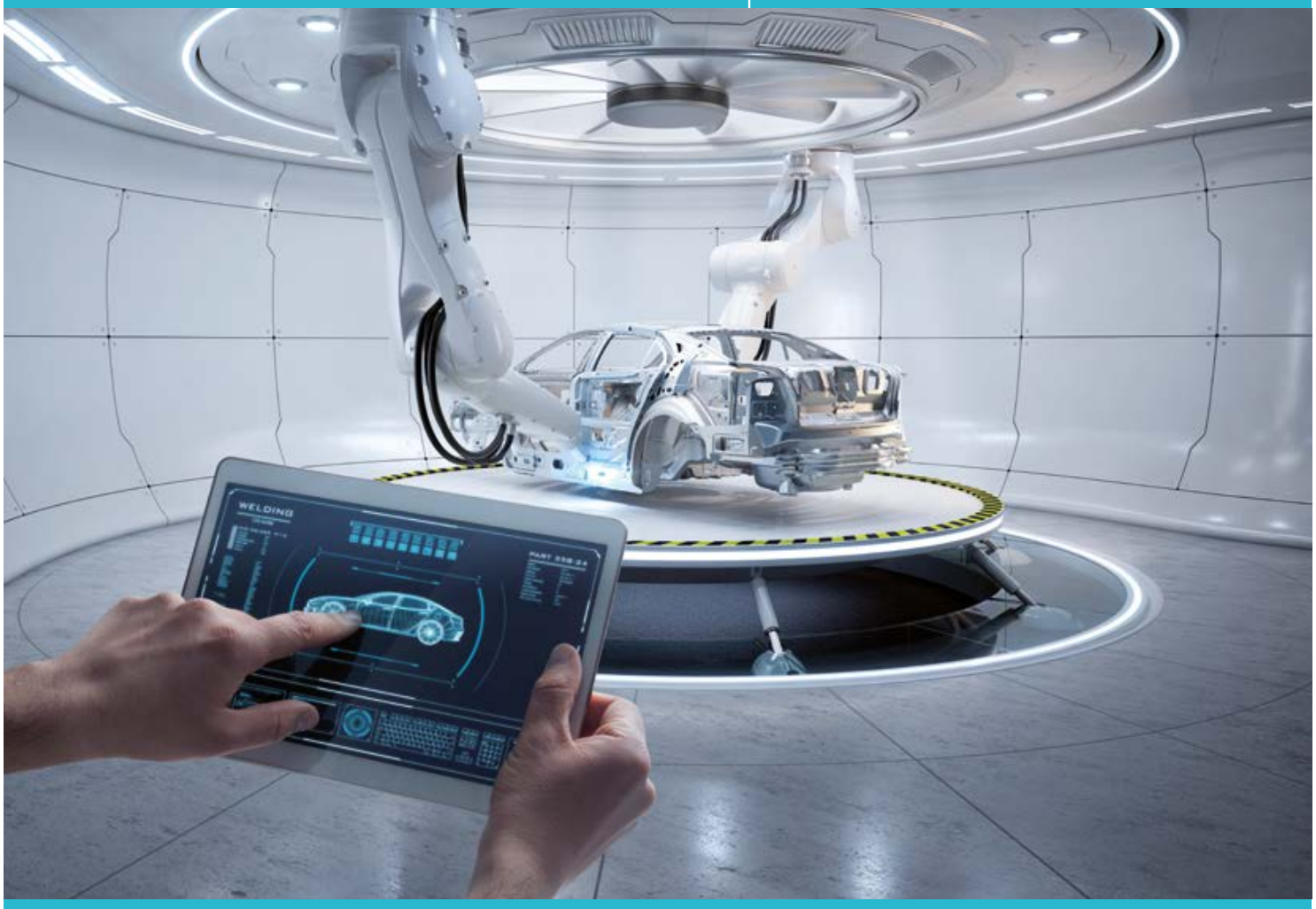
WORLD TRADE ORGANIZATION

WORLD TRADE REPORT 2018

The future of world trade: How digital technologies are transforming global commerce



What is the World Trade Report?

The World Trade Report is an annual publication that aims to deepen understanding about trends in trade, trade policy issues and the multilateral trading system.

What is the 2018 Report about?

The 2018 World Trade Report examines how digital technologies are transforming global commerce. It considers the different ways in which digital technologies affect international trade and the extent of potential forthcoming changes, and discusses the consequences of this transformation for existing and future international trade cooperation.

Find out more

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Disclaimer

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Foreword by the WTO Director-General

Trade and technology are closely interlinked. From the invention of the wheel, to the railways, to the advent of containerization, technology has constantly played a key role in shaping the way we trade – and this phenomenon is accelerating like never before. We are living through an era of unprecedented technological change, and a series of innovations that leverage the internet could have a major impact. For example, the Internet of Things, artificial intelligence, 3D printing and Blockchain have the potential to profoundly transform the way we trade, who trades and what is traded.

These developments could unlock many opportunities for individuals, entrepreneurs and businesses around the world. However, this process is not automatic. Technological advances per se are not a guarantee of greater trade growth and economic integration. History shows that successfully managing the structural changes driven by technology is central to ensuring that everybody can benefit. Therefore, we need to understand how to harness these new technologies. This is key to ensuring that the trading system can promote growth, development and job creation, and helping in the effort to deliver the Sustainable Development Goals.

The *World Trade Report 2018* highlights the interplay between technology and trade. It looks at how digital technologies are transforming global commerce today, and at their implications in the years to come. This report provides a qualitative analysis of the changes that are underway, and attempts to quantify the extent to which global trade may be affected in the next 15 years.

The Report helps to illustrate some of the big changes that are already happening. For example, it shows how digital technologies are reshaping consumer habits. E-commerce is booming thanks to the widespread use of the internet and of internet-enabled devices which provide consumers with direct access to online markets. UNCTAD estimated the total value of global e-commerce transactions, both domestic and cross-border, at US$ 25 trillion in 2015. This represents an increase of around 56 per cent compared to 2013. Firms are also surfing this wave, as digital technologies allow for easier entry into markets and increased product diversity, making it easier for them to produce, promote and distribute their products at a lower cost.

The Report also shows the impact of technological advances in cutting trade costs. Between 1996 and 2014, international trade costs declined by 15 per cent. Technological innovation played an important role here, and it has the potential to do even more. Notwithstanding the current trade tensions, we predict that trade could grow yearly by 1.8 to 2 percentage points more until 2030 as a result of the falling trade costs, amounting to a cumulated growth of 31 to 34 percentage points over 15 years. The Report finds that the decline in trade costs can be especially beneficial for micro, small and medium-sized enterprises, and for firms from developing countries, if appropriate complementary policies are put in place and challenges related to technology diffusion and regulation are addressed. Our estimations foresee that, in such a scenario, developing countries' share in global trade could grow from 46 per cent in 2015 to 57 per cent by 2030.

The advance of digital technologies can also bring about changes in the structure of trade. Beyond easing trade in goods, digital technologies can facilitate services trade and enable new services to emerge. The Report predicts that the share of services trade could grow from 21 per cent to 25 per cent by 2030. Other effects could include, for example, Blockchain helping smaller businesses to start trading by supporting them in building trust with partners around the world. 3D printing may help to democratize manufacturing by lowering the barriers to entry. More generally, these technologies could potentially lead to an expansion in global value chains, further shifting production activities to developing countries. Or we could see the opposite effect if it becomes more efficient to bring production activities back together in "smart" local factories than to offshore them.

Notwithstanding the benefits of digital technologies, they are also giving rise to a number of concerns. This includes market concentration, loss of privacy, security threats, the digital divide, and the question of whether digital technologies have really increased productivity.

These are very important questions, which deserve the attention and action of the international community. We can't simply leave the evolution of our technological future to chance, or trust it to market forces. We all have a duty to make this technological revolution a truly inclusive one.

Domestically, governments may need to look at how to tackle many of these challenges, including in areas such as investment in digital infrastructure and human capital, trade policy measures and regulation. International cooperation can also help governments derive more benefits from digital trade and help drive inclusion. At present, WTO members are trying to get to grips with these issues. The WTO framework, and in particular the GATS, is relevant for digital trade and WTO members have already taken certain steps to promote digital trade within the existing framework. In addition, discussions are ongoing among a large group of members regarding how members may want to respond to continued changes in the economy, and to ensure that everybody can participate and benefit from the digital economy.

Change is part of life. The question is not whether we like it, but rather how we choose to respond. Are we ready to rise to the challenges and seize the opportunities that this brave new world presents? I believe that this is the defining question facing governments around the world today. I hope this report will inform their response, and help to put inclusivity at the heart of these efforts. While there is no "one-size-fits-all" recipe, I am convinced that international cooperation will remain central to helping governments navigate these changes and to ensuring that digital technologies can help build a more open and inclusive trading system – now and for generations to come.

Roberto Azevêdo
Director-General

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.
- International trade costs declined by 15 per cent between 1996 and 2014. New technologies will help to further reduce trade costs. Our projections predict that trade could grow yearly by 1.8 to 2 percentage points more until 2030 as a result of the falling trade costs, amounting to a cumulated growth of 31 to 34 percentage points over 15 years.
- The wide adoption of digital technologies changes the composition of trade in services and goods, and redefines intellectual property rights in trade. Trade in information technology products has tripled in the past two decades, reaching US$ 1.6 trillion in 2016.
- The importance of services in the composition of trade is expected to increase. We predict the share of services trade to grow from 21 per cent to 25 per cent by 2030.
- Digitalization has led to a decline in trade of digitizable goods (e.g. CDs, books and newspapers) from 2.7 per cent of total goods trade in 2000 to 0.8 per cent in 2016. The trend is likely to continue with the advent of 3D printing technology.
- Regulation of intellectual property rights, data flows, and privacy as well as the quality of digital infrastructure are likely to emerge as new sources of comparative advantage.
- The decline in trade costs can be especially beneficial for MSMEs and firms from developing countries, if appropriate complementary policies are put in place, and challenges related to technology diffusion and regulation are addressed. Our estimations foresee that, in such case, developing countries' share in global trade could grow from 46 per cent in 2015 to 57 per cent by 2030.
- Digital technologies give rise to opportunities and challenges that may require the consideration of governments and the international community in areas as diverse as investment in digital infrastructure and human capital, trade policy measures and regulation.
- Provisions referring explicitly to digital technologies have been included in an increasing number of regional trade agreements. The most common provisions refer to e-government, cooperation and the moratorium on customs duties on electronic transmissions.
- While the WTO framework, and in particular the General Agreement on Trade in Services, is relevant for digital trade and WTO members have already taken certain steps to promote digital trade within the existing framework, members will have to consider how they want to respond to continued changes in the economy and the way we do business.

Executive summary

A. Introduction

Technological innovations have shaped global commerce.

From the invention of steamships, railways and the telegraph which fuelled the first industrial revolution in the early 1800s, to the advent of containerization in the 1950s and, more recently, the rise of the internet, technological innovations have significantly reduced trade costs and transformed the way we communicate, consume, produce and trade. However, technological advances are not a guarantee of greater or of stable trade growth or economic integration. In fact, over the past two centuries, it has been the ability to manage technology-driven structural changes that has largely determined whether global trade integration has progressed or regressed.

The rise of digital technologies promises to further transform international trade.

We are entering a new era, in which a series of innovations that leverage the internet could have a major impact on trade costs and international trade. The Internet of Things (IoT), artificial intelligence (AI), 3D printing and Blockchain have the potential to profoundly transform the way we trade, who trades and what is traded.

Understanding how these technologies may impact world trade is essential to help maximize the gains.

While technological advances are an essential enabler of international trade expansion, the capacity to manage the changes at play is equally important. Appreciating the depth and breadth of these changes is critical to help governments reap the benefits that these technologies create and address the challenges that may arise.

B. Towards a new digital era

The digital revolution has been enabled by technological changes in computing, communications and information processing.

The past half-century has seen a massive increase in processing and computing power, an equally enormous decline in its cost, and widespread adoption of personal computers. This has been accompanied by an equally rapid increase in bandwidth – the carrying capacity of a communication system – which has proved to be an important catalyst for the swift growth of the internet and mobile networks. Finally, the ability to turn many forms of information that once existed solely in analogue form into digital information and to collect, store and analyse it has expanded enormously.

The shift from mechanical and analogue electronic technology to digital technologies, the rapid adoption of the latter, particularly in the information and communication sectors, and the sweeping economic and even social changes that have accompanied this shift, have all laid the foundations for the digital revolution.

The technologies that are of particular interest in this report – IoT, AI, 3D printing and Blockchain – have been made possible by these same forces.

The IoT equips everyday objects with identifying, sensing, networking and processing capabilities that allow them to communicate with one another and with other devices via the internet to achieve particular objectives. The IoT can improve consumers' quality of life, for example by helping to track physical fitness and health or to better manage household tasks and supplies through smart appliances, such as connected refrigerators. For businesses, the IoT can help to improve operational efficiency through better preventive maintenance of machinery and products, and can also provide opportunities to sell new digital products and services. Nevertheless, wider adoption of the technology faces some stiff challenges. The deployment of connected devices, many of which were designed without much thought for security, can contain dangerous vulnerabilities. Connecting large numbers of new devices to the internet can create serious bottlenecks in telecommunication systems. Finally, as so many companies are competing to develop new connected devices, compatibility issues are likely to arise in the future.

Artificial intelligence (AI) is the ability of a digital computer or computer-controlled robot to perform tasks commonly associated with humans, such as the ability to reason, discover meaning, generalize or learn from past experience. Much AI today is "narrow" or "weak" AI, in that it is designed to perform relatively limited tasks (e.g. facial recognition or playing chess). However, the long-term goal of many AI researchers is to create "general" or "strong" AI which would outperform humans at nearly every cognitive task. AI can be used to increase efficiency in the production of goods and services and to aid innovation by generating new ideas. While AI has reached a lot of important milestones, numerous

technical challenges still lie ahead of it, including certain cognitive tasks that people often undertake without thinking, such as perceiving and navigating their physical environment. Forthcoming research on AI is likely to focus on making AI systems more robust and maximizing their societal benefits while mitigating adverse effects, which could include increased inequality and unemployment.

3D printing is the process of making a three-dimensional solid object of virtually any shape from a digital model. In time, it could lead to a shift towards more digital and localized supply chains and lower energy use, resource demands and related CO_2 emissions over the product life cycle. However, 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 can be widely adopted in the consumer market. Finally, although declining in recent years, the cost of printers, materials and scans is still relatively high, especially for deployment in micro, small and medium-sized enterprises (MSMEs).

A blockchain is a decentralized, distributed digital record of transactions (ledger) that is secured using various cryptographic techniques. Information, once added to a blockchain, is time-stamped and cannot be easily modified, making it easy to track attempted changes, and transactions are recorded, shared and verified on a peer-to-peer basis by anyone with the appropriate permissions. Blockchain is only one type of distributed ledger technology. However, the term "blockchain" is now commonly used to refer more generally to distributed ledger technology and to the phenomenon surrounding it. Although Blockchain technology presents interesting features in terms of security, immutability, transparency, traceability and automation, its wide-scale deployment currently hinges on various challenges. Scalability remains limited, existing blockchain networks and platforms do not "talk" to one another, and there are a number of unresolved legal issues, ranging from the legal status of blockchain transactions to the question of liability.

With digitalization, economic activity around the world has been subject to tremendous changes.

New business models have emerged, with digital technologies as their main underpinnings; digital platforms are becoming the new marketplace amidst the rapid expansion in internet access over the last decade. Ever-increasing online visibility, through interactive websites, apps and social media, has become embedded in marketing strategies, allowing businesses to interact with customers and thereby boost online sales. Companies also rely increasingly on artificial intelligence (AI) and big data to analyse consumers' online shopping experiences in order to profile preferences and adapt products accordingly.

In this regard, a large array of products and services, including travel booking, telehealth and e-learning are delivered remotely through information and communication technology (ICT) networks. Digital technologies such as 3D printing are making it feasible to supply customized goods and services to consumers who show a preference for personalized products.

The benefits of digital technologies notwithstanding, they are also giving rise to a number of concerns and questions, including about market concentration, loss of privacy, productivity and the digital divide.

There are commercial and social benefits to the collection and analysis of personal data. But there are also growing concerns that companies are not taking data privacy seriously enough. Partly as a result of this, a number of governments are enacting legislation to better clarify what information about individuals companies can collect and retain and what they can do with this data.

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. To this extent, anti-competitive effects that arise may be transient. However, significant welfare losses may arise from these anti-competitive effects before one platform or entrenched business model is replaced by another.

Questions have been raised about how much the adoption of digital technologies has raised economic productivity. Measures of productivity in the United States, for instance, suggest a significant slowdown since 2005. Several explanations have been given to explain this discrepancy, including the mismeasurement of inputs and outputs, and delays in the time needed for technological change to work itself throughout the whole economy.

The digital divide is one of the major challenges facing the digital economy. The digital divide between developed and developing countries remains wide in terms of access to broadband services and e-commerce platforms, quality of infrastructure and legal framework. Similar divides exist within countries, for example, internet penetration rates are higher for men than for women, small firms lag behind large firms

in their readiness to engage in the digital economy, and the impact of digitalization varies significantly across skill categories, increasing demand for high-skill workers which are complementary to that digitalization, while decreasing demand for less skilled workers when the latter are easily replaced by labour-saving technologies and automation.

Digital intensity differs across sectors and firms.

Sectors differ significantly in their dependence on digital technologies. On average, services firms are more intensive users of digital technology than manufacturing firms, while high-tech firms are more intensive users of industrial robots than services or low-tech firms.

Even in the most advanced economies, constant innovation and changing business models inevitably result in gaps in data collection.

Efforts to collect data on digital trade remain in their infancy, particularly in developing economies and least-developed countries (LDCs), where smaller transaction volumes and lower levels of ICT penetration call into question the value of dedicating limited resources to developing the relevant statistics. Despite these challenges, it is possible to illustrate the current state of the digital economy using available statistical and anecdotal evidence and to make inferences about its likely future direction.

Official data on e-commerce transactions is sparse and not comparable across economies, but it does offer some useful information.

In their latest Information Economy Report, the United Nations Conference on Trade and Development (UNCTAD) estimates that the total value of global e-commerce transactions, both domestic and cross-border, was US$ 25 trillion in 2015, up 56 per cent from US$ 16 trillion in 2013 (UNCTAD 2017a). The US International Trade Commission (USITC) offers a similar estimate of US$ 27.7 trillion for global e-commerce in 2016, up 44 per cent from 2012. USITC estimates the magnitude of business-to-business (B2B) transactions at US$ 23.9 trillion in 2016, six times larger than business-to-consumer (B2C) transactions (US$ 3.8 trillion). Current statistics do not break down e-commerce transactions by origin. As a result, domestic and cross-border transactions are not separately identifiable.

The statistical community has developed a "work in progress" conceptual measurement framework, taking into account the nature of the transactions ("how"); the product ("what"); and the actors involved ("who"). Under this framework, "digitally-enabled" transactions are split into "digitally-ordered" and "platform-enabled". E-commerce transactions are understood to be digitally-ordered but may be delivered either digitally or physically.

Firm-level financial data provide indications of where the market is going.

A series of financial reports from leading publicly traded digital economy firms (e.g. Alibaba, Alphabet, Amazon, Facebook, Microsoft, Netflix, Spotify, etc.), taken together, demonstrate not only the global reach of these firms but also the fact that they continue to have vast opportunities to grow their international operations. For example, nearly one-third (32 per cent) of Amazon's net sales are international. The international streaming revenue of Netflix rose from US$ 4 million in 2010 to more than US$ 5 billion in 2017. Although Alibaba's commerce revenue is mostly domestic (92 per cent in 2016-17), it is notable for being a large e-commerce firm based in a developing economy with considerable scope to grow its cross-border activities.

C. The economics of how digital technologies impact trade

New technologies may help reduce trade costs.

New technologies may decrease the relevance of distance, whether geographical, linguistic or regulatory. They also facilitate searches for products, help verifying quality and reputation, and help to match consumer preferences to products.

Certain AI applications can benefit trade in goods, for example by optimizing route planning and enabling autonomous driving, reducing logistics costs through cargo and shipment tracking, using smart robots to optimize storage and inventory, and integrating 3D printing in order to reduce the need for transport and logistics services. New technologies can thereby reduce trade costs by reducing transportation and storage costs, but also by reducing time to transport, as well as the uncertainty of delivery times due to better logistics. These costs represent a major share of overall trade costs and therefore their reduction can have a large potential impact on trade flows.

Trade costs related to customs procedures still hamper trade, especially in manufacturing products. Basic electronic systems reduce the time spent on customs compliance while Blockchain and AI promise further reductions. Their highest potential lies in time-sensitive goods flows such as global value chain (GVC)-related trade or perishable products.

Information and transaction costs are especially important in manufacturing, where they account for around 7 per cent of total trade costs. Online platforms help to overcome obstacles such as a lack of information and of trust in cross-border transactions. In addition, the IoT and Blockchain may simplify verification and certification procedures, and real-time translation and online platforms facilitate communication in different languages.

Innovations in cross-border payments and financial services further facilitate trade – for example, e-commerce platforms that circumvent traditional payment systems through blockchain technologies may help to bring down the transaction costs of cross-border trade.

The potential decline in trade costs can disproportionately benefit MSMEs and firms from developing countries...

Many trade costs such as logistics and transaction costs or cumbersome customs procedures weigh more heavily on MSMEs and are much higher in developing countries. Innovations in cross-border payment systems have had their largest impact in developing countries and for MSMEs. Hence, the potential of new technologies to facilitate trade for MSMEs and developing countries disproportionately can be large.

...but there are also challenges related to complementary policies, technology diffusion and regulation.

While new technologies and big data offer many opportunities for firms to organize their production and reach consumers more efficiently, there are also challenges.

If digital technologies are to realize their promises, ICT services are paramount. Machines need to be able to "speak" to each other regardless of the technology used and of whether the IoT, 3D printing or blockchain technologies are involved, and ITC services can enable this.

Much progress has been made on digital connectivity in terms of mobile/cellular, fixed broadband and internet penetration. Nevertheless, such progress has not been uniform across and within countries, nor between urban and rural populations.

Finally, while preliminary findings on new technologies such as 3D printing or Blockchain are promising, more work is needed in order to explore their potential fully. In addition, a number of technical and regulatory challenges still have to be overcome, including warranty and liability issues, lack of interoperability of various platforms, and the legal status of smart contracts.

New technologies can also significantly affect what we trade, who trades what and how we trade. The wide adoption of digital technologies is changing the composition of trade in different categories of services and goods, and is redefining intellectual property rights in trade.

Services sectors are at the centre of the recent technological revolution, as technological advances have enabled a growing array of services to be purchased online and supplied digitally across borders. Beyond facilitating trade in traditional services, digital technologies are enabling new services to replace trade in goods, ensuring the continued importance of services in the composition of trade. For example, new developments in the field of remote controlled robotics (such as telesurgery) have opened new ways to trade services and could trigger extensive changes in international trade.

With the increasing adoption of digital technologies, trade in information technology products has seen a steady increase in the past decades. A further reduction in trade costs enabled by digital technologies could give rise to increased trade in certain goods, most notably time-sensitive, certification-intensive and contract-intensive goods. Technologies have also enabled mass customization, creating virtually infinite varieties to meet individual consumer needs. On the other hand, digitalization has led to a decline in the trade of certain digitizable goods – such as CDs and newspapers. Trade in certain other consumer goods may be affected by the development of the "sharing economy" business model.

The evolution of digital technologies has radically transformed the linkages between intellectual property and international trade, as the increased availability of digital technologies has significantly lowered the costs to create, copy and distribute creative works on a global scale. Alongside the burgeoning trade in intellectual property licences, trade in the ownership of intellectual property rights is growing in diversity. The rise of the internet as a distribution channel is changing the ways in which creative works are made accessible and revenues generated and shared.

New technologies are likely to change established trade patterns as the importance of traditional sources of comparative advantage changes and new sources emerge.

Digital economies are likely to reinforce the importance of skills and capital endowment, as they are capital-intensive and skill-intensive. AI, 3D printing and advanced robotics could reduce the role of labour as source of comparative advantage.

In contrast, physical infrastructure, border processes and geographical factors might become less relevant, which would benefit remote or landlocked economies, as well as economies with less developed physical infrastructures and customs procedures.

Energy infrastructure is an important factor in defining comparative advantage in digital-intensive sectors, because the servers that support digital technologies depend on storage devices, power supplies, and cooling systems that consume vast amounts of energies.

Another factor that could become more important for trade patterns in the digital age is market size. Digital technologies benefit from access to large amounts of information, which may be advantageous to large developing economies.

With regard to institutions, the digitalization of trade may magnify their importance for comparative advantage, given that data privacy and intellectual property rights regulation rely on credible enforcement, although new technologies may also reduce the role of institutions for comparative advantage.

In addition to these traditional sources of comparative advantage, new sources will arise for trade in digital-intensive products. The regulation of intellectual property rights, data flows, and privacy are likely to be of particular importance, as well as the quality of digital infrastructure, since reliable and fast network access is becoming a necessity for conducting business.

The advance of digital technologies brings about opportunities and challenges for developing and developed countries alike.

For instance, as digitalization increases the complexity of tasks performed by workers, developed economies may strengthen their comparative advantage in skill-intensive sectors, although as new technologies diminish the importance of physical infrastructure, developing economies may also gain comparative advantages in the sectors most affected by the shift from physical to digitalized trade.

Digital technologies may affect the international fragmentation of production. However, the overall impact on GVC trade is hard to predict.

Digital technologies could lead to more GVC trade in the future for two reasons: first, because GVC trade is particularly hampered by communication, transportation, logistics, matching and verification costs, all of which digital technologies have the potential to reduce; and second, because digital technologies increase the quality and availability of services that act as enablers of value chains or that are used as inputs to the production of goods.

On the other hand, smart automation and 3D printing may encourage reshoring, i.e. the relocation of production or other business functions from countries with low labour costs back to countries with larger and richer markets – although, to date, there is little empirical evidence to link the adoption of digital technologies by firms with their reshoring decisions.

The pace and extent of the adoption of 3D printing might significantly affect GVC trade in the future.

3D printing is currently used mostly for upstream GVC activities, such as prototyping, complementing traditional "subtractive" production processes. In the longer run, however, 3D printing may to some extent substitute for traditional manufacturing methods, reducing the need for outsourced production and assembly, the number of production steps, and the need for inventory, warehousing, distribution, retail centres and packaging.

Value chains in a world of pervasive 3D printing may not only become shorter – with the emergence of production centres near every large customer base or near centres of innovation – but they might also look very different, being mostly based on the cross-border exchange of data, in the form of designs, blueprints and software, rather than on the cross-border exchange of material goods and services.

A quantitative projection on changes in the size and patterns of international trade by 2030 shows that digital technologies are likely to boost trade, especially in services and for developing countries.

In order to get a sense of the potential quantitative impacts of the changes that digital technologies will bring, this report uses a computable general equilibrium model to examine the impact of three trends: the reallocation of tasks between labour and capital related to robotization and digitalization, the servicification of the production process, and the fall in trade costs.

These simulations show that future technological changes are expected to increase trade growth, especially trade in services. Global trade is projected

to grow by around 2 percentage points more than in the baseline scenario as a result of these trends, and the share of the services trade is projected to grow from to 21 per cent to 25 per cent. Developing countries are likely to gain an increasing share of global trade, but the quantitative effects will depend on their ability to catch up on the adoption of digital technologies. If this catching up occurs, developing and least-developed economies' share in global trade is predicted to grow to 57 per cent by 2030, from 46 per cent in 2015, whereas if catching up does not occur, this share is predicted to rise only to 51 per cent. The organization of global production is projected to change through a rising share of imported intermediate services in manufacturing.

D. How do we prepare for the technology-induced reshaping of trade?

Digital technologies not only create new markets, new forms of trade and new products, but they also lower trade costs and change trade patterns. These changes offer new opportunities and trade gains, and governments may have a role to play in ensuring that firms can seize these opportunities.

First, governments may need to support or accompany private efforts to develop and facilitate access to affordable digital infrastructure and digital infrastructure services. They may also need to take measures to allow digital technologies to lower trade costs, for instance by enabling faster and more reliable management of data across borders or by facilitating trade operations and customs cooperation. At the same time, however, the reduction of trade costs may lower the prices of imported products relative to those of domestic products, possibly generating protectionist pressures from domestic producers subject to import competition.

Second, digital technologies may reshuffle comparative advantages, for instance by making it possible for firms in remote areas to sell digital products around the whole world or by making it profitable for firms in high-income countries to reshore certain activities. This raises questions as to how governments, in particular those of smaller and poorer countries, can seize new trading opportunities. An important dimension of this issue is the digital divide between richer and poorer countries.

Finally, governments will need to address concerns relating to consumer protection, cybersecurity, data privacy and competition that arise with digital trade in a way that is not more trade-distorting than necessary to achieve these important public policy objectives.

Governments respond to the opportunities and challenges raised by digital trade both unilaterally and in cooperation with other governments. Unilateral responses involve investment in digital infrastructure and human capital, trade policy measures and/or changes in domestic regulation. In most areas, international cooperation is helping governments derive more benefits from digital trade, and there may be scope for more beneficial international cooperation than is already in place.

In order to realize the potential benefits of digital trade fully, an increasing number of governments have adopted digital development strategies, which encompass cross-cutting policy measures aimed at improving infrastructure, establishing an adequate regulatory framework, reducing the cost of doing business and facilitating relevant skills development. Both goods and services trade policies can play an important role in promoting the digital economy.

Despite the evidence of the benefits of open and non-discriminatory policies and the adverse effects of restrictive policies and regulation, however, trade measures are still imposed by some governments to protect local businesses, including digital platforms, from foreign competition, restricting the access and operation of foreign services suppliers.

Governments are also developing and implementing new rules and regulations in the pursuit of public policy objectives such as data privacy, cybersecurity, or consumer protection. Some use competition policy to level the trading field for firms and to address the effects of "winner takes all" dynamics. Differences across domestic regulatory regimes may pose a challenge for their interoperability across countries. There may also be a risk of a regulatory race to the bottom, for example with regard to privacy protection regulations, or of the use of regulation as disguised protectionism.

Governments may choose to prioritize differently among these policy measures, depending on their level of development and the extent of digitalization, with developing countries typically focusing on facilitating connectivity and the adoption of digital technologies, while developed countries pay relatively greater attention to regulatory issues related to competition, data flows and consumer protection. However, skills development and the promotion of MSMEs' involvement in digital trade seem to be common concerns for developing and developed economies.

While the WTO framework, and in particular the General Agreement on Trade in Services (GATS), is relevant for digital trade and WTO members have taken certain steps to promote digital trade within the existing framework, there is debate as to whether and how more could be done to support inclusive digital trade.

As demonstrated by the discussions that have taken place since 1998 in the context of the WTO Work Programme on Electronic Commerce, existing WTO rules apply to e-commerce even when there is no specific reference to e-commerce or online trade. WTO rules on trade in goods, services and intellectual property rights do not contain language excluding their application to trade conducted through electronic means and have proved to be sufficiently flexible to accommodate "new" products, services and technologies.

WTO members have taken certain steps to promote digital trade within the existing framework, including a commitment to maintain the current practice of not imposing customs duties on electronic transmissions until 2019, reducing tariffs on the ICT products of members that are party to the WTO Information Technology Agreement, and including provisions related to digital technologies in the WTO Trade Facilitation Agreement, which entered into force in 2017. At a different level, the Aid for Trade initiative is part of a multilateral effort to bridge the digital divide.

More recently, a group of WTO members initiated exploratory work towards future WTO negotiations on trade-related aspects of e-commerce.

Several international and regional organizations cover specific policy areas related to digital trade. The nature and scope of discussion and commitments, including the participation of the private sector, differs across these organizations.

Digital technologies are not a new issue for the international community. Given the cross-cutting nature of digital technologies, international and regional organizations often address specific policy issues, such as skills development, ICT infrastructure, regulatory framework, competition, intellectual property, the participation of MSMEs, sustainable development and data collection. Some of these organizations have discussed and negotiated specific principles and best practices, and some have also developed capacity-building programmes.

Several international organizations serve as a forum for discussing and negotiating treaties, addressing specific aspects of digital trade, such as the World Customs Organization for customs procedures, the United Nations Commission on International Trade Law for domestic regulatory frameworks, and the World Intellectual Property Organization for intellectual property rights protection.

Most of the other activities undertaken by international and regional organizations take the form of infrastructure investment and capacity-building initiatives to help governments, in particular in developing countries, maximize the benefits of digital technologies and trade. These technical assistance programmes can take different forms, including joint initiatives between international organizations. Some of these initiatives also rely on collaborative public and private partnerships.

Over the last 25 years, provisions mentioning explicitly digital technologies have been incorporated into an increasing number of regional trade agreements (RTAs). These provisions, found in multiple chapters of the RTAs, remain particularly heterogeneous.

Reflecting the cross-cutting nature of digital technologies, provisions related to digital technologies can be found in multiple chapters of RTAs, and not only in the chapter on e-commerce. These provisions cover a broad range of issues, including trade rules and market access commitments, telecommunications and the digital regulatory framework, intellectual property protection, management of e-government (i.e. the use of ICT to deliver services in the public administration), including paperless trading, as well as cooperation and technical assistance on science and technology, ICT and e-commerce.

Although certain provisions related to digital technology replicate or clarify a number of existing provisions and/or commitments established under the WTO, other provisions expand commitments or specify new ones. These provisions often complement other relevant provisions found in RTAs, even though they do not make explicit reference to digital technologies.

Most provisions related to digital technologies do not follow a specific, unique template, even in agreements negotiated by the same country. As a result, provisions related to digital technology remain particularly heterogeneous in terms of structure, language and scope.

Although the importance and scope of provisions related to digital technologies have increased in recent years, the most detailed and

comprehensive provisions are often found in a limited number of mostly recent RTAs.

The most common types of provisions related to digital technologies found in RTAs refer to e-government management, as well as cooperation on e-commerce issues and the moratorium on customs duties on electronic transmissions. An increasing number of RTAs also cover the general domestic legal framework of e-commerce and more specific issues, such as electronic authentication, consumer protection and intellectual property. Other issues addressed in a limited number of relatively more recent RTAs include the cross-border electronic transfer of information, data localization and cybersecurity.

Overall, only a limited number of RTAs include provisions addressing most of the issues related to digital technologies identified in this report. The approach to address some of these issues also differs across some agreements, probably reflecting different political sensitivities. Given the dynamic nature of RTAs and the current trends, provisions related to digital technologies are likely to keep evolving with new and more comprehensive types of provisions.

Recent academic and research literature offers a range of views on steps to be taken within the trading system to promote the expansion of digital trade.

Several studies argue that conventional barriers to trade are a significant obstacle to the expansion of digital trade. Some studies emphasize the importance of clarifying and expanding the scope of WTO members' commitments on market access and national treatment under the GATS, without necessarily requiring the creation of a new stand-alone body of rules, as was done for the Information Technology Agreement (ITA).

In addition, an emerging literature also proposes developing new WTO disciplines or enhancing existing ones in light of what has been achieved in some recent RTAs, for example with regard to the cross-border transfer of information, data localization requirements, e-signatures and e-authentication, protecting the personal information of e-commerce users, or protecting online consumers.

Overall, the expansion of digital trade holds the potential to generate considerable benefits, in particular if it takes place under conditions that adequately address important public policy challenges. Issues concerning inclusiveness, privacy protection and cybersecurity are likely to figure prominently in debates on the future governance of digital trade. International cooperation has an important role to play in helping governments to ensure that digital trade continues to be an engine of inclusive economic development.

A Introduction

Over the last few decades, the internet has entered every corner of our lives, from social interactions to entertainment and work, and has fundamentally reshaped our economies, slashing the cost of acquiring and trading information. It has fuelled the digital revolution, fundamentally changing the ways in which we communicate, consume and produce, and it has profoundly transformed international trade, in terms of what we trade, how we trade, and who is trading.

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The development of digital technologies that leverage the internet to generate, store and process data promises to transform the world economy even more. We are entering a new era in which computers, automation and data analytics are coming together in an entirely new way. Among other functions, the Internet of Things (IoT) – the everyday objects and devices which communicate with one another by means of sensors and other processes – enables the tracking of products along the supply chain and helps to prevent equipment failures. Artificial intelligence (AI) – the ability of a computer or computer-controlled robot to perform tasks traditionally associated with humans – guides robots in warehouses, helps to optimize the packing of products, and allows companies to dive into our preferences and behaviour to offer us tailored products. 3D printing – the process of making a physical object from a three-dimensional digital model – could revolutionize manufacturing by making it possible to fabricate customized products close to consumers.[1] And Blockchain[2] may enhance the transparency of supply chains, accelerate the digitalization of trade processes and automate contractual transactions. These technologies have the potential to reduce trade costs further and to transform international trade profoundly in the years to come.

While this is not the first time that technology has reshaped the world trading order, the pace of adoption of new technologies keeps accelerating. The shift from analogue to digital technologies has changed the world beyond recognition in only a few decades, whereas earlier technological revolutions played out over generations. The "New Digital Revolution" that is underway may spread even more quickly.

Understanding how digital technologies are likely to impact on world trade in the years to come, and appreciating the depth and breadth of these changes, are essential in order to harness the opportunities that these technologies open for the benefits of all, to help address the challenges that they may raise and to design policies to maximize the gains from trade. The purpose of this report is to shed some light on the extent to which these technologies are already transforming global trade and will transform it further in the years to come, and to discuss how international trade cooperation can help governments reap the benefits of digital trade.

1. Technological innovations have shaped global trade

The world economy has been shaped by various phases or "waves" of global integration – each one driven by underlying changes in transport and communications technologies which reduced trade costs over an expanding range of economic activities, led to ever wider and deeper levels of integration and connectivity among national economies, and in turn required new forms of international trade cooperation, rules and institutions to consolidate and reinforce these structural trends. Indeed, it is the critical interplay between technology-driven structural change in the global economy, on the one hand, and the ability of the world trading system to manage these changes and adjustments, on the other, which has largely determined whether global integration has advanced or gone into reverse over the past two centuries.

(a) First wave of integration, 1815-1914

The Industrial Revolution marked the first major turning point for world trade. Although the outlines of a world economy had begun to take shape in the 17th and 18th centuries – as advances in ship design and navigation led to the opening of new trade routes to Africa, the Americas, and Asia (Maddison, 2008) – it was the commencement of the Industrial Revolution in the late 18th century, and the new technologies that accompanied it, that began to lower transport and communications costs dramatically, triggered the massive expansion of trade, capital and technology flows, and led to a process of economic integration that is now referred to as "the first age of globalization" (Ikenberry, 2000). These breakthroughs in transport and communications technologies opened up national economies to trade and investment in ways that differed radically from the past, relentlessly eroding what economic historian Geoffrey Blainey famously termed "the tyranny of distance" (Blainey, 1968).

Steamships were the first revolutionary technology to transform transportation in the 19th century. At first, steamships carried only high-value freight on inland waterways, but a series of incremental technological improvements over subsequent decades – screw propellers, the turbine engine, improved hull design, more efficient ports – resulted in faster, bigger and more fuel-efficient ships, further driving down transport costs, and opening up transoceanic steamship trade to bulk commodities, as well as luxury goods. By the late 1830s, steamships were regularly crossing the Atlantic; by the 1850s, service to South Africa had begun; and, with the opening of the Suez Canal in 1869, which created an important short cut to Asia, transoceanic steam shipping took over Far Eastern trade routes as well.

Railways were the other major transport breakthrough of the early Industrial Revolution, rapidly lowering inland trade costs in the same way that steamships

were lowering overseas trade costs, and ensuring that regional and global integration were increasingly complementary. The world's first freight rail line, the 1825 Stockton-Darlington route, was soon copied, not just throughout Great Britain, but in the rest of Europe, the Americas, and, by the end of the century, Asia and Latin America as well. A transcontinental line linked the East and West coasts of the United States by 1869 (Findlay and O'Rourke, 2009), the Canadian-Pacific railroad was completed by 1885, and the Trans-Siberian Railway by 1903. Worldwide railway lines increased from 191,000 kilometres in 1870 to nearly 1 million kilometres in 1913 (Fogel, 1964). Breakthroughs in refrigeration after the 1830s reinforced the impact of steamships and rail, allowing for the transport of chilled meat and butter over great distances (Mokyr, 1992).

Other technologies contributed to an even more dramatic lowering of communications costs. The development of the telegraph in the mid-19th century was as revolutionary in its day as the internet is now, effectively ushering in the modern era of instantaneous global communications. The first successful transatlantic telegraph message was sent in August 1858, reducing the communication time between Europe and North America from ten days – the time it took to deliver a message by ship – to a matter of minutes. By the end of the 19th century, American-, British-, French- and German-owned cables linked Europe and North America in a sophisticated web of telegraphic communications. As transoceanic steamships linked up distant markets, railways connected emerging industrial centres and telegraphs linked financial centres, world trade and investment surged.

It is estimated that international trade costs for France, Great Britain, the United States and 18 other trading powers fell by almost 25 per cent relative to their domestic trade costs between 1870 and 1913, explaining roughly 55 per cent of trade growth in that period (Jacks et al., 2008). Although technology was the major driver of this process, growing international economic cooperation and the spread of liberal economic policies both reflected and reinforced the underlying integrationist trends.

First, Great Britain removed many of its tariff barriers and trade restrictions unilaterally with the repeals of the Navigation Acts and the Corn Laws between 1846 and 1860, providing a powerful push towards more open international trade. Next, in 1860, Great Britain negotiated the Cobden Chevalier Treaty with France which, by reducing trade barriers between the world's then two biggest economies on a conditional most-favoured nation (MFN) basis, created an incentive for other European countries to conclude similar bilateral trade agreements. Next, in the 1870s, again following Great Britain's lead, the world's major economies shifted to the gold standard and fixed exchange rates, adding perhaps the most important pillar to global economic stability during that period.

While there was no equivalent of today's major multilateral economic organizations, a number of new international agencies developed during this period to manage some of the specific policy challenges associated with the technology-driven economic integration. The International Telegraphic Union – the world's first inter-governmental organization – was created in 1865 in order to link national telegraphic systems into a single international network. In a similar way, the Universal Postal Union was formed in 1874 to help harmonize trans-border postal delivery.

This combination of technological change, trade opening and nascent international cooperation fuelled a period of extraordinary regional and global trade and economic integration. International trade expanded by 486 per cent between 1870 and 1913 (Jacks et al., 2011) – corresponding to an annualized growth of 4.12 per cent, substantially above the 2.1 per cent annual increase in world gross domestic product (GDP) reported by Maddison (2001) for the same period. Indeed, economic historian Kevin O'Rourke (2002) argues that "the most impressive episode of international economic integration which the world has seen to date were the years between 1870 and the Great War".

(b) Disintegration, 1914-1945

The first age of globalization rested on simple but fragile foundations when the First World War delivered a fatal blow – destroying not just the liberal economic order but the assumption, remarkably widespread in the 1800s, that technology-driven integration and interdependence alone were sufficient to underpin international cooperation and peace. Trade was massively disrupted, the gold standard collapsed, economic controls and restrictions were widespread, and Europe, the former core of the world economy, was left devastated and exhausted. Although the 1920s saw some modest progress in efforts to restore the pre-1914 economic order, the Great Depression delivered a devastating blow from which the 1930s never recovered. Economic insecurity fed political insecurity, resulting in the rise of political extremism, the breakdown of collective security, a race to re-arm, and ultimately the outbreak of the Second World War. The average level of trade costs increased by 10 per cent in the 20 years from 1919 to 1939 (Jacks et al., 2008).

The failed attempt to rebuild the global economy after 1918 arose partly from an inability to recognize a fundamentally changed post-war era, and that there could be no easy return to the pre-war "golden age" of open and stable trade. Countries underestimated the immense challenge of restructuring wartime industries, finding work for millions of unemployed soldiers, or coping with raw material and food shortages. They were also slow to recognize that mobilizing countries behind total war – and then addressing the post-war demand for more activist public policies – had required unprecedented government involvement in economies, which complicated efforts to rebuild international economic cooperation in the interwar years. The lack of global economic leadership was perhaps the biggest obstacle to interwar recovery. As Charles Kindleberger famously argued, "the 1929 depression was so wide, so deep, and so long because the international economic system was rendered unstable by British inability and United States unwillingness to assume responsibility for stabilizing it" (Kindleberger, 1973).

Even during this period of disintegration between 1914 and 1945, underlying technological advances in transport and communications continued and, in some instances, even accelerated. War actually fuelled innovations in transoceanic shipping, for example, including the introduction of better boilers to convert steam, the development of turboelectric transmission mechanisms, and the replacement of coal-fired plants with oil and diesel engines. In 1914, almost the entire world merchant fleet, 96.9 per cent, was made up of coal-burning steamships; this declined to about 70 per cent in the 1920s, and less than 50 per cent from the latter half of the 1930 (Lundgren, 1996). Railway networks also expanded rapidly between the two world wars. By 1937, 5.7 per cent of the world's railways were located in Africa, 10.2 per cent in Latin America and 10.9 per cent in Asia (Findlay and O'Rourke, 2009). By the late 1920s, diesel and electric locomotives were increasingly replacing steam engines. The interwar period also witnessed the mass adoption of the motor vehicle. Initially limited to transporting passengers in urban areas, large motorized trucks were soon serving on feeder routes to the main railways lines, and eventually they were competing with those lines. Adoption was particularly rapid in the United States: in 1921 there was one commercial motor vehicle for every 85 Americans, whereas in 1938 there was one for every 29 (Maddison, 2008).[3]

A clear lesson from the interwar period is that while technological advance is an essential enabler of increasing international trade and economic integration, it does not guarantee them – the policy and political contexts matter just as much.

(c) A second wave of integration, 1945-2000

The world economy underwent a process of "re-integration" after the Second World War, returning to the integration path that had abruptly been derailed by the First World War and by the economic and political chaos that followed (Findlay and O'Rourke, 2009). Indeed, the world economy grew far faster between 1950 and 1973 than it had done before 1914, and its geographical scope was far wider, ushering in a "golden age" of unprecedented prosperity (Maddison, 2001). World trade rose by nearly 8 per cent a year, while world per capita GDP rose by nearly 3 per cent a year.

As in the past, this process of re-integration was fuelled by further breakthroughs in transport and communication technologies and rapidly declining trade costs – which fell by a further 16 per cent between 1950 and 2000 (Jacks et al., 2008). Technological change in ocean shipping, including the use of containerization, contributed to a substantial decline in *ad valorem* transport charges – the cost of transport as a share of the value of the traded good – from around 10 per cent in the mid-1970s to around 6 per cent in the mid-1990s (Hummels, 2007).

Likewise, electrification, improved rail design, high-speed trains, intermodal freight, and other innovations have further reduced rail transport costs. The rapid expansion of air freight represented yet another major transportation breakthrough in the second half of the 20th century. With the development of Federal Express in the late 1970s, promising next-day delivery of freight through a dedicated fleet of cargo carriers, the costs of air freight fell by three-quarters in less than a decade (Dollar and Kraay, 2002).

Communications costs have fallen even faster thanks to satellites, fibre optic cables and other telecommunications innovations. A three-minute telephone call from London to New York cost about US$ 250 in 1930. It now costs 2 cents – zero if one is Skyping. Meanwhile, according to International Telecommunication Unions (ITU) data, the number of mobile phones had grown to exceed the number of people on earth by 2014 – and will reach 13 billion by 2019. Overall, declining trade costs were estimated to account for 33 per cent of the trade growth from 1950 to 2000 (Jacks et al., 2008).

One important by-product of this second wave of integration was the growing internationalization of production and distribution. Just as rapidly falling transport costs in the 19th century led to globalization's "first unbundling" – the end of the

need to produce close to the point of consumption – the second wave of integrationist technologies has led to globalization's "second unbundling" – the end of the need to perform most production stages near one another (Baldwin, 2006). Production has come to be managed increasingly through complex global supply chains – effectively world factories – which locate various stages of the production process in the world's most cost-efficient locations.

These global value chains (GVCs) vary depending on what, where and how they produce. Some focus on mass-market consumer products, others on capital goods, and others still on services and on agricultural and natural resources products. GVCs have also continued to evolve as more efficient suppliers arise, new technologies open up, underlying economic conditions change, or consumers' tastes shift. All rely on increasingly sophisticated, seamless and flexible trade and investment networks that allow a wide range of geographically dispersed firms and service providers to deliver "just-in-time" output, at required specifications, in a tightly sequenced and coordinated way. It is estimated that upwards of 80 per cent of global trade now takes place within the international production networks of multinational enterprises.

There was one important difference between the first and the second waves of global integration: whereas the 19th-century wave was accompanied by only rudimentary efforts at international economic cooperation, the 20th-century wave, by explicit design, was built on a foundation of new and mutually reinforcing multilateral economic institutions known collectively as the Bretton Woods system. Thus, the International Monetary Fund would restore exchange rate stability and encourage monetary cooperation, preventing a return to the currency wars and financial chaos of the 1930s; the World Bank would provide soft loans for rebuilding war-torn countries and for accelerating economic development in poorer ones – the opposite of the revanchist spirit that had poisoned relations after the First World War; and the International Trade Organization (ITO) (a projected predecessor of the WTO) would lower tariff barriers and strengthen trade rules, gradually relaxing the protectionism and hostile regional blocs that had suffocated the world economy in the interwar years.

However, when the US Congress failed to ratify the ITO charter in the late 1940s, countries were forced to rely on the General Agreement on Tariffs and Trade (GATT), which had initially been designed to be a temporary tariff-cutting agreement until the ITO was formally established, and embodied most of the ITO's key commercial policy rules. Although the GATT was never intended as an international organization, it gradually came to play that role, both lowering tariffs and strengthening trade rules through eight successive "rounds" of negotiations, until its replacement by the World Trade Organization on 1 January 1995.

2. A new world in the making

As the remainder of this report makes clear, the world economy is being reshaped by an even newer wave of technologies, driven by innovations in telecommunications, computing and the global information networks they have produced. If the 19th century was marked by the falling cost of trading commodities, and the 20th century by the falling cost of trading manufactured products, the 21st century will most likely be marked by the falling cost of trading information. Thanks to fibre optic cables, satellites and digital technology, the cost of overseas telecommunications is approaching zero. As the power of computer chips has multiplied – following Moore's Law (that the power of integrated circuits roughly doubles every two years – see Section B) – the price of computing power has also fallen dramatically. Meanwhile, the internet has emerged, almost by accident, as the embodiment of the "global information superhighway" first predicted in the early 1990s, serving not just as a new means of global communication, but also as a vast source of global information. The fusion of technologies that is currently coming about – often dubbed the Fourth Industrial Revolution – promises to reshape and reimagine the world economy in even newer and more fundamental ways. In this context, four technological innovations – the IoT, AI, 3D printing and Blockchain – are discussed in this report.

These developments have many implications, but the perhaps most important is that they have the potential to accelerate the process of global integration even more. The digital economy is already transforming the way ideas-based products move across borders – from financial services to data processing, medical information and entertainment. It is making itself felt in the ways in which knowledge, skills and expertise can be sourced from around the world, and in the ways in which production can be integrated, 24 hours a day, across times zones and borders.

However, something more fundamental is also going on. Digitalization is also rapidly spreading the very factors of production – technology, information and ideas – that make economic advances possible. Just as digitalization is dramatically expanding trade in some products, such as entertainment, it could reduce trade in others due to re-shoring of

"workerless" factories or to 3D printing. The further unbundling of production in some sectors will go hand in hand with the re-bundling of production in others. This widening circle of technology will, no doubt, continue to transform the world economy in the years to come.

3. Structure of the report

The World Trade Report 2018 examines how digital technologies are transforming global commerce today and are likely to impact it further in the years to come. It provides a qualitative analysis of the changes at play and tries to quantify the extent to which global trade may be affected over the next 15 years. It is, therefore, largely forward-looking. The report also discusses policy options for international trade cooperation in the digital era.

The report is structured in three main parts.

Section B discusses how digital technologies are transforming the economy. It describes the rise of digital technologies and examines how they are changing the economy, by giving rise to new markets, goods and services. It also discusses some of the concerns about privacy, market concentration and the digital divide that have arisen, and examines the challenge of measuring the value of digital transactions, including cross-border transactions.

Section C discusses the nature of what we trade, how we trade, and who trades what. It examines how digital technologies are affecting international trade costs, and how such effects create new opportunities and raise new challenges. The section also discusses how digital technologies affect the composition of trade in goods and services and impact intellectual property, and it examines the determinants of comparative advantage in the digital age, as well as the potential impact of digital technologies on global value chains. It concludes by quantifying the potential impact of important trends in technological development with projections on international trade to 2030, using the WTO Global Trade Model.

Section D focuses on the national and international policy dimensions of the digitalization of international trade. It discusses how international trade cooperation can help governments harness digital technologies, seize the opportunities that they create, and address the challenges that arise. It provides examples of measures taken by governments and discusses whether and how international cooperation can help governments reap the benefits of digital trade and at the same time achieve their public policy objectives, both now and in the future. The section identifies certain aspects of policies that may warrant international cooperation.

Endnotes

1 This report does not cover 3D printing of organic material, i.e. bioprinting.

2 As defined in Section B of this report, 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". Blockchain is, technically speaking, only one type of distributed ledger technology. However, 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.

3 The growing importance of motor vehicles was in turn one of the main factors underlying the rise of petroleum as an increasingly vital energy source for the world economy and the rapid growth in the trade of petroleum products.

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.

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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.

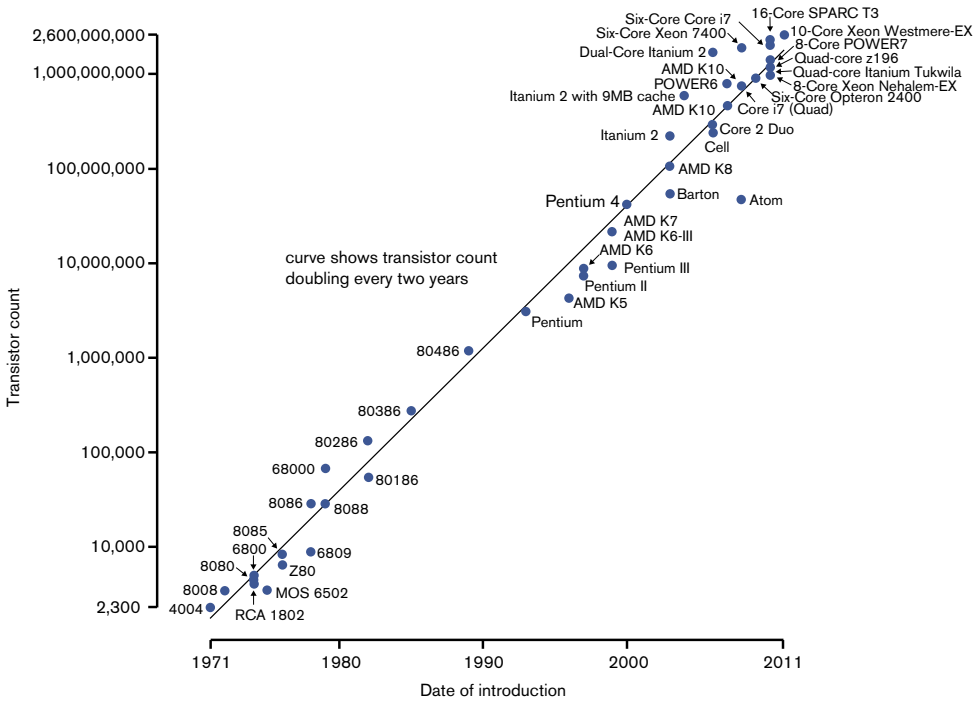
Technologies that underpin the digital revolution have benefitted from three powerful trends in computing, communications and information processing that have combined to enable the rapid technological advances we have observed. These three trends are Moore's Law, Gilder's Law and the digitalization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

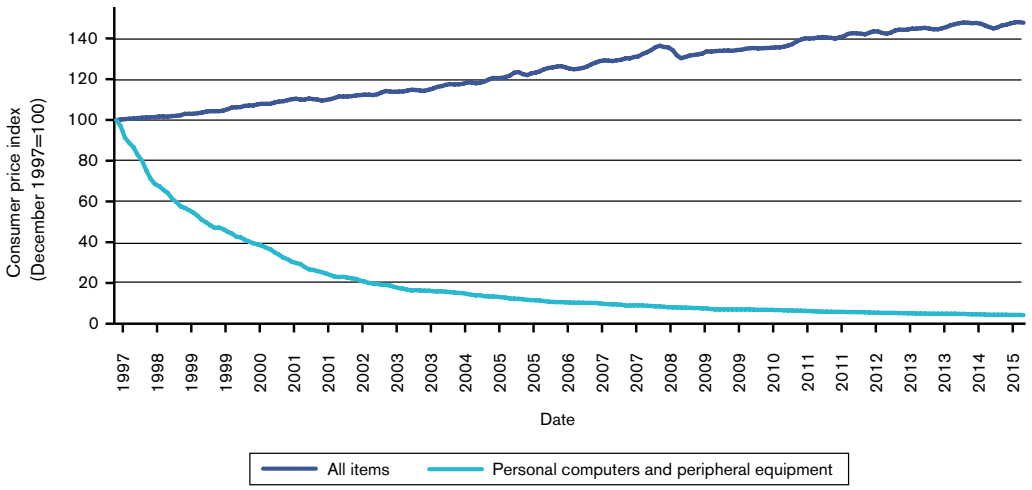
Figure B.1: Illustrating Moore's Law: microprocessor transistor counts 1971-2011



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.

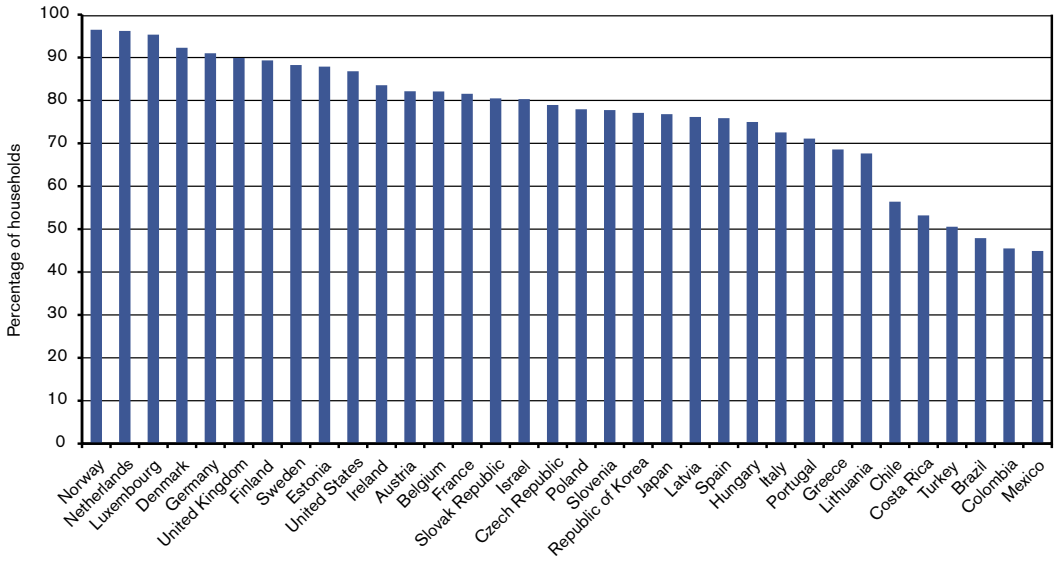
Figure B.2: The falling cost of computers, 1997-2015



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).

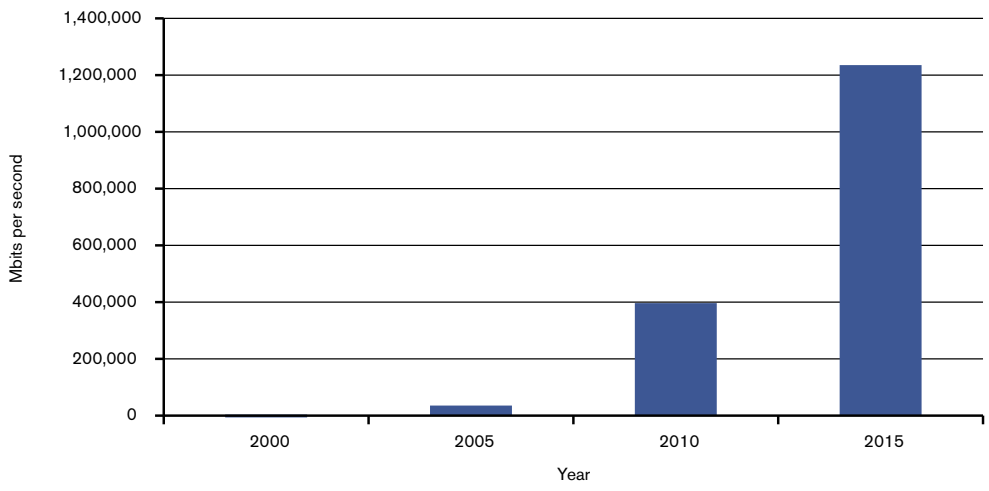
In 1990, less than 5 per cent of the world's population had access to the internet. Today nearly half of the world's population can access the internet, and it is far faster and more pervasive than the dial-up internet of the 1990s. Figure B.5 shows the volume of internet traffic since 1984 when it averaged 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

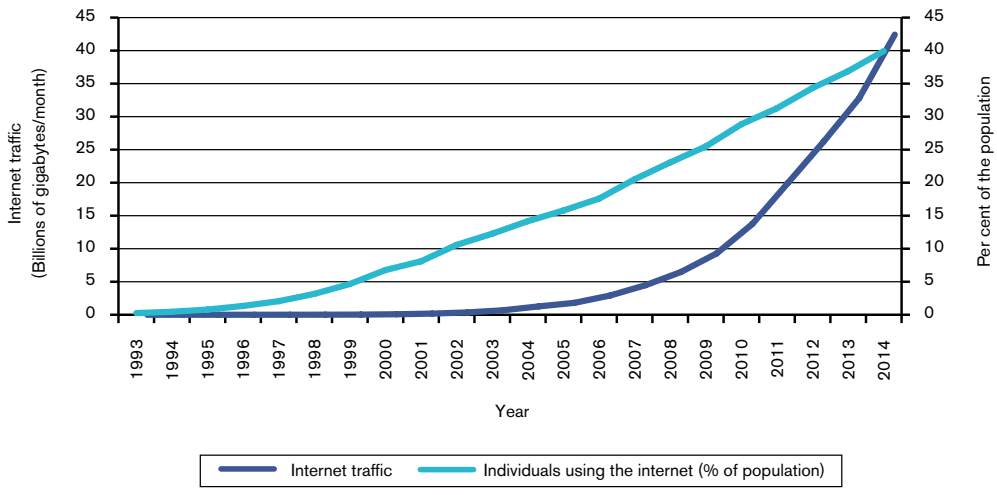
According to Roy (2017), telecommunication services, including internet, mobile telephony, and data transmission services, provide the basic infrastructure and transmission capacity that allow a range of other services to be provided digitally, and also permit goods and services to be offered and purchased 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)

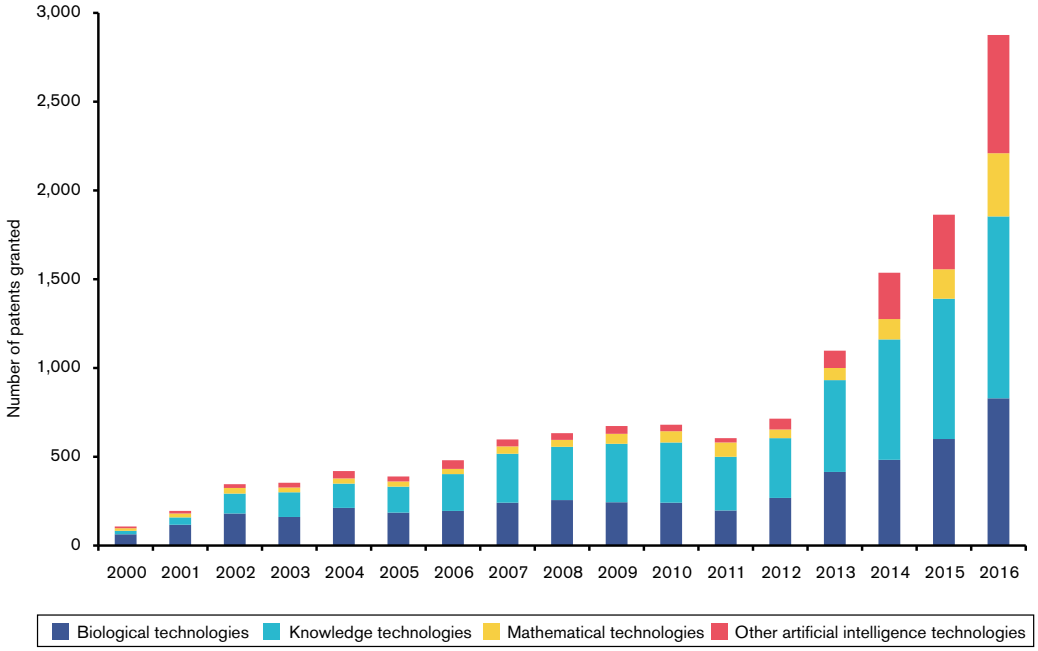
Artificial intelligence (AI) is “the ability of a digital computer or computer-controlled robot to perform tasks commonly associated with intelligent beings [...], such as the ability to reason, discover meaning, generalize or learn from past experience”.[2] Much of today’s AI is "narrow" or "weak", 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.

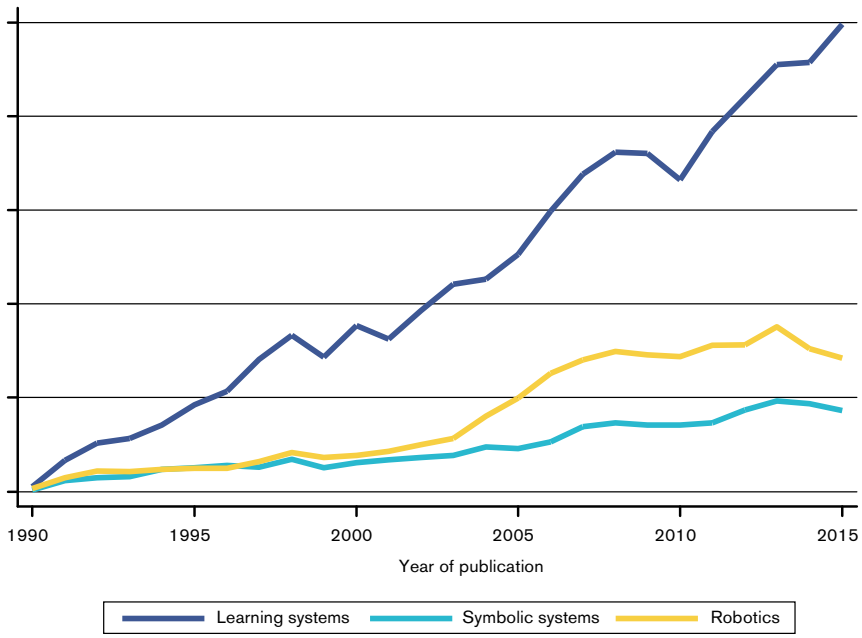
Cockburn et al. (2018) claim that AI is increasingly being used to generate ideas and as a general-purpose "method of invention" that is reshaping the nature of the innovation process. They find support for this hypothesis in the fact that one field of AI, namely learning systems, which involves the 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]

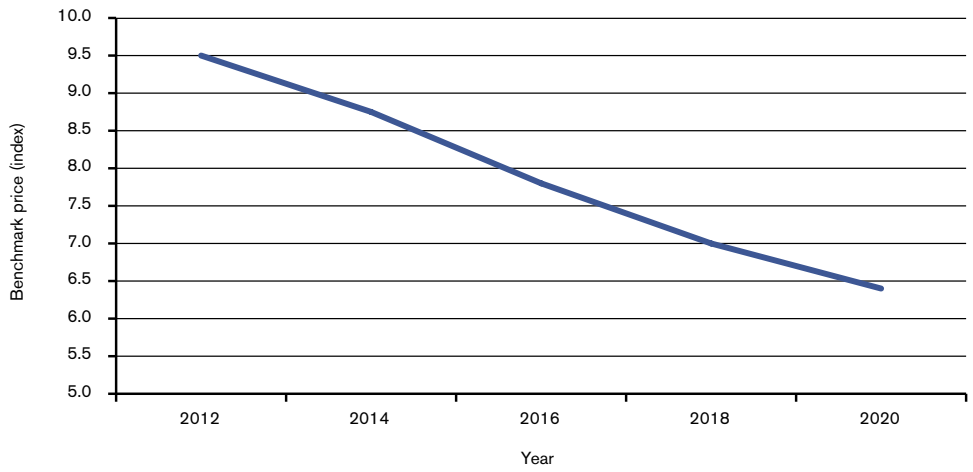
3D printing is currently used for a wide range of applications, from manufacturing parts for planes, trains and cars, to formulating fruit-based snacks (Garrett, 2014; Derossi et al., 2018). 3D printing makes customization much easier and less costly, as it involves a new design and a change in computer 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.

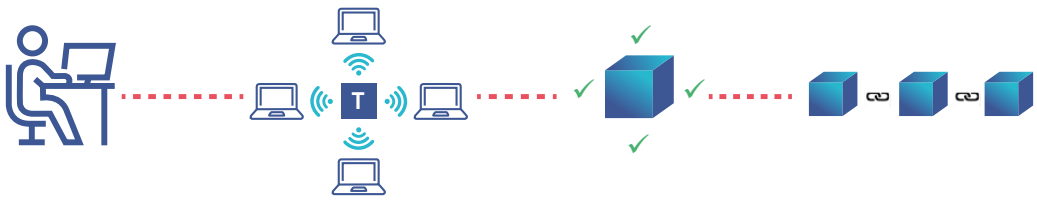
A technology that could "change our lives" for some (Boucher, 2017), a "pipe dream" and "the most overhyped technology" for others (Roubini and Preston, 2018), the real potential of Blockchain to truly transform the way business is done remains to be fully assessed. Indeed, the deployment of Blockchain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

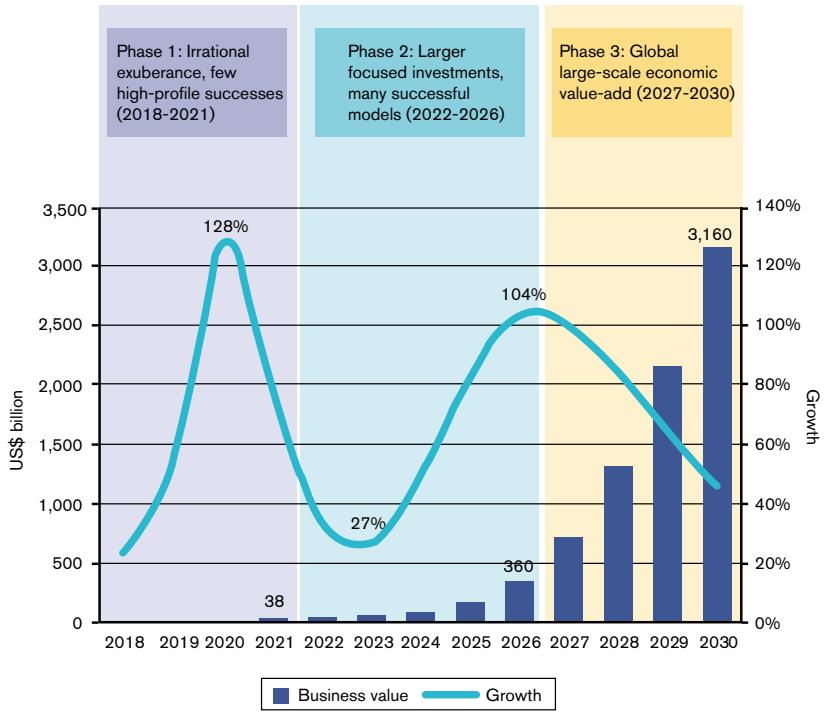
In spite of these challenges, which are the subject of active work to develop technical solutions, the promise of greater security, efficiency, integrity and traceability offered by Blockchain is leading an increasing number of companies to investigate the potential of the technology as a way to cut 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.

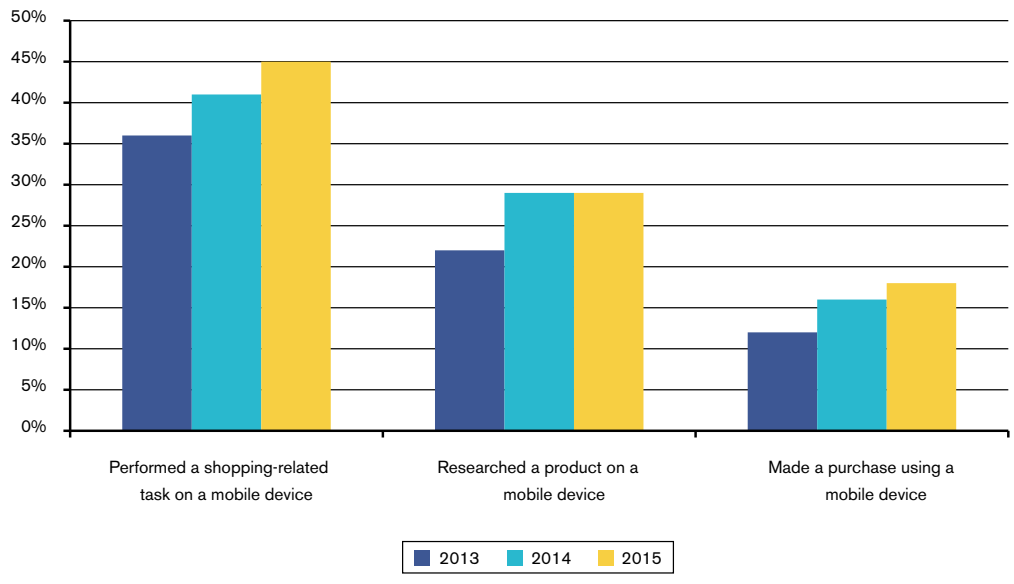
Importantly, the integration of these tools into the shopping experience has gone beyond the simple act of searching and buying items online. Indeed, the vast majority of consumers seek and share opinions and reviews on specialized forums such as Yelp and TripAdvisor and also refer to their peers' "likes" 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".

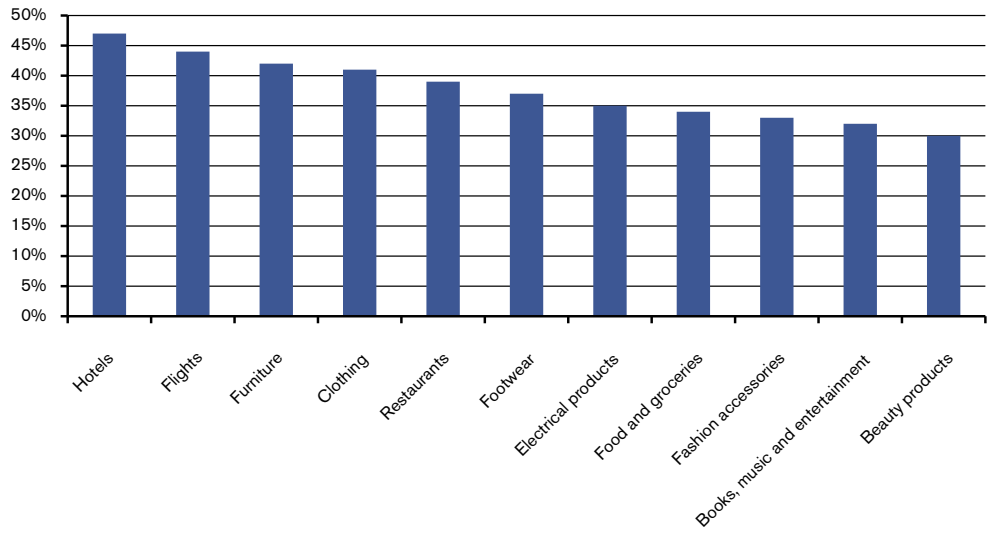
Another type of digitally-enabled service which has been experiencing a sharp increase in demand with the massive use of new devices such as tablets and smartphones is online gaming, and in the EU, for example, online gaming revenue increased ten-fold during the first decade of this century, rocketing 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

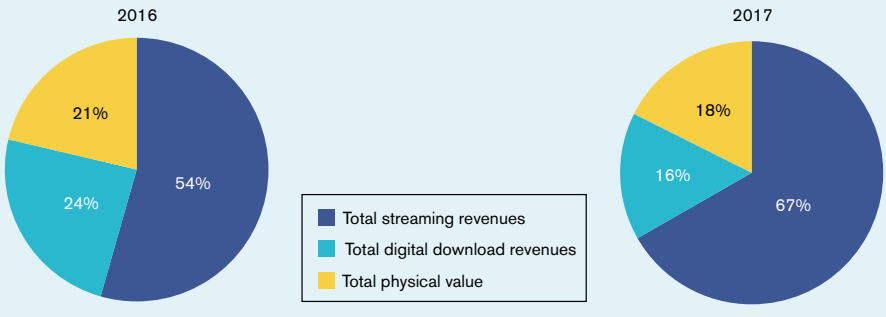
For the purposes of this section, privacy is defined as the right to have some control over how one's personal information, or data, is collected and used.[16]

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.

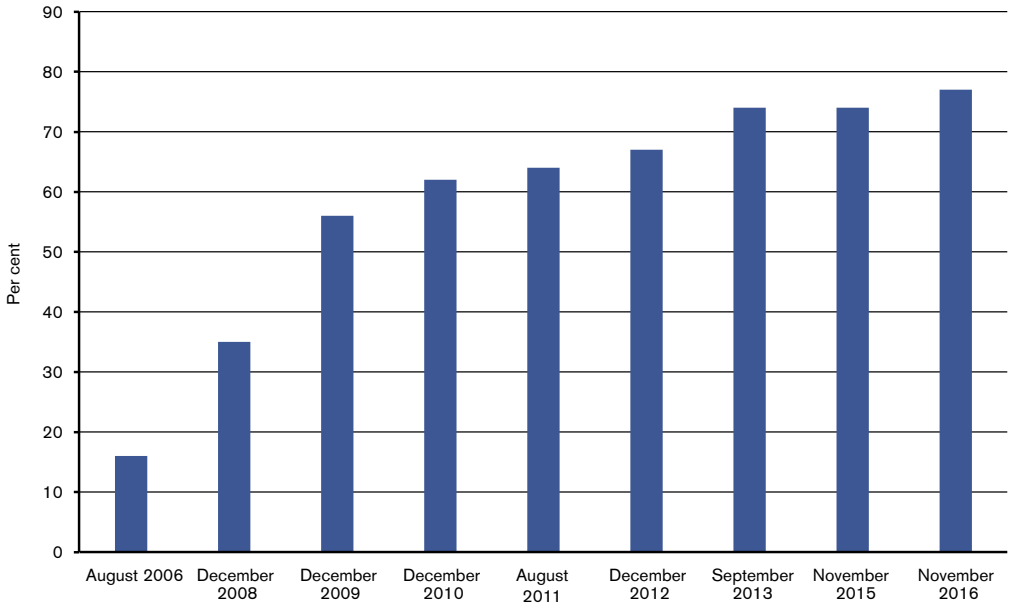
Digital technology will continue to affect the music industry. Analysing the potential of Blockchain for the music industry, De León and Gupta (2017) point out that new technologies may help to replace the complex and obscure royalty regimes by which the industry currently pays artists with simpler mechanisms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

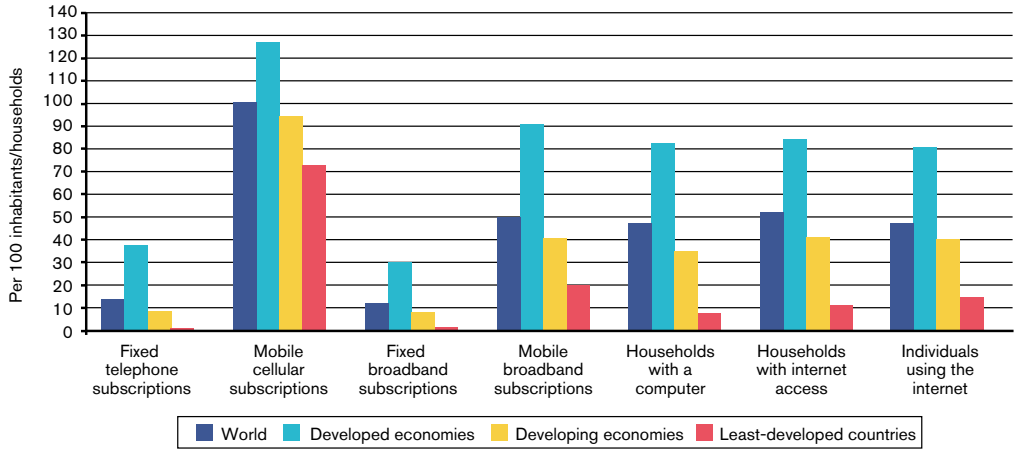
(iv) The many dimensions of the digital divide

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

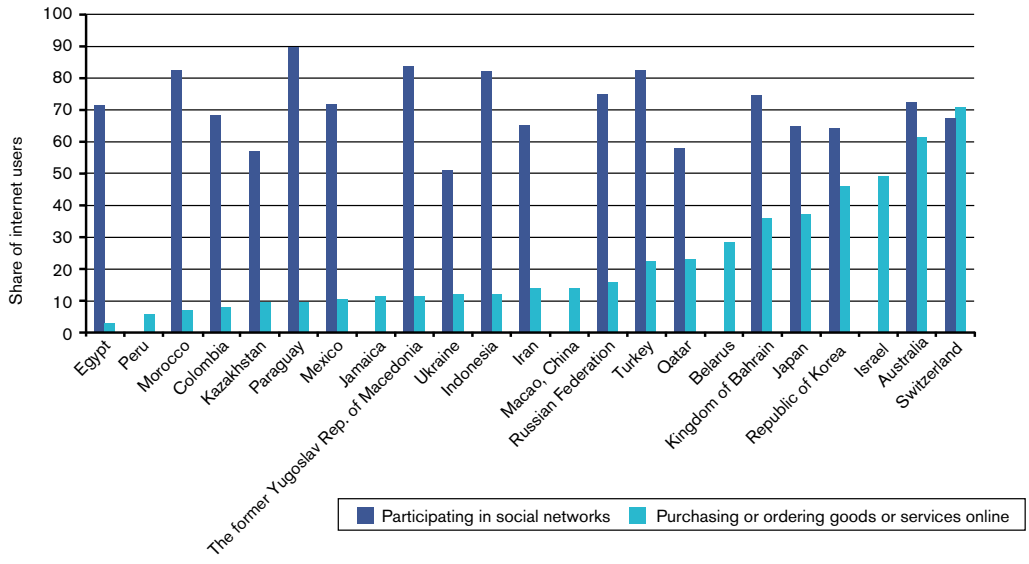


Sources: UNCTAD (2017b), based on ITU data.

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**

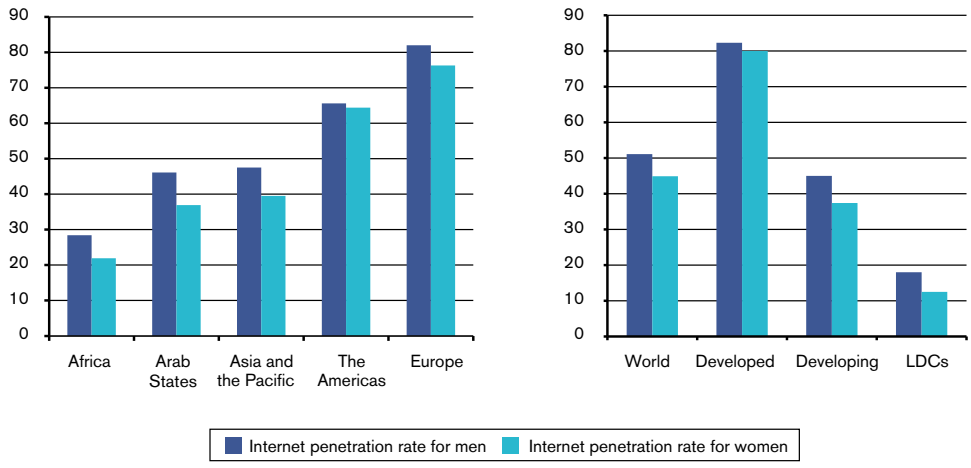
Source: UNCTAD (2018a).

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).

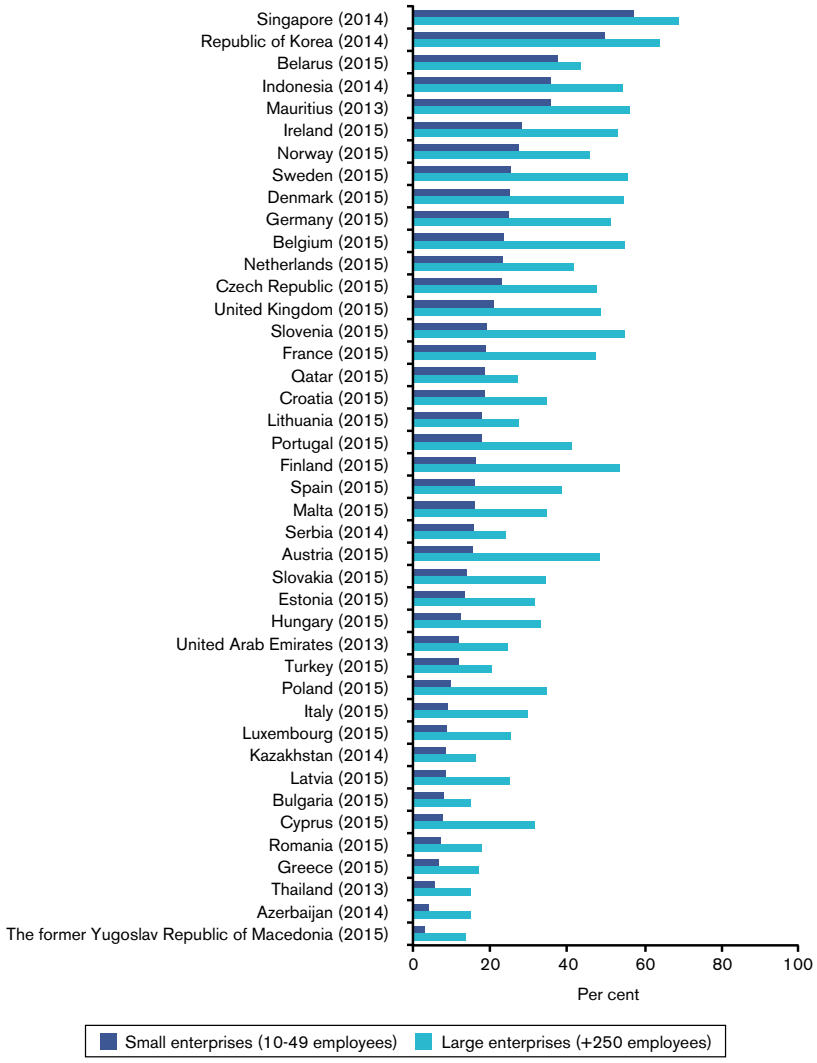
Notes: Penetration rates in this chart refer to the number of women and men that use the internet, as a percentage of the respective total female and male populations.

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.

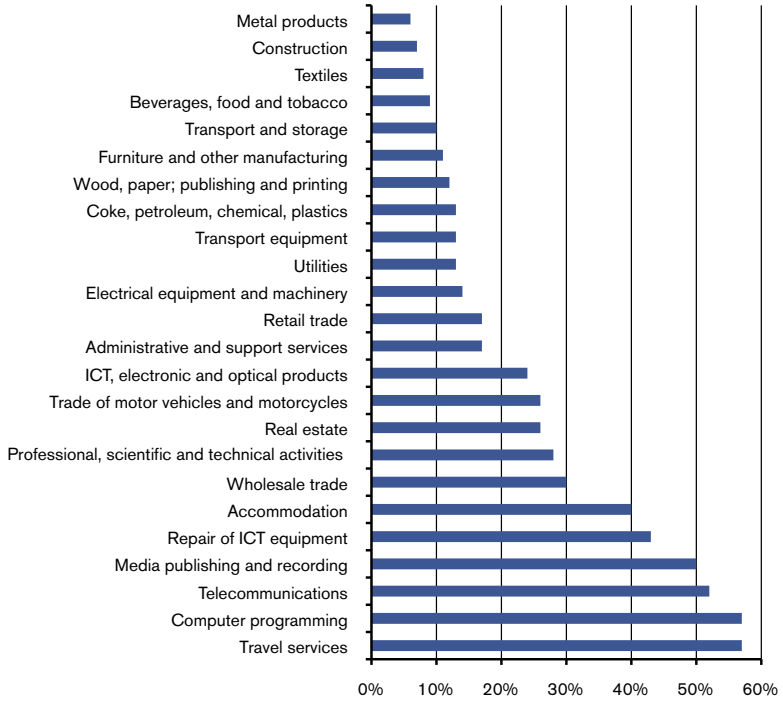
Broadly defined, the digital economy is the application of internet-based digital technologies to the production and trade of goods and services (UNCTAD, 2017c). The digital economy is not separate from the regular economy, as it impacts all industries and business types. Sectors become increasingly 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).

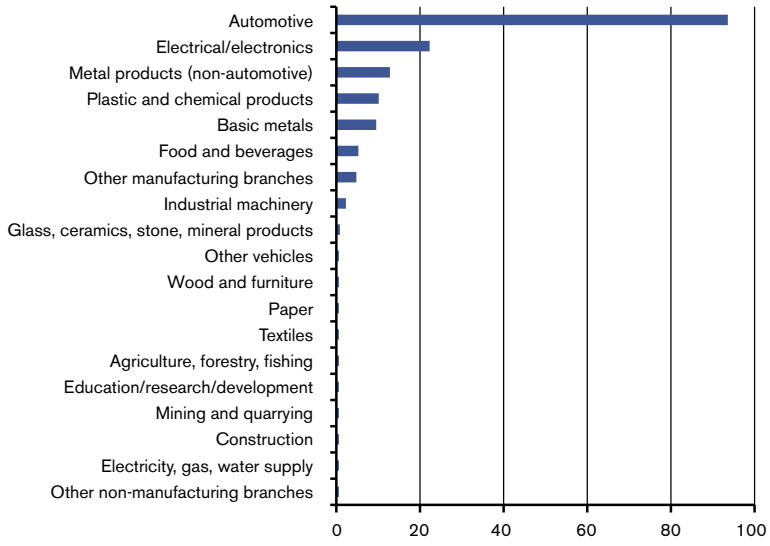
A widely accepted classification of digital-intensive sectors that takes into account both digital inputs in production and the use of digital technologies in sales is currently not available. To get a better idea of the production in manufacturing, one can look at the use of industrial robots per employed 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"

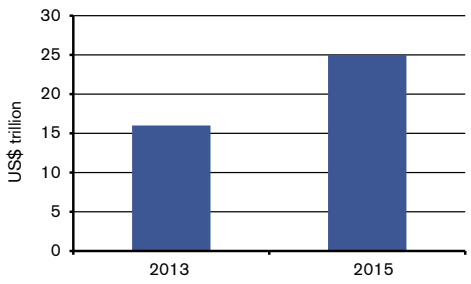
From a consumer's point of view, it is not always clear to what extent goods or services ordered online result in transactions produced and delivered purely domestically or across borders. This, and the ever-changing character and scope of digitalization, complicate the task of developing a comprehensive 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).

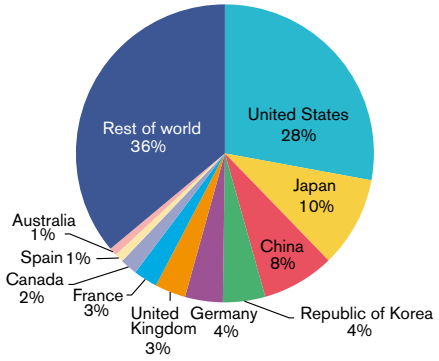
Figure B.21: Value of world e-commerce transactions, 2013 and 2015



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).

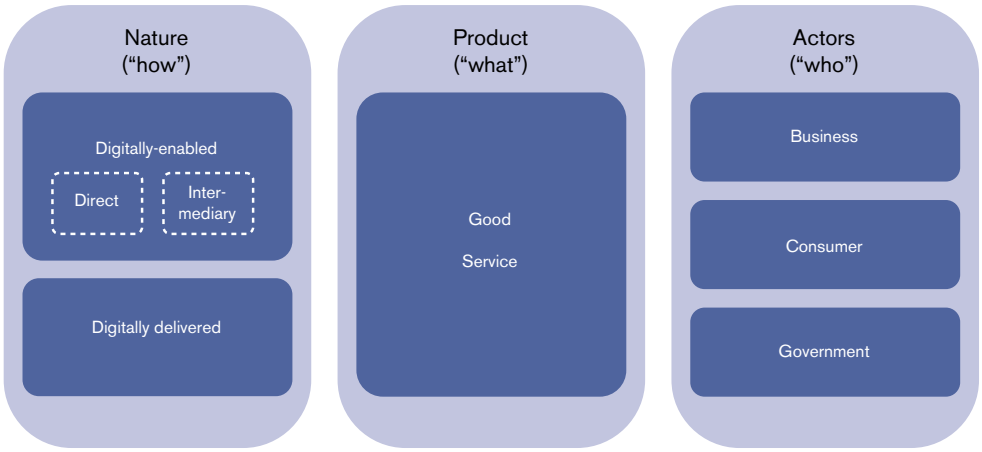
Broadening the discussion from e-commerce to digital trade, López-González and Jouanjean (2017) describe a possible typology. From this starting point the statistical community developed a tentative conceptual measurement framework to characterize digital transactions according to their nature ("how"), 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]

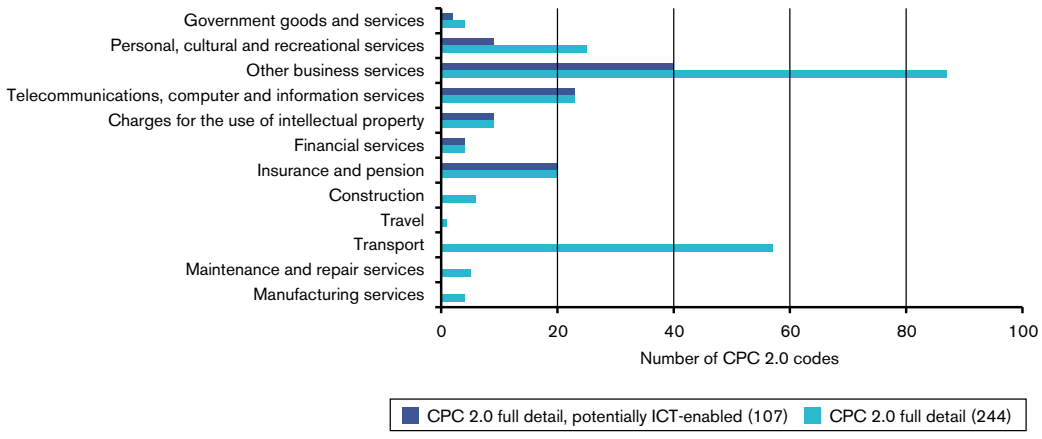
Figure B.24 shows possible EBOPS 2010 categories and counts the potentially ICT-enabled CPC codes. For other business services, the figure shows that

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.

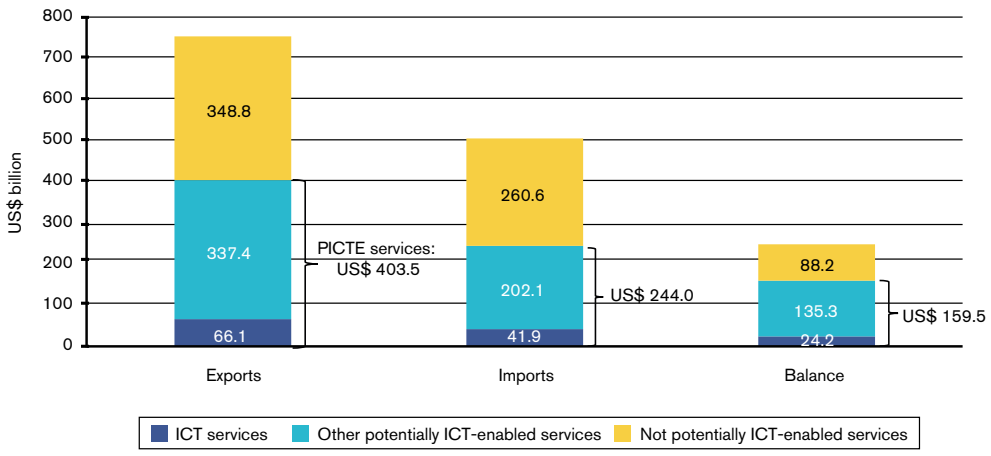
Costa Rica's pilot survey carried out in this context with the support of UNCTAD provides the first developing country perspective. Based on the sample surveyed, it calculates that around 984 of 1,196 resident service exporters in the country (96 per cent) make ICT services exports their primary activity, 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

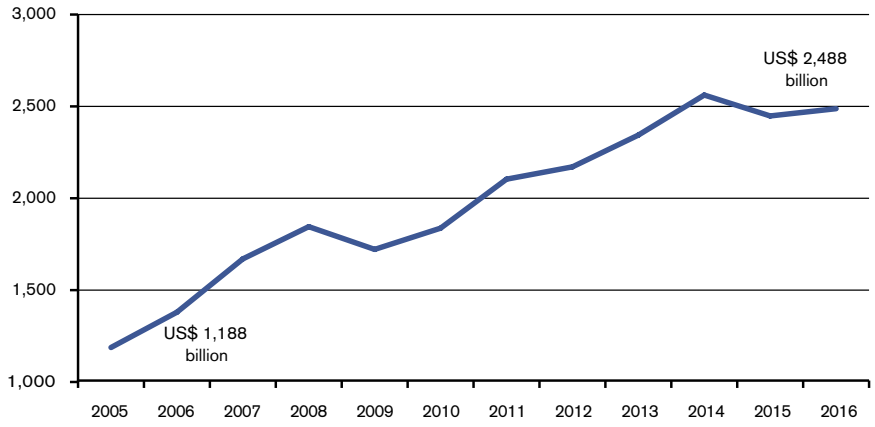
The financial reports of leading publicly traded digital firms (e.g. Alibaba, Alphabet, Amazon, Facebook, Microsoft, Netflix, Spotify, etc.) offer another source of information on the digitalization of trade. This information should be interpreted as a series of case studies rather than as a systematic 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.

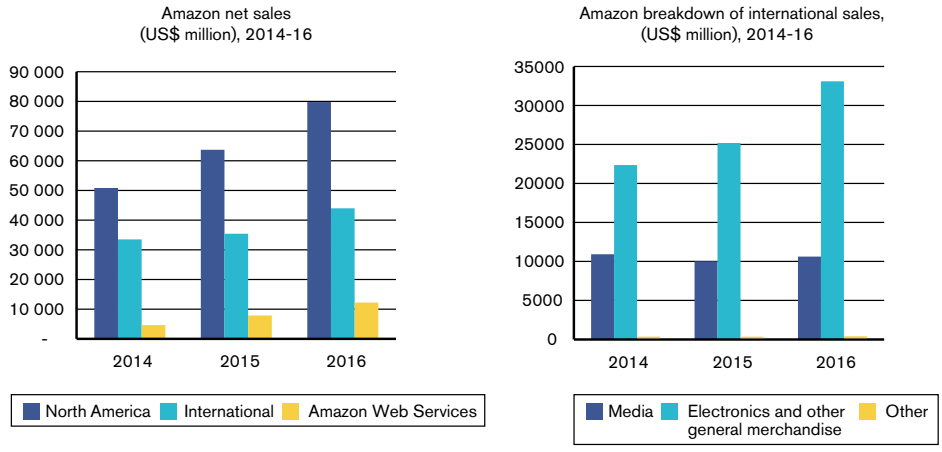
E-commerce platforms

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).

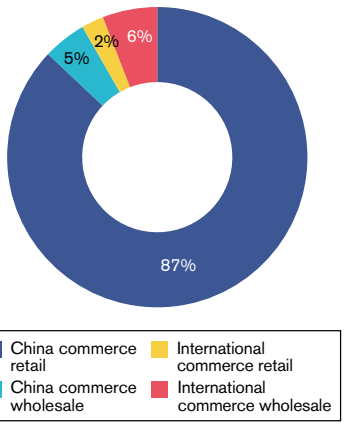
internationally-focused websites (e.g. amazon.de, amazon.fr, etc.), including export sales to customers in Canada, Mexico and the United States but excluding export sales from North American websites. Meanwhile, Amazon Web Services (AWS) include global sales of computing, storage, and database and other 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 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).

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



Sources: 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).

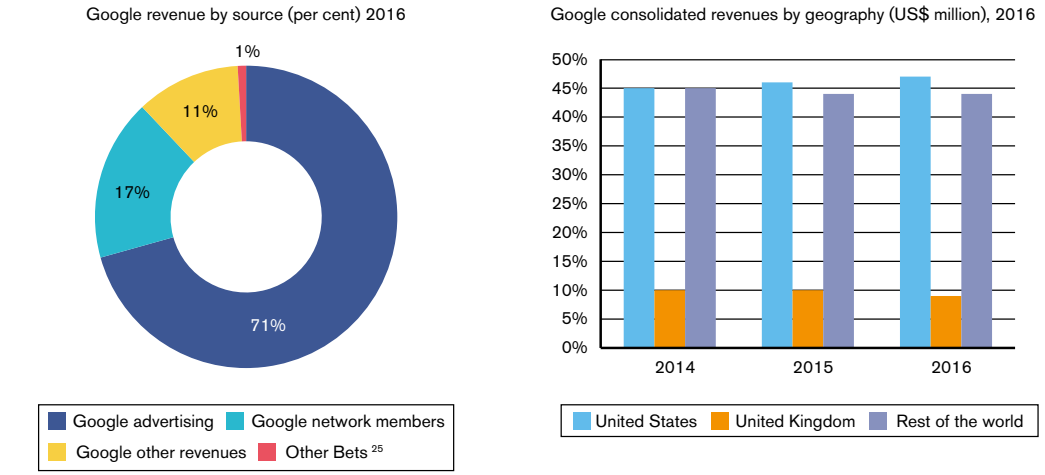
Alphabet/Google's revenue currently comes from Google Advertising (71 per cent); its affiliate Google Network Members (17 per cent), which are the third parties that use Google advertising programmes to deliver relevant advertisements on their websites; and other revenues (11 per cent), including sales 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

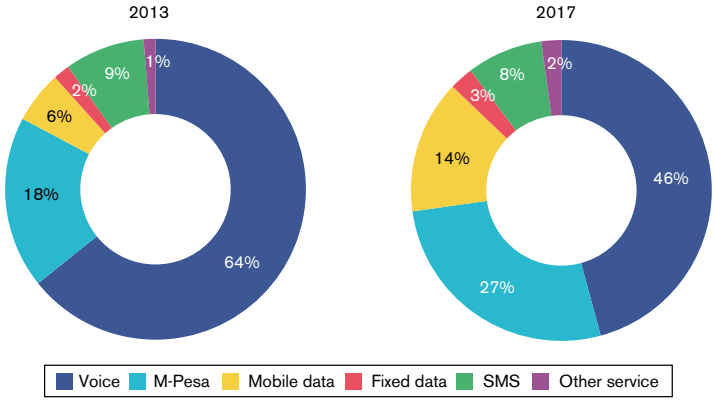
"Mobile"-Pesa (M-Pesa) is a mobile phone-based money transfer, financing and microfinancing service launched in 2007 by Vodafone for Safaricom and Vodacom, the largest mobile network operators in Kenya and Tanzania. It currently comprises 27 per cent of Safaricom's revenues, up from 18 per cent in 2013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

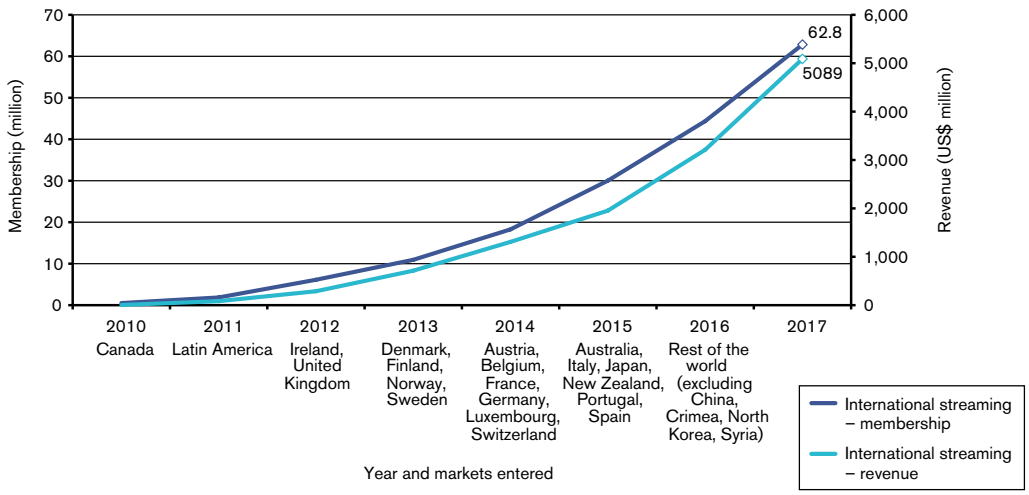
The trend of revenue growth from 2012-16 has been due to growth in the average number of paid streaming subscriptions globally, the majority of which was due to growth in international subscriptions, coupled with an increase in average monthly revenue per subscription resulting from price changes and 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.

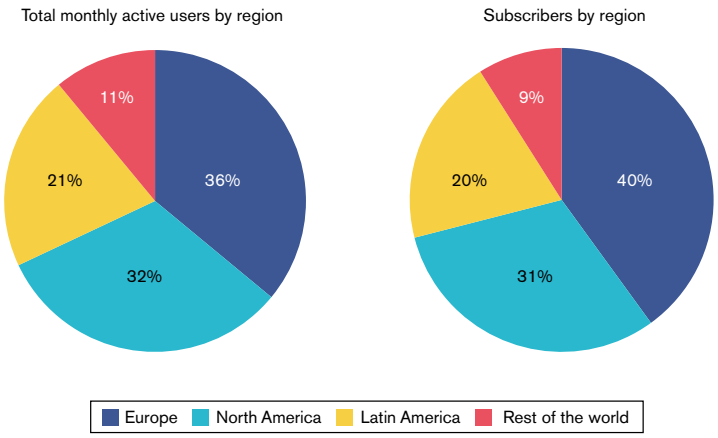
Revenue from paid subscriptions was Euros 1.037 billion in 2018, up 25 per cent from the previous year, with an average revenue per user of Euros 4.72 (down 14 per cent) being driven by growth in family and student plans, and a shift in the market to relatively lower average-revenue-per-user geographies 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.)

C The economics of how digital technologies impact trade

This section focuses on how new technologies are transforming international trade, creating new opportunities for a more inclusive trading system and raising new challenges. The section opens with a discussion of how digital technologies affect international trade costs. This is followed by an assessment of how digital technologies change the nature of what is traded, how we trade and who trades what. Finally, the potential impact of important trends in technological development is quantified and long-term projections on international trade are made, using the WTO Global Trade Model.

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Some key facts and findings

- International trade costs declined by 15 per cent between 1996 and 2014. New technologies will help to further reduce trade costs. Our projections predict that trade could grow yearly by 1.8-2 percentage points more until 2030 as a result of the falling trade costs, amounting to a cumulated growth of 31 to 34 percentage points over 15 years.
- The wide adoption of digital technologies changes the composition of trade in services and goods and redefines intellectual property rights in trade. Trade in information technology products has tripled in the past two decades, reaching US$ 1.6 trillion in 2016.
- The importance of services in the composition of trade is expected to increase. We predict the share of services trade to grow from 21 per cent to 25 per cent by 2030.
- Digitalization has led to a decline in trade of digitizable goods (e.g. CDs, books and newspapers) from 2.7 per cent of total goods trade in 2000 to 0.8 per cent in 2016. The trend is likely to continue with the advent of 3D printing technology.
- Regulation of intellectual property rights, data flows, and privacy as well as the quality of digital infrastructure are likely to emerge as new sources of comparative advantage.
- The decline in trade costs can be especially beneficial for MSMEs and firms from developing countries, if appropriate complementary policies are put in place, and challenges related to technology diffusion and regulation are addressed. Our estimations foresee that, in such case, developing countries' share in global trade could grow from 46 per cent in 2015 to 57 per cent by 2030.

1. Lower trade costs: opportunities and challenges

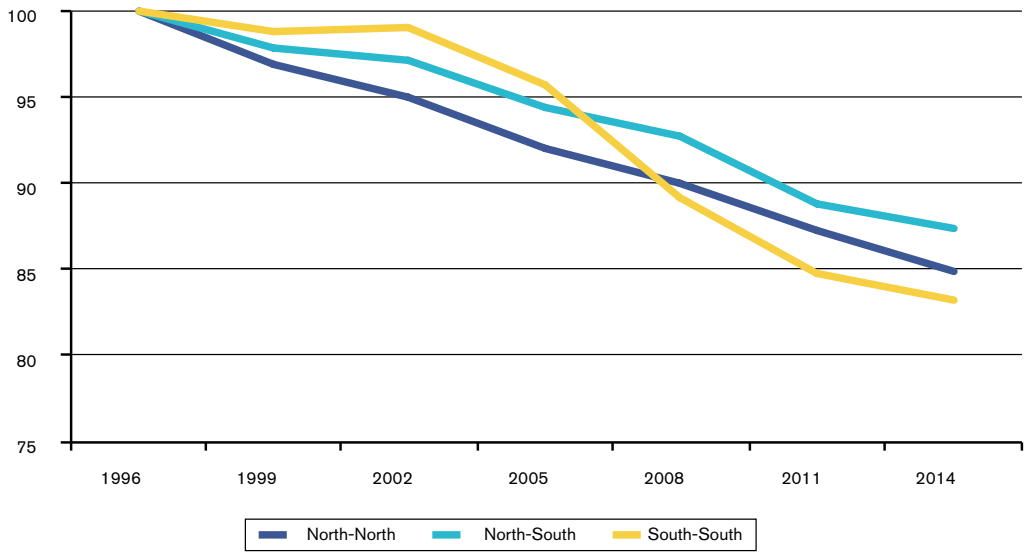
Section B discussed how digital technology is transforming economic activity, focusing purchasing habits increasingly on the internet and changing the ways in which businesses operate by enabling them to access data on consumer preferences and to adapt their product cycles and marketing strategies to this information. In this subsection, we look at the potential of digital technologies to reduce trade costs. We show that digital technologies may decrease the relevance of distance, be it geographical, linguistic or regulatory, and that they also facilitate searches for products, introduce mechanisms to verify quality and reputation, and simplify cross-border transactions.

To see how international trade costs have fallen over time, Figure C.1 plots the trend for three directions of trade flows between 1996 and 2014. The costs are calculated as a ratio between international and domestic trade. A decline in this ratio means that international trade grew faster than domestic trade, which is an indication that the world has become more globalized and that obstacles to international trade have declined. On average this decline was around 15 per cent between 1996 and 2014. The trend was similar for trade among developed ("North-North") and between developed and developing ("North-South") countries. Trade costs among developing countries ("South-South") were the slowest to decline at the beginning of the period, but their decline gained momentum after the mid-2000s, outpacing the rest.

The declining trend is in line with a recent study by Egger et al. (2018), who show that total trade costs declined both in the manufacturing and services sectors during the period between 1995 and 2011. They also show that trade costs are higher for services, mostly due to high variable costs.

Figure C.2 breaks the costs of trading goods and services down into five components: transport costs, logistics costs, the cost of crossing borders, information and transaction costs, and trade policy barriers. The first three categories capture the cost of delivering goods from suppliers to customers. They include the costs of transport, cargo loading, storage, port services and the costs of complying with customs procedures. Information and transaction costs include obstacles that firms have to overcome in order to search for trading partners, acquiring information about tastes, regulations and technical requirements, and enforcing contracts. Acquiring information about product standards in a foreign country, distribution channels and customers' preferences is costly, and

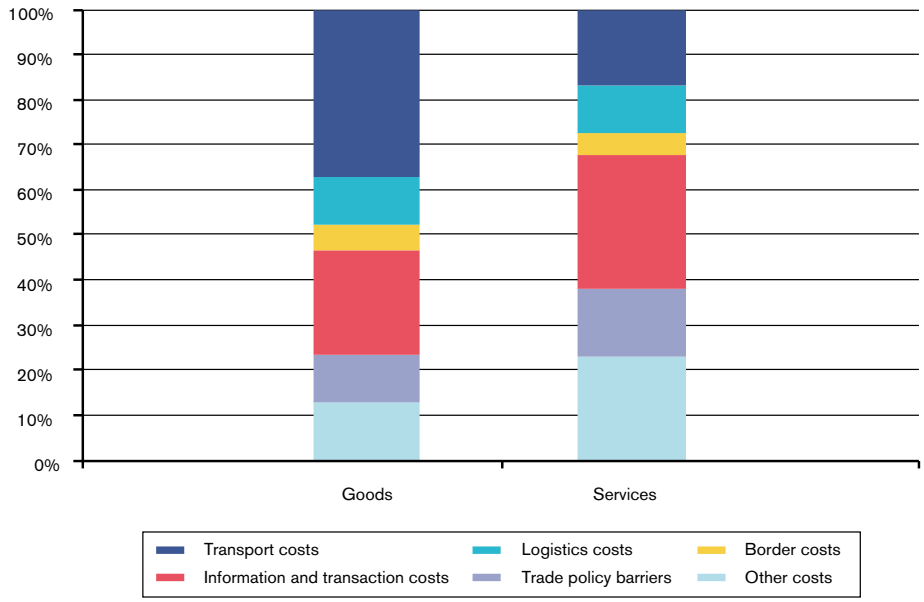
Figure C.1: Overall trade costs, 1996-2014



Source: World Bank-ESCAP database on International trade costs.

Notes: Only those country pairs for which data were consistently available for the years 1996-2014 have been included, i.e. 107 countries that were classified as developed (high-income) and developing (middle-/low-income) based on the World Bank classification for the year 2006, which is the midpoint of the time series. Each time series is standardized to 100 at the beginning of the sample period.

Figure C.2: Trade costs breakdown, based on data from 2014 (per cent)



Source: WTO calculations using World Input-Output Database (WIOD) data and methodology from Chen and Novy (2011).

Notes: The figure shows to what extent various determinants of trade costs explain the cross-country variance in trade costs. The determinants of transport costs taken into account are the effective transportation distance between countries, as constructed by Egger et al. (2018), whether or not a country is landlocked, and whether countries have a common border. Logistics costs are proxied by the Logistics Performance Index and the Liner Shipping Connectivity index. Border costs are proxied by the lead time to export. The determinants of trade policy barriers taken into account are whether countries are part of a free trade agreement, whether they are members of the European Union, and exchange rates. The determinants of information and transaction costs taken into account are whether there is a common ethnic language, a common colonizer, whether different countries were previously the same country or one was previously a colony of the other, the bilateral stock of migrants, the depth of credit information index, and the enforcing contracts indicator. Other costs are the part of the total costs variation that remains unexplained by our variables.

these costs increase with cultural and linguistic distance. Furthermore, transaction costs are high for cross-border trade because of different institutional frameworks and the need for cross-border financial transactions and currency conversions. The last category includes policy measures that make access to the domestic market relatively more difficult for foreign firms. These are tariffs, but also non-tariff barriers, such as technical regulations, product standards or licensing.

Transport costs account for the largest share of cross-country variation in overall trade costs; that is, 37 per cent for goods flows and 17 per cent for services flows.[1] Logistics costs are equally important for the trade of goods and services, accounting for 11 per cent of overall trade costs.[2] The costs of crossing a border that stem from time delays account for between 5 and 6 per cent of overall trade costs. However, since there are other administrative costs related to customs compliance for which we lack measures, these figures are likely to underestimate the importance of all border costs.

Information and transaction costs in goods flows play the second most important role after transport costs.[3] In services, information and transaction costs are the most important trade barriers, accounting for 30 per cent of the total trade costs variation. Finally, trade policy barriers also matter much more for services flows, where they account for 15 per cent, as opposed to goods flows where they account for 11 per cent.

The remaining unexplained component ("Other costs") reflects trade barriers that are not captured by the variables introduced in the estimation. These may include, for instance, taste differences that are not explained by the variables used to proxy for cultural and linguistic differences. It would also include costs of customs and regulatory compliance that go beyond time delays at the border, and those that are

not affected by trade agreements. The unexplained component is considerably higher for trade costs in services than for trade costs in goods, which may also reflect poorer measures for policy barriers in trade in services. For a detailed exposition of the methodology used to estimate the decomposition, see Appendix C.1.

In conclusion, trade costs have declined in both developed and developing countries. Transport costs, together with information and transaction costs, play the most important role, and therefore their decline has the largest potential to further bring down the overall trade costs. Lower costs associated with logistics, trade policy barriers and crossing a border can also bring substantial benefits. In the next subsection, we analyse the extent to which new technologies could play a role in the declining trend and outline the possibilities for further efficiency gains. Section C.3 then builds on this analysis and provides a quantification of potential trade gains from a technology-induced decline in trade costs.

(a) Transport and logistics costs

Transport costs depend on the type of product that is transported, distance between countries, and the trade infrastructure of source, destination and transit countries. Limão and Venables (2001) emphasize that the quality of transport infrastructure significantly affects countries' ability to trade. They create an infrastructure quality index based on roads, railways and telephone lines coverage for 103 countries, and show that a country that ranks on the 75th percentile of the index faced 12 per cent higher transport costs than the median country and 28 per cent lower trade. [4] The study further focuses on the determinants of poor export performance of Sub-Saharan Africa and identifies infrastructure investment as one of the biggest bottlenecks.

Transportation costs are not limited to the price paid to move goods from origin to destination; an important part of those costs is related to time delays and uncertainty. This is due to the increasing importance of global supply chains, just-in-time inventory management and lean retailing. For exporters sourcing intermediate inputs from varied sources, the disruption of one delivery can stymie an entire production process. Hummels and Schaur (2010) quantify the costs of time delays, suggesting that each additional day in transit is equivalent to an *ad valorem* tariff of between 0.6 per cent and 2.3 per cent, and that trade in intermediate inputs is 60 per cent more time-sensitive. Similarly, according to the United Nations Conference on Trade and Development (UNCTAD) (2017b), any additional trans-shipment that lengthens shipping time is associated with a 40 per cent lower bilateral export value.

(i) Artificial intelligence and autonomous driving reduce transport costs

Many recent technological advances have had a significant impact on transportation and logistics costs. The use of GPS (i.e. Global Positioning System) for navigation and route planning has become ubiquitous in recent years. New technologies, such as artificial intelligence (AI), promise to have a similarly pervasive influence, as AI applications currently include autonomous driving capabilities and real time itinerary mapping.

For instance, one Indian start-up may potentially transform long-distance trucking across India by creating a relay network based on AI and big data. This network connects drivers to trucks so that several drivers can divide long drives into four to five hours each, rather than one driver having to cover the entire length of the journey. This system also uses machine-learning algorithms to predict precisely when trucks will arrive and leave pit-stops, and at which petrol stations drivers should refuel. This system is helping to cut down travel time by more than half, by eliminating the need for rest breaks which a single driver would require.

(ii) Cargo and shipment tracking reduce logistics costs

Cargo and shipment logistics are optimized by the combination of vehicle telematics,[5] robotization and artificial intelligence. The main benefits come from cargo and shipment tracking, because it increases operational efficiency, enables real-time adjustments and makes logistics systems more secure. Internet of Things (IoT) sensors, for example, can reduce the costs of global trade by increasing the efficiency of shipping and transport. First, they reduce the amount of goods lost in transport. Second, shipment tracking systems enable companies to optimize routes to efficiently use shipping containers. On average, shipping containers have utilization rates of only 20 per cent because companies often ship merchandise to many locations. Tracking each container using IoT technologies could improve container utilization by 10 to 25 per cent and reduce annual spending on containers by nearly US$ 13 billion by 2025 (Lund and Manyika, 2016). Globally, the total number of installed remote shipment tracking systems stood at 2.9 million units by the end of 2015, and it is expected to grow at a compounded annual growth rate of 23 per cent in the coming years (Bern Insight, 2016). In one of the largest commercial

deployments of shipment tracking systems, Maersk, a Denmark-based shipping company, rolled out a system of real-time tracking for its entire fleet of some 300,000 refrigerated containers in 2015 (see Box C.1).

Decreasing hardware costs and improved battery life should further foster the adoption of cargo tracking technologies in the coming years. It is not only containers, but also each product that can now be tracked using radio-frequency identification technology. This has also proved highly effective in inventory management in global supply chains that involve many production stages, helping to reduce inventory costs by up to 70 per cent and reduce loss in transit by 11 to 14 per cent (McKinsey Global Institute, 2016).

(iii) Smart robots and AI reduce the cost of storage and inventory

Additional cost and time economies result from the automation of warehousing, trailer and container unloading, and packing. Combined with AI algorithms, the use of advanced robotics minimizes the cost of storage and speeds up distribution to final customers. Large e-commerce firms already use AI and robotics intensively to optimize their storage and distribution networks, plan the most efficient routes for delivery

Box C.1: Case study – How Maersk leverages digital technologies to optimize operations and reduce costs

Back in 2012, in response to increasing competition, Danish shipping company Maersk teamed up with Ericsson, a Swedish multinational network and telecommunications company, to develop a real-time remote container management (RCM) system across its fleet of "reefers", or refrigerated containers. Close to 300,000 reefers have been equipped with remote container devices that transmit reefer performance data 24 hours a day, seven days a week, on key parameters such as temperature, power supply and location to Maersk's private data cloud, where they can be analysed in real time at the company's headquarters.

The system, which has been operational since mid-2015, allows Maersk to track and monitor container performance at any point. According to Maersk, prior to the introduction of the RCM system, close to 60 per cent of cargo claims stemmed from malfunctioning reefer units, poor supplier handling of off-power periods and wrong temperature set points. The system can also be used to detect faults, allowing for quicker repair and cutting down on the need for manual equipment inspections. Maersk's end goal now is to use big data analytics for predictive maintenance to prevent faults.

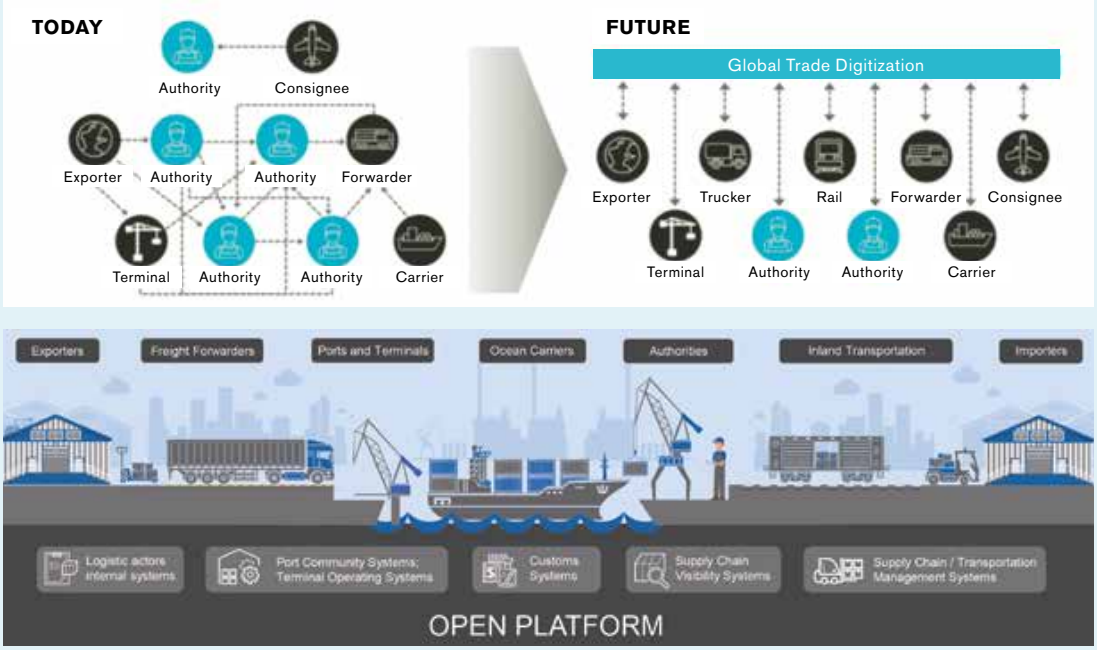
The RCM system has also allowed Maersk to speed up physical inspection processes prior to releasing containers for export. Before RCM, all containers would go through extensive and costly inspections. The use of smart sensors makes it possible to know the condition of the reefer precisely, and helps to determine the type of inspection required prior to release for export. If the reefer is running as expected, only a quick visual inspection is performed prior to release – which is now the case for around 70 per cent of reefers, meaning faster turnaround times, better asset utilization, and operational savings for Maersk (Murison, 2016). The savings generated by the RCM system have led Maersk to launch a pilot project recently to extend the monitoring system to other types of containers.

Since September 2017 customers can view the condition of their cargo in real-time. This allows for corrective actions to be taken in case the container is not operated optimally during any of the various stages of the cold chain, from the supplier's proper pre-cooling of the cargo, to the trucker ensuring that the reefer is plugged in, from accurate performance during the ocean leg, to the correct handling at destination and to final delivery to the end-customer. Should deviations occur, the shipper notifies the customer and discusses possible corrective actions. The use of smart sensors and data analytics has enabled Maersk to expand its activities, which were traditionally focused on the physical transportation of goods across the globe, to the provision of value-added advisory services to customers.

Beyond smart sensors and AI, Maersk, in cooperation with US-owned IBM, announced in January 2018 the creation of a blockchain-based global trade digitalization platform (see Figure C.3). The platform, TradeLens, was officially launched in August 2018. It aims to connect the various parties involved in international trade in order to cut the filing, verification, processing and coordination costs associated with cross-border transportation – according to Maersk, documentation and bureaucracy can represent up to one-fifth of the total cost of moving a container.

Box C.1: Case study – How Maersk leverages digital technologies to optimize operations and reduce costs *(continued)*

Figure C.3: Maersk-IBM Global Trade Platform project



Source: White (2018).

and make the best use of their warehouses. Many start-ups are developing autonomous robots that operate alongside humans and track inventory on shelves in warehouses, factories and distribution centres.

Customers on e-commerce platforms generate vast amounts of data, which AI can use to develop prediction tools to better anticipate consumer demand. A German online retailer that uses machine-learning algorithms to predict what customers are going to buy has developed a system so reliable that it can predict with 90 per cent accuracy what will be sold within the following 30 days (The Economist, 2017b). This results in better supply management by cutting down inventory, and reduces the time required for delivery.

(iv) 3D printing may render transport and logistics costs irrelevant

Additive manufacturing, or 3D printing, has the potential to reduce transport and logistics costs radically by reducing the number of parts and components that need to be traded and by favouring decentralized production close to consumers.

3D printing has two major consequences for the organization of production and global value chains (GVCs). First, it shortens the production chain. Complex and/or customized inputs are typically produced using many parts and components, each of which needs to be designed, prototyped and manufactured separately but to fit together seamlessly. 3D printing allows such complex inputs to be produced in one piece, thus lowering the number of production steps (Section C.2(c) further elaborates on this topic). Large car and airplane producers have been extensively using 3D printing to manufacture replacement materials rapidly, while experimenting with 3D printing the entire product.

Second, 3D printing favours decentralized production strategies. Decreased reliance on specific sub-components and decreased relevance of labour costs make it easier for firms to decentralize production and thus get closer to consumers. For instance, sports shoes are 3D-printed in new automated factories in Germany and the United States. These so-called "speedfactories" are supposed to shorten the time between completion of the shoe design and its delivery to shops to less than one week (The Economist, 2017a).

Such changes in the production process lead to shorter delivery times, reduced shipping and storage costs and potential elimination of import/export costs of the final products. For customized printed objects, the potential differences between the 3D printing cost and the equivalent retail price are anywhere between eight and 80 times (DHL, 2016a).

(v) Opportunities and challenges

New technologies reduce trade costs by reducing transportation and storage costs, but also by reducing both time to transport and the uncertainty of delivery time as a result of better logistics. The costs thereby reduced represent a major share of overall trade costs, as illustrated in Figure C.2, and therefore their reduction can have a large potential impact on trade flows.[6]

A decline in logistics costs allows for a greater participation of micro, small and medium-sized enterprises (MSMEs) in international trade. Small firms trade smaller quantities than big enterprises do. This suggests that fixed trade costs, such as logistics costs, often make up a greater share of the unit cost of their goods as compared to their rivals which export larger volumes. In Latin America, domestic logistics costs, including stock management, storage, transport and distribution, can add up to more than 42 per cent of total sales for MSMEs, as compared to 15 to 18 per cent for large firms (WTO, 2016a). Low reliability and high shipping costs also represent significant barriers for US-based MSMEs exporting to the European Union (USITC, 2014). Hence, cheaper and more reliable logistics services can disproportionately benefit MSMEs.

The use of shipment and goods tracking technology provides opportunities for developing-country governments to better monitor international trade. Such technology can, for example, be used to prevent the "diversion" of export goods. Exemptions from taxes and excise duties on exports often lead traders to divert goods meant for foreign markets into domestic markets and falsely claim tax benefits. A study looking at the Kenyan export market found that tracking goods shipments not only increased tax revenues for the government, but also increased efficiency for businesses because of the reduced turn-around time for trucks (Siror et al., 2010).

For developing countries, investment in basic infrastructure will be necessary if they are to make the most of the savings that new technologies offer. In Africa, potholed roads and missing rail links cause perpetual problems. Estimates suggest that a doubling of the distance between buyer and seller increases transportation costs by four to five times more in Ethiopia and Nigeria than in the United States (Atkin and Donaldson, 2015). The problem is especially acute for landlocked countries such as Malawi, Rwanda and Uganda, where transport costs can make up 50-75 per cent of the retail price of goods. For instance, shipping a car from China to Tanzania on the Indian Ocean coast costs US$ 4,000, but getting it from there to nearby Uganda can cost another US$ 5,000 (The Economist, 2013a).

(b) Costs of crossing a border

It is not just transport infrastructure and distance which affect cross-border trade. It is also what happens at the border. Layers of procedures and customs regulations can be big impediments to the flow of goods, and this is especially true of small firms. Time and resources spent in documentary compliance can sometimes be bigger impediments to trade than traditional barriers such as tariffs.

A study by Volpe Martincus et al. (2015) analysing the export process in Uruguay found that a 10 per cent increase in customs delays resulted in a 3.8 per cent decline in exports. The study also showed that the impact of customs-driven delays is more pronounced for sales to newer buyers, of time-sensitive goods, and to countries that are harder to reach. Table C.1 gives regional information on the time and costs spent in procedural compliance for both exports and imports. A general trend is that the poorer the region, the higher is the time spent in compliance and cost of compliance at the border. Sub-Saharan Africa has the highest cost and time spent in compliance of all regions covered in the table.

(i) Basic electronic systems reduce the time spent on customs compliance

Streamlining procedures using basic information and communications technologies (ICTs) can help reduce the costs of crossing borders. The two main tools are the Electronic Data Interchange (EDI) system and the Electronic Single Window (ESW). The EDI allows trade-related documents to be transferred electronically, while the ESW is more extensive and allows trade stakeholders to submit documentation and other information through a single point of entry to complete customs procedures. Figure C.4 depicts the variation in regional adoption of EDI and ESW systems. While many countries now use EDI systems, the use of single windows lags far behind across regions.

A study on the impact of Costa Rica's adoption of an ESW system and its impact on firms' exports found that the scheme did indeed facilitate trade.

Table C.1: Border bottlenecks according to region

	Exports		Imports	
Region	**Time spent in compliance (hours)**	**Cost of compliance (US$)**	**Time spent in compliance (hours)**	**Cost of compliance (US$)**
East Asia and the Pacific	124.1	499.6	136.1	542.4
Europe and Central Asia	55.9	305.2	53.2	279.8
Latin America and Caribbean	115.8	636.9	144.3	803.5
Middle East and North Africa	136.9	708	206.8	806.9
Organisation for Economic Co-operation and Development (OECD) high-income countries	15.1	185.3	12.2	137.2
South Asia	136.4	549.3	218.5	979.6
Sub-Saharan Africa	187.9	807.2	239.4	986.9

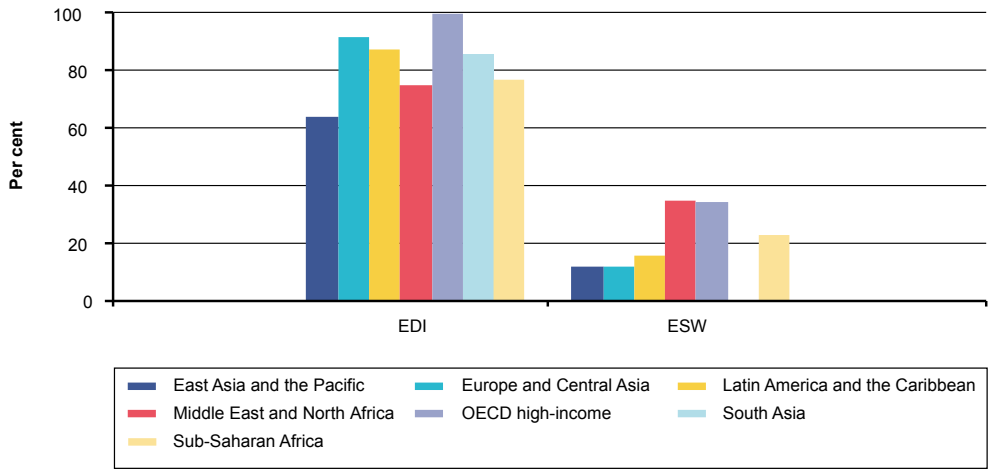
Source: World Bank Doing Business database.

Notes: Compliance includes both border and documentary compliance for a shipment of goods.

Firms whose exports were processed under ESW saw an increase of 22.4 per cent in the number of foreign buyers, and their average exports to each buyer increased by 43.5 per cent (Inter-American Development Bank, 2016). Research by the World Bank also found significant gains for economies with fully operational electronic systems for customs clearance (World Bank, 2017c). Time spent in border compliance falls by more than 70 per cent for both imports and exports when customs declarations can be submitted and processed online (see Figure C.5). This suggests that even the use of simple technologies can go a long way to reduce trading frictions and boosting the competitiveness of countries.

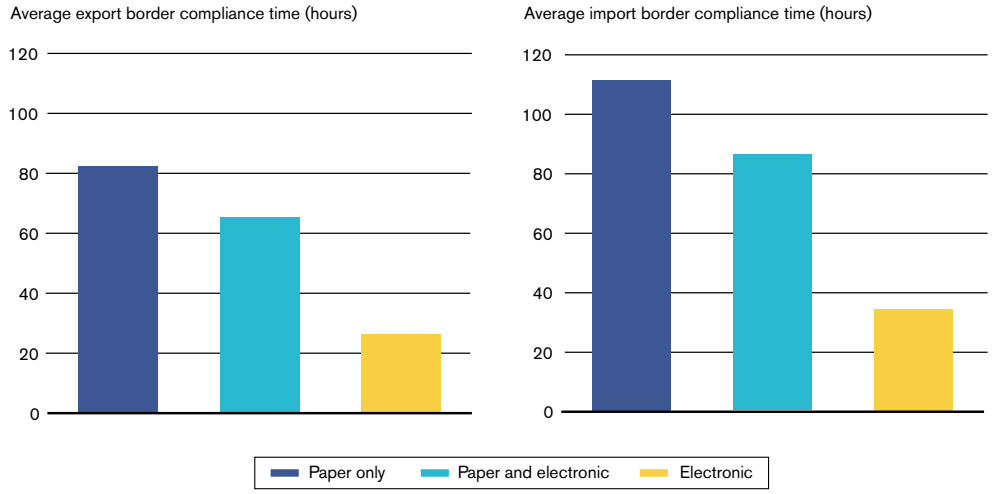
The WTO's Trade Facilitation Agreement (TFA), which came into force in 2017, aims to streamline and modernize import and export processes further by encouraging the adoption of single window systems

Figure C.4: Proportion of countries using EDI and ESW for the electronic processing of customs documents for exports in 2017, by region (per cent)



Source: Data from the World Bank Doing Business database.

Figure C.5: Gains from the digitalization of customs documentation



Source: World Bank (2017).

and simplifying customs procedures. Estimates show that the full implementation of the TFA could reduce trade costs by an average of 14.3 per cent (WTO, 2015b).

(ii) Blockchain and AI can further decrease customs compliance costs

Technology increasingly has a role to play in dealing with both the breadth and complexity of rules and regulations concerning international trade. AI is being used to help businesses deal with regulatory compliance (regulatory technology is also known as "RegTech"). For instance, AI-based software can be used to continually monitor and analyse regulatory changes, and to make recommendations to clients to ensure compliance. It does this by going through millions of pages of regulations, saving both time and monetary costs.

The distributed ledger technology could allow single windows to be administered in a more efficient, transparent and secure manner. It could help streamline customs formalities further by eliminating redundant processes, accelerate customs procedures and customs clearance, reduce costs and fraud, enhance transparency and auditability, and improve coordination between the various agencies, authorities and stakeholders involved in cross-border trade. In addition, the use of smart contracts makes it possible to automate certain processes, such as the payment of duties (Ganne, 2018).

Various organizations such as the United Nations Centre for Trade Facilitation and Electronic Business, the Convention on International Trade in Endangered Species of Wild Fauna and Flora, and the World Customs Organization are investigating the potential of the technology to facilitate cross-border trade, and several proofs of concept and pilot projects have been developed.

(iii) Opportunities and challenges

Technology can save time and resources spent on customs procedures. Digitalization has proved to decrease trade costs substantially, but inefficient customs still hamper trade, especially in manufacturing products. Figure C.2 shows that these costs account for around 6 per cent of total variance in trade costs, and this is likely only to be the lower bound because the estimates are not based on data from least-developed countries (LDCs).

New technologies, such as blockchain, promise further reductions in the costs related to crossing borders. As discussed in Section C.2, the highest potential of such new technologies lies in time-sensitive goods flows such as GVC-related trade. Furthermore, since cumbersome customs procedures are especially harmful to MSMEs, their simplification would particularly foster the entry into the export market of small firms that would otherwise only sell in their domestic markets (WTO, 2016b). Finally, decreasing the cost of crossing borders has the

largest potential to boost both imports and exports in developing countries where these costs are currently the highest.

While preliminary findings on blockchain are promising, more work is needed to explore fully the potential of the technology and how it can be integrated with existing customs systems. In addition, a number of technical and regulatory challenges still have to be overcome before the technology can be used to its full potential, including the lack of interoperability of various platforms, the legal status of smart contracts, and liability issues. This is discussed more fully in Section C.1(c)(v).

In spite of these challenges, the potentially significant opportunities that the use of the distributed ledger technology opens to digitalize cross-border trade and cut related costs has led key private players in the field of logistics and information technology (IT) to launch a global trade platform based on blockchain technology that has the ambition to connect all parties involved in cross-border trade and to completely digitalize and automate transactions (see Box C.1).

(c) Information and transaction costs

Long-distance trading with partners from foreign countries is difficult because it is harder than with local partners to find information about potential buyers and sellers, their products and product quality. It is also harder to ascertain reputation, verify information and enforce contracts.

When trade costs are high, firms cannot take advantage of price differences across markets. Consequently, a lack of trade is manifested in a high spatial dispersion of prices. Several economic studies use this fact to investigate the potential of technology to boost trade. They show that easier access to market information through even relatively simple technology, such as mobile phones, decreases spatial variation in prices in developing countries, and especially in agricultural markets (Bernard et al., 2007; Aker and Mbiti, 2010). In particular, a study analysing agricultural trade flows in the Philippines finds that approximately half the observed price dispersion across islands is due to search rather than transport costs (Allen, 2014). It also documents a known fact that larger farmers are better able to overcome these costs and thus are more likely to "export" to other islands. The authors then show that easier access to market information, through introduction of mobile phones, especially benefited small farmers, as more of them started to engage in inter-island trade.

Reputation and trust are crucial for success in any trade transaction and even more so in trading across borders where reliance on contract enforcement institutions may be limited. Startz (2017) shows that to overcome search and transaction costs, businessmen in Nigeria often choose to travel in order to import goods from a remote location, which makes importing very costly. Startz argues that facilitating searches for information and ensuring that contracts are respected can have a large impact on the volume of and gains from trade. This is especially important for developing countries due to weak contract enforcement institutions, limited access to IT and small firm sizes in those countries.

Selling and buying internationally also requires international financial transactions. Currently, cross-border transactions are almost exclusively handled by banks through correspondent banking, whereby local banks carry out transactions on behalf of each other, as many banks do not have local presence. Banks' share of the cross-border transactions market in business-to-business (B2B) and business-to-customer (B2C) transactions is more than 95 per cent[7] (McKinsey & Company, 2016). Large banks have a monopolistic share of this market segment because of the extensive regulatory compliance framework involved, lack of alternatives and the cost of maintaining large correspondent banking relationships. Consequently, cross-border B2B transactions can be around 10 times more expensive than domestic ones.[8]

(i) Online platforms help to overcome the lack of information and trust in cross-border transactions

As discussed in Section B, online platforms help to reduce the costs of matching buyers and sellers, of obtaining market information and of supplying information to potential consumers. Such platforms can thus help to boost participation in international trade even more than in domestic trade, and provide mechanisms such as feedback and guarantees that improve consumer trust in online sellers.

A long-standing way in which firms can provide credible information about their quality has been by developing their reputations in the form of a brand. Digital marketplaces involve thousands of small players who are often unfamiliar to potential customers. These marketplaces have thus developed alternative mechanisms to brand-based reputations to overcome asymmetric information about quality and trustworthiness that are alternatives to building a brand. The most common such mechanism is an online rating system, in which ratings from past

buyers and sellers are posted for future market participants to see. Another key application is to provide information on product quality. Rather than enhance information about a particular seller, ratings can inform consumers about the best products available within a platform.

Alibaba's own research on its platform suggests that reputation plays a leading role in the performance of exporters, exceeding the impact of observable product quality. A better reputation enables exporters to achieve greater export revenues and volumes as well as a larger number of buyers and markets (Chen and Wu, 2016). Online rating platforms can also significantly affect traditional services markets. Luca (2016) shows how online restaurant reviews impact restaurant demand, particularly for independent restaurants. This suggests that online rating systems help smaller business overcome the necessity to develop a brand (in the way that restaurant chains do) as a means to establishing a reputation.

Online platforms have also ushered in the "sharing" economy and have transformed the tourism services trade. Lodging and transportation arrangements are increasingly mediated through platforms rather than through traditional channels such as travel agencies. Furthermore, sharing platforms expand services markets by allowing physical assets to be disaggregated and consumed as services. The services of apartments, cars and boats are now frequently sold by private owners directly to consumers without the use of traditional intermediaries. Online platforms' inbuilt rating and recommendation systems help establish the trust that underpins their success. Sharing platforms like California-based Airbnb have also expanded markets, such as the accommodation market, by increasing accommodation options in areas and at times where traditional accommodation services are scarce.[9]

(ii) The IoT and blockchain may simplify verification and certification procedures

New technologies offer better and cheaper ways to ensure trust through certification and verification of origin. Electronic traceability systems in supply chains that make use of the IoT and distributed ledger technology (i.e. blockchain) provide new ways for companies to prove the source and authenticity of products. Various initiatives already exist to provide supply chain transparency and prevent counterfeiting. Applications range from pharmaceuticals to luxury items and from diamonds to electronics. In the fair trade market, the UK-based social enterprise Provenance relies on distributed ledger technology, combined with smart tagging, as a means to prove the source of food products, as well as all the places they have passed through before they reach the consumer. The company has run a successful pilot project tracking the provenance of tuna in Indonesia with verified social sustainability claims.

(iii) Real-time translation and online platforms bring down language barriers

Economic literature has long identified how important communication barriers are for international trade (Harris, 1995). Based on a meta-analysis of academic studies concerning the effects of language on international trade, Egger and Lassman (2012) find that a common (official or spoken) language increases trade flows directly by 44 per cent. When trading partners are linguistically distant and their language differences are very pronounced, they are likely to trade little with each other (Isphording and Otten, 2013). In a survey of online shoppers by Eurobarometer, 42 per cent stated that they never made purchases online in a foreign language, while 56.2 per cent said that obtaining information in their own language was more important than the price. A survey by Gallup (The Gallup Organization, 2018) points towards similar preferences.

In recent years, the internet has played a prominent role in breaking down language barriers across the board. The abilities of technology are not limited to text translation anymore. The availability of software performing real-time interpretation (such as Skype Translator, which performs near real time interpretation on online calls) reduces the importance of language barriers. This opens up trade opportunities, especially for small businesses that tend to have less developed language skills. A Eurostat survey from 2017 asked companies whether the lack of knowledge of foreign languages was an obstacle to e-sales. Among medium and large enterprises, 5 per cent of those with e-sales to other EU countries and 11 per cent of those with e-sales outside the European Union replied positively. Among small enterprises, the shares were higher, reaching 6 and 14 per cent, respectively.

Another channel through which the internet has facilitated the breakdown of language and communication barriers is through e-commerce platforms. These platforms minimize the importance of language in two ways. First, they minimize the need for one-on-one interactions between buyers and sellers, making translation redundant. Second, they allow customers to search for goods in their own language, irrespective of where the seller is located. Empirical studies corroborate this impact. A study by

Brynolfsson et al. (2018b) found that the introduction of a machine translation system on eBay increased exporty by 17.5 per cent.

(iv) E-commerce platforms and mobile banking facilitate cross-border payments

E-commerce platforms have developed their own payment systems for cross border e-commerce transactions. By creating in-house payment systems, they are able to further facilitate the exchange of goods and services on their platforms. They circumvent the corresponding banking infrastructure, which results in quicker processing times and no processing fees. This also means that the efficiency of international transactions almost mirrors domestic ones. Chinese Alipay, American Amazon Pay and PayPal are a few examples of payment systems that either are or were affiliated to e-commerce giants.

Mobile banking companies target cross-border payments, especially in certain African countries, where access to traditional banking services is limited and ordinary money transfer operators charge high transaction fees. In March 2015, Kenya's main mobile phone operator partnered with its counterpart in Tanzania to launch a cross-border money transfer system, allowing customers to send and receive money at the same rate as sending money locally. While these services are essential for remittances, they also facilitate business transactions; the value of mobile payments reached 47 per cent of the Kenyan gross domestic product in 2017 (Central Bank of Kenya, 2017).

(v) Blockchain could further reduce the cost of cross-border financial services

An increasing number of start-ups are leveraging distributed ledger technology with a view to further reducing the cost of cross-border payments, in particular transaction fees, exchange rate costs and costs related to correspondent banking. A US start-up, Circle (https://www.circle.com), provides blockchain-based cross-border payment services for zero fees and a zero exchange rate mark-up. The company, which started in the United States before moving to Europe, recently entered the Chinese market with the aim of connecting Chinese consumers to the rest of the world. Another US-based company, Ripple (https://ripple.com), has ambitions to circumvent the correspondent banking model through its distributed ledger platform. It gives banks the ability to convert funds directly into different currencies in a matter of seconds and at little to no cost, without relying on correspondent banks. The company has licenses with more than 100 banks and financial institutions, but it seems that only a limited number of large operations have taken place to date. Banks are still testing the system.

Numerous start-ups, many of which are based in developing countries, are also proposing cryptocurrency-based global payments. Whether these applications will further drive down the cost of cross-border payments depends on the cryptocurrency used, as average transaction fees can vary from zero to more than US$ 7 (Ohnesorge, 2018), not to mention that most cryptocurrencies are extremely volatile. Furthermore, a disadvantage of cryptocurrency cross-border payments is the need for an internet connection, while mobile payment systems only require a mobile phone; this is an important consideration in developing countries.

Beyond the multitude of start-ups that are exploring how blockchain technology can potentially drive down the cost of financial services, including cross-border payments, an array of well-established financial institutions is investigating the potential of distributed ledger technology to streamline payments for international trade. Various consortia have been formed, the most well-known of which is R3 (https://www.r3.com). The consortium, which started in 2015 with nine financial companies and now counts over 100 banks, insurance companies, financial institutions, regulators, trade associations and technology companies as members, announced in October 2017 that it was launching a cross-border payments platform. The platform aims to provide faster and more efficient execution of cross-border payment transactions. Several multinational financial services companies are also launching or piloting their own private blockchain-based cross-border payment platforms.

Beyond initiatives to digitalize payments for international trade, distributed ledger (i.e. blockchain) technology could open new prospects to digitalize trade finance. Trade finance entails a credit or a guarantee operation, implying deferred payments. Experiments in this field aim to digitalize the movement of documents necessary for the credit and element of guarantees to proceed – and to link the financial intermediaries, the exporters and importers, and the merchandise (the collateral in many cases) together digitally (see Box C.2).

(vi) Opportunities and challenges

New technologies and online platforms help to reduce the costs of searching for trade partners and obtaining relevant market information. They also provide

Box C.2: Blockchain and trade finance

The importance of finance and external credit is higher for firms selling internationally compared to domestic retailers. This is both because of the high fixed and variable cost of selling abroad, and because international transactions are more complex and less enforceable, implying the need for credit insurance (WTO, 2016b).

Banks are currently investing significantly in distributed ledger technology with a view to digitalizing financial transactions related to trade, in particular letters of credit and supply chain finance. Regarding the latter, the objective is to digitalize the cascade of payables and receivables between buyers and suppliers within existing supply chain relations. The use of the blockchain technology could enlarge the potential scope of supply chain finance by making it easier and less risky to process B2B payments between companies that do not have a pre-established relationship. Some start-ups already offer blockchain-based, real-time 24/7 B2B payment solutions that bypass letter-of-credit processes.

In regard to letters of credit, the aim is to improve the security of transactions which involve several players (e.g. an importer, an exporter and their respective banks) and many documents (e.g. customs documents and bills of lading). Currently, the issuance, verification and endorsement of letters of credit is still a very labour- and paper-intensive process, employing a large number of people in the trade finance industry. One of the largest banks specialized in global trade transactions reviews up to 100 million trade documents per year, which are necessary to validate letters of credit. Over the past few decades, consortia of banks have invested massively in software-driven projects aimed at developing platforms to digitalize payments and information, but little has been done until recently to digitalize the transactions themselves.

Distributed ledger technology, which enables the transfer of assets in a secure manner, while increasing traceability and the potential speed of transactions, seems to open new opportunities in this respect and is viewed with hope by an industry eager to gain on processing costs, functionality and security in financial and payment transactions related to trade. Given the very large flows involved in trade finance, proofs of concepts using blockchain technology are being developed and tested in all dimensions of existing transactions. Some of them are yielding promising results in terms of increased efficiency and reduced costs.

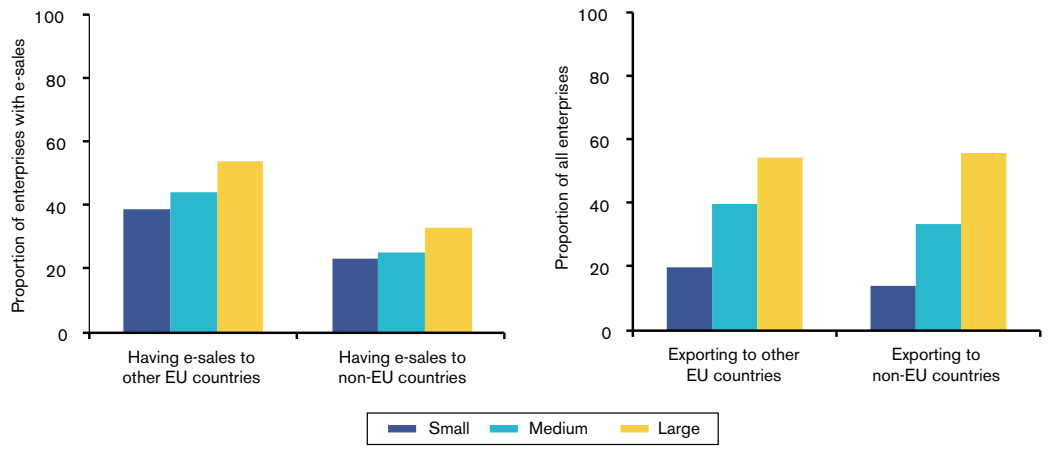
Experiments and proofs of concepts have been ongoing for several years, but doubts remain about whether the technology is best suited for trade finance transactions. Currently, compliance of documents with International Chamber of Commerce (ICC) rules – the ICC currently provides for the legal and professional rules standardizing letters of credit and other trade finance instruments internationally – leads to automatic provision of a letter of credit with legal obligor status, with the Society for Worldwide Interbank Financial Telecommunication (SWIFT) providing the payment channel to do so. By contrast, under blockchain transaction technology, there is still considerable uncertainty regarding the professional and legal standards applying to trade finance transactions, for example: who has liability at what point of the transfer of data and payment; when is obligor status confirmed; and who are the recourse authorities. Ensuring the interoperability of various blockchain platforms is another challenge. Indeed, the proliferation of blockchain projects in recent years has led to a large number of currently non-compatible blockchain platforms which apply different standards. The ICC recently created a working group to look into the "digital island problem".

Ultimately, whether blockchain will succeed in digitalizing trade finance will depend on whether current regulatory challenges are effectively tackled and whether the benefits associated with the use of the technology outweigh the costs of moving away from existing systems – which simply entail sending digital versions of documents. The current system may be costly, paper-intensive and burdensome, but it is efficient in terms of legal protection. The jury is still out.

mechanisms such as feedback and guarantees that improve consumer trust in online sellers and therefore bridge contract enforcement issues related to different legal institutions. Figure C.2 shows that information and transaction costs follow transport costs closely in their importance for the goods trade and constitute the most important trade obstacle in services trade.

Services offered by online platforms facilitate the direct participation of MSMEs in export activities. For example, Lendle et al. (2013) demonstrated that in the United States, 85 per cent of eBay sellers were merchandise exporters, while among all manufacturing firms only 18 per cent of firms exported. This point is also illustrated in Figure C.6

Figure C.6: Share of exporters among European enterprises with e-sales and overall, 2015 (per cent)

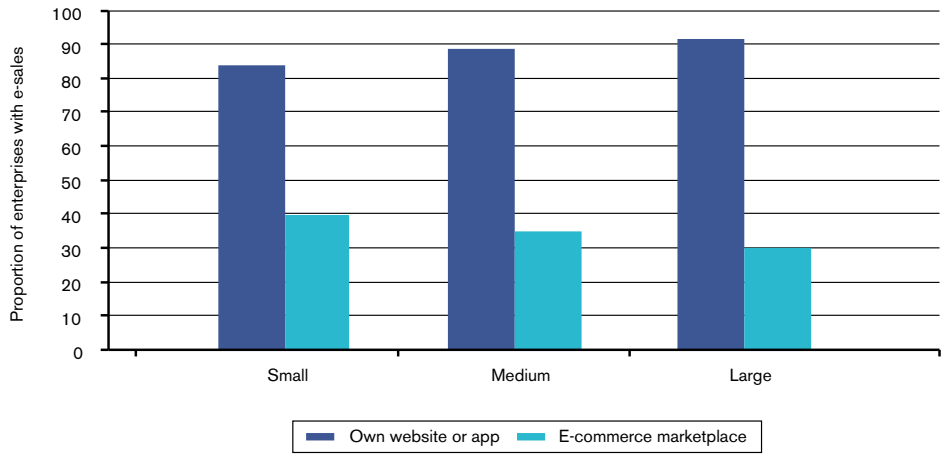


Source: Eurostat.

Notes: Data on e-sales are not available for enterprises with less than 10 employees. Small enterprises are therefore defined as those with 10-50 employees. Medium enterprises have 50-250 employees and large enterprises have more than 250 employees. E-commerce enterprises are those that received at least one e-commerce order in that year. The shares of all enterprises that export relate to merchandise exports only.

which shows that the disparity between small and large European firms in export participation is much smaller for e-sales. Finally, the importance of online platforms for smaller firms is illustrated in Figure C.7 which shows that, among firms with e-sales, the use of e-commerce marketplaces decreases with size, while the use of own website or app increases with size. Many of the services offered by online platforms have traditionally been supplied by large wholesalers and retailers, which act as export intermediaries and facilitate indirect exports for smaller firms. However, with the development of online platforms, even smaller firms can participate in international trade directly.

Figure C.7: Share of European enterprises with e-sales that use e-commerce marketplaces as opposed to their own website or app, 2015 (per cent)



Source: Eurostat.

Notes: Enterprises with e-sales are those who sell their products via their own website or app, or via an e-commerce marketplace. Data on e-sales are not available for enterprises with less than 10 employees. Small enterprises are therefore defined as those with 10-49 employees. Medium enterprises have 50-249 employees and large enterprises have more than 250 employees.

The decline in information and transaction costs holds especially large potential for firms in developing countries which tend to face higher costs for obtaining information and guaranteeing transactions. Easier verification procedures and guarantees also improve the potential for agricultural firms to enter and to upgrade within global supply chains (WTO, 2016b). New technologies enabling the electronic exchange of relevant information, such as food safety requirements, provide opportunities for producers to connect with new, high-value markets. There is also evidence that the easier access to information and the reduced need for face-to-face interactions that digital trade allows facilitate the increased participation in trade by women (see Box C.3).

The expansion of e-commerce can bring substantial benefits to small agricultural producers as well as to consumers living in remote areas. A study by Couture et al. (2018) shows that e-commerce trading access decreases prices and increases product variety for consumers in rural Chinese areas. Furthermore, it has the potential to increase business opportunities for local sellers, particularly in rural communities. For small agricultural producers in particular, e-commerce provides an opportunity to gain direct access to more consumers and renders prices more remunerative, as intermediary costs are eliminated. However, business training, access to credit, targeted online promotions and effective distribution networks are a necessary condition for these economic gains. While the study focuses on domestic e-commerce

Box C.3: How digital technologies empower women

E-commerce platforms, online work platforms and online payments are especially empowering to women's participation in trade. Given that time and mobility constraints are often greater for women, particularly those with children, technological developments like e-commerce can have an important impact on women's work. E-commerce enables women to run their businesses while managing household obligations, and to reach a much vaster market than they could offline.

In addition, digital solutions reduce searching costs between buyers and sellers and remove the need for face-to-face interactions, thus allowing more women to overcome the traditionally male-dominant trade network. Thus, digital platforms help women to work and build companies in cultures where they are expected to stay at home and where they lack men's professional networks and resources (World Bank, 2016).

There is some empirical evidence to suggest that women benefit more from digital trade than men. For example, a 2015 survey of Pacific Island exporters showed that firms that are active online have a greater concentration of female executives under 45 years of age (DiCaprio and Suominen, 2015). A survey by Etsy, an online platform for creative commerce, indicates that 86 per cent of Etsy sellers in the United Kingdom are women (Etsy UK, 2017). A survey by the International Trade Centre (ITC) also shows that the share of firms owned by women doubles when moving from traditional offline trade to cross-border e-commerce. In Africa, three out of four firms trading exclusively through e-commerce are identified as being owned by women (ITC, 2017).

In addition to e-commerce, digital payment technology has the potential to address women's preferences in new and different ways compared to traditional financial services. In Niger, evidence from the social cash transfer programme demonstrates that the greater privacy and control of mobile transfers compared to manual cash transfers shifts intra-household decision-making in favour of women (Aker et al., 2016). Technology-enabled crowdfunding platforms allow women to access trade finance. In China, the top funded industry sectors through peer-to-peer (P2P) consumer lending are in the retail and wholesale trade sectors, and 35 per cent of the fundraisers on the P2P consumer lending platforms are female (Cambridge Centre for Alternative Finance and The Australian Centre for Financial Studies, 2017).

The WTO and its various partner agencies strive to promote gender equality through development assistance programmes. For example, through a project financed by the Standards and Trade Development Facility (STDF), improvements in pest management in Uganda's flower sectors helped to raise the livelihood of the majority of women workers dependent on flower exports. The ITC also launched the "SheTrades" initiative, which seeks to connect one million women entrepreneurs to markets by 2020. Through the SheTrades app, women entrepreneurs are able to share information about their companies, increase visibility, expand their networks, connect and do business internationally.

expansion, its implications are also valid for cross-border e-commerce.

Innovations in cross-border payment systems have also had their largest impact in developing countries and for MSMEs. Starting with e-commerce platforms that ensure safe transactions, all the way to ambitious projects to circumvent traditional payment systems, these new developments bring down the transaction costs of cross-border trade, which are much more important for MSMEs than for larger firms because of their small scale, even more so in developing countries where traditional banking and financial services are available to few.

Access to finance is an acute problem for MSMEs: over half of trade finance requests by MSMEs are rejected, against just 7 per cent for multinational companies (WTO, 2016a). A survey by the United States International Trade Commission (USITC) finds that 32 per cent of US manufacturing MSMEs cite obtaining finance as a leading impediment to trade. Innovative solutions in providing trade credit are therefore essential for MSMEs to participate in international trade and underpin MSMEs' ability to benefit from all the opportunities discussed previously in this chapter.

While new technologies and big data offer many opportunities for firms to organize their production and reach consumers more efficiently, there are also challenges.

An increasingly large share of cross-border transactions does not face any international trade costs, except those caused by regulation. These include internet-enabled services such as web-search or communication services, digital intermediation services such as distributional services, travel services or P2P transactions. Measures that hinder cross-border data flows may therefore hinder the expansion of digital trade. These include, for instance, local data and server requirements, restrictions on payment methods, or requirements to give access to commercial source code or encryption keys as a prerequisite to enter a market (Ciuriak and Ptashkina, 2018a; European Parliament, 2017).

According to some estimates, blockchain technology could reduce banks' infrastructure costs attributable to cross-border payments, securities trading and regulatory compliance by between US$ 15-20 billion per annum by 2022 (Santander et al., 2015). However, if they are to be valid alternatives to the existing correspondent banking system, blockchain applications for cross-border payments will have to connect all currencies and financial institutions worldwide – "a massive undertaking" as McKinsey notes in a 2016 study (McKinsey Global Institute, 2016). Regulatory uncertainties, including liability issues and the lack of interoperability of existing platforms, remain challenges that stand in the way of widespread deployment of the technology. Until these are addressed, key players providing for legal security to a very large market of US$ 2 trillion annually will not commit (Manders, 2017). Although the technology holds interesting promises to cut a variety of costs associated with cross-border payments, its disruptive effect will only be felt if and once these challenges are addressed.

Other services, such as logistics and transport services, are also important determinants of the impact of digital technologies on goods trade. The role of digital platforms in lowering trade costs, for instance, can only go so far in markets where uncompetitive transport services result in exorbitant transport costs. Efficient services markets, therefore, are a necessary pre-condition to reaping the benefits of digital technologies.

Finally, e-commerce has engendered a rapid growth in cross-border shipments of small, low-value parcels that would previously have crossed borders in large shipments destined for local distribution centres (UNCTAD, 2017a). This may overburden customs and lead to delays at the border (see Box C.4).

(d) Trade policy and regulatory barriers

Regulatory compliance features prominently among trade policy barriers. Consumers demand assurances about basic standards and trade authorities need to ensure that imported products comply with national regulations, giving rise to a wide range of non-tariff barriers to trade. While regulatory harmonization and mutual recognition lessen the compliance burden, non-tariff barriers remain significant. Furthermore, new regulatory concerns about environmental, chemical and biosecurity standards are being reflected in international trade agreements and are translating into more regulatory requirements at the border. This compliance burden becomes multiplied in complex supply chains and, according to a survey by the USITC, affects both large firms and MSMEs (USITC, 2010). Product certification, product testing and inspection requirements represent more than half of all firms' complaints about TBT or SPS measures in developing countries (WTO, 2012c).

The adoption of electronic single window systems and electronic certificates can significantly reduce the time and resources spent in regulatory compliance. For instance, digital technologies can

Box C.4: E-commerce and the "parcellization" of trade

Cross border e-commerce accounted for 15 per cent of e-commerce merchandise sales in 2015. It is expected to grow at nearly twice the expected growth rate of domestic e-commerce, by 25 per cent annually until 2020, and account for 22 per cent of global e-commerce merchandise sales in that year (DHL, 2016b). Figure C.8 shows the growth in the number of parcels sent domestically and internationally by postal services since 2000 with the latter growing nearly threefold over the period.

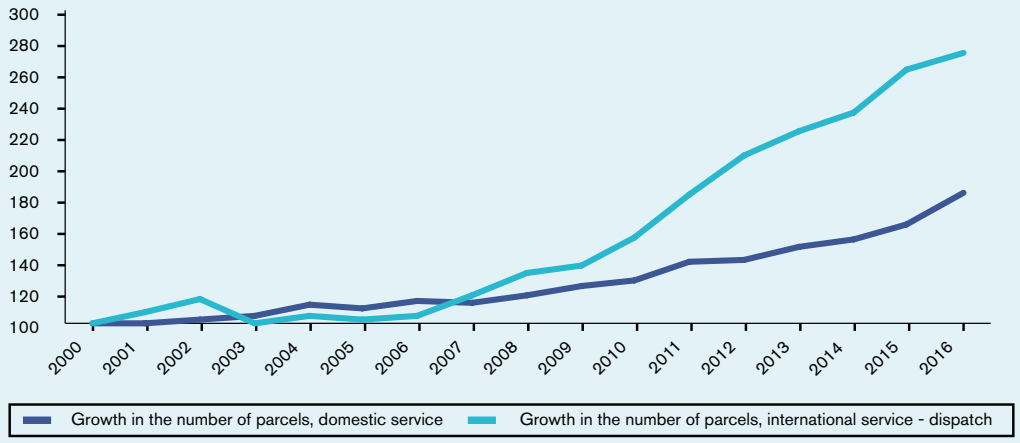
The reason behind this trend is that the number of cross-border B2C online transactions is increasing, while their average value is decreasing, generating more frequent international flows of lighter and cheaper parcels. For instance, 84 per cent of cross-border goods purchased online weighed 2kg or less, and almost 60 per cent of them cost less than EUR 50 in 2017 (IPC, 2018), while 46 per cent of respondents to the 2017 IPC Cross-Border E-commerce Shopper Survey stated that received parcels have been small enough to fit into their mailbox.

While e-commerce may provide new opportunities to export for retailers, and a wider choice and lower prices for consumers, it comes with its own set of challenges. The overwhelming quantity of e-commerce parcels is a big challenge for customs authorities. Their clearance systems are designed to tackle large container shipments, not small parcels. An increase in volume of shipments is sure to stretch customs authorities around the world, especially the ones with outdated infrastructure. Customs officials in Uzbekistan and other Central Asian states using paper-based systems have complained about the large inflows of small shipments (OECD and WTO, 2017). Time delays at the border would not just hurt e-commerce firms, whose business models revolve around fast deliveries, but also impact flows of traditional goods, as customs' resources would be thinly spread.

All other border agencies are also struggling to deal with this relatively new phenomenon, including those in charge of sanitary and phytosanitary (SPS) measures, technical barriers to trade (TBT), cultural goods, counterfeit items, drug trafficking, weapons, money laundering, endangered species or invasive alien species. For instance, the US Drug Enforcement Administration has warned that illicit drugs enter the United States on a large scale through online sales delivered by postal services (DEA, 2016).

Solutions have started emerging from both private sector and governments. The most ambitious initiative is from Alibaba, which has plans to create a network of digital free trade zones, which would enable MSMEs to sell goods across borders with zero import duties and speedy customs clearance. The first such zone opened in Malaysia in 2017, to facilitate e-commerce trade between that country and China. Logistics firms are also trying to make cross-border shipments more efficient. Another approach that has been taken by the largest companies is to set up what they call "fulfilment centres". Making use of big data analytics, they can anticipate demand for particular products, export them in the traditional way, import them and keep them in warehouses of the importing country. This way, they can very quickly ship products directly to consumers. One recent variation of this model is keeping the products in free zones and importing the small shipments after each order.

Figure C.8: Growth in the number of parcels sent by postal services, 2000-16 (per cent)



Source: Universal Postal Union data

Note: Each series is an index of the number of parcels that is standardized to 100 in the year 2000.

Box C.4: E-commerce and the "parcellization" of trade *(continued)*

Governments are making efforts to create parallel systems for customs clearance by diverting inflows of high-volume small parcels to alternate channels. One policy used to address the issue is increasing the *de minimis* value, which is the value under which shipments qualify for duty-free treatment and simplified customs clearance. While the reduction of the workload for governments is the main argument for increasing *de minimis* levels, there are challenges that this solution brings such as the increased need to manage illegal traffic. Information-sharing between customs authorities and e-commerce firms for better risk assessment is crucial to reduce the risk that harmful or counterfeit products slip by under a higher *de minimis* threshold. A survey by the World Customs Organization (WCO) found that 53 per cent of respondent countries already had such a system in place. The best solutions are not yet clear and are subject to ongoing efforts and discussions, for instance in the WCO's Working Group on E-Commerce.

play an integral part in ensuring that products meet the relevant SPS standards in export markets as they move through GVCs. Preliminary experience with SPS e-certificates indicates that transitioning to automated certification systems can reduce the time spent on processing and transmitting data, leading to increased exports and private sector savings (see Box C.5). Electronic certification can also decrease incidences of fraudulent certificates and increase transparency, strengthening trust among trading partners and connections along the value chain.

2. Changes in trade patterns

Digital technologies have transformed economic activities domestically and internationally, reducing trade costs and affecting patterns of trade. The following analysis highlights the trade dimension of digital technologies, shedding light on the changing composition of trade in goods and services, the determinants of comparative advantage and the effects of digital technologies on the international organization of production along GVCs.

(a) Changing sectoral composition of trade: what will be traded?

The wide adoption of digital technologies changes the composition of trade in different categories of goods and services, while redefining intellectual property rights (IPR) in trade. This section begins with an analysis of the impact of digital technologies on services trade, and subsequently discusses the effect on the composition of trade in goods. It also briefly touches upon the relationship between IPR and trade. In cases where digital technologies affect trade in both goods and services, the impacts will be discussed in turn.

(i) Growing importance of services trade

Services sectors are at the centre of the recent technological revolution. On the one hand, technological advances have enabled a growing array of services to be supplied digitally across borders. On the other hand, services form the rapidly evolving digital infrastructure that enables services to be supplied electronically and goods and services to be purchased online. These two facets of services, as enablers of digital trade and products supplied by means of digital technologies, have significant impacts on trade. This section illustrates how digital technologies now facilitate trade in services, either through the reduction of communication and transaction costs or by reducing the need for spatial proximity.

Contrary to the production of physical goods, the provision of services often required intensive direct communication between customer and service provider. Furthermore, some services that alter the physical condition of an object or person, such as hairdressing, required physical proximity. This requirement for spatial proximity, sometimes referred to as the bundling of labourer and labour (Baldwin, 2016), has hindered many services from being traded across borders.

Many services are delivered through communication networks. As digital technologies such as voice over internet, email and online platforms are significantly reducing international communication costs, delivering services over distances becomes cheaper, and therefore it is much easier to supply services overseas, enabling countries to specialise in sectors of their comparative advantages.

Furthermore, digital technologies have reduced the need for physical proximity by innovating the process of service provision. The WTO's General Agreement on Trade in Services (GATS) defines the services trade as spanning the following four modes of supply:

Mode 1 – Cross-border supply trade, Mode 2 – Consumption abroad, Mode 3 – Commercial presence (i.e. FDI), and Mode 4 – Presence of natural

Box C.5: E-certification and electronic traceability of agricultural products

New technologies and innovations have transformed agricultural production and the management of SPS risks within supply chains.

The Standards and Trade Development Facility (STDF)'s global partnership brings together trade, health and agriculture experts to address SPS challenges and drive forward joined-up solutions to boost safe trade, contributing to the United Nations' 2030 Global Goals for Sustainable Development. Many of these solutions draw on new technologies and digital tools. For instance, in Nigeria, the STDF is helping to develop a digital system to support pest surveillance, seed certification and traceability. In Guatemala, an STDF project developed an electronic traceability system for the honey value chain. In the Asia-Pacific region, countries are benefitting from an STDF project to strengthen information systems for pest surveillance and reporting with a view to facilitating trade.

Other ongoing STDF work is advancing the use of electronic SPS certification to facilitate safe trade and reduce transaction costs. The STDF's ePhyto project is setting up a new system for the electronic exchange of phytosanitary certificates, based on a harmonized exchange tool or "hub". Developing countries will benefit from a generic off-the-shelf system to facilitate their use of ePhyto. Following the launch of a new electronic phytosanitary certification system in Kenya in 2011, more than 892,000 ePhyto certificates were issued in the first five years, helping to increase government revenues by 75 per cent. The new system resulted in more efficient service delivery by the Kenya Plant Health Inspectorate Service (KEPHIS), and industry benefitted from time savings and better communications. Kenya's SPS reputation improved, with higher levels of trust among trading partners and greater confidence in the authenticity of Kenya's certificates.

Another STDF project is assessing the use of e-certification for trade in animals and animal products to identify how veterinary authorities in developing countries can benefit. Initial results show that transitioning to automated certification systems reduces the time spent on processing and transmitting data, leading to increased exports and private sector savings.

These experiences show how technologies can help developing countries to access lucrative regional and international markets, and can contribute to sustainable economic growth and poverty reduction, in line with the STDF's aims. They also offer valuable lessons on the benefits of expanding the use of digital technologies so that more developing countries can benefit. Giant leaps forward have been made possible by modern solutions like the IoT and blockchain. However, concerns remain about a widening inequality across countries in terms of connectivity, access to new technologies and the skills to apply them.

persons. The wide adoption of digital technologies has reduced trade costs for services and renders some services easily deliverable across borders (i.e. Mode 1), rather than via the presence of commercial entities or natural persons (i.e. Modes 3 and 4).

Finally, new developments in the field of remotely controlled robotics have opened new ways to trade in services and may continue to grow. Although such technology is relatively costly at present, lower-priced robots controlled over internet connections could have significant consequences for international trade in the future.

Reduction in trade costs increases trade in some services

Measured on a balance-of-payments (BOP) basis, trade in services now accounts for 23 per cent of total trade in goods and services, compared to 18 per cent in 1995.[10] The strong growth of trade in services is largely a result of the internet revolution. Studies have found that greater internet penetration and usage are associated with higher levels of trade in services, both in terms of exports and imports (Choi, 2010; Freund and Weinhold, 2002).

What services are digitally deliverable? Lanz et al. (2012) point out that digital technology makes those services that consist of routine codifiable tasks (e.g., performing calculations, checking a document for spelling errors) especially tradeable across borders. Looking at the phenomenon of business process offshoring, Blinder and Krueger (2013) estimate that 25 per cent of all US jobs held in 2008 could potentially be provided by workers abroad. They find that jobs in the finance, insurance and information service sectors, as well as technical and professional services, can be provided remotely.

A report by UNCTAD identifies a list of "ICT-enabled services", which is aggregated into different services sectors in Figure C.9. Consistent with what has long been observed in services trade, the services that can be delivered remotely over ICT networks are telecommunications, sales and marketing, insurance and pensions, finance, and intellectual property (IP) services. Many of these service sectors have indeed been leaders in adopting ICT technologies in the past decades.

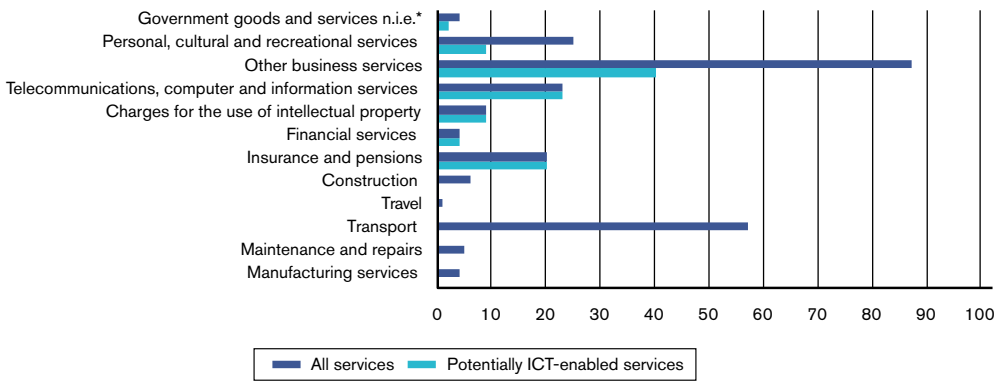
Technological advances and increased cross-border tradability have led to significant changes in the composition of trade in services. The fastest growing service exports since 2005 are digitally-enabled services such as telecommunications, computer and information services, other business services and financial services. Figure C.10 shows that trade in these service sectors is growing much faster than traditionally traded services such as travel or transport. This is not surprising, as digitally-enabled services have benefited significantly from the increased efficiency of digital networks arising from technological advances. The cross-border supply of these services offers potential for new export opportunities and for export diversification. Figure C.11 illustrates the evolution of services trade: since 2014, trade in potentially digitally-enabled services has accounted for more than half of total trade in services.

Beyond the effect of lowering communications costs, digital technology opens up new channels through which services can be delivered. Services that require more than just timely communication over the internet or phone are now tradable across borders through innovative business models that leverage digital technology.

The United Kingdom's National Health Service provides a list of online mental health services that provide access to moderated support groups and personal counselling with professional therapists directly via instant messaging or a webcam (National Health Service UK, 2018). In the field of legal services, some law firms are replacing brick-and-mortar offices with online platforms to which private clients can connect via the internet. Rocket Lawyer is an internet platform that provides free legal documents and connects lawyers to private and small enterprise customers, with the aim of reducing search costs and complexity for customers who seek legal advice (The Guardian Labs, 2017). As a consequence of the technology, clients can choose lawyers based on their qualifications rather than their geographical location.

In the education sector, digital technology has created virtual classrooms that relax geographical constraints and enable the delivery of massive open online courses (MOOCs) to students worldwide via video recorded lectures, digital slides, digital problem sets and online fora. Class Central (2017) an online catalogue of MOOCs, counts 81 million MOOC students worldwide. In comparison, around 20 million tertiary-level students are currently enrolled

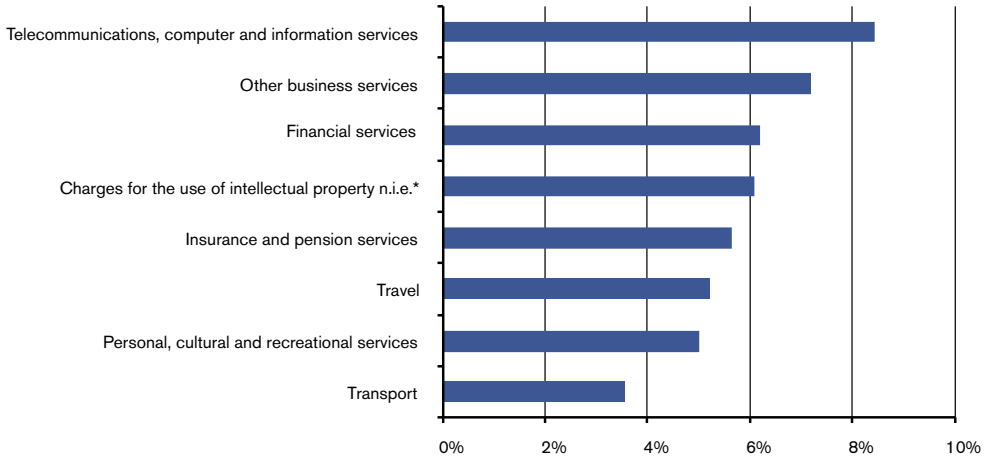
Figure C.9: Approximation of potentially ICT-enabled services by sector (per cent)



Source: Figure 1 in UNCTAD (2015), derived from UNSD "Correspondence between the EBOPS 2010 and the Central Product Classification (CPC, version 2) – Detailed version".

Notes: This figure shows the total and ICT-enabled number of CPC 2.0 (Central Product Classification) codes, grouped by EBOPS 2010 service categories (n.i.e. is "not included elsewhere").

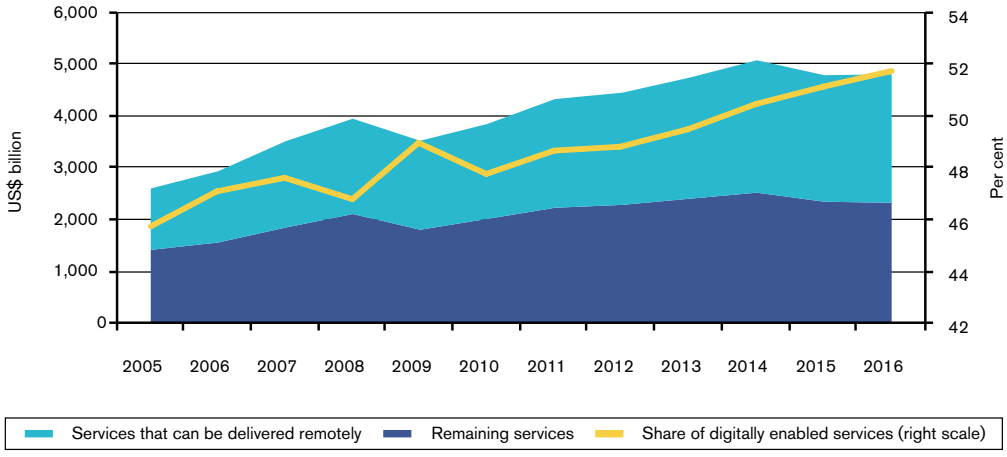
Figure C.10: Average yearly growth rates of trade in different service categories (per cent)



Source: Author's calculation based on data from the WTO Trade in Services Database (BPM6) and UNCTAD (2015).

Notes: The figure shows the compound yearly growth rates of services categories between 2005 and 2016 (n.i.e. is "not included elsewhere").

Figure C.11: Average yearly values and growth rates of trade in different service categories



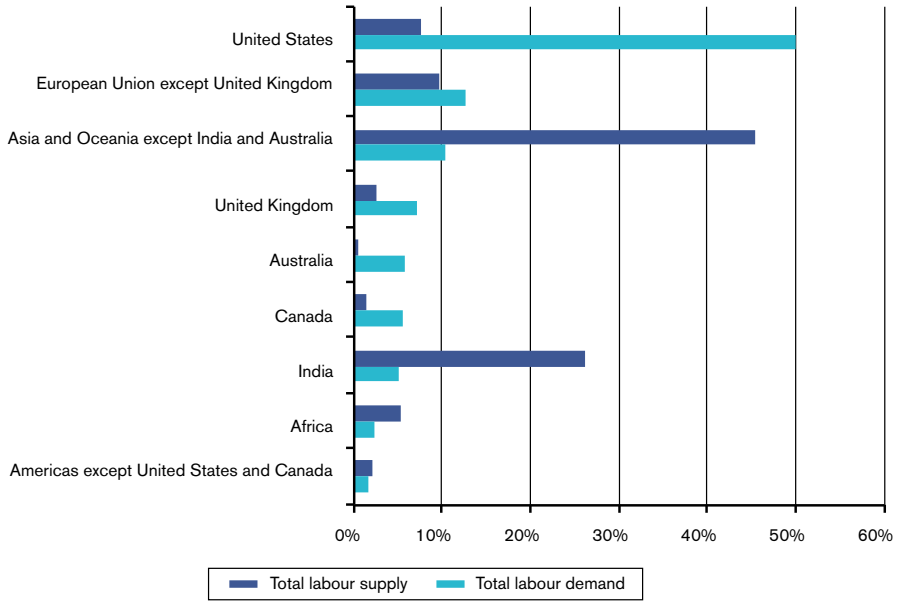
Source: Author's calculation based on data from the WTO Trade in Services Database (BPM6).

Notes: The figure shows the total world trade volume in services between 2005 and 2016, split between services that can (at least partially) be delivered remotely as defined by UNCTAD (2015) and other services.

in brick-and-mortar institutions in the European Union and the United States respectively. With the first MOOC delivered in 2008, this industry is young and still evolving. But the international element is already strong: 71 per cent of the students taking courses on HarvardX and MITx, Harvard's and MIT's online course facilities, are from outside the United States (Chuang and Ho, 2016).

For less standardized services, online labour platforms connect freelance service providers with worldwide clients, making trade in digitally delivered services such as accounting, programming or writing profitable even for small projects. Data collected by the iLabour project of the University of Oxford shows how supply and demand of such services are differently distributed over high- and

Figure C.12: Supply and demand for services on online labour platforms



Source: Authors' calculation based on data from the Online Labour Index (Kässi and Lehdonvirta, 2016).

Notes: This figure shows the share of labour offers and labour requests on the six biggest English-speaking online labour platforms for the period 16/06/2017 to 13/03/2018.

low-income countries. Figure C.12 shows that half of the employers of online labour come from the United States, while 68 per cent of the online labour offer comes from India, Bangladesh or Pakistan, and international trade in digital services is flourishing on these platforms.

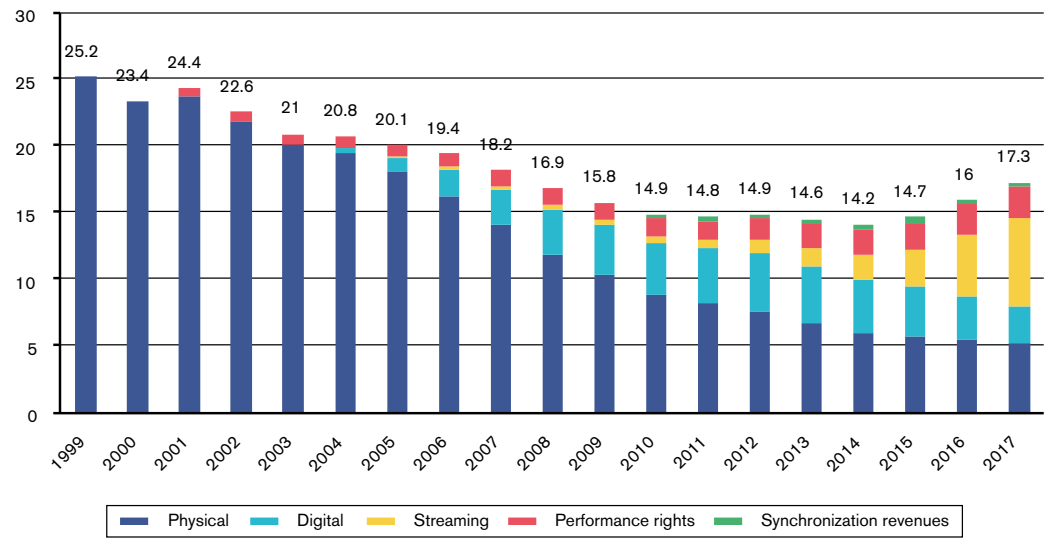
However, even though digital technologies relax some of the major constraints on cross-border trade in services, obstacles remain. As discussed in Section C.1, cultural and social differences, as well as language barriers, between workers or service providers and clients can restrict efficient communication. Furthermore, time zone differences can hinder timely communication, and geographical distance makes it difficult to build trust and social capital between business partners. Studying an applications and job posts on oDesk, a fast-growing platform for contract labour, Agrawal et al. (2016) found that employers from developed countries generally prefer to employ contractors from developed countries. However, online platforms also attempt to resolve the trust barrier by providing more information such as the contractor's education, work experience, location and the contractor's job history on the platform. The same study found that standardized information about work experience conducted on the platform and ratings of workers benefit job applicants from less-developed countries more than applicants from developed countries. As a result, digital technology can reduce information asymmetries and uncertainty, which in turn encourages trade.

Digital technologies create new ways of delivering services

Beyond facilitating trade in traditional services, digital technologies create new ways of delivering services. Take as an example the business of music streaming, which is a digital service. Figure C.13 illustrates how digitalization profoundly changed the way recorded music is consumed: while music has been bought for years in physical and later digital form, revenues from music streaming have been growing rapidly since 2014 and constituted more than one-third of recorded music industry revenues in 2017 (see also Section B and Box B.2 for a detailed analysis on how digitalization has changed the music industry).

These figures show that the recorded music industry is moving away from selling physical or digital downloads and instead relies increasingly on a

Figure C.13: Global recorded music industry revenues, 1999-2017 (US$ billion)



Source: IFPI Global Music Report (2018).

business model that provides a streaming service over the internet. As physical distance plays no role in the delivery cost of digital streaming services, a concentration of streaming service providers and an increase in cross-border streaming can be expected. This development is emblematic of a range of industries that see their physical goods becoming substituted by digital downloads, many of which are provided as a service.

On a different note, digital technology gives rise to P2P-based services, often referred to as the "sharing economy". The sharing economy is defined as the P2P-based activity of acquiring, providing or selling access to goods and services that is facilitated by a community-based online platform.

Digital technologies such as mobile applications (apps) have lowered barriers to entry in the sharing economy when it comes to building brands and scaling up quickly. Trust, convenience and a sense of community are factors that drive the adoption of the sharing economy business model. A survey shows that 19 per cent of the total US adult population has engaged in a sharing economy transaction, and nearly half of US adults are familiar with the sharing economy. Among those consumers who have tried the sharing economy, 72 per cent agree that they could see themselves being consumers in the sharing economy in the next two years (PWC, 2015a).

Connecting private service providers with private consumers for occasional transaction has often been hindered by high transaction costs. Online platforms reduce the costs of searching for business partners, communicating with them and establishing trust with them. This development makes it profitable for small entrepreneurs and private individuals to rent out durable goods such as cars, apartments or electrical appliances. One particular effect of the sharing economy is that it increases the share of traded services while possibly reducing the purchases of durable goods. The bottom line is that, by enabling the sharing economy, digitalization and the internet create new opportunities for cross-border trade in services (see Box C.6 on "Airbnb and the sharing economy").

Further revolutionary changes in the service sector may be triggered by technologies known as "telepresence" and "telerobotics". Telepresence refers to technology that enables the user to feel present or give the effect of being present in a space other than the space in which she or he really and physically is; telerobotics refers to technology that allows the user to control robots from afar. Both concepts would relax the constraints related to the regulatory barriers of services trade and costs of moving people, which inhibit trade in services that currently require face-to-face contact, such as psychological treatment or medical surgery.

Box C.6: Airbnb and the sharing economy

According to The Economist (2013b), Airbnb is a typical example of the "sharing economy". Since it was launched in 2008, more than 300 million guests have used the online platform. Airbnb currently offers 300 million different types of accommodation in 65,000 cities in over 191 countries. Consumers choose their accommodation and pay online, but this accommodation is provided by private individuals, rather than by hotel chains.

Although the business model does not appear very different from running a bed-and-breakfast, technology has reduced transaction costs, making sharing assets cheaper and easier than ever, and therefore possible on a much larger scale. The big change that digital technologies allow is to make available more data about people who may want to rent something and things (houses, flats, cars, etc.) available for renting. This allows the use of these things to be separated into smaller parts and consumed as services. Thus, platforms such as Airbnb match up owners and renters; smartphones with GPS let people see where the rentable good is and compare the locations of other similar goods; social networks provide a way to check up on both owners and renters and to build trust; and online payment systems handle the billing.

The sharing economy model is used mainly for items that are expensive to buy and are widely owned by people who do not make full use of them. Accommodation and cars are the most obvious examples, but one can also rent goods as varied as camping spaces, fields and washing machines, in most places in the world. According to Botsman and Rogers (2010), the consumer P2P market alone is worth US$ 26 billion.

Such "collaborative consumption" brings several benefits. Owners make money from under-used assets. Airbnb says that hosts in San Francisco who rent out their homes do so for an average of 58 nights a year, making up to US$ 9,300. Renters, meanwhile, pay less than they would if they turned to a traditional provider such as a hotel. It is not surprising that many sharing firms survived during the financial crisis. And there are environmental benefits, too: compared with hotels, home-sharing promotes the efficient use of existing resources, and results in reductions in energy and water use, greenhouse gas emissions and waste generation.[11]

Regulatory uncertainty remains an issue for the future of the sharing economy business model. Online platforms have so far benefited greatly from special, or lack of, legal and regulatory treatment, but this regulatory vacuum is not likely to last. Home-sharing sites are often accused of reducing the supply of affordable housing in big cities, and governments around the world are finding ways to regulate and tax the sharing economy. Many cities are creating new rules, or enforcing existing ones, on who can rent out their homes and for how long. One example is New York's move to pass a law imposing fines of up to US$ 7,500 on hosts who advertise stays of less than 30 days on Airbnb and similar sites. In Amsterdam officials are using Airbnb listings to track down unlicensed hotels. On the other hand, some argue that people who rent out rooms should not be subject to the same tight regulations as hotels. Overly strict regulations on the sharing economy could suffocate the growth of this new business model, particularly for start-up enterprises.

Source: Adapted from The Economist (2013b).

The key elements of telerobotics are the control console used by the operator, the physical robot and a stable and fast internet connection. A bipedal robot called HERMES (Highly Efficient Robotic Mechanisms and Electromechanical System), which can be remotely controlled by a human operator and will be capable of performing human-like manual activities, is currently being developed by the Massachusetts Institute of Technology (Chu, 2015). The robot is intended to be used where working conditions are too dangerous for humans, such as disaster sites. Once fully developed, it is anticipated that remotely controlled humanoid robots will be able to perform a wide range of daily manual services sector tasks, such as gardening, painting, and even complex tasks such as telesurgery (see Box C.7).

While telerobotics make it possible to undertake manual labour from afar, telepresence provides new means of digital communication in order to facilitate better intellectual collaboration. High-resolution conference call systems paired with synchronized digital whiteboards may increase productivity in meetings, while also enabling the participation of geographically distant participants. Virtual reality glasses, providing a 360-degree view of distant

Box C.7: Telesurgery

Telesurgery gives an indication of the extent to which robotics may transform the service industry. Originally developed by the United States National Aeronautics and Space Administration (NASA) and funded by the United States Defence Department, telesurgery (or remote surgery) promised to make surgery possible in places where surgeons are not present, such as on space ships or in conflict zones. The first transatlantic telesurgery took place in 2001, when a surgeon in New York, United States, removed the gall bladder of a 68-year-old woman in a hospital in Strasbourg, France, using a remotely controlled surgery robot (Wall and Marescaux, 2013).

Today, remote-controlled surgery is still unusual but is becoming more common – for example, a Canadian doctor has performed more than 20 long-distance operations by controlling a robot surgeon in an entirely different part of the country (Eveleth, 2014). Avgousti et al. (2016) review 56 medical telerobotic systems, most of them still in development, that allow surgery to be performed over long distances. They identify several challenges that need to be addressed before telesurgery can be adopted more widely. Some of the challenges are of a technical nature, involving, for example, the stability and security of networks that connect the two ends of the operation; others are legal and regulatory issues that have to be resolved. Furthermore, at present the cost of acquiring and maintaining telesurgery systems is extremely high. However, as these challenges are resolved and as the costs for technical equipment fall over time, new ways for international trade of medical treatments will open up and benefit patients worldwide.

Although telesurgery is still in its infancy, telepresence technology is already widely used in hospitals. With the help of cameras and microphones, expert surgeons can mentor other surgeons in operating theatres thousands of kilometres away. Studies find that such telementoring improves the outcomes of medical treatments (Wall and Marescaux, 2013). By detaching the expertise of a medical practitioner from her or his geographical location, digital technology can give rise to further specialization and more efficient allocation of practitioners' expertise.

locations, make it possible for specialists to remotely inspect production facilities in other countries. And telepresence robots – remotely controlled screens-on-wheels – allow workers virtually to be present in an office, attend meetings, visit a co-worker or even join co-workers for lunch. So far these technologies have mainly been used by workers who wish to check into their offices while working from home. Yet, as telecommuting technologies improve, a virtual presence might soon be enough for productive collaboration.

In a near future in which medical telerobotic systems become part of the standard equipment in hospitals, and telepresence systems make interactions over the internet deceptively real, it will probably be possible to provide certain services regardless of the supplier's geographic location. The consequences of such developments might be similar to those of digital trade in business services: workers in high-wage countries may be put in direct competition with workers from low-wage countries offering their services remotely. Ultimately, this may result in completely new ways to order the service industry as tasks are relocated across the globe, following the forces of comparative advantage. Baldwin (2016) predicts that this development will have a very large impact on the service sector, as it will enable a much wider range of services to be traded across borders than what has been traded up to now.

It is crucial to this scenario that the costs of telerobotics and telepresence systems fall while demand for these services remains stable. However, as robotic technology advances, so does AI. Vacuum-cleaning robots or self-driving cars are compelling because of their labour-substituting technology. Ultimately, in the future, the issue of whether manual services will be performed by telecommuting workers or by AI may depend on the importance of human judgement involved in the task. Therefore, the nature and substitutability of the tasks involved in the provision of services will determine the extent to which services will be sourced from abroad by means of digital technology.

To summarize the preceding subsection, it is conceivable that the relevance of trade in services will increase as digital technologies reduce trade costs and generate new means of delivering services across borders. Furthermore, technological advancements in the foreseeable future have the potential to render most services traded across borders. Such developments may have revolutionary

effects on the international trade system, national economies and labour markets. The global production of services could be entirely reorganized along the lines of countries' comparative advantages.

(ii) New technologies affect the composition of trade in goods

New technologies have the potential to transform how and where goods such as electronics, auto parts, machinery and medical instruments are produced. With the increasing penetration of digital technology, international trade in some goods may rise while trade in other products may decline or even disappear in the coming decades.

Trade in information technology goods has expanded

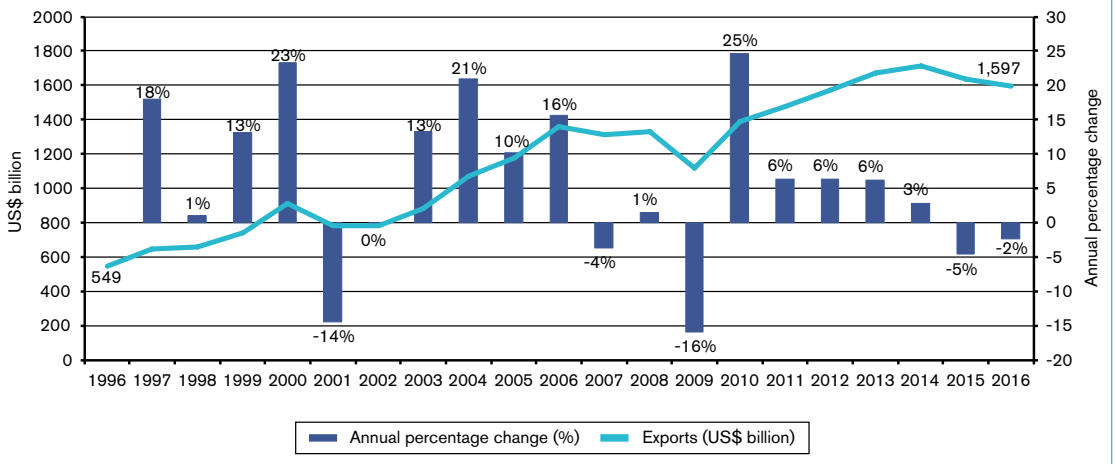
The trade flow of information technology goods has increased exponentially in the past decades. The WTO Information Technology Agreement (ITA) – originally signed in 1996 and expanded in 2015 – covers a large number of high-technology products, including computers, telecommunication equipment, semiconductors, semiconductor manufacturing and testing equipment, software, and scientific instruments, as well as most of the parts and accessories of these products.

The information technology sector has been one of the fastest growing sectors in world trade. Products covered under the ITA accounted for an estimated US$ 1.6 trillion in 2016, almost three times as much as when it was signed in 1996 (see Figure C.14). Today, trade in these products accounts for approximately 15 per cent of global merchandise exports.[12]

There have been profound changes in the type of ITA products that are being traded, partly driven by technological advancements and variations in consumer preference. Figure C.15 compares the share of ITA product categories between 1996 and 2015. In 1996, "semiconductors" and "computers and calculating machines" represented the categories with the highest shares of IT product export; 20 years later "semiconductors" remained the product category with the highest trade share and the share of "telecommunication equipment" increased from 9 per cent in 1996 to 21 per cent in 2015. This increase is largely explained by the increasing popularity of mobile phones, including smartphones (WTO, 2017a).

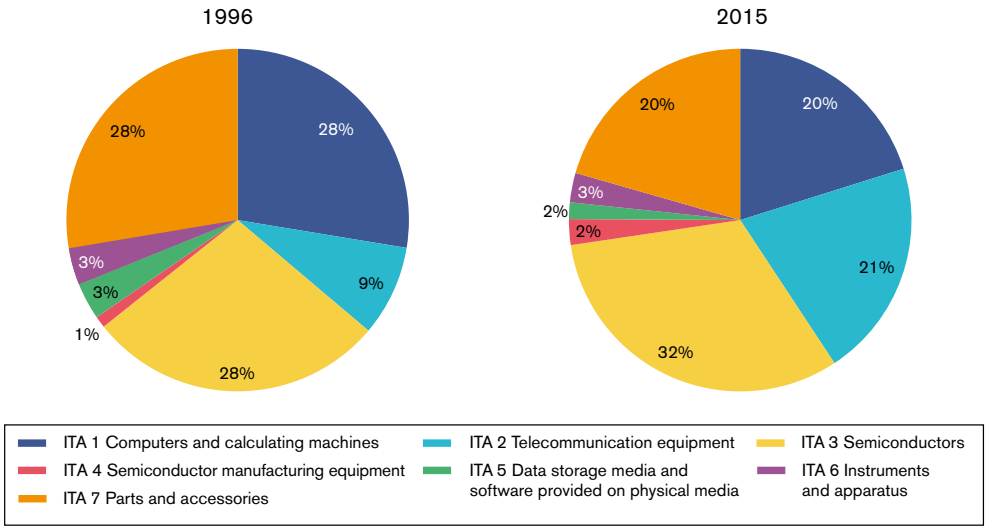
The expansion of trade in ITA products provides the basic infrastructure that enables information processing and communication, playing a vital role in promoting the adoption and use of digital technology. The lower cost and greater availability of computers and mobile phones has resulted in increased access to the internet and the growth of the digital economy, also creating new opportunities for trade. The expansion of trade in IT products is likely to continue with the increasing penetration of digital technologies and the invention of new products.

Figure C.14: World exports of ITA products, 1996-2016



Source: WTO Secretariat based on UN Comtrade (reported data, complemented by mirror estimates).

Figure C.15: World exports of ITA products, by product category (percentage share)



Source: WTO Secretariat, based on UN Comtrade.

Reduction in trade costs affects sectors differently

Digital technology changes the economics of doing business across borders, bringing down the cost of cross-border communications and transactions (see Section C.1). The reduction of trade costs has enabled an expansion of trade in some goods that were previously more costly to trade.

The extent to which products can benefit from a reduction in trade costs depends on the structure of trade costs and the amount of digitally-induced cost reduction. Freund and Weinhold (2004) provide suggestive evidence that the internet increased trade in physical goods due to a reduction in the cost of international communication. In the same vein, Fink et al. (2005) and Tang (2006) show that the decline of cross-border communication costs has had a significant influence on bilateral trade flows, particularly in sectors that exhibit a greater extent of product differentiation or low international transport costs.

Empirical research comparing trade through online platforms with offline trade offers interesting insights on the nature of digital trade. Based on data from Alibaba's international B2B e-commerce platform from five Asian LDCs – Bangladesh, Cambodia, Lao People's Democratic Republic, Myanmar and Nepal – ITC (2017) finds that products that trade particularly well off-line also feature prominently in e-commerce. For the five Asian LDCs in the study, apparel and textile products, along with agricultural products, were the largest export categories in both offline and online trade. In addition, e-commerce specifically facilitates trade for processed consumer goods. Product lines in which MSMEs dominate, such as gifts and craftwork, attract a greater share of total demand in online trade. E-commerce also provides opportunities to expand and diversify exports in terms of both products and markets. Apparel and clothing accessories account for around 86 per cent of Bangladesh's total exports, for example, but only 47 per cent of online demand. Agriculture, food and beverages, and consumer electronic products fill the gap.

The increasing use of digital technologies could give rise to trade in goods that have traditionally incurred higher costs in transportation, regulatory compliance, information and transaction. Time-sensitive goods, certification-intensive goods and contract-intensive goods are among these that are likely to benefit from a reduction in trade costs.

Time-sensitive goods

The growing use of digital technologies allows companies to manage complex supply chains and speed up delivery of products. Although digitalization cannot shorten the physical distance between countries, new technologies such as the IoT and AI afford companies up-to-the-minute visibility into complex supply chains and enable them to coordinate global vendors in real time.

Digital technologies also reduce the time and cost of delivery. Hema, a retail grocery concept developed by Alibaba, can deliver groceries to a consumer within 30 minutes of the order being placed. The company has managed to achieve speedy delivery by combining a mobile payment system with physical stores in high-density areas in major Chinese cities. Users of the New Retail-driven mobile app who live within a three-kilometre radius of a store can still get round-the-clock delivery service. Aside from regular fresh produce such as fruits and vegetables, the online retailer also delivers live fish and other seafood products (Wang, 2017).

A number of academic studies explore the time-sensitivity of different goods. For example, Hummels and Schaur (2013) investigate the probability of air transport being chosen as a means of transportation compared with ocean freight for different manufacturing industries. They find that the most time-sensitive trade flows involve the parts and components trade, which has a time sensitivity 60 per cent higher than other goods, as the presence of multi-stage global supply chains may magnify time costs, and so the absence of key components due to late arrival or quality defects can interrupt work in an entire assembly plant. An earlier draft of the paper (Hummels, 2001) also found the most time-sensitive manufacturing industries are in office equipment, electric power machinery and photographic equipment. Djankov et al. (2010) estimate the cost of time delay in trade. They find that each additional day of delay reduces trade by at least 1 per cent. Delays have an even greater impact on developing country exports of time-sensitive products. In particular, a day's delay reduces a country's relative exports of time-sensitive to time-insensitive agricultural goods by 7 per cent.[13]

Since speed to market matters more than ever in a digital world, many companies are re-evaluating the merits of lengthy and complex supply chains. According to a recent UPS survey, approximately one-third of high-tech companies are moving their manufacturing or assembly closer to end-user markets (UPS, 2015). Section C.2(c) discusses digital technologies' impact on value chains in more detail.

As a result of lower costs of transportation and logistics, trade in time-sensitive products may increase in the future. Digital technologies have the potential to reduce transportation costs further and to enable firms to optimize supply chains. As systems are getting better at routing items efficiently and predicting their arrival, integrating AI into the complex web of production and distribution could mean big potential gains for trade in time-sensitive products such as perishable food products, fast fashion items, life-saving medical supplies and intermediate inputs in supply chains (The Economist, 2018a).

Certification-intensive goods

Products that require certification and labelling may see a rise in trade volume as digital technologies enable a reduction of costs in verification and regulatory compliance.

The economic justification for certification requirements rests on the theory that the flow of information among market participants plays a critical role in the efficient operation of markets (Akerlof, 1970; Stiglitz, 1996). By making the information initially held by the firm also available to consumers, certifications remove information asymmetry and reduce search costs. Increasingly, firms in developing countries voluntarily obtain certifications that signal the quality of their products in order to enter international markets (Hudson and Jones, 2013; Auriol and Schilizzi, 2015). Complying with certification requirements, however, can be costly for companies, particularly for small enterprises in developing countries (Maskus et al., 2005).

Digital technologies remove some information asymmetries by making product attributes and processes more transparent, so that markets function more efficiently. This can result in a reduction of certification costs.

What types of goods may be affected? Certifications are often required for food and agricultural products, to verify that the product meets food safety, animal and plant health standards. For industrial goods, the top sectors using quality management standards include basic metal and fabricated metal products, electrical and optical equipment, and machinery and equipment, according to a survey of the International Organization for Standardization (ISO, 2017).

The question of whether a product can benefit from a reduction of certification costs depends on whether a credible link can be established between online and offline events. Analyzing the use of blockchain, Catalini and Gans (2016) point out that, while it is relatively cheap to verify the transaction of goods with offline attributes that are easy to capture and difficult to falsify (e.g. diamonds), in many cases, maintaining a robust link between online events and distributed ledgers is still expensive, and therefore asymmetric information and moral hazard continue to be an issue. In this context, IoT devices may be instrumental, because they can be used to record real-world information through sensors, GPS devices, etc.

By lowering the cost of obtaining certifications and by increasing transparency in the supply chain, digital technologies may lead to a rise of trade in products that entail high certification costs. The likely technology-induced reduction in certification costs varies according to the sector; products that are likely to benefit the most include luxury items, consumer electronics and food products.

Contract-intensive goods

International trade requires large amounts of paperwork, from contracts to cargo documents and bills of lading. The complication involved in drafting and executing an international trade contract can discourage entrepreneurs – especially small enterprises – from participating in trade.

Empirical research finds that transactions costs associated with insecure exchange resulting from corruption or imperfect contract enforcement significantly deters international trade (Anderson and Marcouiller, 2002). Traders in countries with weak institutions often need to rely on costly intermediaries and networks (Rauch, 1999) or bias their trade towards partners they trust (Guiso et al., 2009).

As discussed in the previous section, digital technologies can significantly reduce information and transaction costs in trade, most notably through online platforms which match buyers and sellers and rating systems that reduce information asymmetries. Emerging technologies are expected to further reduce the costs associated with cross-border transactions by removing the need for third parties to manage transactions and keep records. blockchain-based smart contracts, for example, may provide an efficient and reliable way to release payment for a supply of goods automatically following a secure and transparent confirmation of the execution of the contract (Weernink et al., 2017).

As a result of lower transaction costs, goods that require more relationship-specific investments are likely see a rise in trade. Nunn (2007) constructs a measure of "contract intensity" of industries by measuring, for each good, the proportion of its intermediate inputs that require relationship-specific investments.[14] According to his calculation, the manufacture of transport equipment, professional and scientific equipment and other machinery relies heavily on contracts. Since the inputs in these manufacturing industries are not standardized, buyers and sellers need to establish mutual trust by drafting and enforcing contracts. Studying the use of Electronic Data Interchange (EDI) in the Czech Republic, Vrbová et al. (2016) find that industries with a high ratio of EDI use include auto parts, electronics, engineering, plastics, retailing and textiles. These are sectors associated with well-organized value chains. A technology-induced reduction of transaction costs is therefore likely to affect trade of both final and intermediate goods in these sectors.

New technologies affect the composition of trade through mass customization

Technological advancements drive the shift towards mass customization, creating virtually infinite amounts of varieties fitting individual needs (see Section B.1(d)). This trend could be an important factor that stimulates trade.

Several technological developments are behind the trend towards mass customization. Data collection technologies can precisely gauge consumers' needs and tastes, enabling more individualized product design. Technologies such as online interactive configuration can assemble customers' preferences and enable shoppers to envision the final product. Developments in 3D scanning make it easier to measure real-world objects, for example a human body, with a view to tailoring individualized products to fit that object. Social media and crowdsourcing (i.e. obtaining goods and services from a large, relatively open and often rapidly-evolving group of internet users) also allow companies to analyse components of both real or virtual products, paving the way for better customization.

In manufacturing, flexible production systems are essential to making small batch production for mass customization. In the automotive industry, for example, Ford and General Motors have invested in dynamically programmable robotics with interchangeable tooling that can switch agilely between models and variants with no loss of efficiency. Companies from other industries are adapting these technologies. Caterpillar's production system, for example, cuts out shoe parts according to customers' measurements with an automated, computer-guided cutter (Gandhi et al., 2013).

Mass customization is expected to find applications in a wide variety of sectors, particularly in industries where customization would serve a functional or aesthetic purpose, usually based on preferences dictated by biology or taste, such as apparel, food, health care, consumer electronics and the automotive industry.

Some clothing brands already offer consumers the option of configuring products with different colours and different elements. One California-based

website, for example, allows its users to configure custom-made shoes. Users choose the shoe type and the design of the toe, back and heel, as well as any decorations, with each click automatically updating a preview. In the future, 3D scanning technology and flexible manufacturing systems may allow companies to make customized clothing to fit individual body measurements.

Food and beverage companies allow users to choose different toppings or flavours, while collecting data that would allow them to measure the popularity of particular ingredients and flavours.[15] With increasing amounts of data available on consumers' tastes and nutritional needs, food companies in the future may offer personalized food and vitamins based on individuals' tastes and nutritional needs.

In the healthcare industry, it is possible that, in the future, pharmaceutical companies may offer DNA-based personalized medicines. Gene-based information should help doctors prescribe more effective, accurate doses, and predict whether a person will benefit from a particular medicine or suffer serious side effects (Adams, 2008).

In consumer electronics, companies have already developed online configurators that allow consumers to configure products according to their preference. Advances in product visualization and the increased speed and adaptiveness of configuration software make product configuration an engaging experience. Technological developments could further enable companies to produce highly customized electronics with individualized colours and graphics.

Likewise, the automotive industry is expected to customize vehicles with personalized colours, artwork and designs that suit individual preferences. Technological advancements in 3D scanning, which analyses a real-world object to collect data on its shape and appearance, could facilitate the manufacturing of individualized components such as car seats and interior accessories designed to fit specific body shapes.

Various empirical studies show that technology-induced mass customization expands product variety and leads to welfare gains. For instance, Broda and Weinstein (2006) find the impact of increased choices to be statistically and economically significant and estimate that the value of US consumers of the expanded import varieties to be about 2.6 per cent of GDP. Brynjolfsson et al. (2003) show that increased product variety made available through electronic markets can be a significant source of economic welfare for consumers.

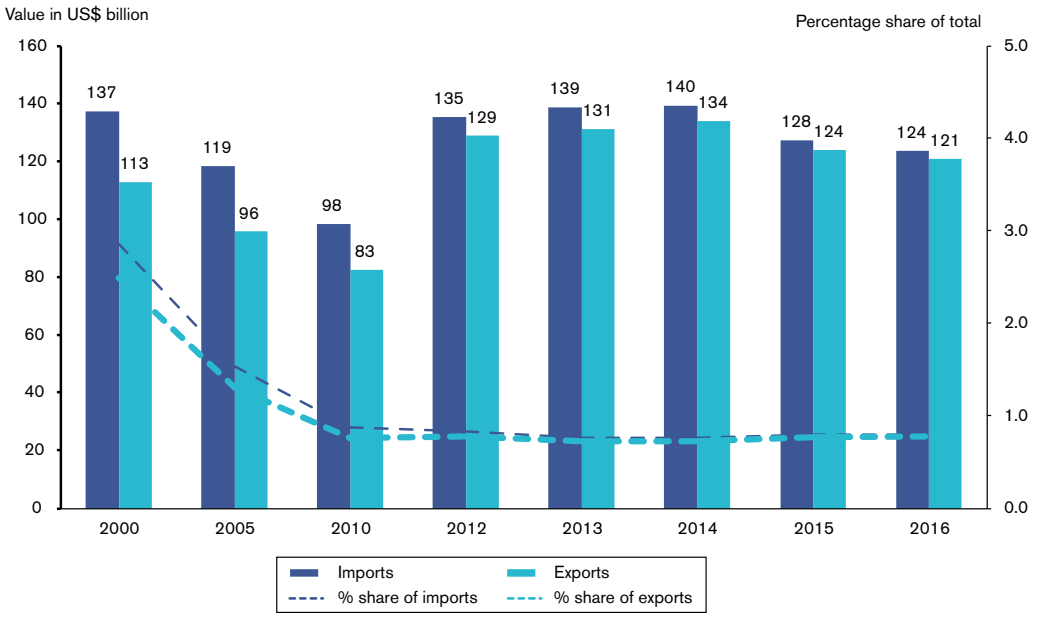
Mass customization could lead to an increase in international trade. The seminal work by Paul Krugman (1979; 1980) posits that consumers' love of variety, coupled with economies of scale in production, explains trade in similar products between similar countries. Empirical studies have also shown that the internet has expanded trade in sectors where products are easily differentiated. For example, Lendle et al. (2016) compare offline international trade flows with cross-border transactions on eBay and find that distance matters less online, especially when products are more differentiated and thus information frictions are high. As firms located in different countries increasingly specialize in customized production and as technologies enable online purchases at lower costs, this type of mass customization could lead to an increase of trade in similar yet highly differentiated products that meet different consumer preferences. On the other hand, mass customization could also allow production to be located closer to customers, thus reducing cross-border trade in some products.

Trade in digitizable goods is likely to continue falling

Over the past decades, digitalization has dramatically reduced the cost of copying, creating, accessing and diffusing creative work such as text, image and music, bringing about a decline in the trade of physical products embodying the work. Books, newspapers, video cassettes/DVDs and music records/CDs now gradually replaced by e-books, news apps and media content streaming or download services. Digitalization has transformed the industries concerned. As the cost of 3D printing declines, this trend of digitization could expand to new categories of goods — for instance, three-dimensional objects that currently exist in only physical form.

Conventionally defined digitizable goods (physical goods that can be digitalized) include cinematograph film; traditionally printed matter such as books, pamphlets, maps, newspapers, journals, periodicals, postcards and personal greeting message or announcement cards; video games; computer software; and recorded media such as musical records, tapes and other sound or similar recordings.[16] The share of trade in these products has been gradually falling. The current value of imports of digitizable goods by WTO members, not accounting for intra-EU trade, is around 0.8 per cent of total imports. In 2000, by contrast, total imports of digitizable goods were at 2.86 per cent of total imports (see Figure C.16).

Figure C.16: Trade of digitizable goods, value and as per cent share of total trade



Source: WTO Secretariat calculations based on UN COMTRADE data.

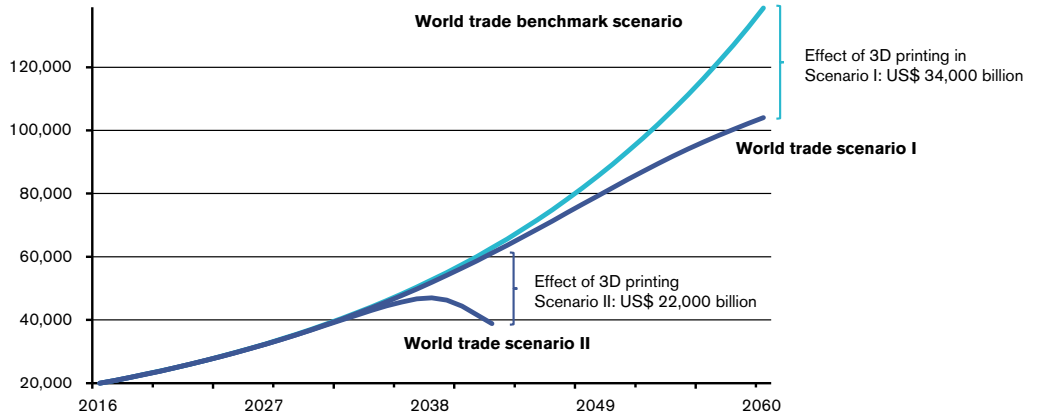
The advent of 3D printing technology could expand the reach of digitalization to a new category of products. By making a three-dimensional solid object from a digital model, 3D printing makes it possible to produce physical objects locally based on data files downloaded from the internet. This could reduce the need for international trade in commodities, intermediate and finished goods, while increasing trade in the materials used in 3D printing, such as plastics and resins. As discussed earlier, 3D printing has successfully moved from being a nascent technology to enjoying a high level of investment. Although the amount of goods produced with 3D printers and the value of related services currently only account for a fraction of total worldwide production, the annual growth rate for investment in 3D printing has been 29 per cent over the five-year period between 2012 and 2016 (Wohlers Associates, 2017), compared to an average of 9.7 per cent for global investment growth in traditional machines (ING, 2017). This growing trend of 3D printing implies that goods will increasingly be digitally transmitted and locally produced.

According to some industry estimates, 3D printing could lead to a significant reduction of trade in goods. ING (2017) estimates in a scenario analysis that if the current growth differential between investments in 3D printers and investments in traditional capital goods continues, 3D printers will print half of all manufacturing goods produced in 2060. Alternatively, if the growth rate of 3D printed production doubles after five years, this break-even point would be reached in 2040. These two scenarios are indicated in Figure C.17. In scenario I, total world trade in manufactured products will be 19 per cent lower than would be the case without the rise of 3D printing because these goods are made locally with 3D printers. In scenario II, it is calculated that two-fifths of world trade in goods will be lost by 2040.

3D printing could also affect trade in services. While some manufacturing-related services such as trade finance, transport and logistics may decline, other 3D printer-related services like installation, repair, design, software and education could increase.

The five industries that are the largest buyers of 3D printers and related services are the industrial machinery, aerospace, automotive, medical/dental devices and consumer products (electronics, etc.) industries. They are responsible for 75 per cent of all investment in 3D printing (see Table C.2). These five frontrunner industries make up 43 per cent of world trade, and their 3D activities will have the greatest impact on international trade.

Figure C.17: Scenarios comparing the effects of 3D printing on world trade (goods and services) (US$ billion)



Source: ING (2017); Wohlers Associates (2017).

Notes: This scenario analysis is based on the following assumptions:
(1) The global annual real GDP will grow on average at the same rate as during the past 30 years (2.9 per cent) and that world inflation will be half the rate of 5.1 per cent that it has been. This holds both for scenario I and scenario II.
(2) The benchmark trade growth (without 3D printing) is calculated by assuming that world trade in volumes will grow on average at 1.2 times the rate of world real GDP growth until 2060, so real world trade will grow 3.5 per cent per year.
(3) World trade prices will grow at only half the rate of the past two decades at 1 per cent per year.
(4) The share of manufacturing in world GDP will keep on declining so that it will make up 10 per cent of world GDP in 2060 (12.5 per cent in 2040), instead of the current 15 per cent.
(5) Since half of manufacturing production will then be made with 3D printers, traditionally produced goods (that are subject to exporting) will worth US$ 37,500 billion. If, as currently, half of this is exported, manufacturing exports will be US$ 18,750 billion.
(6) World trade is measured on the basis of national export turnover statistics, subject to double counting. According to the World Input-Output Database, export values are on average 1.4 times as high as the value-added of exports. Multiplying this production value by 1.4 times to translate the production figures to export figures results in remaining worldwide exports of traditionally manufactured goods of US$ 26,250 billion.

Table C.2: Fields of application and the consequences of 3D printing, 2016

Field of application	Share in sales of 3D printers	Examples of application	Effects of 3D production
Industrial machinery	19%	Production of tools like jigs and fixtures.	Less time-consuming/cheaper to produce (shorter lead time).
Aerospace	18%	Small quantities of geometrically complex and lightweight parts.	Fewer stocks and sometimes faster (and cheaper) to produce.
Automotive	15%	Functional prototypes, small and complex parts for luxury and antique cars. Mainly non-mass production of specific tools and parts and for prototyping.	Reduce or even eliminate tooling, welding and entire assembling lines. Design and manufacturing tools become dispensable.
Consumer products (e.g. electronics)	13%	Micro-electromechanical systems, microwave circuits fabricated on paper substrates, radio-frequency identification devices inside solid metallic objects (radio-frequency identification technology), polymer-based three-dimensional grippers.	Easier adaption to domain specific development processes, acceleration of design process, functional integration of a number of different electronic devices in just one product, functional prototypes, spare parts produced on demand.
Medical and dental devices	11%	Digital prostheses, dental aligners and invisible dental braces, dental restoration.	Reduced processing times, digitalization of manufacturing process, easy reproducing of production properties.
Others	24%		

Source: ING (2017); European Parliament (2015b); Wohlers Associates (2017).

Notes: Based on responses from 61 producers of 3D printers who were asked what their customers use the printers for. Respondents were from North America, Europe and Asia, and South Africa.

The possibility of digitalizing physical objects incorporating creative work highlights the importance of IPR protection. As digital technology allows households to manufacture goods based on designs downloaded from the internet, it is challenging for IP owners to identify whether and how they can enforce their rights in this sector. While anecdotal evidence suggests that 3D printing companies are enforcing patents in industrial 3D printing (Bechtold, 2015), the personal 3D printing sector could pose significant challenges to the protection of IPR. Infringement could be difficult to detect as it would often take place at home. The possibility of copying and modifying objects which are wholly or in part IP-protected might raise new challenges (OECD, 2017e).

The "sharing economy" is also likely to affect trade through its impact on the demand for durable goods

New business models like the "sharing economy" are also likely to affect trade through their impact on the demand for durable goods. The sharing economy offers the possibility to monetize underutilized assets or to forgo buying those assets altogether, which has dramatically altered consumer purchase behaviour, particularly when it comes to expensive items such as automobiles and houses.

In addition to generating new services trade flows (see the previous section), the sharing economy model could affect the demand for durable consumer goods. Some factors point to an increased demand for these goods, while others may lead to a reduced demand. How digital technology is likely to affect demand for durable goods depends in part on the way digitalization might affect: (1) the services provided in conjunction with such products (for example car-sharing services), which might ultimately increase the efficient use of the product; and (2) the content of these products, in particular the relationship between the digital (service) part and the manufactured part. Box C.8 focuses on the automotive industry and discusses the impact of digitalization on the demand for these durable goods.

Durable goods are also trade-intensive. The slowdown of global trade in recent years has led to research about its causes and possible consequences. Auboin and Borino (2017) have estimated the standard import equation for 38 advanced and developing economies using an import intensity-adjusted measure of aggregate demand. They found that the prolonged weakness of aggregated demand since the end of the global crisis, particularly in the most trade-intensive components (investment and consumer goods), has been the primary restraint on trade growth, accounting for up to three-quarters of the overall slowdown. Therefore, the evolving demand for durable goods could have implications for the composition of trade.

Whereas digital technologies have expanded trade in certain goods, the trade flow in some other goods has gradually declined, giving rise to trade in services and data flows. This section has analysed the impact of digital technologies on the trade of goods. Trade in IT products has seen a steady increase in the past decades with the development and increasing adoption of digital technologies. Digital technologies can enable a further reduction in trade costs, thus giving rise to trade in notably time-

Box C.8: The impact of digital technology on automotive demand

By making the use of cars more efficient, digital car-sharing services reduce transport costs for the consumer and help to increase the cross-border ordering of that service (e.g. a person ordering a car-sharing transport service online to transfer them from the airport). The fall in the cost of individual transport services linked to digital applications has certainly increased the demand for them, which more than offsets the fall in demand for existing substitutes (e.g. taxis). The sharing economy business model enables the optimization of the use of existing vehicles, which could contribute to reducing the overall number of cars needed for transportation. On the other hand, new functionalities brought about by digital technologies could create a new order of preferences that would make the purchase of new vehicles more attractive. The literature covers a rather wide spectrum of scenarios.

On one side of the spectrum, Barclays Bank (2016) forecasts that shared driverless cars entering the market could cut total US auto sales by 40 per cent in the next 25 years. As a result, auto-makers would need to shrink to survive (Naughton, 2015). Under this scenario, automated vehicles would significantly reduce the operational costs (no driver costs for example) for ride-sharing and vehicle-sharing services, and the demand for such mobility services would increase. The model of vehicles wholly owned by households would gradually change. Urban residents would eventually try to avoid the fixed costs of owning a car. As shared automated vehicles are utilized more intensively than conventional cars, however, shared automated vehicles would wear out faster and would need to be replaced more frequently (Milakis et al., 2017).

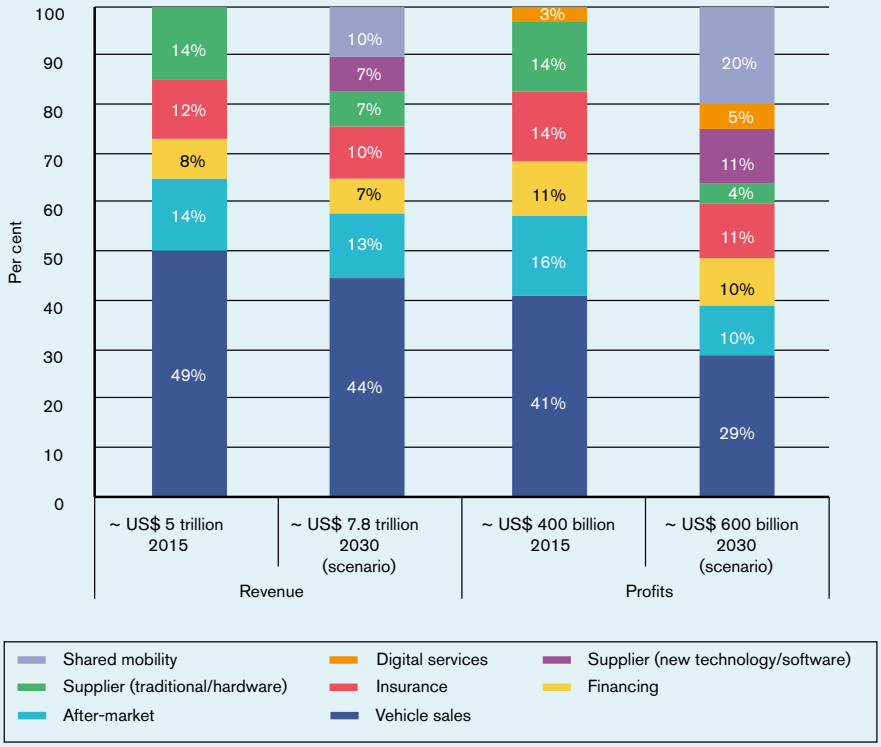
Box C.8: The impact of digital technology on automotive demand *(continued)*

On the other side of the spectrum, several scenarios for the automotive industry foresee a continued increase in the demand for vehicles, although with limited growth in "mature" markets (the United States and Europe), and a continued expansion in emerging markets. These scenarios also take into account the digitalization of car functions and the increased expectations of customers regarding technological developments. Most customers would expect their vehicles to incorporate digital technologies that could operate autonomously during driving, to have fewer accidents, and have self-learning and communication capabilities. The baseline scenario in the latest PWC 2016 connected car report forecasts a relatively regular increase in the demand for vehicles and in the automotive industry's revenue by 2030, from US$ 5 trillion currently to US$ 7.8 trillion, mainly due to the increase in demand in developing countries (PWC, 2016).

Here the main variable is falling profits for car-makers despite increased volumes, as increased entrants' market shares relative to traditional car-makers, and shifts in the value of car parts in favour of share mobility and digital services (see Figure C.18) would erode margins. The idea that connectivity will trigger a redistribution of revenue pools from the car industry is widely shared in these scenarios (McKinsey & Company, 2014).

A relevant question is whether the integration of an increased set of digital technologies, creating new functionalities, would affect the overall price of vehicles. The software value of a car is expected to increase in line with the new functionalities provided by digital technologies (e.g. functionalities available in connected cars, such as software assistance with key mechanical functionalities). However, several observers argue that the automotive industry already has a long history of leveraging cross-cutting advantage in design and production (see Deloitte, 2015c). Customers have become accustomed to having music and other

Figure C.18: Scenario for value shifts in the auto industry, 2015-30 (per cent)



Source: PWC (2016).

Box C.8: The impact of digital technology on automotive demand *(continued)*

entertainment, often for free, and "have been resisting paying extra for those services in their cars" (Kaiser, 2013). While nearly all observers predict a race between software and traditional automotive companies to capture the rent from increased connectivity, that rent may be falling in line with the falling price of technology and customers' reluctance to pay for more expensive cars. The solution would be for car-makers to aim for shorter design and production cycles. According to Deloitte (2015c), several auto-makers have started to re-design the product-development process with a view to increasing production flexibility, reducing time-to-market and decreasing production costs.

For the time being, the literature on the (connected) car industry is inconclusive, as it is unclear whether the final global demand for vehicles will increase or decrease. The demand for capital goods to produce durable goods can, in the short run, be expected to increase (more robots in factories), and the integration of more connected software will require more data centres, hence a greater demand for servers and other hardware.

sensitive goods, certification-intensive goods and contract-intensive goods. Technologies have also enabled mass customization, creating virtually infinite varieties to meet individual consumer needs. On the other hand, digitalization has led to a decline in the trade of certain digitizable goods – such as CDs, books and newspapers – and the trend is likely to continue with the advent of 3D printing technology. In this context, IPR have a pivotal role to play in the future of trade. The "sharing economy" business model could possibly affect trade in some durable consumer goods. Taking the automotive industry as an example, the sharing economy could lead to a decline in demand as households have less incentive to purchase new cars. Meanwhile, new car models integrating software and hardware could create new demand, particularly in emerging markets.

(iii) Intellectual property in trade

The evolution of digital technologies has radically transformed the linkages between IP and international trade. Conventionally, IPR were seen as a component of the added-value embedded in traded goods and services. Trade in music, film, books, journals, newspapers, and even consumer software, used to be essentially conducted through the exchange of physical carrier media. The transformation of the internet, especially from the early 1990s, from a largely scientific and academic network into a platform for social, cultural and commercial exchanges, has led to fundamental shifts in these industries.

Part of the transformational impact of this development has been that the linkages between IP and trade have become more evident. Transactions for products such as books, music and software in the digital environment are not generally defined by the transfer of ownership of a physical medium from a seller to a buyer; and ownership or control of a physical copy is no longer a proxy for the bundle of rights required to use the embedded content. Instead, the online "purchase" of an e-book, an app, a music download or a 3D printer design is typically defined in legal terms by contract and as a limited licence to use IPR and may also be structured by technological protection measures that constrain the effective uses of the licenced material. As one widespread content platform clearly states it: "Apps made available through the App Store are licensed, not sold" (Apple Inc., 2018). Such B2C licenses of IP are generally reserved for certain private, non-commercial uses, imposing significant constraints on further downstream use.

Alongside this burgeoning trade of products with important IP components and international licensing transactions, the international transfer of ownership of IP rights is growing in diversity. Increasingly, the acquisition of firms may be undertaken essentially to enable the transfer of ownership of strategic IP portfolios. A WIPO report on renewable energies charted how the rapid rise of emerging economy firms as leading owners of wind technology patent portfolios "can be attributed in large part to their strategic pursuit of knowledge acquisition through a strategy of licensing and M&A" (Helm et al., 2014).

Analysing the economics of copyright and the internet, Wunsch-Vincent (2013) points out that a few important factors brought about by digital technologies fundamentally change the way in which content is created and accessed, and potentially changes how copyrights are administered.

First, the internet and the increased availability of digital technologies have significantly lowered the cost of creating and distributing creative works on a global scale. While the distribution costs of content have plummeted, many content sectors have experienced increased costs due to production in the digital context. At the same time, the same tools used to distribute creative works facilitate piracy of the same works, as the variable cost of copying and

disseminating unauthorized copies is reduced to close to zero.

Second, the rise of the internet as a new distribution channel has introduced a change in the ways in which works are made accessible and revenues generated and shared. Value chains and business models – and associated revenue opportunities and incentives – have changed, and the impact on the supply of and the access to creative works is uncertain. This is not to say that the revenues of content creators, the content industry or others need be negatively affected. If the overall pie of revenues increases, original creators potentially stand to benefit. Whether revenues for creators have increased or decreased due to the digital transformation is ultimately an empirical question.

The emergence of such diverse forms of trade which necessarily involve IP has immediate implications not merely for trade policy, but even for how we understand the very character of "trade" – the growth of digital platforms has enabled hundreds of billions of valuable transactions across the globe that are, in legal terms, B2C licences, defined by reference to IP rights. It is not clear to what extent these transactions are recorded in current trade statistics, but their value is now a major component of revenues in the content industries, and a share of these earnings is redistributed to app developers, musicians, authors and other creators internationally. A clearer picture of these sizeable revenue flows would improve our understanding of the pattern of international trade in these sectors, and could lead to a more accurate understanding of how economies benefit from this form of international trade, as internet platforms serve to connect content developers across the globe with consumers in multiple jurisdictions. The scale of international transactions involved is illustrated by the example of one firm, Apple, which reported in June 2017 that it had been the channel for payments totalling over US$ 70 billion to its "global developer community" since its App Store was opened in 2008, as over 180 billion applications had been downloaded since then (Apple Inc., 2017).

(b) Who trades what? Trade patterns in the digital age

What will determine the trade patterns of the future? As the previous sections have shown, digital technologies create new products, change the characteristics of traditional products, lower trade costs, and shift the sectoral composition of production. These developments affect trade patterns by changing the relative importance of their underlying determinants (e.g. labour endowments, productivity differences) and by establishing completely new determinants (e.g. digital infrastructure). To answer the question of who trades what in the digital age, this section examines which traditional determinants of trade patterns are likely to become more important and outlines which new determinants of trade patterns may arise in the digital age.

Determinants of trade patterns are typically country characteristics that interact with product or sectoral characteristics to give a country a relative cost advantage in the production of these products vis-à-vis its trade partners. They are commonly referred to as sources of comparative advantage. Classical examples of such country characteristics are differences in relative productivity or in factor endowments, such as capital, natural resources or labour. Countries abundant in capital tend, for instance, to specialize in the production and export of goods that are capital-intensive, while labour-abundant countries export labour-intensive goods.

In addition to these canonical determinants of trade patterns, researchers have shown that differences in regulation, market size and infrastructure influence what countries trade. For instance, Nunn (2007) finds that countries with strong legal institutions have a comparative advantage in products that are contract-intensive. Helpman and Krugman (1985) suggest that countries with large domestic markets export in scale-intensive sectors. Beck (2003) and Manova (2013) show that financial institutions matter for comparative advantage since sectors differ in their dependence on external capital. Cuñat and Melitz (2012) and Tang (2012) provide evidence that labour market regulations also have an impact on comparative advantage in sectors that exhibit high volatility in sales or depend on sector-specific skills. Kowalski (2011) establishes the availability and affordability of energy as source of comparative advantage, since sectors differ considerably in the amount of energy they require for production.

With digital technology changing the determinants of trade patterns, opportunities will arise for both developing and developed countries. For instance, as digitalization raises the complexity of tasks performed by workers, developed economies can strengthen their comparative advantage in skill-intensive sectors. Similarly, as new technologies diminish the importance of physical infrastructure, developing economies will be able to gain comparative advantage in sectors that are most affected by the shift from physical to digitalized trade. Moreover, as developed economies increasingly specialize in high-tech production, developing economies should be able to diversify their export portfolio and move into new sectors that have been

freed up. Digital technologies can thus increase the gains from trade in countries across all income levels.[17]

In order to determine how the advent of digital technologies causes the determinants that matter for trade to change, sectors need to be classified according to their use of these technologies. Section B has demonstrated that sectors differ significantly in their dependence on digital technologies, and has provided rankings of sectors according to their digital intensity. These rankings show that services sectors, with the exception of construction and transport, tend to use digital technology more intensively than manufacturing and agriculture sectors. Within manufacturing, the transport equipment and electronics sectors stand out as digital-intensive, which is mirrored in data from the International Federation of Robots, which show that the automotive industry uses a significant number of robots and is likely to benefit from progress in smart robotics. Sectors such as textiles and paper, on the other hand, are ranked low based on robot and digital-intensity data.

Classifying the data in this manner will eventually allow researchers to examine digital comparative advantage but, not least due to data issues, currently research in this area is still limited. Deardorff (2017) shows that the concept of comparative advantage remains relevant in explaining trade in the digital age. Goldfarb and Trefler (2018a) point out that digital technologies like AI have special characteristics that make an assessment of trade patterns in the digital age complex. They highlight in particular the following aspects: economies of scale, economies of scope, and knowledge externalities. Evaluating how country characteristics interact with these three aspects can facilitate such an assessment.

Economies of scale exist because creating and maintaining local AI expertise is expensive and has a substantial fixed cost component. In addition, the quality of most new technologies increases exponentially with scale; for example, map applications are more reliable the more users provide data on traffic flows, while Google's search suggestions improve with every search undertaken by the user. Economies of scope are the outcome of many digital firms providing different services that each benefit from each other. Both characteristics suggest that the factors that attract digital technology firms should also benefit comparative advantage, since economies of scale and scope provide natural barriers to entry. Digital technologies are also likely to exhibit knowledge externalities, that is they benefit a wider set of actors than just the producer who does not take these benefits into account, since progress in this area is typically shared through publications or open source software. Goldfarb and Trefler (2018a) argue that policies that support comparative advantage in digital-intensive sectors can only be effective when knowledge externalities remain local. Whether this is the case is an open empirical question.

It is important to point out at this stage that a comparative advantage in one sector implies by definition a comparative disadvantage in another sector. Trade tends to raise incomes and welfare in all countries independent of where their comparative advantages lie. Moreover, many determinants of trade patterns are outside the reach of policy (e.g. geography) or the outcome of region-specific preferences (e.g. towards privacy). Hence, even if regulation can influence comparative advantage, it is not optimal to strive for a comparative advantage in a particular sector but rather to take comparative advantage as given and create an environment where this advantage can thrive.

With this qualification in mind, the first part of this subsection examines the impact of new technologies on the importance of traditional sources of comparative advantage for trade patterns. The second part discusses new determinants that have the potential to shape future trade flows such as digital infrastructure or data regulation. The third section concludes with a careful assessment of what this means for the future of trade patterns across developed and developing countries.

(i) New technologies, same old sources of comparative advantage?

Will the role of traditional sources of comparative advantage for trade patterns change in the digital age and what are the implications for countries at different stages of development? Traditionally, trade flows have been shaped by differences across countries in terms of labour and capital endowments, relative productivity differences, geography, infrastructure or institutional factors. New technologies have the potential to turn around such established trade patterns as robots affect the available labour supply or as the digitalization of trade renders geography and infrastructure less, or potentially more, relevant. Countries will therefore see their export baskets develop and reflect these changes.

Starting with factor endowments, countries that have a high supply both of skilled labour and of capital are likely to exhibit a comparative advantage in certain digital-intensive sectors. A common theme of the economic literature is biased technological change, which was reviewed in the 2017 *World Trade Report*

(WTO, 2017d). The current evidence points to the fact that technological change has been mainly routine-biased, which means it reduces the demand for employment in routine activities. Manual and complex tasks, on the other hand, have benefitted from innovation. However, the evidence collected in WTO (2017d) also points to the fact that digital technologies increasingly touch upon a wider set of activities and push demand towards high-skilled labour. In addition, by substituting labour to some extent, digital technologies are also considered to be capital-biased, as the discussion surrounding the falling labour income share in the 2017 report shows. As a result, high-skilled digital-intensive products are mainly exported by economies that have high levels of capital and educational attainment.

In a more extreme and futuristic scenario, advanced AI, additive manufacturing and robotics may come to exclude labour endowments as a determinant of trade patterns. As technologies develop and become cheaper, they might be able to substitute for workers of all skill levels, and since the supply of smart robots and 3D printers can potentially become unlimited, this would lead to an equalization of labour endowments across the globe. At the same time, robots do not generate additional demand. As a result, trade flows driven by differences in labour endowments could potentially run dry with considerable consequences for current trade patterns. On the path to this extreme outcome, it is likely that trade patterns will evolve with the skills and adoption of additive manufacturing and robots in production across sectors. Figure B.20 suggests in this regard that the automotive trade will be affected first, followed by electronics and metals.

The effect of digital technologies on the relevance of the second canonical source of comparative advantage, differences in technology, is less clear. Such differences are often linked to research and development (R&D) expenditure and policy (Costinot et al., 2012; Griffith et al., 2004; Goldfarb and Trefler, 2018a). The central question emphasized by Goldfarb and Trefler (2018a) in this regard is whether knowledge externalities and R&D spillovers in digital technologies are confined within borders or extend beyond. That is, how easy is it in an age of GVCs and high-skilled migration to keep research insights and know-how within innovating countries? Knowledge externalities that extend beyond borders would facilitate potential technological leapfrogging of developing countries and blur out differences in technology. If digital knowledge externalities are, however, confined within borders, the existing advantages of high-income economies in innovation are likely to persist and provide these economies with a lasting comparative advantage in digital-intensive sectors.

A source of comparative advantage whose role is likely to increase for comparative advantage in digital-intensive sectors is energy infrastructure. The server farms that are necessary to support digital technologies depend on storage devices, power supplies, and cooling systems that consume vast amounts of energies. Van Heddeghem et al. (2014) estimate that communication networks, personal computers and data centres were responsible for about 5 per cent of global electricity consumption in 2012, a number that had increased by around 20 per cent since 2007. Based on Facebook's 2013 sustainability report, Burrington (2015) shows that its data centres alone consumed as much energy as Burkina Faso and, as Section B.1(b) found, the Bitcoin network uses as much electricity as a country the size of Ireland.

Another factor that will become more important for trade patterns in the digital age is market size. This is due to the extraordinary economies of scale and scope that exist in digital-intensive sectors. As pointed out above, Goldfarb and Trefler (2018a) explain how firms relying on digital technologies, and in particular AI, benefit from having access to large amounts of information. As a consequence, when such firms from larger domestic markets enter export markets, they will be more competitive than competitors coming from smaller markets that have less access to information prior to entering foreign markets. This can partly explain the dominance of Chinese and US firms in digital-intensive sectors, and it also suggests that there is potential for large developing economies to enter digital-intensive sectors.

In contrast, border processes, geographical factors and physical infrastructure with the exception of telecommunications and energy infrastructure, may become less relevant for remote or landlocked countries, as well as countries whose physical infrastructure and customs procedures are underdeveloped and which wish to enter new markets. As products are increasingly supplied digitally and GVCs possibly become shorter (see Section C.2(c)), trade will rely less and less on roads, ports, airports or railways, and this would counteract some of the competitiveness gains of high-income countries in digital-intensive sectors and tasks. However, Section C.2(c) also discusses a scenario in which GVCs become longer. New technologies make logistics and transport more efficient, consumers prefer higher degrees of customization, and e-commerce brings markets closer together, leading to a parcellization of trade (see Box C.4). Thus, infrastructure and geographical factors will remain important for digital intensive products that are still traded physically.

The digitalization of trade can be expected to magnify the importance of formal and informal institutional factors for comparative advantage. The role of legal institutions that measure the ability of countries to enforce contracts will increase insofar as they interact with other policy fields. For instance, data privacy or IPR regulations rely on credible enforcement. As a consequence, their effectiveness will be ultimately determined by the strength of legal institutions in affected countries. The same holds true for financial institutions which can facilitate access to capital and therefore investments in the necessary infrastructure and equipment. Labour market regulation, in contrast, could become less important, as robots and 3D printers will be less protected by labour rights. Finally, informal institutions have been shown to play their part as well. Amongst others, Lanz et al. (2018) show that migrant networks can substitute for formal institutions in enforcing contracts and bridging information asymmetries.

At the same time, new technologies can reduce the role of institutions and facilitate the trade of countries with weak institutions. As discussed in Section C.1, technologies such as blockchain can circumvent intermediaries in trade and lower demand for contract enforcement institutions. There is also evidence that standardized information provided by digital technologies can reduce the importance of trust and reputation in online transactions (Agrawal et al., 2016). They find that this can in particular boost the exports of digitizable products from developing economies.

(ii) New determinants of trade patterns in the digital age

Beyond changing the role of traditional determinants, digital technologies also create new determinants of trade patterns. As, for instance, the role of physical infrastructure decreases for some sectors, digital infrastructure will increasingly become central for digital trade. Similarly, as labour market regulation might become less important for comparative advantage, the regulation of data flows will become more important. The importance of regulation is reflected in recent trade agreements or trade policy announcements that include substantive chapters on IP protection and e-commerce, and these will be discussed in Section D. How these new areas will affect comparative advantage in digital intensive tasks and sectors will determine trade patterns in these activities in the future.

Privacy, personal data protection and web content restriction policies will play an important role in this regard. From an economic perspective, limitations on firms' abilities to collect and assign data to individual users can restrict the development of economies of scale and scope and hamper competitiveness in digital-intensive sectors. For example, Goldfarb and Tucker (2010) show that the tightening of European privacy laws in 2004 decreased the effectiveness of online advertising in Europe by 65 per cent relative to the United States. Related to this, Miller and Tucker (2011) find that variations in US state medical privacy laws can explain differences in neo-natal mortality rates because strict laws prevent access to electronic medical records.

The same logic applies to web content restrictions that have been enacted by certain countries. By blocking certain websites or content on certain websites, countries limit firms' abilities to understand consumers' preferences. More importantly, blocking content can reduce incentives to invest in and produce digital-intensive products. Zhang and Zhu (2011) provide evidence that the blocking of the Chinese-language Wikipedia in mainland China reduced the contributions of non-blocked Chinese-speaking contributors in Chinese Tapei, Hong Kong (China), Singapore, and other regions in the world considerably, since the rewards, in this case the social benefits of adding content, were reduced.

The evidence presented above thus suggests that privacy, personal data protection and web content restriction regulation can affect comparative advantage in digital-intensive sectors. In other policy fields, such as environmental regulation or tax policy, such insights have led to the discussion of regulatory race-to-the-bottom developments. However, empirical support for such an outcome in these fields is limited (Mendoza and Tesar, 2005; Copeland, 2013). An exception is the area of labour regulation where Olney (2013) and Davies and Vadlamannati (2013) find that reductions of labour standards in one country can trigger similar changes in countries nearby. Consequently, weakening privacy and personal data protection in one country to gain competitiveness in digital sectors may lead other countries to follow suit.

On the other hand, the Porter hypothesis (Porter and van der Linde, 1995) argues that, with respect to environmental regulations, strict standards can in fact raise productivity and innovation and thus be a source of comparative advantage. A mechanism behind the Porter hypothesis could be selection effects whereby regulation shifts resources to the most innovative and productive firms by driving less productive firms out of the market (Qiu et al., 2017). While empirical evidence in this area is inconclusive (Ambec et al., 2013), such a mechanism could allow countries to

combine strict regulation with comparative advantage in digital-intensive sectors.

Since data protection and privacy regulation are still in their infancy in many countries, it is difficult to predict the impact on trade patterns that will arise from differences in this area. Anecdotal evidence suggests that the European Union has a relatively high degree of data protection and privacy standards, with Spain and Germany standing out as particularly stringent. Singapore and the Republic of Korea have also passed regulations protecting privacy, and several South American states have passed privacy laws in order to comply with European regulations. In contrast, the laws in Australia and the United States are considered to be less strict (Gustke, 2013). Section D will discuss this evidence in more detail.

Unlike privacy, personal data protection and web content restriction regulation, Goldfarb and Trefler (2018a) emphasize that data localization and government data access policies tend to impose costs primarily on foreign firms. These policies typically restrict the transfer of individual-level data across borders or limit access to publicly collected data to domestic firms. That is, in case privacy laws allow for data collection, this data can only be used and accessed domestically. As a result, strict data localization laws and restricted access to government data limit economies of scale of foreign firms and might necessitate the setting up of foreign affiliates and local servers. If knowledge spillovers in digital technologies are local, this can boost the competitiveness of the home market in digital-intensive sectors. However, Ferracane and van der Marel (2018) and Ferracane et al. (2018) provide evidence that data flow restrictions, such as data localization regulation, lead to lower levels of services traded over the internet and lower productivity, which hurts competitiveness.

The importance of IPR regulation is also bound to increase in the digital age because many digital products are replicable at zero cost and are of a non-rival nature. This means that they can be consumed by an indefinite amount of people at the same time without a loss of utility. To ensure profitable prices for producers, strict and enforceable IPR are central and can increase the attractiveness of a country for digital firms. Goldfarb and Tucker (2017) review evidence that shows that weak copyright enforcement has led to a reduction of revenues in the music, film and publishing industries (see Box B.2). However, Goldfarb and Tucker (2017) also discuss literature which shows that strict IPR policies could constrain the creation and quality of digital products by limiting access or raising royalty costs. Whether IPR regulations increase or reduce competitiveness in digital sectors is therefore ultimately an empirical question. Preliminary evidence presented in Appendix C.2 suggests that more stringent IPR boosts exports of IP-intensive industries, especially in countries with relatively less stringent IP protection.

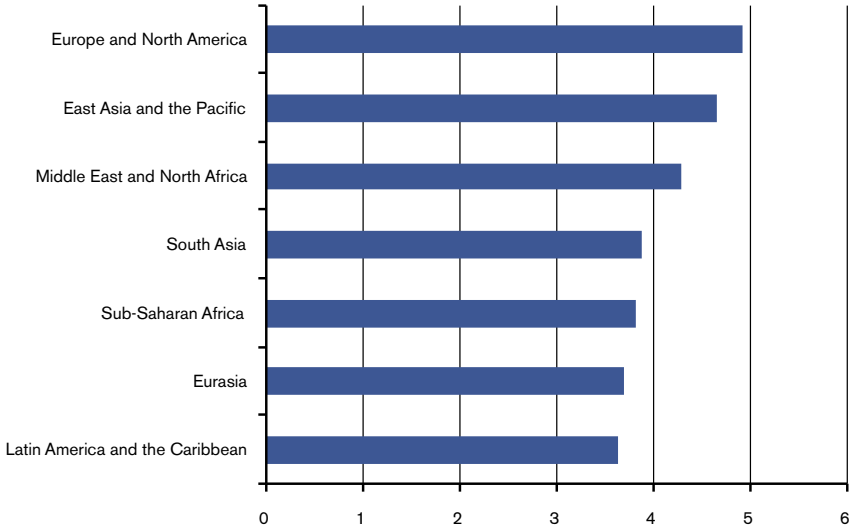
Turning to differences in IPR laws across countries, Park (2008) provides a patent right index for 122 economies from 1960 to 2005. The index combines information on coverage (i.e. sectors excluded from patenting); membership in international treaties; duration of protection; enforcement mechanisms; and restrictions on IPR. According to this index, the most stringent IPR in 2005 were among OECD members, but Bulgaria, the Philippines, Singapore and South Africa also exhibited high values. The United States topped the list, which has a maximum value of 5, with a value of 4.88.

More recent data is available from the World Economic Forum (WEF) in its Global Competitiveness Report database, which is updated annually and currently extends to 2018. In contrast to Park (2008), the database is survey-based. In 2017, Switzerland exhibited the highest score, ahead of Finland, Luxembourg and Singapore. Overall, Figure C.19 shows that European and North American as well as East Asian and Pacific economies have stringent IPR policies while the index reports low values for Latin America and the Caribbean. However, regional aggregations tend to hide significant heterogeneity within regions. To give an example, Chile, Colombia, Costa Rica and Panama all have stronger IPR than the median country in the sample.

Turning from policy to infrastructure, a reliable, comprehensive and affordable high-speed broadband network will become a central factor for competitiveness in the digital age. For instance, the amount of data that is required for the IoT will demand large investments in digital infrastructure. As the digital content of manufacturing increases, high-quality broadband access will become a necessity for competitiveness in all sectors that heavily rely on digital technologies (see also Box B.1 on the pivotal role of the telecommunications sector). Yi (2013) finds for 21 OECD countries that better broadband access provides for a comparative advantage in less routine sectors. She argues that ICT complements workers when they perform non-routine tasks, and can therefore increase competitiveness in these tasks. Given that digital technologies tend to involve many non-routine tasks, broadband access will become ever more important.

To understand how good broadband access is in different regions, it is possible to look at indicators of

Figure C.19: Intellectual property protection index



Source: WEF, the Global Competitiveness Index Historical.

Notes: IP protection as measured by the 2016/2017 WEF Executive Opinion Survey.

broadband subscriptions and broadband speed split into fixed and mobile access; these data are available from the International Telecommunications Union (ITU) and the website www.speedtest.net. Combining these four indicators into a single index shows that cross-country broadband access is highly correlated with income, as shown in Figure C.20. Figure C.21 also indicates, from a regional perspective, that North America is best prepared for the digital age, while South Asia, Sub-Saharan Africa, and Latin America and the Caribbean are lagging behind and would benefit from additional investments into their broadband networks when it comes to comparative advantage in digital-intensive activities.

(iii) Adding it all up: comparative advantage in the digital age

The advance of digital technologies brings about opportunities and challenges for developing and developed countries alike. Digital technologies have quickly become an integral part of many sectors but to varying degrees. This means that established trade patterns will change considerably as the importance of traditional sources of comparative advantage changes and new sources arise. An assessment of how these different forces will play out jointly and determine future trade patterns in digital-intensive sectors is inherently difficult. Rigorous empirical evidence on the relative strength of the individual factors for comparative advantage that have been discussed here is not available because many new technologies, such as self-driving cars or the IoT, have not been widely adopted yet. A rough evaluation is possible but should only be taken as indicative, in particular since these new forces pull at times in different directions and it is not certain which effects are going to dominate in the future.

Such a preliminary evaluation suggests that several new sources of comparative advantage could allow high-income economies to become net exporters of digital-intensive tasks and sectors and therefore reinforce existing trade patterns. High-tech activities would continue to be performed in developed economies and be a major part of their export baskets. These economies typically have a large capital stock and pool of skilled workers at their disposal. In addition, internet content restrictions are rare and the broadband infrastructure is usually well advanced. Combining this with strong formal and informal institutions should make for a comparative advantage in digital-intensive sectors, a conclusion that is reflected in the discussion on the digital divide in Section B.1(d) or in assessments like the *Readiness for the Future of Production* by the WEF, which almost exclusively lists high-income economies as leading countries (WEF, 2018b).

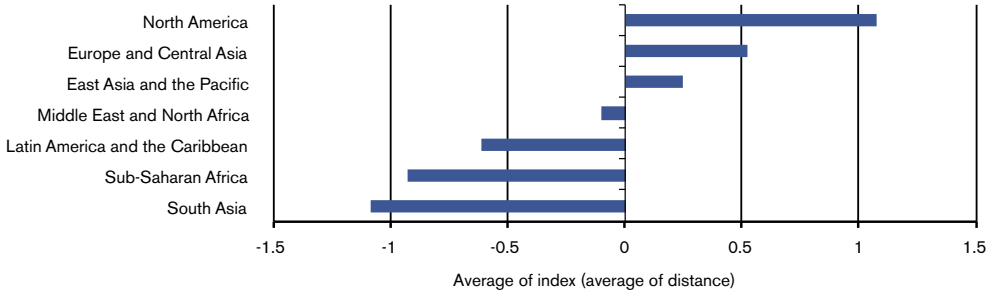
However, several developing countries might equally be able to gain market shares in these activities. Traditional sources of comparative advantage in which

Figure C.20: Broadband access index, countries grouped by income

Source: Calculations by authors, data from ITU World Telecommunication/ICT Indicators and speedtest.net.

Notes: The index combines four indicators capturing proliferation and speed of fixed and mobile broadband internet connections, defined by the ITU as networks that provide download speeds of at least 256 kbit/s. It is the average of the distances between a country's value and the mean of the respective indicator, normalized by the mean. A positive index value indicates above average broadband access. Income groups as defined by the World Bank.

Figure C.21: Broadband access index, countries grouped by geography



Source: Calculations by authors, data from ITU World Telecommunication/ICT Indicators and speedtest.net

Notes: The index combines four indicators capturing proliferation and speed of fixed and mobile broadband internet connections, defined by the ITU as networks that provide download speeds of at least 256 kbit/s. It is the average of the distances between a country's value and the mean of the respective indicator, normalized by the mean. A positive index value indicates above average broadband access. Geographic groups as defined by the World Bank.

developing economies might lag behind are likely to become less important for certain types of products. When trade becomes digitalized, underdeveloped infrastructure and ineffective border procedures might become less burdensome. Along the same lines, advances in technologies like blockchain can overcome weak contract enforcement abilities. Another central aspect of digital technologies is that they will amplify economies of scale and scope. Large developing economies could be the main beneficiaries of this development. Market size itself will create competitiveness in selected sectors and can counterbalance underperformance in other areas of relevance. Finally, knowledge externalities that spread beyond borders can facilitate technological leapfrogging, as has already been the case of financial technology ("fintech") in Kenya (see the opinion piece by Wim Naudé, Maastricht University, UNU-MERIT, and IZA Institute of Labor Economics, on page 46).

Evidence that digital technologies already help developing countries to export digital-intensive products has recently been provided by Loungani et al. (2017). They find that while developed countries are responsible for the majority of exports in (potentially) digitally-enabled services, exports of these services have been growing the most in developing countries. Some developing countries have built up strong positions as exporters of ICT services. India, for example, is the leading exporter of computer services, exporting computer services worth an estimated US$ 53 billion in 2016, while the Philippines exported ICT services worth US$ 5 billion, making it a global top 20 exporter of ICT services.

In sum, new technologies have the potential to benefit trade in countries across all stages of development. Innovation will continue to shape trade patterns and, therefore, offers vast opportunities for developing and developed countries alike. This certainly requires minimum levels of factors such as skilled labour or capital, digital infrastructure and institutional quality, but as long as such minimum levels are ensured, countries will be able to participate in the new gains from trade that will arise.

(c) Digital technologies and GVCs: an uncertain outlook

In GVCs, intermediate products are outsourced and production becomes fragmented across borders. The GVCs phenomenon began in the 1970s[18] and thrived from the mid-1990s to the late 2000s.[19] During the 2000s, both the value of GVCs' trade flows and their complexity increased (see Figure C.22). The global financial crisis of 2008 caused a collapse in international trade, which was moderately amplified by GVCs.[20] While value chain trade rebounded after the crisis, the last few years have witnessed a further slowdown in GVCs (this can be seen in the last two data points of Figure C.22).

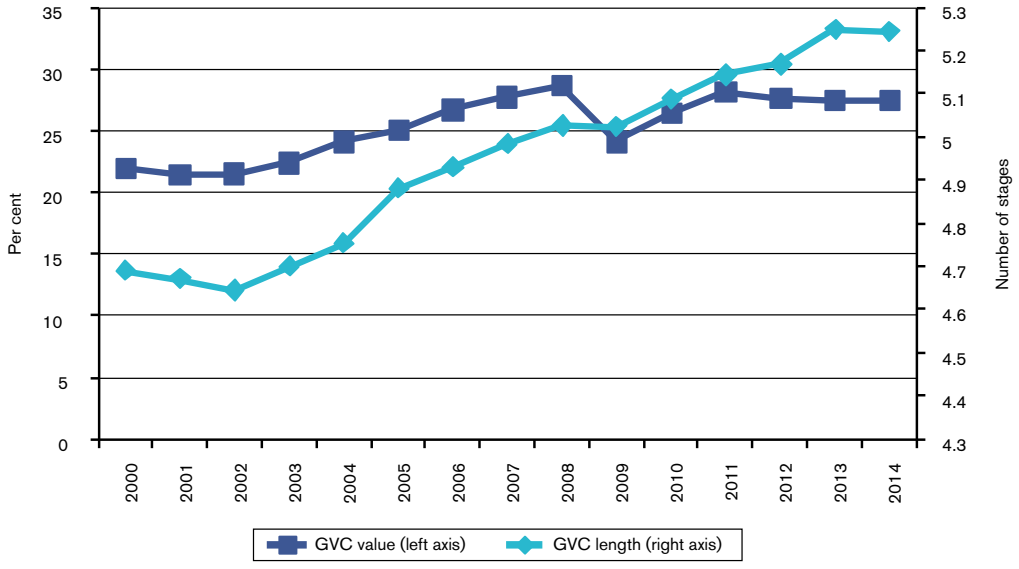
The objective of this section is to assess the role of technology in driving GVCs. In particular, insights are provided on how the digital technologies that are the focus of this report can contribute to explain the patterns described above, and on whether the current slowdown in GVCs might persist in the future, or further GVC expansion might be expected.

(i) Technology is a key driving factor of GVCs

Technology is a key factor driving international fragmentation of production in GVCs.[21] As explained by Amador and Cabral (2016), adequate technology is required to combine parts and components produced in different locations in sophisticated final products, and more generally to coordinate and manage dispersed production activities. Such coordination and management is carried out by technology-intensive services. Management and IT services synchronize the worldwide production process; transportation services move parts and components between production facilities; and marketing and sales services make sure that products are sold in the most suitable way on different national markets.

Accordingly, theoretical analyses of GVCs highlight the role of technology, and the services enabled

Figure C.22: GVC value and GVC length, 2000-14 (per cent and number of stages)



Source: Timmer et al. (2016), Degain et al. (2017).

Notes: GVC values are proxied by global import intensity, computed as the ratio of "GVC imports" (imports needed in any stage of production of a final good or service) to the value of the final product (Timmer et al., 2016). GVC length is the average number of stages in the production process of "complex" GVCs – defined as domestic value-added that is embodied in intermediate exports and used by a partner country to produce exports (intermediate or final) for other countries (Degain et al., 2017).

by technology, in their development. The spatial unbundling of production and consumption (the "first unbundling" in Baldwin's 2006 terminology) which occurred at the end of the 19th century was made possible not only by the great reductions in transport costs which resulted from steam power (Baldwin, 2006), but also by the fall in communication costs which came about due to the telegraph (Juhász and Steinwender, 2018).[22] The spatial unbundling of production stages previously clustered in factories and offices (the "second unbundling") which occurred in the 1990s, is largely due to sharp falls in communication and coordination costs, or in the "cost of moving ideas", in Baldwin's term, originated by the ICT revolution. As communication and coordination costs fell below the expected cost advantages through specialization, economies of scale and differences in labour costs, companies found it more attractive to organize their production processes on an international scale (De Backer and Flaig, 2017).

The work by Baldwin and Venables (2013) further shows how technology fundamentally shapes the way in which different stages of production are linked. Production processes in which multiple parts and components are assembled in no particular order (which the authors call "spiders") differ from production processes where goods move in a sequential way from upstream to downstream stages in value chains (which the author call "snakes") because of intrinsic engineering (i.e. technological) requirements.[23]

(ii) Digital technologies will affect GVCs in opposing ways

Digital technologies do, and will in the future, have ambiguous effects on GVC trade. This subsection reviews the mechanisms through which various digital technologies can increase or decrease supply chain trade, starting with those mechanisms which point to a positive link between digital technologies and supply chain trade.

How can digital technologies increase supply-chain trade?

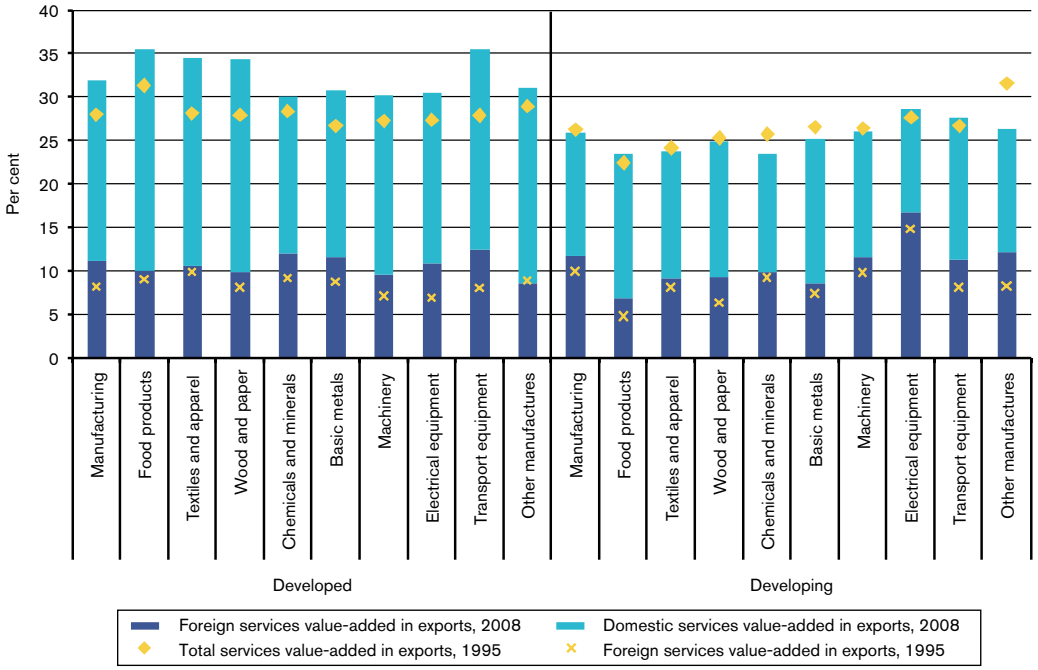
There are two ways in which digital technologies can lead to more GVC trade. First, as argued in Section C.1, the adoption of digital technologies can reduce costs that negatively affect GVCs. Second, digital technologies can also lead to more GVC trade when they increase the quality and availability of services that act as enablers of value chains or that are used as inputs to the production of goods.

GVC trade is particularly sensitive to communication costs, transportation and logistics costs, and to matching and verification costs. This is because the higher these costs, the harder it is to coordinate geographically dispersed tasks. Technologies that reduce these costs, therefore, are particularly likely to favour GVC trade. Improved broadband applications, the spread of smartphones and tele-, video- and virtual-conferencing make it easier to operate longer and more complex GVCs by lowering communication costs.[24] Technologies that make it cheaper and easier to track and monitor components as they move through the supply chain, such as radio-frequency identification technology, reduce inventory management costs[25] and simplify logistics (see Section C.1a). Blockchain technology has the potential to reduce verification costs greatly. This is likely to increase transparency and expand trade along value chains. Another potential impact of blockchain technology on value chains works through its effects on matching costs between upstream suppliers and downstream buyers. Such costs often arise due to a lack of trust, which is not an issue in blockchain-based transactions. Accordingly, sourcing along value chains could become more diversified.[26]

The trade cost-reducing impact of some digital technologies is particularly relevant within value chains, relative to trade in final goods and services, because trade costs tend to cumulate along value chains, as was first argued by Yi (2003). When supply chains require semi-finished goods to cross international borders more than once, the effect of a marginal variation in trade costs everywhere in the supply chain is much larger than would be the case if there were a single international transaction. Ferrantino (2012) shows that when trade costs apply in proportion to the value of a good, the total cost of delivering the product through the supply chain down to the final consumer increases exponentially with the number of production stages. In practice, the accumulation effect, while still relevant, may be lower than what a simple exponential formula suggests, because of two mitigation forces: the topology of the supply chain (there is less accumulation in "spiders" than in "snakes"), and the fact that trade costs have to be significantly reduced before GVCs start expanding (Diakantoni et al., 2017).[27]

The second way in which digital technologies can lead to more GVC trade is through their impact on services. Digital technologies increase the quality and availability of a wide range of intermediate services (domestic or imported) that act as enablers of GVCs, for example, computer, R&D, advertising, telecommunications, financial and professional services.[28] Moreover, as argued in Section C.2.(b), services provide significant inputs to the production of goods. Figure C.23 portrays the services value-

Figure C.23: Service value-added content of manufacturing industry exports, 1995 and 2008 (per cent)



Source: Lanz and Maurer (2015).

Notes: Figures are divided by provenience of value-added.

added content of exports of manufacturing industries for developed and developing countries in 1995 and in 2008. Services account for close to one-third of manufacturing exports in developed countries and 26 per cent in developing countries, with the share of foreign services value-added (i.e., value-added coming from imported services) being above 11 per cent for both country groups (Lanz and Maurer, 2015). Recent studies estimate that up to half of the value-added in manufacturing exports is contributed by external and internal (i.e. in-house provided) services (Miroudot and Cadestin, 2017).[29]

New technologies will magnify such estimates because they will further increase the share of services in the value of goods. The value of self-driving cars, for instance, will be increasingly determined by the software steering the wheel. Smart fridges will be priced more according to the relevant software development costs than the costs of their physical parts and components. The combination of rising shares of value-added in manufacturing exports and of the greater ease of supplying services remotely (discussed in Section C.2(a)) will lead, all other things being equal, to more value chains trade in the future.

Do digital technologies trigger reshoring?

The recent slowdown in GVC activities (both in value and in length) documented above is consistent with three explanations (Degain et al., 2017):

(i) the rising tide of protection around the globe after the global financial crisis (Georgiadis and Gräb, 2016);

(ii) substitution of imported intermediate inputs with domestically produced intermediate inputs in major emerging economies, such as China;[30] and

(iii) reshoring, i.e. firms' relocation of production or other business functions from abroad to the domestic country of the firm.

In what follows, the focus is on reshoring, and in particular on how digital technologies may affect this phenomenon.[31]

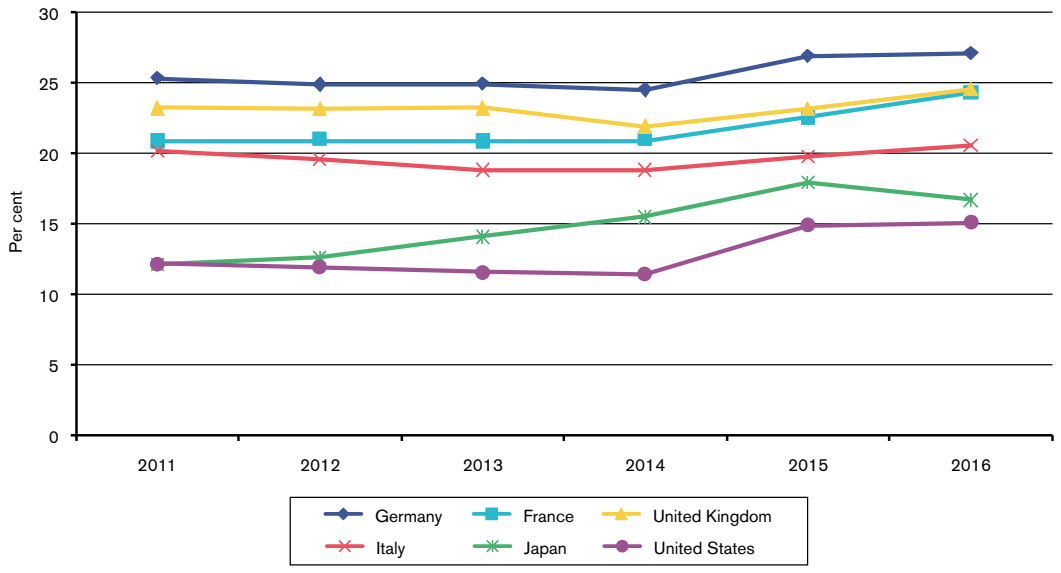
Anecdotal evidence of reshoring is not difficult to find. Dachs et al. (2017) provide the example of an Austrian producer of metal parts. One of the core production processes of this firm is smoothing and

polishing large metal parts. This time-consuming task, requiring between 100 and 150 working hours per part, was initially offshored to Hungary. Recently, the firm automated this production step, installing a robot. The robot works 24/7 and only requires 20 hours to smoothe and polish one metal part. Such enormous productivity advantages largely compensate any wage gap that motivated the offshoring decision. Therefore, the investment in robots allowed the firm to relocate the task back to Austria, re-concentrating production in one place. Since transport of metal parts between the two countries is not needed anymore, the firm is also able to take orders that were not possible before because of the time needed for transport between the production facilities (Dachs et al., 2017). In the United States, companies such as General Electric, Master Lock, Caterpillar, Whirlpool and Ford have moved parts of production of some of their products back from abroad (Oldenski, 2015). A.T. Kearney (2015) reports 16 cases of reshoring to the United States in 2010, 64 in 2011, 104 in 2012, 210 in 2013, and 208 in 2014.

All systematic evidence, however, shows that reshoring has been so far a limited phenomenon, and has exhibited no significant trend. In a sample of 2,120 manufacturing firms from Austria, Germany and Switzerland, each with at least 20 employees, from the European Manufacturing Survey, Dachs et al. (2017) find that the share of firms that reshored production in 2013 or 2014 was only 3.8 per cent, increasing to 10 per cent if only firms with production activities abroad were considered. If all countries covered by the European Manufacturing Survey were considered (Austria, Denmark, France, Germany, Hungary, the Netherlands, Portugal, Slovenia, Spain, Sweden and Switzerland), again only around 4 per cent of firms moved production activities back home between 2010 and mid-2012 (De Backer et al., 2016). In the case of the United Kingdom, the Manufacturers' Organisation (EEF)[32] (2014) reported that approximately 15 per cent of manufacturing firms engaged in reshoring (whether bringing production back in-house or to a UK supplier from abroad) in 2013. For the United States, Oldenski (2015) considers, as inverse proxies of reshoring, imports of US-based multinational corporations, using data from the US Bureau of Economic Analysis. Both imports from affiliates (intra-firm trade) and imports from non-affiliates (arm's-length trade) exhibited an upward trend between 1999 and 2012. This is evidence of offshoring, rather than reshoring.[33]

Further confirmation that there has been no significant reshoring trend is conveyed by Figure C.24, which displays the evolution between 2011 and

Figure C.24: Share of foreign value-added in domestic final demand, 2011-16 (per cent)



Source: Asian Development Bank's Inter-Country Input-Output table.

Notes: Foreign value-added as a share of domestic final demand reveals the share of foreign value-added present in final goods or services purchased by households, government, non-profit institutions serving households or as investments. It shows how industries abroad (upstream in a value-chain) are connected to consumers at home, even where no direct trade relationship exists, and can be interpreted as "imports of value-added". Note that the share of foreign value-added in domestic final demand is equal to one minus the share of domestic value added in domestic final demand.

2016 of the share of foreign value-added embodied in domestic final demand in selected advanced economies. Reshoring would be associated with a decrease in the share of foreign value-added in domestic final demand and a corresponding increase in the share of domestic value-added, as reshoring firms source more value-added domestically. For the United States, with the exception of the 2008-09 dip (corresponding to the Great Recession), the trend is slightly negative between 2011 and 2014, but positive afterwards, in line with Oldenski's (2015) finding that the available evidence for the United States is in favour of more offshoring rather than reshoring. Similar results also apply to the largest European economies, namely France, Germany, Italy and the United Kingdom. The only large advanced economy in which the share of foreign value-added in domestic final demand recently declined is Japan. However, the decrease between 2015 and 2016 did not overturn an overall positive trend since 2011.

Various factors can explain the slow pace of reshoring (UNCTAD, 2016b). First, relatively weak aggregate demand, and investment in particular. Second, developed countries may lack the supplier networks that some developing countries have built to complement assembly activities. Finally, as indicated by the fact that offshoring continues to take place, labour-cost differentials are not the only factor in the decision of firms on where to locate production. Demand factors such as the size and growth of local markets are becoming increasingly important determinants. Therefore, production of labour-intensive manufactures destined for rapidly growing markets in large developing countries that have domestic production linkages is unlikely to be reshored (UNCTAD, 2016b).

The evidence against an existing reshoring trend does not imply that, in the future, sourcing patters of multinational firms will not change. The example of the Austrian producer of metal parts illustrates how automation technologies can lead to reshoring. Automation reduces the share of labour costs in total costs. Since labour cost differentials are the main determinants of offshoring, smaller labour cost differentials will lead, other things equal, to more reshoring. Automation does not need to be smart for this mechanism to work. However, smart automation provides additional reasons to reshore. Smart robots not only can work in "dark factories" like traditional robots.[34] They can also perform a wider range of relatively complex manual tasks and adapt to changing conditions (De Backer and Flaig, 2017). In sectors like consumer electronics, traditional robots may not be flexible enough to adapt production to the short life cycle of products (with the consequence that production is often manual), but smart robots may. The incentives to reshore production closer to larger and richer markets would therefore increase.[35]

Against this theoretical background, there is quite limited empirical evidence that digital technologies can trigger reshoring. De Backer et al. (2018) find a negative association between robotics investment and the growth of offshoring for developed economies in the period 2010-2014. This begs the question of whether investments in robots will lead to the actual reshoring of activities to developed economies. The evidence in De Backer et al. (2018) points to a negative answer, leading the authors to conclude that the use of robots does not (yet) trigger reshoring of activities to developed economies. Conversely, in a survey of 2,120 manufacturing firms from Austria, Germany and Switzerland with at least 20 employees, Dachs et al. (2017) find a positive relation between reshoring and an index of "Industry 4.0 readiness".[36]

As will be further discussed in Section C.3, simulations conducted using the WTO Global Trade Model produce mixed results on the effect of digital technologies (as measured by changes in the degree of digitalization and robotization across sectors and countries) on reshoring. In particular, when the share of intermediate imports in gross output is used as a measure of reshoring, there is indication of future reshoring. On the contrary, when foreign value added in exports is used as a measure of reshoring, there is hardly any change from the baseline scenario. This would indicate that the reorganization of tasks in production due to changing degrees of digitalization and robotization will not necessarily lead to a change in the organization of GVCs.

Future scenarios matter

It has been argued so far that digital technologies will have ambiguous effects on GVCs. On the one hand, those technologies that help to coordinate geographically dispersed tasks will likely lead to longer and more complex value chains in the future. On the other hand, those technologies that reduce the relative costs of domestic production to offshore production could lead to less GVC trade.

The outlook is uncertain not only because different digital technologies have different effects, but also because the same technology could increase or decrease GVC trade, depending on future scenarios regarding its adoption. This is most notably the case of 3D printing. Along value chains, most 3D printing is concentrated in upstream activities like prototyping, product development and R&D.[37] In a scenario in

which 3D printing continues to be used mostly for upstream activities in GVCs, it is likely that traditional production methods and 3D printing will complement each other rather than compete (WTO, 2013c).

In the longer run, however, 3D printing may to some extent substitute traditional manufacturing methods. By making it possible to produce final consumption goods at the point of sales, the need for outsourced production and assembly might be reduced, thus lowering the number of production steps (De Backer and Flaig, 2017; Moradlou et al., 2017; Strange and Zucchella, 2017). Value chains in a world of pervasive 3D printing might overwhelmingly be based on the cross-border exchange of digitally-transmitted designs, blueprints and software, rather than on the cross-border exchange of material goods (PWC, 2014; Kommerskollegium, 2016).

A radical shift in the organization of production, from mass production to mass customization, would also have radical implications for value chain trade. Long and complex GVCs emerged as an efficient way of organizing production of standardized products, exploiting economies of scale and gains from specialization. In a world where supply shifts away from mass production towards mass customization, long and complex value chains do not provide the necessary flexibility to adapt to changing demand conditions. According to some commentators (Standard Chartered, 2016; De Backer and Flaig, 2017), value chains may become shorter in response to such shifts, with production centres emerging near every large customer base (Baldwin, 2013) or near centres of innovation (Spence, 2018).

To conclude, while it is undisputed that digital technologies will deeply affect the nature, complexity and length of value chains in the future, the question of whether the net effect of digital technologies will be a reduction or an increase in GVC trade is an open one.

3. Quantitative analysis of the impact of new technologies on trade

In this section, the qualitative analysis undertaken earlier, which identified the ways in which new technologies and digitalization can affect international trade, is complemented with quantitative projections on changes in the size and patterns of international trade. To this end, the Global Trade Model, a recursive dynamic computable general equilibrium (CGE) model is employed, featuring multiple sectors, multiple production factors, intermediate linkages, capital accumulation, a global transport sector and a host of taxes.[38] The model is based on the facelift version of the GTAP-model (Version 7) with the following additional features. The model is recursive dynamic, allowing for endogenous capital accumulation, features endogenous factor supply, contains different options to allocate global savings, and is flexible in its trade structure allowing to switch between the Armington perfect competition, Ethier-Krugman monopolistic competition, and Melitz-structures firm heterogeneity structures. More details on the model are provided in Appendix C.3.

Quantitative analysis serves three important goals. First, it disciplines the qualitative predictions, as it forces analysts to translate the storylines into quantitative shocks in a micro-founded economic model, which is based on agents' optimizing behaviour. Second, the use of a consistent general equilibrium model (that is, within a set up where all markets and their interactions are taken into account) implies that indirect effects of shocks across countries and sectors are all taken into account. Third, the fact that the model is computable makes it possible to go beyond qualitative predictions and provide actual numbers on the expected effects of new technologies on international trade. As a caveat, it should be emphasized that some of the expected changes are inherently difficult to predict. Quantitative predictions should therefore be interpreted with care.

In particular, the impact of the following three trends on the size and patterns of international trade is explored. First, the impact of digitalization, robotization, and artificial intelligence (AI) on the allocation of tasks between labour and capital is studied. These trends will reallocate more tasks in the economy away from labour towards capital (defined in a broad way) and at the same time raise productivity. The task-based approach in Acemoglu and Restrepo (2016), discussed further below, is employed to model this phenomenon. AI can be a form of automation which, rather than substituting machine power for manual labour, substitutes the computing ability of machines for human intelligence and expertise. As such labour is substituted by capital (broadly defined, the capital intensity of production rises).

In the quantitative analysis, changes in the capital intensity of production are projected conservatively, based on historical empirical trends and productivity growth varying by sector and region, based on various studies and indicators on the differential productivity impact of these phenomena.

Second, changes in the production structure leading to a more intensive use of ICT-services by other

sectors in the economy, defined as servicification, are explored. New technologies are expected to lead to a more intensive use of ICT services inputs in other sectors. Conservatively, the change in ICT-services over the next 15 years is projected based on changes in the last 15 years visible in global input-output data from the World Input-Output Database (WIOD).

Third, the impact of new technologies on trade costs is examined. Along various channels, digital technologies are expected to reduce trade costs. In particular, the improvement of customs procedures, the rising efficiency of logistics, falling communication costs associated with different languages, and falling contract enforcement costs due to the development of blockchain are taken into account. The expected reductions in trade costs are inferred by employing empirical estimates of the impact of the mentioned channels on the size of trade costs.

Before exploring the impact of new technologies and digitalization, a baseline scenario for the world economy needs to be constructed. The baseline scenario projects the development of the world economy until 2030 without technological changes as a result of digitalization, robotization and AI. The baseline is constructed using 2011 base data from GTAP 9.2 and macroeconomic projections from IMF, OECD, and CEPII and WTO calculations on structural change. To keep the model and presentation of results tractable the base data are aggregated to 14 regions, 16 sectors, and five factors of production. Further details on the construction of the baseline are provided in Appendix C.3.

(d) The impact of new technologies on trade

To study the impact of digitalization on global trade, the effects of three trends are explored quantitatively: (i) a reallocation of tasks in production because of robotization and digitalization; (ii) the servicification of the production process with a rising share of the use of ICT services in the rest of the economy; and (iii) falling trade costs as a result of technological changes. The three trends are translated into quantitative shocks to the baseline projections, which are the business-as-usual projections of the economy without technological changes. For each of the three shocks, a core scenario and a convergence scenario are developed, where the latter foresees an acceleration of the three trends in developing countries.

Since technological developments are highly uncertain, the trends modelled are an indication of the direction global trade is projected to take. The size of the effects of different trends is based on econometric work together with scenario building (for falling trade costs), on predictions from the literature (for the productivity part of digitalization and robotization) and on trends in the past (for rising capital income shares and servicification).[39] This subsection discusses the way the shocks are introduced in our model. The next subsection compares the outcomes of the implementation of these shocks in terms of the most relevant variables in the baseline, core and convergence scenarios.

(i) Description of the three trends

Digitalization, robotization and reallocation of tasks

The expected technological changes as a result of digitalization, robotization and AI are described extensively in Section B. Technological changes as a result of robotization and artificial intelligence are modelled here following the approach in Aghion et al. (2017).

In this set-up, a continuum of tasks has to be completed in order to produce. Robotization will reallocate tasks from labour to capital, which has two effects: first, it will raise the capital income share, and second, it will raise productivity. The second effect occurs if the initial allocation of tasks is not optimal, as pointed out by Acemoglu and Restrepo (2016).[40] Since the extent of reallocation of tasks cannot be observed, the base scenario will be disciplined by changes in two observable variables, the capital income share and productivity growth, varying across countries and sectors. Appendix C.2 describes how average projected changes in capital income share and productivity are calculated and how they then vary across sectors and countries. The variations in changes in the capital income share and in productivity growth are assumed to be identical.[41] With respect to variation across countries, two scenarios are developed for productivity growth and rising capital income shares as a result of robotization: a base scenario and a convergence scenario with developing countries catching up in comparison to the base.[42]

Servicification of the production process

Digitalization will affect the sectoral structure of production, generating a process of servicification. In particular, the use of information and communication technology services by other sectors of the economy will rise. To infer the extent of servicification, the change in the share of ICT services in the World Input-Output Database (WIOD) from 2000 to 2016 (more specifically the share of sectors J62 –

"Computer programming, consultancy and related activities" – and J63 – "Information service activities") were computed. The data show that the average share of sectors J62 and J63 in the total intermediate demand by all sectors has doubled in 15 years from about 2.5 per cent to 5 per cent.

Based on these changes in the last 15 years, two scenarios are developed in this report, a core scenario and a convergence scenario. In the core scenario the share of ICT services used by other sectors grows at a constant rate for all regions. In the convergence scenario, the share grows more in countries that started with a lower share in the 2000-2016 period than the region with the highest share.

Falling trade costs

New technologies are expected to lead to a reduction of trade costs in a number of areas. First, digitalization will improve the handling of customs procedures. Second, logistics efficiency is expected to rise. Third, the negative impact of language differences may have less impact with the development of new technologies. And fourth, the emergence of blockchain and other digital forms of finance may reduce the effects of bad contract and credit environments. A detailed description of how falling trade costs are modelled can be found in Appendix C.3.

(ii) The impact of new technologies on trade

This section presents the impact of the three trends described above in the core, and convergence scenarios on the following outcomes: (i) annual trade growth; (ii) the share of developing countries in global exports; (iii) changes in the sectoral and geographical distribution of production; (iv) changes in the global value chain measures imported intermediates in gross output and foreign value-added; and (v) the share of imported services in manufacturing output. For comparison the values in the baseline are also presented. Table C.3 displays an overview of the three trends modelled in the different scenarios.

Four main results are obtained. First, technological changes are expected to raise trade growth, as a result of both falling trade costs and the more intensive use of ICT services. Second, the trend of a rising share of developing countries in global trade can be weakened if developing countries do not manage to catch up in terms of all three phenomena modelled: technology growth associated with new technologies, reductions in trade costs, and increased ICT services in the production process. Third, the trend of a rising share of services exports

Table C.3: Overview of trends modelled in the two scenarios

	Scenarios	
Trends	**Core**	**Convergence**
Digitalization and robotization	Differential productivity growth by sector and region as a function of, respectively, scope for technological change and digital readiness.	Differential productivity growth across sectors in the same way as in the core scenario, with lagging regions catching up to 25% best performing regions in terms of productivity growth.
Servicification	Doubling of the share of ICT services and consultancy used by all other sectors. Constant growth in the share across regions.	Doubling of the share of ICT services and consultancy used by other sectors. Larger growth in the share in lagging regions.
Falling trade costs	Reductions in iceberg trade costs* as a result of new technologies along four channels. Identical reductions across different regions.	Reductions in iceberg trade costs as a result of new technologies along four channels. Trade costs in high-trade cost pairs converging to trade costs in 25% lowest-trade cost pairs.

* Iceberg trade costs (first modelled by Samuelson, 1954) are the costs of transporting a good when that transport uses up some fraction of the good itself, rather than other resources. Iceberg trade costs are called this way in an analogy with floating icebergs, part of which melt while floating.

in total exports is reinforced for most countries by the modelled technological developments. Fourth, the impact of these developments on the organization of value chains as measured by foreign value added in exports or imported intermediates in gross export is limited. Nevertheless, we find that the rising share of services imports in manufacturing gross output becomes much stronger with technological changes, both as a result of servicification and falling trade costs for services.

Table C.4 contains the first main message of the analysis: technological changes are expected to raise trade growth. This is the result of both falling trade costs and the more intensive use of ICT services. The figure compares the annual trade growth in the baseline, the core scenario, and the convergence scenario. It is clear from the figure that the additional trends raise trade growth considerably in the different regions. The impact is bigger in regions displaying smaller trade growth in the baseline scenario. As expected, the lower-income regions display stronger trade growth in the convergence scenario. Globally trade grows by 1.8 to 2 percentage points more in

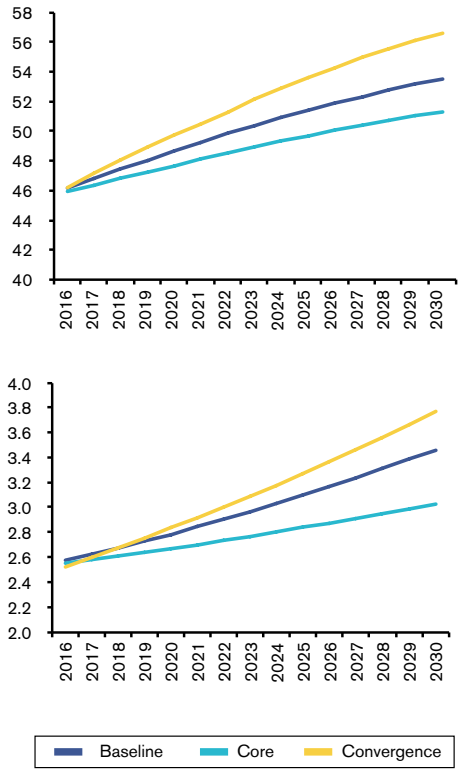
Table C.4: The average annual real trade growth between 2016 and 2030 (%)

Region	Baseline	Core	Convergence
ASEAN	5.47	7.60	7.99
Brazil	1.69	4.86	4.66
China	6.62	8.72	8.66
European Union (28)	1.51	3.20	3.27
India	7.46	9.33	9.61
Japan	1.54	2.96	2.98
Latin America and Caribbean	3.37	5.44	5.68
Middle East and North Africa	3.66	5.76	6.22
Nigeria	5.72	7.13	7.93
Other Asian countries	3.96	6.12	6.51
Other developed countries	2.46	4.35	4.27
Rest of the world	2.61	4.65	5.25
Sub-Saharan Africa	5.27	7.05	8.25
United States	2.40	3.85	3.47
Global	3.29	5.17	5.32

Source: Authors' own calculations with WTO Global Trade Model.

Notes: The figure displays annual real trade growth in the different regions and globally (trade weighted average). Details on the aggregation are in Appendix Table C.3. ASEAN is Association of Southeast Asian Nations.

Figure C.25: The share of developing (upper panel) and least-developed (lower panel) countries in global exports (per cent)



Source: Own calculations with WTO Global Trade Model.

Notes: The figure displays the share of developing countries' (upper panel) and LDCs' (lower panel) exports in global exports (including intra-regional international trade).

the different regions in the core and convergence scenarios compared to the baseline. This corresponds with a 31 to 34 percentage points larger trade growth in the core and convergence scenarios over 15 years.

Figure C.25 displays the second main message of the analysis: the trend of a rising share of developing countries in global trade can be weakened if developing countries do not manage to catch up in terms of all three phenomena modelled, i.e. technology growth associated with new technologies, reductions in trade costs, and the rise of ICT services in the production process. The figure shows that the export share of developing countries (upper panel) rises over time, but much less so in the core scenario. The share of developing countries in global exports rises from 46 per cent in 2015 to 57 per cent in the convergence scenario, whereas it rises only to 51 per cent in the core scenario without catch-up. A similar positive trend holds for the share of LDCs (lower panel).

The third main message of the analysis is that the trend of a rising share of services exports in total exports is reinforced for most countries by the modelled technological developments, as shown in Table C.5. This is due to the fact that trade costs fall more for the services sectors and that the servicification trend leads to a rising importance of services in the economy and thus also of trade. Globally, the share of services trade in total trade rises from 21 per cent in 2016 to 25 per cent in the two scenarios, whereas it is projected to stay at 22 per cent in the baseline scenario (see the last row of Table C.5).

Examining the results of the separate servicification shock indicates that global export shares of the affected ICT-services are reallocated away from the traditionally strong exporters of these goods.[43] The reason is that the largest producers of ICT services will demand the largest increase in demand for these services in terms of values. Therefore, they will produce more for the domestic market and also attract more imports from other countries. Hence,

Table C.5: The share of services exports in total exports per region in 2016 and in the baseline, core and convergence combined scenarios in 2030 (per cent)

Region	2016	Baseline 2030	Core 2030	Convergence 2030
ASEAN	20.14	21.03	22.33	21.99
Brazil	15.04	15.65	17.57	18.58
China	8.37	9.12	10.21	10.56
European Union (28)	28.30	33.20	35.71	36.17
India	30.73	33.45	39.35	39.60
Japan	15.04	20.16	22.75	23.67
Latin America and Caribbean	12.49	13.06	14.65	16.23
Middle East and North Africa	13.66	13.48	16.59	17.15
Nigeria	3.37	3.04	4.17	4.39
Other Asian countries	26.36	28.54	29.35	26.80
Other developed countries	19.63	21.09	23.95	26.14
Rest of the world	14.49	15.53	18.44	20.71
Sub-Saharan Africa	12.44	11.91	14.83	13.02
United States	24.76	27.68	31.62	33.26
Global	20.95	21.08	24.70	25.03

Source: Authors' own calculations with WTO Global Trade Model.

Notes: The figure displays the share of services exports in total exports in 2016 and in 2030 in the baseline, core and convergence scenarios (including intra-regional international trade).

Table C.6: The share of imported intermediates in gross output in 2016 and in the baseline, core and convergence combined scenarios in 2030 (per cent)

Region	2016	Baseline 2030	Core 2030	Convergence 2030
ASEAN	18.03	18.10	18.64	18.67
Brazil	5.38	5.53	5.68	5.68
China	8.00	7.54	8.20	7.90
European Union (28)	15.25	14.80	14.42	14.48
India	11.49	12.09	11.87	11.83
Japan	6.60	6.98	6.83	6.80
Latin America and Caribbean	9.62	9.12	9.58	9.45
Middle East and North Africa	11.65	10.96	11.46	11.65
Nigeria	5.16	5.53	5.52	5.57
Other Asian countries	17.25	17.52	17.82	18.21
Other developed countries	9.55	9.09	9.19	9.09
Rest of the world	7.94	7.80	8.35	8.82
Sub-Saharan Africa	11.83	11.52	11.78	12.27
United States	6.04	6.09	6.34	5.98
Global	10.33	10.07	10.32	10.29

Source: Own calculations with WTO Global Trade Model.

Notes: The figure displays the share of imported intermediates in gross output in 2016 and in 2030 in the baseline, core and convergence scenarios (including intra-regional international trade).

comparative advantage export patterns of ICT services will become less pronounced as a result of the demand-driven shock.[44]

Fourth, the impact of the three trends on the organization of value chains is limited. Table C.6 displays the share of foreign value-added in imported intermediates, showing that for most regions, except for the European Union, the share of imported intermediates in gross output rises in both the combined core and convergence scenario. This is again due to the fact that trade costs are falling, thus making it more attractive to employ imported intermediates in production.

Nevertheless the rising share of services imports in manufacturing gross output becomes much stronger with the technological changes, as is clear from Table C.7. This is caused by the combination of falling trade costs, especially for services, and the servicification leading to more imports of ICT services.

Finally, it is found that the reallocation of tasks leading to a rising capital income share will not lead to a fall in foreign value-added or imported intermediates in gross output. Hence, there seems to be no support for the idea that rising capital shares in developed economies would lead to reshoring of manufacturing activity and thus reduced imports of foreign intermediates. This result is in line with other findings in the literature as discussed in Section C.2(c).[45]

Table C.8 displays the share of foreign value-added in output to illustrate this point. The separate task reallocation shock also generates other interesting results. In particular, it is predicted to reduce the

Table C.7: The share of imported services in manufacturing (gross) output in 2016 and in the baseline, core and convergence combined scenarios in 2030 (per cent)

Region	2016	Baseline 2030	Core 2030	Convergence 2030
ASEAN	0.99	1.08	1.32	1.39
Brazil	0.58	0.74	0.83	0.86
China	0.49	0.43	0.52	0.49
European Union (28)	2.76	3.22	4.00	4.00
India	1.21	1.17	1.47	1.60
Japan	0.37	0.41	0.51	0.50
Latin America and Caribbean	0.70	0.78	0.91	0.94
Middle East and North Africa	1.31	1.47	1.71	1.83
Nigeria	0.49	0.65	0.68	0.74
Other Asian countries	0.94	1.03	1.30	1.40
Other developed countries	1.34	1.55	1.90	1.85
Rest of the world	0.72	0.79	0.94	1.05
Sub-Saharan Africa	1.39	1.46	1.71	1.86
United States	0.39	0.45	0.58	0.53

Source: Own calculations with WTO Global Trade Model.

Notes: The figure displays the share of imported services intermediates in manufacturing gross output in 2016 and in 2030 in the baseline, core and convergence scenarios (including intra-regional international trade).

Table C.8: The share of foreign value-added in exports in 2030 as a result of digitalization and robotization (per cent)

Region	Baseline	Core	Convergence
ASEAN	23.75	23.75	23.73
Brazil	9.97	9.68	9.81
China	18.75	18.51	18.50
European Union (28)	17.68	17.44	17.45
India	23.68	23.22	23.23
Japan	16.05	15.95	15.95
Latin America and Caribbean	12.63	13.21	13.24
Middle East and North Africa	6.98	7.00	6.98
Nigeria	2.24	2.33	2.30
Other Asian countries	28.71	28.48	28.57
Other developed countries	15.55	15.66	15.75
Rest of the world	6.98	6.95	6.93
Sub-Saharan Africa	11.95	12.09	11.97
United States	14.58	14.65	14.70

Source: Authors' own calculations with WTO Global Trade Model.

Notes: The figure displays the share of foreign value-added in exports (as defined in Koopman et al., 2014) in 2030 in the baseline, core and convergence scenarios (excluding intra-regional international trade).

export share of the United States in global exports. The United States is projected to display the largest technological changes, which in turn leads to a stronger orientation of the United States on its domestic economy

(iii) Comparison with other studies

The quantitative projections in this section on the impact of new technologies on trade are comparable to a number of studies in the literature. First, De Backer and Flaig (2017) conduct quantitative simulations on the future of global value chains modelling various trends of which one is digitalization. They predict that this trend will lead to some reshoring of economic activity, as measured by a reduction of imported intermediates in production. The current study predicts instead a positive small increase in the share of imported intermediates in production, especially for the share of imported services intermediates. The difference in findings can be explained with the modelled shocks. Whereas De Backer and Flaig (2017) model a standard increase in total factor productivity varying by sector, the current study models productivity increases in the framework of a reallocation of tasks between labour and capital to capture *both* digitalization and robotization. Furthermore, the current study includes also falling trade costs and servicification to capture the effects of new technologies. These trends lead to an increase in trade and also an increase in imported intermediates in gross output.[46]

De Backer and Flaig (2017) also construct a combined scenario including different shocks, which also generates a falling share of intermediate inputs

in gross output. This result is hence contrasting the findings in this report, suggesting an increase in the share of intermediate inputs in gross output. The reason for this difference is threefold. First, as discussed above, the digitalization shock is implemented more broadly in this report as a reallocation of tasks. Second, this report models a fall in trade costs as a result of new technologies, whereas De Backer and Flaig (2017) include rising trade costs in their combined scenario (reflecting rising energy prices). Third, other shocks are different. This report incorporates rising servicification, leading to a rising share of imported (services) intermediates in gross output, while De Backer and Flaig (2017) incorporate a growing labour force, rising wages and rising consumption in emerging countries. The latter three trends are already part of the baseline in this report.

Second, several studies have conducted simulations projecting the future of the world economy and global trade, for example the *World Trade Report 2013* (WTO, 2013c). Compared to the current study, the *World Trade Report 2013* attempted to make general projections about the future of global trade, whereas this report focuses on the impact of new digital technologies on the future of global trade. To show how the current projections on the future of global trade differ from earlier work by the WTO-secretariat, In Appendix C.3, outlining the baseline projections, differences and similarities between the simulations in the *World Trade Report 2013* and the current simulations are further addressed.

4. Conclusions

Understanding the factors that will be shaping trade as digital trade evolves is essential to maximize the gains from trade and address the challenges. This section aims to identify the mechanisms by which digital technologies will affect trade as well as opportunities and challenges. The section identifies five key messages.

First, digital technologies have lowered and will continue to lower traditional trade costs. As described in Section C.1, several recent technological advances have had a large impact on transportation and logistics costs. The use of GPS for navigation and autonomous driving capabilities or real time itinerary mapping reduce costs, enable real-time adjustments and make delivery more secure. Online platforms help reduce the costs of matching buyers and sellers, of obtaining market information and supplying information to potential consumers. Such platforms can help boost participation in international trade even more than domestic trade and provide mechanisms such as feedback and guarantees that improve consumer trust in online sellers.

Second, digital technologies provide new opportunities for MSMEs and developing countries to benefit from trade, but they also raise new challenges. One the one hand, many innovative and productive small firms now have the potential to become successful international traders as well. Moreover, since distance matters less in online trade, trade provides opportunities for remote countries and remote areas.

On the other hand, these innovations may be impeded by challenges, such as the lack of digital connectivity in some parts of the world. Progress in terms of mobile/cellular, fixed broadband, and internet penetration is not yet uniform, and this causes difficulties for some smaller businesses. Other challenges include inadequate regulatory frameworks, institutional weaknesses, insufficient private investment and underdeveloped infrastructures (including not only ICT infrastructure, but also payment mechanisms, for example). “Winner-takes-all” dynamics and new forms of barriers (such as to data flows) will also determine how gains from this new technology revolution will be distributed.

Third, new technologies will affect the composition of trade, increasing its services component of trade and fostering trade in certain type of goods. Technological developments in digital infrastructure services have enhanced the cross-border tradability of services, in turn expanding export opportunities and changing the structure of international trade in services (increasing importance of Mode 1 services – i.e. cross border trade – and of sectors other than travel and transport). Services sectors that can more readily be supplied electronically have experienced strong growth. The participation of developing countries in trade is strong in sectors such as computer services and back-office services.

The services component of trade has increased not only because of the greater ease of supplying services digitally, but also because new ways of delivering services emerge and replace trade in goods (like in the case of music streaming versus trade of CDs), and because international production networks increase the services content of manufacturing goods. These phenomena can be expected to continue, and so will the importance of services in the composition of trade. This will increase the relative importance of barriers to trade in services.

As regards the composition of trade in goods, we should expect the reduction of trade costs induced by digital technologies to foster trade in time-sensitive goods, certification-intensive goods and contract-intensive goods. By the same token, we should also expect an increase in trade in customizable goods. The decreasing trend in the trade of certain digitizable goods – such as CDs, books and newspapers – is likely to continue with the advent of 3D printing technology. Finally, the "sharing economy" business model could affect trade in durable consumer goods.

Fourth, digital technologies will deeply affect the nature, complexity and length of value chains in the future. However, it is hard to predict whether digital technologies will reduce or increase GVC trade. In combination with innovations in logistics, the reduction of transaction costs through the internet has led to an enormous expansion of GVCs. Yet, new technologies can also bring a reversal of this process: reshoring.

Fifth, new technologies will affect the role that capital, labour and institutions play to determine the patters of trade. There is the impact of AI on capital, of 3D printing on the role that port infrastructure play, and potential of blockchain technologies to affect the role that institutions play. Other factors will however also shape patterns of trade in the future. These are regulations and digital infrastructure endowment. These factors will be key determinants of the extent to which developing countries will be able to participate in the new global e-markets.

In order to get a sense of the potential quantitative impacts of these changes, in this section we also simulate the impact of some of the changes that new technologies may bring on international trade by 2030. Using a computable general equilibrium model, we examine the impact of three trends: the reallocation of tasks between labour and capital related to robotization and digitalization, the servicification of the production process, and the fall in trade costs. Our simulations show that future technological changes are expected to increase trade growth, especially trade in services, compared to the baseline-standard projections of the world economy until 2030. Global trade is projected to grow by around 2 percentage points more as a result of these trends compared to the baseline, and the share of services trade is projected to grow from 21 per cent to 25 per cent. Developing countries are likely to gain an increasing share of global trade, but the quantitative effects will depend on their ability to catch up on the adoption of digital technologies. With that catching-up, developing and least-developed countries' share in global trade is predicted to grow to 57 per cent by 2030 from 46 per cent in 2015. The organization of global production is projected to change through a rising share of imported intermediate services in manufacturing.

Appendix C.1: Trade costs decomposition

As proposed by Head and Ries (2001), bilateral iceberg trade costs can be expressed as a ratio of intra-national trade flows to domestic trade flows. Mathematically, this translates to

$$t_{ij}^k \cdot t_{ji}^k = \left(\frac{x_{ii}^k \cdot x_{jj}^k}{x_{ij}^k \cdot x_{ji}^k} \right)^{\frac{1}{\sigma_k - 1}},$$

where t_{ij}^k are trade costs faced by imports from country i's industry k to country j, x_{ii}^k is domestic trade of country i, x_{ij}^k are bilateral imports from country i's industry k to country j, and σ_k is industry-specific elasticity of substitution. This structure allows a calculation of bilateral trade costs using the observed bilateral and domestic trade flows.

Since the above-defined trade costs are non-directional at the bilateral level (see Chen and Novy, 2011 for more details), a geometric average is used by taking the square root of the above expression. The average bilateral trade costs (θ_{ij}^k) can then be expressed as

$$\theta_{ij}^k = \left(\frac{x_{ii}^k \cdot x_{jj}^k}{x_{ij}^k \cdot x_{ji}^k} \right)^{\frac{1}{2(\sigma_k - 1)}}.$$

The more two countries trade with each other (i.e., the higher is $x_{ij}^k \cdot x_{ji}^k$), the lower is the measure of relative trade frictions *ceteris paribus* (i.e. all else being equal). Conversely, if the domestic trade increases in either of the two countries (i.e. the higher is $x_{ii}^k \cdot x_{jj}^k$), the higher is the measure of relative trade frictions *ceteris paribus*. In the subsequent analysis, we identify the factors which explain θ_{ij}^k, run a regression analysis and use the results to decompose the variation in θ_{ij}^k into different types of trade costs.

To construct the dependent variable θ_{ij},[47] we use the international and domestic trade data from the World Input-Output Database (WIOD) and, following Chen and Novy (2011), σ is assumed to be the same across sectors and take the value of eight.

The estimated equation is

$$\ln(\theta_{ij}) = \alpha + \beta \cdot Transport_{ij} + \gamma \cdot Logistics_{ij} + \delta \cdot Border\ costs_{ij} + \varphi \cdot Information\ and\ transaction\ costs_{ij} + \rho \bullet Trade\ policy_{ij} + \epsilon_{ij}.$$[48]

▪ To capture the impact of transportation costs on total trade frictions, the set of variables in $Transport_{ij}$ includes the geometric average of the effective transportation distance as in Egger et al. (2018), being landlocked and having a common border (Mayer and Zignago, 2011).

▪ To capture the impact of logistics costs, $Logistics_{ij}$ includes the log of the geometric average of the Liner Shipping Connectivity Index[49] and the log of the geometric average of five out of six sub-components of the Logistics Performance Index – the quality of trade and transport infrastructure; the ease of arranging competitively priced shipments; the competence and quality of logistics services such as trucking, forwarding, and customs brokerage; the ability to track and trace consignments; and the frequency with which shipments reach consignees within scheduled or expected delivery times.[50]

▪ To capture the impact of time delays related to customs procedures, $Border\ costs_{ij}$ is the geometric average of the lead to time to export.[51]

▪ To capture the impact of information and transaction costs, the set of variables in $Information\ and\ transaction\ costs_{ij}$ includes common ethnic language, common coloniser, previous colony, previously the same country (Mayer and Zignago, 2011), the log of geometric average of the bilateral stock of migrants,[52] the log of geometric average of the depth of credit information index and the log of geometric average of the enforcing contracts indicator.[53]

▪ Trade policy barriers ($Trade\ policy_{ij}$) are captured by dummies for having a free trade agreement and being part of the European Union (Egger and Larch, 2008). They also include the log of geometric average of the two countries exchange rates.[54]

The regression is run on data from 2014 and includes 36 countries, which is the largest sample for which all variables are available. Cyprus, Luxembourg and Malta are excluded due to their small sizes.

The regression coefficients are then used to identify the contribution of different trade costs categories to the variance in trade costs across countries. For instance, the contribution of border costs to the trade costs variance is calculated as:

$$\hat{\delta} * \frac{Covariance(\ln(\theta_{ij}),\ Border\ costs_{ij})}{Variance(\ln(\theta_{ij}))}$$

where $\hat{\delta}$ is the estimated coefficient associated with the *Border costs* variable. The coefficient is multiplied by the covariance between the dependent variable and the *Border costs* variable, and divided by the variance of the dependent variable. Contributions of trade costs categories that consist of several variables are calculated as a sum of the individual contributions. The contributions of all the explanatory variables sum to the R-squared of the regression. The unexplained component then reflects any frictions that are not captured by the variables included in the regression.

Appendix C.2: IP protection and comparative advantage in IP-intensive industries

Digital assets and technologies play an increasingly important role in the production process. Because digital products are sensitive to IP protection, strong IP protection might have a productivity-enhancing effect on industries that rely on a digitalized production process.

In light of this, strong IP protection might be a source of comparative advantage because it raises the relative productivity of IP-intensive industries in countries that have strong IP protection compared to other countries.

Nevertheless, very strong IP protection can also impede productivity growth as it reduces the availability of more efficient production technologies and might slow down innovation. Therefore, the effect of strong IP protection is in principle ambiguous.

This appendix gives an empirical assessment of the relationship between the level of IP protection in a country and exports from industries that require relatively more IP protection.

To examine whether countries with high IP protection have a comparative advantage in IP-intensive industries, the following econometric specification was estimated by ordinary least squares (OLS).

$$\ln(Trade_{gij}) = \alpha_i + \alpha_{gj} + \beta(ipi_g * IPP_i) + \theta(ipi_g * GDPpc_i) + \sum_a \delta^a (z_g^a * Q_i^a) + \boldsymbol{X_{ij}\gamma} + \varepsilon_{gij}$$

Chor (2010) derives this specification from a sectoral Eaton and Kortum (2002) model. The dependent variable is the natural logarithm of exports from country *i* to country *j* produced by industry *g* denominated in US$. The main explanatory variable of interest is the interaction term between the use of IP protection in industry *g* (ipi_g) and the strength of IP protection in the exporting country i (IPP_i). All further terms in the specification control for confounding factors.[55]

The use of IP protection by industry is measured as the number of filed patents divided by the number of employees in that industry. This information is available for 82 manufacturing industries from a report by the European Patent Office and the European Union Intellectual Property Office (EPO and EUIPO, 2016). The level of IP protection is based on a survey-based measure of IP protection from the WEF's Global Competitiveness Index (Schwab and Sala-i-Martín, 2014).[56] The results are reported in Appendix Table C.1.

Column 1 in Appendix Table C.1 shows that the coefficient on the IP interaction term is statistically significant and positive. This result suggests that IP-intensive industries export significantly more from countries that have strong IP protection mechanisms. This effect persists even when controlling for the interaction of industry IP intensity and GDP per capita ($ipi_g * GDPpc_i$), which controls for the level of economic development (column 2) and accounting for traditional sources of comparative advantage: human capital ($z_g^{HC} * Q_i^{HC}$) and physical capital ($z_g^{PC} * Q_i^{PC}$) (column 3).[57]

Heterogeneous effects across countries with different levels of IP protection are further investigated. To this end, the interaction of industry IP intensity and GDP per capita ($ipi_g * GDPpc_i$) is in turn interacted with an indicator variable D_i that is 1 if the IP protection index in exporting country i is above the global median of the index. This specification allows for the separation of the comparative advantage effect for countries with high IP protection and countries with lower IP protection. The results are reported in Appendix Table C.2. As before, the coefficient on the IP interaction is positive and statistically significant. However, the triple interaction term is significant and negative. The two effects have the same absolute size. This result indicates that the positive effect of IP protection on IP-intensive exports holds as long as a country's strength of IP protection is below the median level of protection. Once a country is positioned in the upper half of the IP protection index, further strengthening IP protection has no effect on exports from IP-intensive industries.

To summarize, it is found that, on average, strong IP protection is a source of comparative advantage in IP-intensive industries. Furthermore, once a country's strength of IP protection is above a certain threshold, a further increase in IP protection does not increase comparative advantage in IP-intensive industries.

Appendix Table C.1: Intellectual property protection as a comparative advantage

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable	**ln($Trade_{gij}$)**	**ln($Trade_{gij}$)**	**ln($Trade_{gij}$)**	$Trade_{gij}$	$Trade_{gij}$	$Trade_{gij}$
$ipi_g * IPP_i$	0.0211***	0.00524***	0.00477***	0.0281***	0.00514	0.00820*
	(0.000599)	(0.00103)	(0.00101)	(0.00299)	(0.00356)	(0.00384)
$ipi_g * GDPpc_i$		0.0105***	0.0078***		0.0142***	0.0155***
		(0.00544)	(0.00053)		(0.00162)	(0.00150)
$z_g^{HC} * Q_i^{HC}$			2.614***			-1.444***
			(0.0774)			(0.336)
$z_g^{PC} * Q_i^{PC}$			-0.0794***			0.0037***
			(0.00978)			(0.00038)
Observations	366429	365241	364697	861186	852825	836103
Adjusted R-squared	0.588	0.588	0.591			
Exporting countries	103	102	100	100	100	100
Importing countries	103	103	103	103	103	103
Number of industries	82	82	82	82	82	82
Trade volume (US$ billion)	10197.6	10196.1	10195.9	10195.9	10195.9	10195.9

Source: WTO Secretariat estimates.

Notes: The table reports coefficients (and standard errors clustered by country pair in parentheses) from OLS (columns 1-3) and Poisson pseudo-maximum likelihood (PPML) (columns 4-6) estimations that regress $Tradeg_{ij}$ (or the log of it) on the interaction term $ipi_g * IPP_i$ and further covariates.

Trade data is from the CEPII's world trade database, BACI (Gaulier and Zignago, 2010); ipi_g is the number of filed patents divided by the number of employees in ISIC industry g; IPP_i is the WEF's Global Competitiveness Index for country i (Schwab and Sala-i-Martín, 2014); and D_i is a dummy being 1 if $IPP_i > median(IPP)$ and 0 otherwise.

Q_i^{HC} is an index of human capital per person, proxied by years of schooling and returns to education and Q_i^{PC} is capital stock at current PPPs (in trillion 2011 US$); both measures are from the Penn World Table version 9 (Feenstra et al., 2015).

$GDPpc_i$ is GDP per capita in country i from the CEPII gravity base (Head et al., 2010; Head and Mayer, 2014).

z_g^{HC} and z_g^{PC} are human capital intensity and physical capital intensity, equivalent to z_2 and k_3 in Romalis (2004), calculated using North American Industry Classification System (NAICS) industry-level data from National Bureau of Economic Research/the US Census Bureau's Center for Economic Studies (NBER-CES) that is mapped to the International Standard Industrial Classification of All Economic Activities (ISIC) classification using the NAICS 2002 to ISIC REV. 3.1 correspondence from EUROSTAT's Reference And Management Of Nomenclatures (RAMON) metadata server.

All specifications include exporter fixed effects, importer-industry fixed effects and the following controls for country-pair characteristics: bilateral distance, common language, common colonial history, shared border, common regional trade agreement membership and common WTO membership; these indicators are from the CEPII gravity base (Head et al., 2010; Head and Mayer, 2014). All data are for the year 2015, except for Q_i^{HC} and Q_i^{PC} (average 2008-2009), z_g^{HC} and z_g^{PC} (2011) and ipi_g (average 2011-2013).

Appendix Table C.2: Intellectual property protection as a comparative advantage. Heterogeneity across countries

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable	**ln($Trade_{gij}$)**	**ln($Trade_{gij}$)**	**ln($Trade_{gij}$)**	$Trade_{gij}$	$Trade_{gij}$	$Trade_{gij}$
$ipi_g * IPP_i$	0.0405***	0.0316***	0.0301***	0.120***	0.0864***	0.108***
	(0.00324)	(0.00327)	(0.00321)	(0.0172)	(0.0165)	(0.0192)
$ipi_g * IPP_i * D_i$	-0.0177***	-0.0296***	-0.0263***	-0.0943***	-0.0882***	-0.107***
	(0.00339)	(0.00327)	(0.00321)	(0.0177)	(0.0165)	(0.0192)
$ipi_g * D_i$	0.0484***	0.0981***	0.0832***	0.334***	0.329***	0.400***
	(0.0118)	(0.0114)	(0.0112)	(0.0633)	(0.0591)	(0.0689)
$ipi_g * GDPpc_i$		0.0110***	0.00799***		0.0149***	0.0163***
		(0.00056)	(0.000543)		(0.00171)	(0.00162)
$z_g^{HC} * Q_i^{HC}$			2.609***			-1.484***
			(0.0776)			(0.326)
$z_g^{PC} * Q_i^{PC}$			-0.0793***			0.369***
			(0.00977)			(0.0383)
Observations	366429	365241	364697	861186	852825	836103
Adjusted R-squared	0.588	0.588	0.591			
Exporting countries	103	102	100	100	100	100
Importing countries	103	103	103	103	103	103
Number of industries	82	82	82	82	82	82
Trade volume (US$ billion)	10197.6	10196.1	10195.9	10195.9	10195.9	10195.9

Source: WTO Secretariat estimates.

Notes: See notes to Appendix Table C.1.

Appendix C.3: Details on the quantitative analysis using the Global Trade Model (GTM)

(a) Global trade model and baseline projections

The WTO Global Trade Model (GTM) is a recursive dynamic CGE model, based on the facelift version of Purdue University's Global Trade Analysis Project (GTAP) model (Version 7). This means that the model features multiple sectors, multiple factors of production, intermediate linkages, multiple types of demand (private demand, government demand, investment demand and intermediate demand by firms), non-homothetic preferences for private households,[58] a host of taxes, and a global transport sector. Each region features a representative agent collecting factor income and tax revenues and spending this under utility maximization on private consumption, government consumption and savings. Firms display profit-maximizing behaviour, choosing the optimal mix of factor inputs and intermediate inputs. Savings are allocated to investment in different regions. The model is calibrated to the current GTAP database, which has 141 regions and 57 sectors, implying that baseline shares are equal to actual shares.[59]

The starting point is a baseline projection of the world economy until 2030. For the simulations described in Section C.3, an aggregation with 16 sectors, 14 regions, and 5 factors of production is used, as displayed in Appendix Table C.3. The sectoral aggregation includes the sectors of interest related to digitalization of the economy, such as telecommunications, business services, and electronic equipment. In order to shed light on the question how some of the newly emerging countries are affected by digitalization, countries like Brazil and Nigeria are included in the aggregation.

The simulations start from 2011 based on the latest release of GTAP 9, GTAP 9.2. Following standard approaches, projections on growth in GDP per capita growth, population, labour force and skills are used to discipline the trajectory of the world economy until 2030. The growth in population, labour force and skills are imposed on the projections, and GDP per capita growth is targeted by endogenizing labour productivity growth, while allowing for endogenous capital accumulation based on recursive dynamics. GDP per capita growth is based on actual International Monetary Fund (IMF) data and projections with the IMF Global Projection Model until 2014 (Carabenciov et al., 2013). From 2015, the

Appendix Table C.3: Overview of regions, sectors and production factors

Regions	Sectors	Production factors
Japan	Agriculture	Land
China	Mining and extraction	Unskilled labour
India	Processed food	Skilled labour
ASEAN	Chemicals and petrochemicals	Capital
United States	Other goods	Natural resources
Brazil	Metals	
Latin America and the Caribbean	Electronic equipment	
European Union (28)	Other machinery and motor vehicles	
Middle East and North Africa	Utilities and construction	
Nigeria	Trade	
Sub-Saharan Africa	Transport	
Other developed countries*	Communication	
Other Asian countries**	ICT services and consultancy	
Rest of world***	Other business services	
	Financial services and insurance	
	Other services	

Source: Authors' own aggregation based on regions, sectors, and production factors from GTAP 9.

* Australia, New Zealand, Canada, Norway, Switzerland.

** All other Asian countries.

*** All other GTAP regions.

OECD Shared Socioeconomic Pathways projections, SSP2, are used (Dellink et al., 2017). Population and labour force growth come from the United Nations population projections, medium variant for 2015 (UN DESA, 2015). Changes in the number of skilled and unskilled workers are inferred from projections on education levels by the International Institute for Applied Systems Analysis (IIASA) (KC and Lutz, 2017). In particular, the changes in the share of tertiary educated are used as a proxy for changes in the share of skilled workers. To allow for changes in the amount of land and natural resources employed, supply functions with supply elasticities equal to 1 are used. All the other parameters are set at standard values provided by the GTAP 9.2 database.

Besides these standard sources two other elements are incorporated in the model. First, to account for structural change (a rising share of services output in total output and falling shares of agriculture and manufacturing), we allow for differential productivity growth across sectors based on historical data. Second, the domestic savings rates are targeted to the projections of the CEPII macroeconomic model MaGE (i.e. (Macroeconometrics of the Global Economy) (Fouré et al., 2013). In this model, saving rates are determined by demographic developments in a life-cycle framework. Savings rates stay virtually constant in the basic model with savings a Cobb-Douglas share of national expenditures.

The results of the baseline simulations are similar to the results of the analysis on the future of world trade in the *World Trade Report 2013* (WTO, 2013c), so the results will be described only briefly. The baseline simulations display three main characteristics. First, the included structural change has a considerable impact, with production shares of services rising and production shares of manufacturing and agriculture falling. The extraction sector also displays growth, because there is limited scope for productivity growth in this sector which is mainly using natural resources. Second, the geographic distribution of trade is changing with developing countries taking over the dominant position in global trade from the developed countries. The LDCs also raise their market share in global trade, although it remains small in 2030. Third, the sectoral distribution of trade follows the production pattern driven by structural change, featuring a rising share of services trade at the expense of manufacturing trade.

Although some of the predictions of the simulations are similar, the current simulations differ both in setup and in focus from the simulations in the *World Trade Report 2013*. There are two main differences in set-up. First, in the current simulations, the baseline does not contain an autonomous reduction in trade costs to generate an increase in the trade-to-income ratio based on observed trade growth in the past, as in the *World Trade Report 2013*. This choice is made for two reasons. First, the experiments contain reductions in trade costs as a result of new technologies, which generate additional trade growth. Second, trade growth has largely followed income growth in the first half of the current decade (from 2011 to 2016) with a ratio of trade growth to GDP growth close to 1.

A second difference with the simulations in the *World Trade Report 2013* is that macroeconomic projections from different international agencies (such as the UN for population projections and the IMF and World Bank for growth projections) were employed to generate baseline projections in the current report. In the *World Trade Report 2013* the macroeconomic projections were based on one macroeconomic model, MaGE.

In terms of results, the current report comes to similar findings as the World Trade Report 2013. Geographically, both reports predict rising shares of developing countries in global trade and sectorally, both reports predict rising shares of services in global trade. However, the focus of the current report is different. Whereas the World Trade Report 2013 intended to make general projections on the trajectory of the global economy in general and trade in particular, the simulations in the current report focus on the impact of new technologies on global trade.

(b) Modelling technological change as a result of digitalization and robotization

Consider first the size of the average change in the capital income share. Changing capital income shares are modelled based on historical trends. Data from the Organisation for Economic Co-operation and Development's STructural ANalysis Database (OECD-STAN) and data collected by Karabarbounis and Neiman (2013) show that there is a long-run downward trend in the labour income share. The data show, moreover, that the downward trend is a phenomenon exclusively taking place in developed economies. Since it is hard to predict how large the impact of robotization on the labour income share will be until 2030, we take as a benchmark the historical decline in the labour income share. Bekkers and Francois (2018) display the change in the global labour income share over time, both globally based on the data collected by Karabarbounis and Neiman (2013) and in OECD countries only, based on data from OECD-STAN. The analysis shows that the

labour share fell from 0.54 in 1980 to 0.48 in 2010, a decline of about 0.002 per year. Phrased differently, this corresponds to a reduction of 2 percentage points in the labour income share per decade (0.2 percentage points annually).

Second, the size of the average productivity growth is discussed. Several studies have attempted to come up with projections on productivity growth as a result of robotization and digitalization. Information on the average size of productivity growth and on the distribution across sectors and countries is needed. For the size of the shock, two studies are employed, Bauer and Horváth (2015) and Boston Consulting Group (2017). The former study projects productivity growth in six sectors until 2025 in Germany as a result of "Industry 4.0", predicting average yearly growth of 1.27 per cent until 2025. The latter study examines the impact of robotization on productivity across sectors and countries, predicting an average cost reduction of 16 per cent up until 2025 (from 2015). Based on these studies, the average yearly productivity growth is assumed to be 1.25 per cent.

Third, consider the variation in the degree of digitalization across sectors. Four studies on variation across sectors in the degree of digitalization and robotization are used (Bauer and Horváth, 2015; Boston Consulting Group, 2017; Booz and Company, 2011; McKinsey Global Institute, 2015). These studies display to a large extent a uniform picture on which sectors mostly benefit from digitalization. The rankings of sectors in each of these studies were added up. This leads to the sectoral scaling factors as displayed in the first two columns of Appendix Table C.4.

Fourth, projections of the variation across countries in terms of digital readiness for the changes provoked by robotization and digitalization are needed. This variation is based on the Network Readiness Index (NRI) of the WEF (Baller et al., 2018), which is based on 53 sub-indices classifying countries in terms of regulatory and business environments related to ICT, usage of ICT, readiness (infrastructure, affordability and skills), and economic and social impact. The NRI is available for 139 countries and was aggregated using GDP-weighted averages. This leads to the country scaling factors displayed in the last two columns of Appendix Table C.4. For the convergence scenario, it is assumed that the regions lagging behind are catching up to the 75th percentile best performing country in terms of the NRI and thus also in terms of scaling.

Appendix Table C.4: Scaling factors for countries and sectors of digitalization shock

Sectors		Regions	
Metals	0.64	Nigeria	0.71
Processed food	0.65	Sub-Saharan Africa	0.77
Agriculture	0.65	India	0.84
Other services	0.66	Latin America and the Caribbean	0.86
Transport	0.73	Brazil	0.89
Extraction	0.86	China	0.93
Utilities	0.87	ASEAN	0.97
Other goods	0.87	Middle East and North Africa	0.97
Chemicals	0.99	Rest of the world	0.99
Other business services	1.05	Other Asia	1.14
Trade	1.07	European Union (28)	1.16
ICT and consultancy	1.22	Japan	1.24
Communication	1.23	Other developed economies	1.25
Finance and insurance	1.30	United States	1.29
Other machinery and motor vehicles	1.56		
Electrical machinery	1.64		

Source: Authors' own calculations.

(c) Modelling falling trade costs

To gauge the impact of technological change on trade costs, proxies for iceberg trade costs were regressed on variables associated with these developments. Using the approach originally proposed by Head and Ries (2001) and applied, among others, by Novy (2013), (symmetric) iceberg trade costs can be written as the ratio of international relative to intra-national trade flows in trade models with constant elasticity of substitution preferences such as the Armington or Krugman models (see Appendix C.1).

Employing the same methodology and data described in Appendix C.1, the equation for iceberg trade costs is estimated for the three aggregate sectors primary (agriculture and extraction), secondary (manufacturing), and tertiary (services) employing data from WIOD for 2014. Controlling for variables such as transport costs, the existence of a free trade agreement and a dummy for EU-membership, the following variables were included to determine the

Appendix Table C.5: Annual *ad valorem* equivalent trade cost reductions as a result of technological change, averages across importing regions and across sectors

Regions	Total	Common language	Lead time to export	Liner shipping connectivity index	Credit and contracts
Sub-Saharan Africa	-1.30	-0.34	-0.22	-0.21	-0.54
Rest of the World	-1.05	-0.42	-0.23	-0.34	-0.08
Middle East and North Africa	-0.91	-0.35	-0.19	-0.16	-0.21
Nigeria	-0.87	-0.30	-0.35	-0.12	-0.10
Other Asia	-0.85	-0.33	-0.09	-0.13	-0.30
ASEAN	-0.78	-0.35	-0.07	-0.15	-0.22
European Union (28)	-0.78	-0.41	-0.08	-0.14	-0.15
Brazil	-0.76	-0.43	-0.14	-0.06	-0.12
Latin America and the Caribbean	-0.66	-0.21	-0.18	-0.12	-0.15
Other developed economies	-0.63	-0.33	-0.04	-0.20	-0.06
India	-0.60	-0.26	-0.10	-0.06	-0.18
Japan	-0.59	-0.39	-0.10	-0.03	-0.08
China	-0.56	-0.35	-0.10	0.00	-0.12
United States	-0.43	-0.25	-0.11	-0.01	-0.06
Commodities					
Transport	-1.27	-0.68	-0.21	-0.30	-0.09
Communication	-1.25	-0.68	-0.20	-0.30	-0.09
ICT and consultancy	-1.24	-0.63	-0.21	-0.28	-0.12
Other business services	-1.23	-0.69	-0.19	-0.27	-0.09
Trade	-1.21	-0.70	-0.19	-0.24	-0.09
Processed food	-1.17	-0.48	-0.18	-0.19	-0.34
Other services	-1.16	-0.64	-0.23	-0.23	-0.07
Finance and insurance	-1.14	-0.66	-0.19	-0.22	-0.08
Utilities	-1.10	-0.55	-0.20	-0.30	-0.06
Chemicals	-0.79	-0.33	-0.13	-0.11	-0.22
Agriculture	-0.75	-0.48	0.00	-0.12	-0.15
Metals	-0.62	-0.26	-0.10	-0.09	-0.18
Other goods	-0.60	-0.27	-0.10	-0.07	-0.16
Other machinery	-0.59	-0.27	-0.10	-0.07	-0.16
Electrical machinery	-0.48	-0.22	-0.08	-0.04	-0.15
Extraction	-0.36	-0.22	0.00	-0.06	-0.08

Source: Authors' own calculations.

expected impact of technological change on trade costs: (i) lead time to export as a measure of customs procedures; (ii) the liner shipping connectivity index as a measure of logistics efficiency; (iii) the depth of credit information index and the enforcing contracts indicator as a measure of the contract and credit environment; and (iv) the existence of a common language as a measure of the importance of language differences. The first three variables are from the World Bank Doing Business project and the last variable from CEPII. The country-specific variables are bilateralized by taking geometric averages.

Based on the estimated coefficients, like for the other trends, a core scenario and a convergence scenario were developed for the reduction in trade costs. In the convergence scenario it is assumed that countries with poor performance in terms of the different measures converge partially to the level of the country with the 75th percentile best performance. In particular, we assume that laggard countries close half of the gap with the 75th percentile best performing country.[60] The *ad valorem* equivalents of these changes are calculated for all the countries available in the World Bank and CEPII database and are aggregated up to the level of the aggregate regions using bilateral trade weighted averages per sector. Given the lack of information on the impact of technological changes on trade costs, we develop a core scenario with identical trade cost reductions across regions in the different sectors, in such a way that the trade-weighted average reduction in trade costs is identical to the one in the convergence scenario.

The *ad valorem* equivalents are mapped to yearly changes in such a way that trade costs fall as predicted by the empirical estimates and the convergence scenario over the course of 15 years. Appendix Table C.5 displays the trade-weighted annual reductions in trade costs varying across regions (employed in the core and convergence scenario) and across importing regions (employed in the convergence scenario). As is clear from the table, the average yearly reduction in trade costs is about 1 per cent and the reduction is strongest in the convergence scenario for the least-developed regions.

Endnotes

1 Transport costs are important for modes of supply that involve travel, such as consumption abroad (for instance, tourism) and the presence of a natural person (for instance, providing personal services abroad). They may also be important when cross-border supply requires some face-to-face communication and thus business travel.

2 Both transport and logistics costs may matter for services because they also matter for the goods trade. Recent empirical findings suggest that the exports of many business, financial and transport services are tied to exports of goods, and therefore to the extent that some barriers hamper flows of goods that tend to be exported together with a service, these barriers thereby also have consequences for services flows (Ariu et al., 2018).

3 One of the proxies for information costs is the number of migrants from the trade partner's country. While it has been shown in the literature that migrant networks make it easier to search for and enforce contracts with trade partners, the variable may also capture their impact on consumer taste similarity because migrants tend to keep consumption preferences of their country of origin (Rauch, 2001; Rauch and Trindade, 2002; Felbermayr et al., 2015; Parsons and Vézina, 2018).

4 If there were 100 economies in the sample, the 75th percentile would correspond to the 75th ranking and the median would correspond to the 50th ranking.

5 These include the use of telecommunications, vehicular technologies, electrical engineering and computer science for vehicle, container and trailer tracking and for fleet management.

6 Even if transportation costs go to zero, distance will probably continue to matter. This is because it proxies for taste similarity. As demonstrated by Blum and Goldfarb (2006), internet surfing behaviour follows the well-established empirical finding in the trade literature that bilateral trade decreases with distance. In other words, even for a product with zero shipping costs, people are more likely to visit websites from nearby countries than from faraway countries. This relationship between distance and website visits is driven by taste-dependent categories of products such as music or games, but does not matter in non-taste-dependent categories such as software.

7 This is in contrast with consumer-to-consumer transactions, where the market share of banks is 60 per cent.

8 More specifically, the banks' revenue margin on cross-border transactions is 20 per cent as compared to 2 per cent on domestic transactions. The revenue calculations include transaction fees, float income and foreign exchange fees (McKinsey & Company, 2016).

9 According to Zervas et al. (2017), 70 per cent of Airbnb offerings are outside central hotel districts.

10 BOP statistics do not capture trade in services through a commercial presence (Mode 3), which is estimated to account for the bulk of world trade in services. Excluding "travel", most BOP statistics on services trade relate to Mode 1.

11 According to a report by Cleantech Group, a home-sharing guest uses an estimated 63 per cent to 71 per cent less energy than a hotel guest in North America. In the European Union, a home-sharing guest uses 78 per cent to 84 per cent less energy than a hotel guest.

12 It is worth noting that not all products covered under the ITA are "ICT products", as originally defined by the OECD and then adapted by UNCTAD in collaboration with the UNSD (United Nations Statistics Division). See the OECD Guide on Measuring the Information Society 2011: http://www.oecd.org/sti/ieconomy/oecdguidetomeasuring theinformationsociety2011.htm However, the expanded ITA includes as much as 80 per cent of all product codes included in the ICT goods definition, and ICT goods still represent the bulk of ITA goods imports (UNCTAD, 2015).

13 The authors defined time-sensitive agricultural goods as products with a minimum storage life of two weeks or less, for example apricots, beans, currants and mushrooms. In comparison, time-insensitive agricultural goods are defined as those with a minimum storage life of 4 weeks or longer, for example apples, cranberries and potatoes.

14 Nunn (2007) defines an input as "relationship-specific" if it is not sold on an organized exchange or reference priced in trade publications.

15 For example, a website called "Totally Chocolate" allows users to design and order customized chocolate bars, helping consumers to configure their own bars from four base chocolates and 100 different toppings.

16 See Appendix 1 of WTO official document JOB/GC/114 (available via the "Documents Online" function of https://www.wto.org/) for a full list of digitizable goods and their Standard International Trade Classification codes.

17 A relevant concern in this regard is the potential reshoring of low- and medium-skilled activities, which is discussed in Section C.2(c).

18 Chen et al. (2005) find that trade in those intermediate goods that are imported and used to make goods that are later exported (i.e., "vertical specialization trade" as defined by Hummels et al., 2001) increased between the late 1960s and the late 1990s in the ten OECD countries in their sample (Australia, Canada, Denmark, France, Germany, Italy, Japan, the Netherlands, the United Kingdom and the United States).

19 Los et al. (2015) find evidence of international fragmentation of production (higher foreign shares in the value of final products) in a sample of 35 industries in 40 countries between 1995 and 2008. In particular, foreign value-added shares increased on average by about 20 per cent (see also Timmer et al., 2014). Johnson and Noguera (2012) and Baldwin and López-González (2015) also show evidence that supply chains fragmented across the board between 1995 and 2009.

20 Bems et al. (2011) show that between the first quarter of 2008 and the first quarter of 2009, real world trade fell by 15 per cent, a figure roughly four times larger than the fall in real GDP (3.7 per cent). According to these authors, vertical specialization trade (the difference between gross trade and value-added trade) fell by 12.9 per cent, while value-added trade fell by slightly less, 10.3 per cent. Therefore, vertical specialization played a moderate role in amplifying the trade collapse.

21 A comprehensive review of all the factors determining GVC integration is beyond the scope of this report. The interested reader is referred to the survey by Amador and Cabral (2016).

22 Juhász and Steinwender (2018), focusing on the cotton textile industry, show that that connection to the global telegraph network (the first ICT) disproportionately increased trade in intermediate goods relative to final goods. This was due to differences in codifiability, i.e. the extent to which product specifications could be communicated at a distance using only words (and thus by sending telegrams) as opposed to inspecting a sample of the product.

23 "Spiders" and "snakes" are theoretical benchmarks. Fragmented production processes normally include a combination of the two forms, as argued by Diakantoni et al. (2017).

24 Teleconferencing is the conduct of a conference with several individuals who are in different locations, as opposed to just one place at the same time. Videoconferencing adds the ability to see, and not only hear, all the participants. Virtual conferencing allows remote participants to enjoy a virtual experience, making them feel they can move around in the room.

25 The Economist (2018a), citing IHL research, reports that in 2015 the cost to companies of overstocking was around US$ 470 billion, and that of understocking US$ 630 billion worldwide.

26 See Korpela et al. (2017) for a discussion of how supply chain integration through the use of blockchain technology can help transform digital supply chains and networks.

27 For empirical estimates of trade cost accumulation effects, see Rouzet and Miroudot (2013) and Muradov (2017).

28 More than 70 per cent of world services imports are intermediate services (De Backer and Miroudot, 2014). It should be noted that when the production process of a final service is fragmented, value is often created not along linear, sequential value chains, but rather by linking consumers (the so-called "value network", as in insurance or banking services) or by solving customer problems (the so-called "value shop", as in professional services). See Miroudot and Cadestin (2017).

29 This finding echoes the "smile curve", i.e. the higher contribution to value added provided by pre- and post-production services than the contribution provided by the actual fabrication process of goods (Baldwin, 2016). WIPO (2017) argues that "smile curves" reflect the growing importance of "intangible capital" – in the form of technology, design and brand value as well as workers' skills and managerial know-how. Since a large fraction of such capital depends on IP protection, licensed IP rights can be seen as a mechanism allocating "intangible" production inputs into GVCs, in the form of embedded technologies, manufacturing know-how, product design, or branding. See also the discussion in Section C.2(b) on the role of IPR protection for comparative advantage.

30 When the domestic division of labour deepens in emerging economies, more intermediate inputs are produced domestically. With the domestic value chain lengthening, cross-border production-sharing activities may decline.

31 A comprehensive review of all the factors (including those unrelated to technological developments) that may lead to lower GVC trade and reshoring in the future is beyond the scope of this report. The interested reader is referred to De Backer et al. (2016); Standard Chartered (2016); and De Backer and Flaig (2017).

32 Formerly called the Engineering Employers' Federation.

33 The upward trend in multinational corporation imports is also apparent when weighting imports by sales. Using slightly different offshoring proxies from the US Census Related Party Trade database, Oldenski (2015) shows that the increasing trend in multinational corporation imports continued from 2012 to 2014.

34 Dark factories are literally factories that run with the lights out because they require no human presence on-site. Very few factories currently operate without humans (and not at all times), making the concept of dark factories a theoretical benchmark for the time being. Note that fully robotized factories not only need no lights, but also no heating. To give an idea of the enormous contrast with "traditional" factories with humans, consider that (human) workers' productivity depends on appropriate heating (in cold climates) and cooling (in hot climates). Moreover, it depends not only on the working environment being properly lightened, but also on the quality of installed lights. The move from standard fluorescent lighting to LED lighting greatly improves working conditions and productivity in factories in Bangalore (India), due to the lower heat emissions produced by LED lighting (Adhvaryu et al., 2018).

35 Markoff (2012) reports the case of the Philips shaver factory in Drachten (The Netherlands). Instead of moving the high-end of their shaver product line to China, Philips opened this factory with 128 robots, capable of moving at two-second intervals and producing about 15 million shavers a year. The type of tasks performed by these robots is described by the author as "dexterous".

36 Dachs et al. (2017) measure reshoring (which they call "backshoring") as a dummy variable equal to 1 if the firm backshored production in 2013 or 2014, and 0 otherwise. The main explanatory variable, readiness to Industry 4.0, is an index ranging from 0 to 5, constructed using information on whether the firm adopted digital management systems, wireless human-machine communication and cyber-physical-systems (CPS) technology. The data are from the European Manufacturing Survey 2015.

37 In a survey of 114 industrial manufacturers in the United States conducted in 2014 (PWC, 2014), among the 37.7 per cent of respondents who indicated that their company was currently using 3D printing technology, a large majority (24.6 per cent) claimed that the use of 3D printing technology only concerned prototyping; 9.6 per cent claimed that the use of 3D printing technology concerned a combination of prototyping and production; and only 3.5 per cent indicated that the use of 3D printing technology concerned production of final goods, components or products that could not be made from traditional methods. Similarly, De Backer and Flaig (2017) report that only 15 per cent of the 3D printing output currently concerns goods (final but especially intermediate parts), with the majority being models, tools and prototypes.

38 The GTM has been developed by a team of Purdue University's Global Trade Analysis Project (GTAP) in cooperation with the Economic Research and Statistics Division at the WTO.

39 Basing trends on the past is a conservative approach for rising capital income shares, given that technological changes leading to rising capital shares such as robotization and AI are expected to accelerate. Also, for servicification, the use of trends in the past is probably a conservative approach, given the trends described earlier in this report, such as digitalization and AI.

40 If the initial allocation of tasks is optimal, a reallocation will not have an impact on productivity, an application of the envelope theorem.

41 This assumption can be rationalized based on the theoretical framework of a reallocation of tasks, although also other combinations (stronger variation in productivity growth than in capital income shares for example) can also be motivated.

42 The approach in this section is partially inspired by De Backer and Flaig (2017). Based on the German study by Bauer and Horváth (2015) on Industry 4.0, De Backer and Flaig also define scenarios for the differential impact of digitalization on productivity growth across sectors and countries, leading to sectoral productivity growth rates and scaling factors for countries like in our study.

43 Simulation results are available upon request.

44 Servicification is also predicted to raise the skill premium, because ICT services are relatively high-skill-intensive.

45 The result is also found when only the reallocation of tasks is modelled.

46 Neither De Backer and Flaig (2017) nor the current study take into account the effects of a potentially disruptive technology, additive manufacturing. As discussed elsewhere in the report, this technology could drastically reduce international trade in goods. Since there is not sufficient information about this technology and its development is highly uncertain, it is not included in the quantitative simulations.

47 We run the analysis separately for goods and services and therefore in what follows we omit the industry superscript k.

48 Letters in bold indicate vectors of multiple coefficients.

49 If a country is landlocked, an average of the neighbours of the landlocked country is taken. The variable comes from UNCTAD (http://unctadstat.unctad.org/wds/TableViewer/tableView.aspx?ReportId=92).

50 Source: World Bank (https://lpi.worldbank.org/).

51 Source: World Bank (https://data.worldbank.org/indicator/LP.EXP.DURS.MD?view=chart).

52 Source: World Bank (http://www.worldbank.org/en/topic/migrationremittancesdiasporaissues/brief/migration-remittances-data).

53 Both variables come from World Bank's Doing Business project (https://data.worldbank.org/indicator/IC.CRD.INFO.XQ?view=chart and http://www.doingbusiness.org/data/exploretopics/enforcing-contracts).

54 Source: World Bank (https://data.worldbank.org/indicator/PA.NUS.FCRF).

55 α_i are exporter fixed effects, α_{gj} are importer-sector fixed effects, $(ipi_g * GDPpc_i)$ is an interaction of industry IP intensity and GDP per capita, $\delta^a(z_g^a * Q_i^a)$ are measures of comparative advantage for human capital (a=HC), and physical capital (a=PC), X_{ij} is a vector of controls for country-pair characteristics: bilateral distance, common language, common colonial history, shared border, common regional trade agreement membership and common WTO membership. The combined use of exporter and importer-sector fixed effects is standard in the related literature – see for instance Chor (2010) and Nunn and Trefler (2014).

56 The results are robust to alternatively using an index comparing the strength of patent protection across countries for the year 2005 from Park (2008).

57 Because OLS estimates could be inconsistent and biased due to heteroskedastic (i.e. non equally dispersed) error terms and the omission of zero trade flows, we estimate the same specification in exponential form, using the Poisson pseudo-maximum likelihood (PPML) estimator, as proposed by Santos Silva and Tenreyro (2006). The PPML results (Appendix Tables C.1 and C.2, columns 4 to 6) confirm the findings of the OLS specification in most cases.

58 Non-homothetic preferences display non-unitary income elasticities and are thus able to capture changing budget shares as countries grow.

59 Bekkers and Francois (2018) describe differences between the GTM and the GTAP-model.

60 In line with this approach, the negative impact of not having a common language on trade costs is assumed to fall by half.

D How do we prepare for the technology-induced reshaping of trade?

This section examines how international trade cooperation can help governments all over the world harness digital technologies and seize the new trading opportunities they will create for firms both large and small. Section D.1 summarizes the main opportunities and challenges that arise with the expansion of digital trade. Section D.2 provides examples of the policies that governments put in place to exploit these opportunities and to address these challenges. Section D.3 then considers whether and how international cooperation can help governments exploit the gains from digital trade, cope with the challenges and at the same time achieve their public policy objectives, now and in the future.

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Some key facts and findings

- Digital technologies give rise to opportunities and challenges that may require the consideration of governments and the international community in areas as diverse as investment in digital infrastructure and human capital, trade policy measures and regulation.
- Provisions referring explicitly to digital technologies have been included in an increasing number of regional trade agreements. The most common provisions refer to e-government, co-operation and the moratorium on customs duties on electronic transmissions.
- While the WTO framework, and in particular the General Agreement on Trade in Services, is relevant for digital trade and WTO members have already taken certain steps to promote digital trade within the existing framework, members will have to consider how they want to respond to continued changes in the economy and the way we do business.

1. Main opportunities and challenges

The discussion of domestic policies and of existing international regulation and other forms of cooperation in this section refers back to the challenges and opportunities raised by digital trade in general (as covered in Section C) rather than by specific technologies (the Internet of Things (IoT), artificial intelligence (AI), etc.). It is organized along the broad categories of trade regulation (i.e. goods, services, intellectual property), as existing trade regulation typically does not refer to specific innovations or technologies.

Sections B and C discussed how digital technologies create new markets, modify forms of trade and encourage the emergence of new products, and how they lower trade costs and change trade patterns. These changes and in particular the lowering of trade costs offer new opportunities to trade and to gain from trade, and governments have a role to play in ensuring that firms can seize these opportunities.

First of all, the impact of digital innovation and of digital technologies on trade depends on access to digital infrastructure and a workforce with appropriate digital skills as well as on the availability of efficient and low-cost digital infrastructure services. Governments can invest or encourage investment in digital infrastructure and digital skills, and can contribute to the development of digital infrastructure services. Second, governments can also take measures to allow digital technologies to lower trade costs, for instance by enabling the faster and more reliable management of data across borders through the interoperability of data exchange systems and harmonization of e-certificates. They can use digital technologies to facilitate trade operations and customs cooperation. They can also choose to take measures (such as *de minimis* provisions, i.e. the value under which shipments and parcels can be imported duty-free through simplified customs procedures) when digital trade raises challenges for customs administrations, such as those related to the increase in the number of small parcels being sent by post or courier as a result of the growing number of purchases made online. At the same time, however, the reduction of trade costs will, in principle, lower the price of imported products relative to that of domestic products, possibly generating protectionist pressure from domestic producers subject to import competition.

Digital technologies raise concerns relating to loss of privacy, consumer protection or security threats as was discussed in Section B. This chapter discusses how, in the context of digital trade, governments need to develop a domestic regulatory framework to achieve a number of legitimate public policy objectives such as consumer protection, cybersecurity and data privacy in ways that are not more trade-distorting than necessary.

Section C examined how digital technologies may modify comparative advantage, for instance by making it possible for firms in remote least-developed countries (LDCs) to sell and supply by digital means products around the whole world or by making it profitable for firms in high-income countries to reshore certain activities. This raises new development opportunities and challenges. An important dimension of this issue is the digital divide between richer and poorer economies, raising the question of how smaller, poorer countries may seize the new trading opportunities.

Section B examined how digital trade may involve a winner-takes-all environment and raise market dominance issues (product competition becoming fiercer, the rise of platforms creating monopoly positions) while section C explained how digital technologies create new opportunities for small firms to participate in trade. For governments, important questions that arise are whether the new competition dynamics raise policy questions that they must address and whether there is a role for them in helping small firms seize the new opportunities.

2. How do governments respond?

This subsection examines how governments respond to the opportunities and challenges raised by digital innovation and discusses some of the issues that may arise if they fail to coordinate their responses and instead act non-cooperatively.

In order to realise fully the potential benefits of digital trade, most governments have adopted digital development strategies which involve cross-cutting policy measures aimed at improving infrastructure, establishing an adequate regulatory framework, reducing the cost of doing business and facilitating relevant skills development. Such measures consist of interventions such as investing in relevant infrastructure or improving the business environment to encourage private investment in information and communications technology (ICT) infrastructure; establishing a regulatory environment which is favourable to digital development but which also ensures adequate levels of cybersecurity, consumer protection or data privacy; using both merchandise and services trade policies to promote the digital economy and to improve their competitiveness; and using competition and micro, small and medium-sized

enterprise (MSME) policies to level the playing field for firms and to address the new "winner takes all" dynamics described in Section B.

Governments may choose different priorities among these policy measures, depending on their level of development and the extent of digitalization within their economies, with developing economies typically focusing on facilitating connectivity and adopting digital technologies, while developed economies pay relatively greater attention to regulatory issues related to competition, data protection and consumer protection. Skills development and the promotion of MSMEs' involvement in digital trade seem to be common concerns for both developing and developed economies. In a number of areas, the unilateral responses of governments to changes in trade induced by digital technologies seem to generate negative spillovers for their trading partners, or simply higher trading costs than if they were coordinated. In those areas, there may be scope for more international cooperation than is already in place.

(a) Investment in infrastructure and human capital

As highlighted in Section C, one of the key prerequisites for reaping gains from digital trade is the availability of adequate infrastructure, physical as well as digital. The need for investment in infrastructure is more acute in developing countries, as they tend to lag behind developed economies in terms of the pace of digital innovation and the level of infrastructure required to facilitate the adoption and effective use of digital technologies.

According to a United Nations Conference on Trade and Development (UNCTAD) digital strategies survey, which focused on two specific digital development objectives, namely broadband infrastructure development and digital business development, out of the 102 strategies surveyed, 91 (of which 64 from developing and transition economies) were found to include digital infrastructure objectives (UNCTAD, 2017e). While most of the digital strategies do not provide details on investment requirements, they do acknowledge potential sources of funding for digital development, with public funding being the primary source of finance, followed by private sector investment and public-private partnerships respectively. UNCTAD (2017e) also examines the various other policy tools used by governments to promote and facilitate investment in broadband infrastructure or the digital industry, finding that the focus seems to be on improving the enabling (sectoral) regulatory framework. Other measures include investment incentives, investment facilitation, digital standards, and clusters and incubators for digital business development. Governments also invest in other infrastructure areas (such as electricity supply, trade logistics, delivery, tracking and payment systems) which complement the digital infrastructure.

In addition to the provision of reliable internet services and widespread mobile phone penetration, the availability of affordable payment solutions is crucial for businesses as well as for consumers to engage in commercial transactions online. To enable the growth of e-commerce, many developing countries, such as Bangladesh, India, Kenya and Tanzania, are promoting the shift towards electronic payments by investing in mobile phone-based payment solutions to facilitate money transfers and microfinancing services. In Thailand, in order to fuel e-commerce, a government-sponsored e-payment system called PromptPay, that creates a peer-to-peer payments system and involves all major Thai banks, has been launched. However, the availability of electronic payment systems alone is not enough to encourage digital trade. It is also important for governments to put in place an adequate regulatory framework to enhance the level of trust in online transactions among both businesses and consumers. Some examples of the government policies undertaken in this direction are discussed in the following subsection on "Domestic regulatory framework".

Governments all over the world are using or promoting the use of digital technologies to facilitate trade by reducing delays in the clearance of goods at borders, thereby lowering associated costs (see Section C.1(b)). According to the World Bank's "Doing Business: Trading Across Borders 2018" questionnaire, 175 of the 190 surveyed economies have electronic data interchange (EDI) systems already operational or in progress (World Bank, 2018). EDI systems facilitate the quick and reliable exchanges of paperless data and thus play a major role in speeding up the customs clearance procedure by allowing documents to be shared more easily between different authorities, thereby reducing the cargo dwell time. Furthermore, 117 out of the 190 surveyed economies have either already established or are in the process of putting in place an electronic single window system, i.e. a system which allows trade stakeholders to submit documentation and other information electronically through a single point of entry to complete customs procedures.

Developing countries such as China, India and Kenya are also investing in automation as a means of reducing dwell time and standardizing their port operations. At the same time, some economies, both developed (e.g. Belgium or the Netherlands) and

developing (e.g. the United Arab Emirates) are seeking to capitalize on more sophisticated digital innovations such as blockchain technology to streamline cargo flows and organize port logistics more efficiently. The ports of Antwerp and Singapore, for example, have already undertaken pilot projects to test blockchain solutions aimed at simplifying paperwork, lowering administration costs and limiting attempts at fraud. In developing economies, such measures directed towards improving port logistics are typically state-led. However, in developed countries, there is greater involvement by the private sector, which may undertake such measures independently or in partnership with government authorities.

Most countries, including many LDCs, now rely on foreign direct investment (FDI) inflows to develop their digital networks. With a view to attracting foreign investment and spurring trade, and in particular digital trade, many governments are working towards improving their investment climate in digital infrastructure services (see Section D.2(b) on the role played by trade policies in this context). Over the past 25 years, regulation in the telecommunications sector has undergone fundamental transformations. According to the International Telecommunication Union (ITU), a majority of countries has moved from monopolies to regulatory environments that encourage effective competition, including foreign participation, with reduced barriers to entry and often privatized state-owned incumbents (ITU, 2016).

In the case of LDCs, inadequate ICT infrastructure services, coupled with the workforce's low levels of digital skills, is a major hindrance to realising the potential benefits of digital trade. In view of this, several LDCs, such as Haiti and Rwanda, are improving their investment climate by offering various incentives to foreign investors (e.g. tax holidays and exemptions, and reduced import duties).[1] With a similar aim of attracting FDI and encouraging digital trade, the Chinese government is currently focusing on the creation of more cross-border business-to-consumer (B2C) e-commerce comprehensive pilot zones, such as that in Hangzhou, to facilitate cross-border e-commerce flows, driven largely by domestic demand for foreign goods and MSME exports (The State Council Information Office of the People's Republic of China, 2017). These zones provide seamless cross-border logistics services, such as special customs facilities (including pilot work on single window declarations) and special arrangements for international payments and tax refunds.

In addition to the development of their digital infrastructure, many governments, in developing and developed countries alike, are undertaking substantial investment in human capital through training and skills development to facilitate the effective uptake and usage of digital technologies. Various governments are offering adult learning programmes focusing on digital skills development and complex cognitive skills such as information processing and problem-solving. These efforts are often supported by local non-governmental organizations that offer training to marginalized groups such as the unemployed, women and the elderly, especially in the case of developing countries. (e.g. the ICT Academy in India and the Committee for Democracy in Information Technology in Mexico, Colombia and Brazil).[2]

In order to bridge the digital divide within countries, arising due to factors such as income disparity, age, gender and disabilities, many governments have undertaken initiatives to provide affordable access to ICT, specifically targeting disadvantaged groups such as women, the elderly, the disabled and people in rural/remote areas. Initiatives in Chile, India and Mexico, for example, typically offer grants and subsidies to facilitate access to ICT equipment, as well as digital literacy programmes and training in ICT skills (BBVA, 2018).[3]

Another key dimension of the digital divide is that of the divide between developing and developed countries, in terms of access as well as effective usage of digital technologies. Bridging the digital divide between poor and rich countries would contribute to the convergence of "digitally advanced" economies and "digitally lagging" economies and help to realize fully the potential of ICT as an engine of socio-economic development.

Building on unilateral efforts, international cooperation has a major role to play in this context. First, as discussed in Section D.3, international cooperation, in particular in the context of the WTO, can help governments to adopt more open trade and investment policies in the ICT sector which, if supported by an adequate regulatory framework, could help them to attract FDI, develop their digital infrastructure, and bridge the digital divide between poor and rich economies (see Box D.1). Second, cooperation, in terms of technical assistance and capacity-building efforts undertaken by developed and richer developing countries and international organizations, can help to facilitate digitalization in developing countries.

(b) Trade policy measures

(i) Services

As already mentioned in Section C.1(e) and as explained in more detail in Box D.1., trade and

Box D.1: The effect of services trade policies on the digital economy

According to Roy (2017), existing research suggests that policies which limit services trade, for example by restricting market entry and foreign investment in services markets, or by impeding online cross-border supply, constrain the development of the digital economy. Generally, services trade costs are significantly higher than those of the goods trade, and services sectors with lower trade costs, themselves associated with lower barriers to services trade, tend to be more productive and to experience higher productivity growth than those with higher trade costs (Miroudot and Shepherd, 2016; Miroudot et al., 2012). This carries implications for ICT services and their ability to foster more inclusive trade.

There also appears to be a negative correlation between entry barriers and regulatory restrictiveness in services, on the one hand, and investments in digital technologies and ICT on the other (World Bank, 2016). This suggests that barriers to entry and competition in service sectors reduce the incentive of suppliers to invest in digital technologies (e.g. the use of cloud facilities by transport companies, the supply of online services by professional services firms, or use of the internet by retailers).

Barriers to trade in services may also shield domestic suppliers from competition, leading to higher prices and reduced incentives to invest, innovate, or otherwise improve services quality. Indeed, services trade restrictions, are negatively associated with performance in a number of important services sectors, as measured by comparable indicators across a broad range of countries (Nordås and Rouzet, 2016; Borchert et al., 2017).

Recent research also evidences the negative impact of services trade restrictions on foreign investment inflows into service sectors. Countries with lower restrictiveness are significantly more likely to attract foreign investment in services than countries with more trade-restrictive regulatory frameworks (OECD, 2017f). Furthermore, restrictions not only limit new investments, but also are associated with lower sales by foreign affiliates already established in the host country. Aside from affecting foreign suppliers, regulatory restrictions also discourage small domestic firms and newer firms from competing in the market, with implications for innovation and job creation. This dissuading effect can limit investments in new technologies and network infrastructure, and restrain expansion in productive capacity, as well as curbing competition and limiting the availability of quality low-cost services. This, in turn, has implications for connectivity and trade through its impact on digital infrastructure services.

Restrictiveness in the services trade limits not only imports but also exports of services from the country imposing the measures (Nordås and Rouzet, 2016). This may be because, by limiting competition, restrictions negatively affect the performance of domestic suppliers, reducing incentives to improve efficiency through innovation, the adoption of new technologies and investment. This in turn affects the capacity of domestic suppliers to compete in international markets.

Services trade policies also play a key role in the development of the necessary backbone infrastructure, with resulting impacts on the economy as a whole. Over the past decades, governments have tended to adopt policies encouraging greater FDI and competition in the telecommunications sector. Many studies have found that these changes have been associated with enhanced affordability, as well as a higher quality and greater diversity of telecommunications services (Lestage et al., 2013).

As noted in ITU (2017), countries that have introduced quality regulation – including, in particular, regulation allowing competition – have had greater success than other countries in stirring up market growth and developing their digital economy. Positive regulatory settings are necessary to drive ICT investment, use and uptake. Bridging the digital divide, therefore, hinges largely on government policies.[4] As reported by the UN Broadband Commission (2013), a study of 165 countries shows that between 2001 and 2012, mobile broadband penetration levels were 26.5 per cent higher in countries with competitive markets. Recent research (e.g. Nordås and Rouzet, 2016 and Borchert et al., 2017) has found that higher levels of services trade restrictiveness in telecommunications services are associated with lower penetration rates for fixed, mobile and broadband internet.

Box D.1: The effect of services trade policies on the digital economy *(continued)*

Open trade and investment policies in the telecommunications sector, supported by adequate regulatory frameworks, can therefore be seen as key building blocks for the development of quality infrastructure to help reduce the digital divide and take advantage of digital opportunities. Policies affecting foreign commercial presence may prove to be a particularly determinant factor. Studies have shown that markets characterized by more intense competition experience greater price decreases and improved services; others have linked telecommunications liberalization to higher gross domestic product (GDP) growth rates (Mattoo et al., 2006; Eschenbach and Hoekman, 2006), as well as higher productivity in firms in other sectors (Arnold et al., 2008; Balchin et al., 2016).

Prepared by the authors, based on Roy (2017).

services policies can affect the development and performance of both digital infrastructure services and digitally-enabled services, as well as the use and uptake of digital technologies more broadly (Roy, 2017). As such, they have an important role to play in complementing cross-sectoral investment facilitation and promotion measures. Trade policy does not only affect digital infrastructure services and digitally-enabled services; measures related to services sectors such as finance, distribution, logistics and transport are key determinants of the impact of digital technologies on the trade of goods. The role of digital platforms (distribution services intermediaries) in lowering trade costs, for instance, can only go so far in markets where uncompetitive transport services result in exorbitant transport costs. Efficient services markets, therefore, are a necessary pre-condition for reaping the benefits of digital technologies.

An examination of policy changes in services between 2000 and 2015 reveals a significant push towards greater liberalization, which has continued despite the economic crisis (Roy, 2015). While preferential trade agreements (PTAs) do sometimes lead to new liberalization, the preponderant share of such reforms likely occurs autonomously. Over this period, most policy changes related either to financial services or were cross-sectoral in nature. There were relatively few policy changes in telecommunications or audiovisual services. By contrast, the Organisation for Economic Co-operation and Development's (OECD) Services Trade Restrictiveness Index (OECD, 2018a) suggests that, over the period 2014 to 2017, the highest net liberalization has taken place in some of the sectors that form part of the digital network and the transport and logistics chain. For specific examples of services trade policy reforms in the telecommunications/ICT/audiovisual services sectors, see Annex 4 of WTO (2017c) and WTO (2018b).

Despite evidence of the benefits of open and non-discriminatory policies and the adverse effects of restrictive policy and regulation, trade restrictions are still maintained and erected by some governments to protect local industries, including digital platforms, from foreign competition and/or to foster the emergence of "national champions". Requirements for majority domestic equity ownership in ICT firms, minimum quotas for local employment, various forms of performance and/or local content requirements (not only with regard to the use of local services and/or service suppliers but also with regard to locally produced hardware components) are some examples.[5] These policies restrict access for and the operation of foreign services suppliers, and they may also take a toll on the broader economy.

Indeed, most benefits arising from the digital economy – notably through innovation and productivity growth – come through the adoption of digital technologies, not necessarily from their creation. Local content requirements, for example, merely increase companies' costs, slowing down digital technology assimilation.[6] The ICT services sector, which includes computer and related activities and telecommunications services, usually accounts only for 3 to 4 per cent of GDP, but the services it provides have a much larger impact, affecting productivity and efficiency in other sectors, such as retail, banking and even manufacturing.[7] Interestingly, the OECD's Services Trade Restrictiveness Index (OECD, 2018a) suggests that in 2017, the largest overall increase in services restrictiveness at the sectoral level was seen in the telecommunications sector.

International cooperation in the WTO or regional agreements can help governments to open up and stimulate competition in their digital infrastructure services sectors which, when supported by an adequate regulatory framework, can make an important contribution to the development of quality digital infrastructure (see Section D.3).

(ii) Goods

As is the case with services, merchandise trade policies can have an impact on the development and performance of digital infrastructure and on the use and uptake of digital technologies more broadly. According to the WTO's Trade Monitoring Database, some countries, such as Argentina, Brazil and Switzerland, have reduced or entirely eliminated import tariffs on certain informatics and telecommunications equipment. India, on the other hand, notified a 10 per cent import duty increase on certain telecommunication equipment (see section 3.5 of WTO, 2017c).

Several governments have revised the *de minimis* threshold, and some governments have raised it, allowing more shipments and parcels, often shipped by individuals and small businesses engaging in cross-border e-commerce, to be imported hassle- and duty-free (see Box C.4 on e-commerce and the "parcellization" of trade). The United States, for example, raised its *de minimis* threshold from US$ 200 to US$ 800 in 2015. Other governments, however, have lowered their *de minimis* threshold.

The Global Trade Alert lists both "liberalizing" and "harmful" non-tariff measures affecting ICT-related sectors which have been adopted by governments in the last 10 years. In the computing machinery and parts sector for instance, around 100 harmful non-tariff measures were adopted, compared to 26 liberalizing measures. Among the most frequently used "harmful" measures are those that relate to trade finance and tax-based export incentives, while the most frequently observed liberalizing measures relate to the internal taxation of imports and import licensing requirements.[8]

As discussed in Section D.3, international cooperation in the WTO or regional agreements can help governments maintain or facilitate access to digital technologies and thereby help the development of quality infrastructure.

(c) Domestic regulatory framework

As already mentioned, governments typically improve the enabling regulatory framework to promote and facilitate investment in digital infrastructure or the digital industry. At the same time, however, they also introduce regulations which aim to achieve public policy objectives such as consumer protection, data privacy protection and cybersecurity. These regulations, like many other public policies, may affect trade in one way or another.

(i) Electronic authentication, contracts and signatures

In order to facilitate digital trade, many countries have taken steps towards building an adequate legal framework that regulates electronic transactions and, in particular, establishes the standards for the validity of electronic contracts and signatures. Legislations related to electronic authentication aim to promote the growth of e-commerce by recognizing the legal enforceability of electronic records and signatures and ensuring the security of electronic transactions. For example, the Philippines' Electronic Commerce Act of 2000, based on the UNCITRAL Model Law on Electronic Commerce of 1996, stipulates that no electronic document or message shall be denied legal effect because it is in electronic form. The Act does not discriminate between different types of technology, and covers electronic data messages and documents created for both commercial as well as non-commercial purposes (Galexia, 2013).

It is noteworthy that over 71 states have adopted legislation based on or influenced by the UNCITRAL Model Law on Electronic Commerce (UNCITRAL, 2018). However, there is still scope for international cooperation in this area to harmonize e-signatures originating under different jurisdictions and, in turn, facilitate smooth cross-border flows of digital trade.

(ii) Consumer protection

The presence of a robust legal framework for consumer protection fosters consumer confidence and enhances trust in digital markets and online transactions, thereby making it easier for them to engage in cross-border flows of e-commerce. According to UNCTAD's Global Cyberlaw Tracker, out of the 125 countries for which data exists, 97 (of which 61 are developing or transition economies) have adopted consumer protection legislation related to e-commerce (UNCTAD, 2018b). The existence of consumer protection laws is particularly low in Africa, with only 23 out of 54 countries having legislation in place.

Most of the existing legislations related to consumer protection aim to protect consumers from fraudulent and deceptive commercial activities online and to safeguard consumers against misleading online advertising. For example, Viet Nam's Law on Protection of Consumers' Rights (McCaig and Pavcnik, 2017; Vietnam Law Official Gazette, 2011) safeguards consumers engaging in electronic transactions by prohibiting suppliers from sharing misleading, deceitful and incomplete information related to their goods and/or services. Under

this law, consumers also have the right to resolve disputes via negotiation, mediation or arbitration, or in court. Colombia's general consumer protection law (Congreso de la República de Colombia, 2011) has a special provision for e-commerce and offers the buyer the right to withdraw a purchase within five days of the transaction. It also safeguards consumers against abusive clauses in membership contracts.

A number of countries have adopted legislation to protect consumers from unsolicited commercial electronic messages, commonly known as "spam". Considering spam to be an invasion of privacy, the Federal Government of Australia passed the Spam Act 2003 which states that sending a commercial electronic message would constitute a breach of the Act, unless the recipient has provided "express or inferred consent" (Bartier Perry Lawyers, 2004).

Since countries develop their consumer protection legislations independently at the national level, applicable law may often be an issue in case of cross-border e-commerce. There may be a role for international cooperation in developing a common understanding of consumer protection with a view to reducing the cost to exporters of having to adapt to multiple different national laws, and specifically, to address jurisdictional issues that may arise in the case of a dispute or conflict regarding cross-border online transactions.

(iii) Data privacy protection

According to UNCTAD's Global Cyberlaw Tracker, 107 countries (of which 66 were developing or transition economies) have introduced legislation to ensure the protection of data and privacy (UNCTAD, 2018b). These legislations may differ significantly between countries because of differences in countries' preferences. Even though underlying privacy principles may be relatively similar across countries, interpretations and applications in specific jurisdictions differ significantly. In some countries privacy is protected as a fundamental right, while in other countries, the protection of individual privacy is based on other constitutional doctrines or in tort. Other countries have not yet adopted privacy protections. Such differences will increasingly affect individuals, businesses and international trade (UNCTAD, 2016a).

The new General Data Protection Regulation (GDPR), which entered into force in the European Union on 25 May 2018, is the most important change in European data privacy regulation in 20 years (see Box D.2). Malaysia, Singapore and South Africa are some of the other countries that have adopted data protection legislation most recently, with each of them resulting in the establishment of an independent national data protection regulator. Australia, Canada, Japan, New Zealand, Poland and Russia have been some of the most recent countries to amend their existing laws related to data protection, and their amendments focused on the removal of exemptions, the centralization of data protection regulation in a single national agency, and the expansion of data protection requirements to include matters related to security (UNCTAD, 2016a).

Many data protection laws contain significant gaps and exemptions. For instance, exemptions might apply to small businesses (in the cases of Australia and Canada) or to small datasets (in the case of Japan). Some data protection laws may apply only to specific sectors such as health and credit, whereas other laws may include exemptions based on the subject (for example, data concerning children versus employee data) and the source of the data (for example, data collected online versus offline). The existence of these gaps and exemptions in different data protection regimes poses a challenge for their interoperability across countries (UNCTAD, 2016a).

Lack of data protection legislation can reduce trust and confidence in a wide range of commercial activities. As for exemptions, they create several problems from a trade perspective. They require a wide range of stakeholders (business, trading partners, consumers and regulators) to identify and categorize data in complex ways. They severely limit opportunities for countries to meet an "adequacy test" for cross-border transfers. Finally, they can lead to complex complaints and disputes over coverage. It is worth noting, however, that data protection regimes need not be identical in order for them to be interoperable; it is possible for data protection regimes to achieve shared goals through different mechanisms.

Also, as discussed by Avi Goldfarb and Dan Trefler, Rotman School of Management, University of Toronto (see their opinion piece on page 140), there may be a need for international cooperation on data privacy protection aimed at avoiding a race to the bottom, i.e. a situation where governments deregulate their business environment (or reduce tax rates), in order to attract or retain economic activity in their jurisdictions (see also Goldfarb and Trefler, 2018a). In theory, restrictive data privacy policies can restrict the use of such technologies for a given level of data, but they can also increase the supply of available data if it leads consumers to trust firms that collect data. In practice, however, the first effect seems to dominate, and less restrictive data privacy protection policies

Box D.2: The European Union's General Data Protection Regulation

The European Union's General Data Protection Regulation (GDPR), which unifies data privacy protection regulations across the European Union, came into force in May 2018. The provisions of the GDPR are consistent across all 28 EU member states and apply to all businesses processing the personal data of data subjects residing in the European Union, irrespective of where the business is based. In particular, the GDPR is applicable to the processing of personal data by both "controllers" and "processors", wherein a "controller" is the entity that determines the purposes, conditions and means of the processing of personal data, while the "processor" is an entity which processes personal data on behalf of the controller. Under the GDPR, personal data is defined as any information that may be used directly or indirectly to identify an individual. It may refer to a name, a photo, an email address, bank details, posts on social networking platforms, medical information or a computer IP address.

The GDPR requires data protection by design and by default. Data protection by design means that data controllers must put in place technical and organizational measures (such as the use of pseudonyms) to minimize personal data processing. Data protection by default means that data controllers must put in place appropriate measures to ensure that, by default, they process only those personal data which are necessary for each specific purpose of the processing. This obligation applies to the amount of personal data collected, the extent of their processing, the period of their storage and their accessibility. With the aim of improving data transparency and empowering the data subjects, the GDPR also requires the controller to provide a copy of the personal data to the data subject, free of charge, in an electronic format. The GDPR also introduces "data portability" as the right of a data subject to transmit the data to another controller.

Non-compliance with the provisions of the GDPR may result in fines of up to 4 per cent of a business's annual global turnover, or EUR 20 million. This is the highest penalty that can be imposed on a business for not having sufficient customer consent to process data or for violating the requirement of data protection by design.

Prepared by the authors, based on EU GDPR (2018).

seem to benefit firms that use digital technologies (Goldfarb and Tucker, 2012). As already mentioned in Section C.2, the fact that lax privacy policies can confer an advantage on domestic digital industries relative to digital industries in countries with stricter policies suggests that there is potential for a race to the bottom in privacy policy. Goldfarb and Trefler (2018a) point out that this is at odds with the fact that in recent trade negotiations, the underlying assumption has been that privacy regulation is disguised protection. In their view, discussions should start with the public policy goal of the social benefits of protecting the personal information of users of electronic commerce, before moving to any particular situation in which privacy regulation might really be disguised protection.

(iv) Cybersecurity

The growth in digital trade has raised issues related to cybersecurity, the act of protecting IT systems and their contents from cyberattacks. Cyberattacks in general are "deliberate attempts by unauthorised persons to access IT systems, usually with the goal of theft, disruption, damage or other unlawful actions" (Fischer, 2014). Cybersecurity measures are aimed at protecting countries against cyber threats while trying to promote the benefits of a cyber-enabled world.

According to the ITU's Global Cybersecurity Index (GCI) 2017, there is a huge range in cybersecurity commitment among the ITU's 193 member states. Of these 193 member states, 96 have only started to make commitments in cybersecurity; 77 have developed complex commitments and engage in cybersecurity programmes and initiatives; and 21 demonstrate high commitment according to the ITU's evaluation criteria (ITU, 2018a). Moreover, only 38 per cent of the surveyed economies have a published cybersecurity strategy and only 11 per cent have a dedicated standalone strategy, while another 12 per cent have a cybersecurity strategy under development. The French National Security Strategy (ANSSI, 2015) for example, is quite comprehensive in that it has multiple objectives such as:

> "safeguarding fundamental interests of the State information systems; maintaining digital trust and protecting personal data; raising awareness about cybersecurity and facilitating training of cybersecurity specialists; developing a favourable environment for digitalization of businesses and promoting European digital strategic autonomy".

Cybersecurity strategies involve various types of policies which may have an impact on trade.

OPINION PIECE

How artificial intelligence impacts international trade[9]

By Avi Goldfarb and Dan Trefler, Rotman School of Management, University of Toronto

Artificial intelligence (AI) is an emerging new general-purpose technology that promises to increase productivity and improve well-being. Within a generation, it will transform some of the largest categories of international trade in goods (e.g., autonomous vehicles) and international trade in services (e.g., financial services). Remarkably, AI technologies have already diffused to China, which is set to become an AI world leader in less than a generation. This is a development that has the potential to reconfigure world trade patterns.

Whether this potential is realized is an open question largely because regulatory frameworks surrounding AI will be major determinants of how AI-based products are traded. This is already apparent. Some of the largest US firms by market capitalization (Google, Facebook and Amazon) do not have access to the Chinese market due to regulation. Likewise, some of the largest Chinese firms by market capitalization (Tencent and Alibaba) may be excluded from the US market on the basis of national security concerns.

At the heart of these obstacles to AI-based trade is a fundamental regulatory tension. On the one hand, AI-based firms want a lax regulatory framework in their own country that allows them to harvest and deploy massive amounts of data. This creates a regulatory race to the bottom. (While it is theoretically possible that strict privacy regulation could create national advantage, the empirical evidence suggests a trade-off between privacy regulation and innovation). On the other hand, deployment often requires industry standards which, if not coordinated internationally, will fragment world markets and drive demands for disguised protection by domestic players.

To illustrate these two forces, it is useful to consider them in the context of a specific policy. The most important of the many behind-the-border regulations that impact international comparative advantage in AI is privacy policy. Recent advances in AI have been driven by advances in machine learning. Machine learning is prediction technology in the statistical sense. It takes data and uses it to fill in missing information. In other words, a key input into today's AI is data. Companies with access to more data will be able to create AI that makes better predictions. More data mean better products.

By restricting the acquisition and use of data, privacy regulation hampers AI-driven innovation. Where this regulation is relatively strict, companies have struggled to use data in innovative and productive ways. Where this regulation is relatively permissive, companies have been able to develop remarkable new platform technologies with multiple apps, each generating data that enhances the predictive power of all apps on the platform. For example, Tencent is experimenting with credit scoring that uses data such as individuals' purchasing data, gaming behaviour and social media contacts to develop a credit score. Such credit scoring would likely violate US anti-discrimination laws and EU transparency rules (the General Data Protection Regulation or GDPR). This is just one of dozens of examples of how AI-based products offered in one country may violate the laws of another.

This poses several challenges for the WTO. The WTO may be called upon to rule on whether domestic regulations are disguised protection. For example, are "algorithmic transparency" requirements that prevent foreign autonomous vehicles from operating in the domestic market a form of disguised protection, or a legitimate right of citizens who might be injured in an autonomous vehicle accident?

This example in turn points to the fact that the WTO may have to expand its role in fostering cooperation in the area of regulation. The domestic regulation of AI may lead to a regulatory race to the bottom, as it has been argued in areas such as environmental and labour policy. Trade agreements may have a role to play in encouraging cooperation on minimum privacy standards.

In summary, AI will generate transformative products and services that alter world trade patterns. This makes it essential to understand how behind-the-border regulatory and industrial policies affect comparative advantage in AI-based products.

Governments have a strong interest in securing their own IT systems and many have proposed security standards or requirements for their purchasing systems. In some cases, all foreign participation in government systems is prohibited. In others, components from a single country are explicitly forbidden. Some governments also see a state interest in ensuring that the IT systems used by their citizens are secure, in particular in their critical infrastructure. They may encourage or require domestic IT operators to better protect their systems through national security standards. Even in cases where they do not impose such national security standards, governments may have an interest in verifying that the IT products sold on their home market are secure. This would involve testing and certification which can be costly, in particular when processes differ between countries. Finally, several countries see security risks in the use of encryption systems and may require a specific certification process for cryptographic technology, or may even take more restrictive measures.

(v) Competition policy

Digitalization, while it can have important pro-competitive effects, can also bring with it exclusionary and/or collusive behaviours and restrictions to competition (see the discussion of market concentration effects in Section B.1). Digital innovation has resulted in the emergence of new "winner-takes-all" dynamics. In particular, the emergence of tech giants such as Amazon, Alibaba and Google raises important potential concerns about market dominance. Many governments and regulatory authorities are turning to competition policy to address perceived excesses of market power and/or to ensure a level playing field for smaller firms. For example, to prevent e-commerce giants from obstructing fair competition, China's State Administration for Industry and Commerce (SAIC) introduced a regulation in October 2015 explicitly prohibiting e-commerce platforms from barring merchants from participating in promotions on other websites (CNBC, 2015).

France was the first country to pass a law setting a fixed price that retailers (foreign or domestic) may charge for an e-book published by national publishers.[10] Amazon (the biggest online seller of books) responded by offering free shipping, in addition to the maximum allowed discount. Once more, threatened by digital competitors, traditional retailers and booksellers lobbied for an amendment to the original law, proposing a ban on the combination of free shipping and discount. This amendment, informally known as the "Anti-Amazon Law", finally came into effect in 2014, prohibiting shipping books for free. In return, Amazon fixed its delivery costs at EUR 0.01 per order (Blattberg, 2014), reflecting how the market reacts and adjusts.

It is also noteworthy that, very recently, Germany's Monopolies Commission, in its July 2018 XXII Biennial Report (Monopolkommission, 2018), asserted that digital changes require corresponding legal adjustments, which in turn should be shaped both for the benefit of consumers and with fair rules for traditional and new suppliers. Particularly, the Monopolies Commission proposes: (1) to systematically investigate markets with algorithm-based pricing for adverse effects on competition; (2) to further harmonize the regulatory framework for audiovisual media services restricting the online services of public service broadcasters to socially and culturally relevant content; and (3) to reform the reimbursement system in the supply of medicines renouncing on a ban on mail-order sales of prescription medicines. This interest in the digital market is not something new. In an earlier Report, the Monopolies Commission (Monopolkommission, 2015) already touched upon the subject, specifically in relation to search engines, suggesting that it is possible for search engines to "make it more difficult for competing services to be found". Furthermore, the Monopolies Commission noted that:

> "Arbitrary non-inclusion in the web index, or the deletion of a website from it, could constitute abusive conduct on the part of a dominant search engine if inclusion in the index were to be technically possible and customary, and hence one company were to be treated differently than companies of the same kind". (Bundesministerium der Justiz und für Verbraucherschutz, 2010).

Perceptions regarding possible anti-competitive effects associated with digital markets have also given rise to a number of very significant competition law enforcement cases in recent years, spanning a range of major jurisdictions. Several of these are summarized in Box D.3. In addition, various jurisdictions are addressing concerns related to anti-competitive outcomes in the digital economy in the competition advocacy activities of relevant agencies. Related longer-term "competition advocacy activities" that are being pursued in various jurisdictions are set out in Box D.4.

The OECD identifies the following characteristics as being intrinsic to competition law enforcement and competition advocacy in digital markets: (i) data as a primary competitive asset; (ii) privacy as an

Box D.3: Competition enforcement activities in digital markets

In the *Intel Corporation v European Commission* case, in 2017 the Court of Justice of the European Union reversed a ruling of the General Court, which had initially upheld the European Commission's EUR 1.06 billion fine for Intel's alleged abuse of its dominant position through a loyalty/exclusivity rebate scheme for its x86 central processing units (Giles and Modrall, 2017). Following this decision, such rebates, rather than being seen as restrictive of competition by object (the practice reveals in itself a sufficient degree of harm to competition), are now to be analysed under an effects-based approach (possibility of exempting the allegedly anti-competitive conduct because of efficiencies). The case has been remitted back to the General Court, where Intel will have a new chance to overturn the decision or achieve a significant reduction of the fine (Court of Justice of the European Union, 2007; De Muyter and Verheyden, 2017).

In the case of *Google Shopping* (European Commission, 2017a), the European Commission found in 2017 that:

> "Google abused its market dominance as a search engine by promoting its own comparison shopping service in its search results, and demoting those of competitors […]. It [thereby] denied other companies the chance to compete on the merits and to innovate. And most importantly, it denied European consumers a genuine choice of services and the full benefits of innovation".

The European Commission, on this basis, imposed a fine of EUR 2.42 billion on Google (European Commission, 2017a). US commentary on the decision has emphasized how difficult it would be to bring a similar case in the United States, given the prevailing differences of competition law doctrine and evidentiary standards:

> "Pursuing a US case against Google would be more complicated than in Europe, antitrust experts said, because of a higher standard of evidence needed to prove wrongdoing by the search giant. Rather than go to court, the Federal Trade Commission closed a similar investigation against Google in 2013 in exchange for Google's changing some of its business practices" (Washington Post, 2017).

The latest case is *Google/Android* (European Commission, 2018). In July 2018, the Commission fined Google EUR 4.34 billion for illegal practices after finding that the tech giant imposed illegal restrictions on Android device manufacturers and mobile network operators to cement its dominant position in general internet search. In particular, the Commission investigation found that Google had engaged in three separate types of practices: (1) illegal tying of Google's search and browser apps; (2) illegal payments conditional on exclusive pre-installation of Google Search; and (3) illegal obstruction of development and distribution of competing Android operating systems. At the time of the writing, Google had not filed an appeal.

Google also faced an antitrust ruling by the Federal Antimonopoly Services in the Russian Federation, which imposed a fine of RUB 438 million (about EUR 7.3 million) in 2017 (Federal Antimonopoly Service of the Russian Federation (FAS Russia), 2017a).

Prepared by the authors, based on Anderson et al. (2018a).

important component during the merger reviews; and (iii) the definition of the relevant market[11] and market power. As digital markets often involve nominally free products, a key competitive factor concerns control over data, and therefore a variety of competition law provisions may be relevant, including provisions relating to mergers, abuses of a dominant position and cartels (OECD, 2013).

In addition to the above-mentioned issues, collusive effects (facilitating inter-firm coordination of supply and pricing) can also arise in digital trade. 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. In this regard, though, it is still not clear how far machine learning algorithms may facilitate the reaching of collusive outcomes. If market conditions are prone to collusion, it is likely that algorithms learning faster than humans would also be able through high-speed trial-and-error to eventually reach a cooperative equilibrium (OECD, 2017a). For example, the so-called tit-for-tat algorithm – a strategy that starts

Box D.4: Competition advocacy regarding digital markets by WTO members

A recent report by the Canadian Competition Bureau highlights that, although global developments in technology have allowed firms to harness data in ways that drive innovation and quality improvements across a range of industries, the use of big data, (i.e. very large data sets that may be analysed to reveal patterns, trends, and associations, especially relating to human behaviour and interactions) by firms may raise challenges related to competition law enforcement. The Competition Bureau, while adapting its tools and methods to this evolving area, will continue its investigations and analysis to be guided by fundamental competition law enforcement principles (The Canadian Competition Bureau, 2018).

The European Commission (2017d) has observed that certain practices may restrict competition by unduly limiting how products are distributed throughout the EU, potentially limiting consumer choice and preventing lower prices online. As noted by the Directorate-General for Competition, the inquiry's findings allow the Commission to target its enforcement of EU antitrust rules in e-commerce markets (European Commission´s Directorate General for Competition, 2018). This is particularly relevant in the light of recent enforcement cases such as Google, Amazon and Facebook. For more details, see also European Commission (2017c; 2017e; 2017f).

The Japan Fair Trade Commission (2017) has referred to possible risks of competition being impeded and the interests of consumers being harmed as a result of concentration of big data in certain enterprises. While Japan's Competition Act is applicable to most competition concerns related to the collection and utilization of data, some issues such as "digital cartels" and monopolization and oligopolization of digital platforms still need to be addressed.

In the Russian Federation, a need has been identified to adapt antimonopoly regulation in order to address anti-competitive conduct on cross-border markets in the contexts of digitalization and globalization (President of the Russian Federation, 2017). The Federal Antimonopoly Service (FAS) has taken an important role in the development of new regulations to maintain competition. The primary focus has been on regulation of the inherent elements of modern digital markets, such as digital platforms, network effects and big data (Rudomino et al., 2018). These proposals are in line with FAS's recent enforcement activities in the Google case (Federal Antimonopoly Service of the Russian Federation, 2017b).

Prepared by the authors, based on Anderson et al. (2018b).

with cooperation but then will just copy exactly what the opponent did in the previous period – can often lead to cooperative behaviour. Although in terms of technology an AI sophisticated enough to take over business decisions arguably is not yet evident, competition law needs to keep a close eye on AI developments in order to be pro-active and prepared to address challenges ahead (Deng, 2018).

In sum, the successful operation of digital markets in the interest of consumers as well as producers seems very likely to entail significant activities on the part of national competition authorities. At the same time, the proliferation of cases and relevant policy initiatives carries the potential for coordination failures. The cross-border activities of digital firms can result in spillovers, for example in the case of varying stances across different jurisdictions towards anti-competitive agreements, abuses of dominant position and mergers (Epstein and Greve, 2004).

(d) Data localization

Data localization policies involve restrictions on the ability of firms to transmit data on domestic users to foreign countries. They may take the form of rules requiring data servers to be located within the country or data to be stored or processed in the country, prohibiting the collection or transfer of data without government approval and/or specifying government procurement preferences and technology standards that favour local companies. Such policies may be broad rules covering most or all types of data, or they may be focused on specific types of data. Narrower measures within this category include requirements for payments to be processed locally or requirements that personal information, such as medical or tax records, be stored within the country.

A report by the Albright Stonebridge Group (ASG, 2015) indicates that data localization requirements differ significantly between countries and that data

localization requirements are constantly changing. While some countries have laws that contain explicit data localization requirements, which require the entities that process data related to the country's citizens to have servers physically located within that country's borders, others have partial measures, including regulations applying only to certain domain names and regulations which require the consent of an individual before data about that individual can be transferred internationally, as well as mild restrictions, i.e. restrictions on international data transfers under certain conditions, and specific restrictions on the transfer of data in very specific sectors such as health and finance, on grounds of protecting citizens' sensitive data.

Policy-makers often justify data localization requirements on the basis of privacy or security concerns. Governments may argue that the data of their citizens need to be protected by the laws of the country where they live. They may also argue that data relating to domestic citizens should not be accessible to foreign national security agencies, and that foreign companies, when they use data, should be bound by the laws of the country where the data have been collected (Goldfarb and Trefler, 2018a). The argument that data localization requirements can be justified on privacy or cybersecurity grounds is subject to debate. Cory (2017), for example, argues that in most instances, data localization mandates increase neither commercial privacy nor data security. This is because most foreign companies doing business in a country have "legal nexus" which puts them in that country's jurisdiction. This means that they must comply with the host country's privacy and security laws and regulations on whether they store data in the host country, the home country or a third country. Cory also argues that the confidentiality of data does not generally depend on the country in which the data is stored, but rather on the measures used to store it securely.

Whether or not data localization is an appropriate means of addressing data privacy or security concerns is an important question, in large part because data localization requirements may impose a significant cost on foreign companies wanting to do business and may thereby impact trade. As discussed in Section C.2, data localization may force foreign companies who wish to collect data to establish commercial presence in all countries in which it is imposed. Foreign companies may also need to put in place a system that prevents data traffic from being routed internationally. As a consequence, they may have to spend more on IT and data storage services, than without data localization measures. They may be prevented from transferring data required for day-to-day activities, such as for human resources, and may have to pay for duplicative services. And they may also be compelled to spend more on compliance activities, such as hiring a data protection officer, or putting in place systems to seek the approval of individuals or governments to transfer data. These additional costs can undermine a foreign firm's competitiveness by cutting into its profit margins (Cory, 2017). Depending on how they are designed and implemented, data localization requirements may also prevent some data storage or data processing services from being provided on a cross-border basis.

The economic literature that discusses the impact of data localization requirements on international trade and investment is scarce. Recent research by Ferracane and van der Marel (2018), however, suggests that data policies do indeed inhibit imports of services over the internet. These authors use an empirical approach to assess whether regulatory data policies implemented in 64 countries between 2006 and 2015 have had a significant impact on a country's ability to import services over the internet. More specifically, they develop and use a regulatory index of data policies that measures how restrictive countries are in regulating the usage and cross-border movement of data. This index of data policies is then related with trade in services over the internet to study whether indeed restrictive data policies reduce the imports of services over the internet.

(e) Intellectual property-related issues

Intellectual property (IP) protection, by determining the scope and extent of use-rights (i.e. licenses) to intangible content, provides much of the legal framework in which digital products are traded domestically and internationally (see Section C). As in many transactions the purchased product is never present in a physical form, but exists only in digital form on various devices, it is often the ownership and transfer of use-rights to this material that largely determines the commercial transaction when music, software and films are purchased and downloaded online. Some forms of services trade therefore consist of IP transactions, and in the case of many digital products purchased by consumers, the underlying IP license often defines the nature of the underlying commercial transaction. IP also facilitates various ways of trading in physical goods and in services using electronic means: for instance, the IP system enables the electronic flow of data and information necessary for e-commerce to function. In the intangible world of the internet, the significance of intellectual property rights (IPRs) such as trademarks to identify and market goods and services, and of

the copyright which covers the software running websites and apps, and of defining the use-rights (i.e. licenses) when music or movies are downloaded, has appreciably increased beyond the significant role IPRs already play in offline trade to channel and frame commercial information and proprietorship.

Advancements in communications technology have not only made digital content-sharing extremely easy, fast and cheap, they have also vastly increased the ability of private individuals to create digital content. While the facilitation of digital content-sharing has led to concerns about the rapid unauthorized distribution of films, music and other commercial content across the digital environment, the increased ability of private individuals to create digital content has given rise to business models such as YouTube, Google and Facebook, which rely on the exchange of such "user-generated content" on their platforms in order to attract third-party advertising.

In light of the multi-faceted interaction of the IP system with electronic commerce, governments' IP-policy responses to these phenomena cover many different areas of intellectual property. One focus of government responses since the early days of the internet has been the successive adaptation of IP enforcement tools to the challenges of the online world. Following the adoption of the World Intellectual Property Organization (WIPO) Copyright Treaties in 1996 (see Section D.3(c)), a number of countries have introduced varying degrees of legal protection against the circumvention of technological protection measures (TPMs) or the removal of digital rights management (DRM) information. These measures created civil – and sometimes criminal – liability for the circumvention of technical measures (e.g. digital locks, passwords or encryption) that was used to control access to copyright-protected material on the internet, sometimes regardless of whether the use of the material would have constituted a copyright violation (see for example Ginsburg, 1999 and Hinze, 2006). Other systems further prohibited the manufacture and sale of tools that could be used for TPM circumvention (see for example Besek, 2003). The details of these regulations have a direct impact on software developers, and on the sale and distribution of digital downloads, such as in TPMs in video games (see for example Miller, 2007).

The practice of linking to and sharing content on the internet, which is at the root of the many trade opportunities offered by the internet, has also forced countries and jurisdictions to develop a more elaborate concept of "contributory infringement", answering to whether, and under what circumstances, merely hyper-linking to infringing material, or providing the possibility to search and locate infringing material on the internet, itself constituted IP infringement. Different policies have also been adopted as regards the extent to which the individual end-user and consumer of IP-protected material – as opposed to those actors producing it and making it available on the internet – should, in a departure from the traditional view, be held liable or even criminally responsible for IP infringement.

In order to further discourage illegal file-sharing, France in 2009 adopted the so called HADOPI Law (i.e. "Haute Autorité pour la diffusion des œuvres et la protection des droits sur Internet", or "High Authority for the dissemination of works and the protection of rights on the internet"), which provides for a "graduated response", i.e. a successive reduction – up to complete suspension – of internet access for users who have repeatedly been notified of online IP infringement. This type of enforcement system, used to different degrees also by Korea and New Zealand – which aims to discourage IP infringement by threatening the suspension of internet access of the end user through Internet Service Providers (ISPs), has sparked increased discussion about the appropriate balance of IP enforcement in the online world, and has had a profound impact on the designs of B2C business models (see for example Danaher et al., 2014 and Lucchi, 2011).

As many new online business models centre on novel ways to search, locate and present the vast amount of – mostly copyright-protected – content on the internet, countries have had to develop responses to the question of how the traditional exceptions and limitations to IP protection – which permit the appropriate balancing of the interests of IP users and rights-holders – are to be applied in the new digital world. This challenge has been to maintain the policy objective of IP regulation by transposing the existing legal concepts into the digital context, and to assess whether the existing balance between rights and obligations inherent in IP regulation conceived for the analogue world needed to be reviewed in light of the scale and nature of IP use in the digital world and the new business models it has triggered.

One example of these challenges is the issue of whether image search services, which display their search results as miniature versions or thumbnails of the images found on the internet, could benefit from existing exceptions to copyright protection, or whether image search engines require the authorization of each holder of image rights involved in the search (see McFarlane, 2007 and German Federal Court (BGH), 2017).

The Google Books Project – Google's initiative to scan entire libraries of books and provide full text searches of their content, displaying the results in "snippets" of relevant text, financed ultimately and partially through advertising (see also Box D.5) – and the ensuing large-scale litigation is an emblematic example of how IP regulation is often the essential determinant for the viability of such new business models that exist entirely in the digital space. Responses to these business models have highlighted that common law and civil law systems, and the different mechanisms of how these provide for copyright exceptions (i.e. specific permitted uses) or fair use (i.e. a doctrine permitting unauthorized uses under certain flexible factors), face very different challenges in accommodating such new business models (Hugenholtz and Senftleben, 2012).

An issue that is determinative for the viability of the many platform business models that rely on user-generated content is the liability of such platforms and of internet service providers (ISPs) in respect of the transmission and storage of material initiated by other parties by means of those platforms and ISPs. While this issue concerns any potentially illegal activities that may occur within the digital network environment, it has been much debated in the area of copyright and related rights. In the course of a normal process of transmission of protected content, a number of temporary reproductions of that content may be produced by service providers. These intermediaries may have only limited knowledge about the information they transmit or store, as well as limited ability to control or monitor such information.

The question that has arisen is to what extent service providers, who act as intermediaries transmitting or storing potentially infringing content, are or should be held liable for such content and, if so, what remedies should be available. The liability of intermediaries has now been addressed in various jurisdictions at the national level by limiting the liability of service providers, under specified conditions, to certain forms of injunctive relief in respect of certain IPR-infringing material or activities initiated by a person other than the service provider. In some of the varied systems employed by different WTO members, the conditions include that the service provider complies with a "notice and take down" procedure that allows the rights-holder to notify it of allegedly infringing material residing on its system and require it to take down or disable access to such material after receiving such notice. A certain form of "safe harbour" for cooperating service providers has also been reflected in recent international agreements (such as the IP Chapter of the Trans-Pacific Partnership Agreement (TPP)).

In the area of trademark protection, the relationship between trademarks and internet domain names has received particular attention. Some of the problems have derived from the fact that under each top-level domain (such as ".com") there can be only one of each particular second-level domain name (e.g. "amazon.com"), which is usually allocated on a first-come, first-served basis within each top-level domain name. More recently, the introduction of new generic top-level domains that can consist of any string of letters, including brand names or geographical names, has further increased the focus on the interaction between registered trademarks and other distinctive signs (such as geographical indications), and the modalities of acquisition and use of domain names. These new top-level domains include names such as ".swiss", ".patagonia" and ".wine".

Specific problems also relate to the question of how terms that enjoy privileged status in the trademark system – such as names of international organizations under Article 6ter of the Paris Convention of 1967, incorporated into TRIPS by Article 9.1 – would be treated in the context of the domain name system administered by the Internet Corporation for Assigned Names and Numbers (ICANN). These names, such as "WTO" or "WIPO", are not themselves trademarks, but are protected against unauthorized registration and use under international law.

A number of approaches have been developed to resolve these issues, including the WIPO Domain Name Processes and the adoption of the successful Uniform Domain Name Dispute Resolution Policy, and principles of taking into account trademark rights have been integrated into the allocation process for new generic top-level domains. However, various questions remain with respect to how the trademark standards and permissible exceptions interact with the essentially private allocation mechanism for the new generic top-level domains, as well as the second-level domains that can be created by their owners.

(f) MSMEs specific measures

The advent of the internet and of advanced digital technologies has made it easier for MSMES to participate in trade and provided them with access to consumers in international markets. Taking note of the export potential of MSMEs, many governments are undertaking special efforts to increase the participation of MSMEs in digital trade.

For example, the Malaysian government, in partnership with the Alibaba Group and Malaysia Digital Economy Corporation (MDEC), has launched

Box D.5: The Google Books Project

Google operates Google Books, a programme under which Google scans and copies millions of books from participating libraries into an online database. Google Books houses both in-print and out-of-print books. Approximately 93 per cent of the books in the database are non-fiction, while only 7 per cent are fiction.

Two digital book programmes make up Google Books: the Partner Program and the Library Project. The Partner Program contains material provided to Google by book publishers or other rights-holders. The Library Project hosts scanned copies of books that Google borrows from collections of the New York Public Library, the Library of Congress and a number of university libraries. Google never sought the permission of the copyright-holders to copy or display the books used in the Library Project. After scanning a book into the Library Project, Google retains a copy for its own records and gives a digital copy to the participating library from which it borrowed the book. Google maintains an overall index of all the scanned books, and users can conduct searches using their own queries, to which Google returns a list of the most relevant books in which users' search terms appear. The user clicks on a particular result, whereupon Google directs the user to an "About the Book" page, which includes links to sellers of the book or libraries that list the book as part of their collections.

During searches, users can look at "snippet views" of selected books. Each snippet view comprises one-eighth of a page of the book. Google takes security measures to prevent users from viewing a complete copy of a snippet-view book by "blacklisting" certain pages in each book. An "attacker" that tries to obtain an entire digital copy of a book by stringing together words appearing in successive passages would obtain, at best, a patchwork of snippets; at least one snippet would be missing from every page, and 10 per cent of the pages would missing.

In the ensuing court US case, Authors Guild, Inc. v. Google Inc. (United States District Court, 2013), in which author's associations and publishers challenged the project for copyright infringement, the court began its analysis by pointing out five notable benefits of Google Books. First, Google Books provides a new way for people to locate books and serves as a beneficial research tool for librarians. Second, Google Books promotes "data mining", permitting humanities scholars to analyse massive amounts of data quickly. Third, Google Books increases access to books by providing literature in a format compatible with various types of software and devices used by print-disabled individuals to read and locate books. Fourth, Google Books preserves old books, many of which are out of print or in a deteriorating condition. Finally, Google Books benefits authors and publishers by exposing users to books to which they might not otherwise be exposed and directing readers to shops that sell the books, thereby generating new audiences and profits.

The court then evaluated Google's defence by balancing the four fair use factors: (1) the purpose and character of the use, (2) the nature of the copyrighted work, (3) the amount and substantiality of the portion used in relation to the copyrighted work as a whole, and (4) the effect of the use on the potential market for the copyrighted work.

The court found the first factor, the purpose and character of the use, to weigh heavily in favour of fair use. The court determined that Google's use of the copyrighted books is highly transformative. Google Books transforms expressive text into a comprehensive word index, which helps readers, scholars, and researchers find books and opens new fields of research. Further, the court found that Google Books does not replace actual books because it is not a tool for reading books. Instead, it allows for the creation of "new information, new aesthetics, new insights and understandings". The court acknowledged that Google benefits commercially from Google Books because the programme draws users to Google websites, but found the important educational purpose of the programme to outweigh its commercial nature.

The court also found that factor two, the nature of the work, weighed in favour of fair use, as the vast majority of the books in Google Books are non-fiction. Non-fiction books are typically afforded less copyright protection than other works due to their educational value.

Turning to the third factor, the amount and substantiality of the portion taken, the court found it slightly weighted against fair use, since Google scans entire books and copies expression *verbatim*.

Box D.5: The Google Books Project *(continued)*

The court found that the fourth factor, the effect of the use upon the potential market, weighed strongly in favour of fair use. Google does not sell the scanned books, and the scans do not replace the books. Libraries can only download copies of books they already own. Further, users cannot obtain enough snippet views of the books to comprise an entire book because Google blacklists certain pages and snippets, meaning readers must still purchase the copyrighted works to obtain full access.

The court found that Google Books does not serve as a market replacement, but rather enhances book sales to the benefit of the copyright-holders by acting like a traditional in-store book display.

Lastly, in its overall assessment, the court noted that Google Books provides significant public benefits and advances the progress of the arts and sciences while maintaining a respectful consideration of the authors' rights (United States District Court, 2013; Viveros, 2014).

Prepared by the authors, based on Viveros (2014).

the Digital Free Trade Zone, combining a physical zone and a virtual platform to connect MSMEs with potential export markets and facilitate cross-border e-commerce activities.

In another example, as a part of its budget for 2017, Singapore announced an elaborate programme called "SMEs Go Digital" that aims to facilitate the adoption of digital technologies by MSMEs. The programme offers specialist advice and consultancy services to help MSMEs with their digitalization requirements. In addition to promoting skills development and lifelong learning for employees, the programme also offers pre-approved digital solutions for MSMEs in the logistics and retail sectors.

Other governments, such as Brazil, Canada, Chile and Switzerland, are undertaking programmes to assist local MSMEs in tapping international markets, streamlining their business processes, developing digital marketing strategies and improving their e-customer services. Along the same lines, many governments, in addition to offering advisory services on e-marketplaces, are also facilitating training programmes tailored for MSMEs to help improve their online export capabilities.

3. Digital trade and international cooperation

This subsection will start with a discussion of the rationales for international cooperation in the context of digital trade. It will then examine how existing international trade agreements and international organizations active in the trade area help governments to seize the opportunities and address the challenges associated with digital trade. It will also review current discussions in the WTO context on related issues. Finally, the section will discuss issues that have been identified by academic researchers or other experts.

(a) Standard rationales for international trade cooperation and their applicability to digital trade

The fundamental purpose of international trade agreements, according to the traditional theory, is to ensure that governments internalize the negative externalities they impose on their trading partners (see the opinion piece by Robert W. Staiger, Department of Economics, Dartmouth College, on page 150). In other words, the core insight here is that if countries are large enough to have some market power, they can manipulate their terms of trade (the relative price of exports and imports) in their favour by unilaterally imposing import tariffs (or non-tariff measures). If two large trading partners behave in a non-cooperative way, they may end up in a Prisoner's Dilemma i.e. a situation in which actions that are rational for each country individually leave them worse off collectively (Bagwell and Staiger, 2002). The internalization of such negative externalities through reciprocity and the principle of non-discrimination will resolve this Dilemma and result in a level of tariffs and market access that is efficient from a global perspective. Whereas the terms-of-trade theory is based on international negative externalities, another approach, the commitment theory approach, views the rationale of trade agreements in terms of a domestic externality. According to the commitment theory, the role of trade agreements is to provide an external commitment device so as to enable governments to enhance the credibility of their trade policies (WTO, 2012c).

A number of qualifications are in order. First, neither the terms-of-trade theory nor the commitment theory provides a satisfactory explanation of the role of international trade agreements in the area of services. For example, the existence of a mode of supply of services through a foreign commercial presence makes it difficult to apply the terms-of-trade theory and the flexibility provided for in the General Agreement on Trade in Services (GATS) casts doubt on the relevance of the commitment theory. Thus, alternative explanations for international trade agreements in the area of services have been advanced.[12] Second, the terms-of-trade rationale for trade agreements explains traditional trade agreements that provide for "shallow integration" through rules on tariff reductions coupled with rules to ensure that the value of tariff reductions is not undermined by non-tariff measures. However, provisions on non-tariff measures in international trade agreements often go beyond the need to avoid policy substitution between tariffs and non-tariff measures. This can be explained by various factors, including the differences between non-tariff measures and tariff measures, such as information problems, the role of private standards, the possible strategic competitive use of non-tariff measures and new forms of cross-border spillover effects resulting from the growth of global value chains (WTO, 2012c).

Negative international externalities may arise from factors other than terms-of-trade manipulation. In particular, regulatory heterogeneity may lead to significant trade costs. Thus, trade agreements can also serve to help governments reduce the costs that result when firms are required to comply with different regulatory requirements in different markets (Hoekman and Mavroidis, 2015). Yet another role that a trade agreement may be called upon to play is to prevent a race-to-the-bottom through a competitive lowering of regulatory standards (Sheldon, 2006; Bagwell and Staiger, 2002).

Digital trade measures may give rise to various types of negative externalities and thereby warrant international cooperation. First, where such measures favour domestic producers over foreign ones, the negative externality is similar to the terms-of-trade externality and the rationale for trade cooperation is to create a mechanism preventing governments from behaving opportunistically by compelling them to take into account the costs of their actions for foreign firms. Second, international cooperation may also be warranted where measures affecting digital trade produce negative externalities of a jurisdictional nature. Thus, for example, the cross-border dimension of digital firms can result in cross-jurisdictional spillovers in the domain of competition law and policy, as discussed in Section D.2. Third, negative externalities can arise as a result of costs incurred because firms have had to comply with different regulatory requirements in different countries. In this respect, Section D.2 identifies several possible subjects for regulatory coordination, including electronic signatures, consumer protection, and data protection regimes. Finally, Section D.2 also discusses the need to avoid a race-to-the-bottom dynamic as a possible reason for international cooperation with respect to privacy protection.

Recent initiatives in the context of the trading system reflect these various rationales for international trade cooperation. There would appear to be an emerging recognition that adequate arrangements for trade by means of digital technologies must address a range of policy concerns in order to minimize the risks of negative externalities. In addition, the important role of foreign investment in the development of the digital economy means that the commitment theory mentioned above is particularly relevant in this context insofar as rules that lock in more open policies can help attract foreign investment, particularly in services enabling or supporting digital trade.

Finally, two observations can be made regarding the current international policy landscape regarding digital trade. First, over the last decade, digital trade has become an increasingly debated aspect of international trade relations. Economies are pursuing divergent policies in a context that some analysts have characterized as exhibiting features of strategic trade rivalry and in which market dominance of firms from certain countries has raised concerns. Tensions arising from differing economic policies have been exacerbated by differences in approach to the appropriate regulatory role of governments. While many analysts consider that there has been a rising trend towards "digital protectionism" or "digital trade barriers",[13] it has also been argued that measures alleged to constitute barriers to digital trade may often serve legitimate public policy objectives (Aaronson, 2016). These divergent policy and regulatory approaches can be seen as contributing to the more general phenomenon of what has been referred to as the "balkanization" or "fragmentation" of the internet (Drake et al., 2016; GCIG, 2016).[14]

Second, recent research on the rule-making challenges posed by digital trade discusses the need to address the interface between trade governance and various other policy objectives pursued by governments with respect to certain aspects of internet governance (Ashton-Hart, 2017; Ciuriak, 2018b; Ciuriak and Ptashkina, 2018b; Singh et al., 2016; Aaronson, 2016). One aspect of this may be how to bridge the intellectual, cultural and institutional

OPINION PIECE

On the implications of digital technologies for the multilateral trading system

By Robert W. Staiger, Department of Economics, Dartmouth College

There is little formal research into the implications of digital technologies for the multilateral trading system and the role of the WTO. However, the literature on the economics of trade agreements offers a possible approach to thinking about these issues. On the basis that trade agreements address the international externalities associated with unilateral trade policy decisions (see Bagwell and Staiger, 2016; Grossman, 2016), two questions might be asked: (1) How might digital technologies interact with the traditional international policy externalities addressed by the WTO; and/or (2) might they create new forms of international externalities that the WTO could address?

Consider the first question. In the literature on the economics of trade agreements, shifting a portion of the costs of unilateral trade policy interventions onto trading partners gives rise to a "terms-of-trade" externality. The market access issues that dominate WTO discussions can be reinterpreted within this literature as terms-of-trade-manipulation/international-cost-shifting issues (Bagwell and Staiger, 2002). The question can then be rephrased as whether digital technologies might alter the trade rules that are necessary to deal effectively with terms-of-trade manipulation.

There are many channels through which digital technologies could have such an effect (see, for example, the discussion in Gao, 2018). A basic issue in this context is how to classify digital trade for the purpose of applying existing WTO rules. For example, is a blueprint for use in a 3D printer, when delivered from abroad, a traded good or a traded service? If the latter, should the transaction be considered as services trade under GATS Mode 1 or Mode 2?

Answering these questions is important, in part because of the different nature of the WTO approaches to liberalization in the GATT and in the GATS. While the GATT's approach may be termed "shallow integration", based on "tariffication" of protective measures and the subsequent focus of liberalization efforts on tariffs, the GATS's approach can be characterized as "deep integration", since it focuses on a variety of sector-specific behind-the-border regulatory measures. Will digital technologies, and the associated blurring of the goods/services distinction, make the distinction between GATT and GATS increasingly untenable? If so, the rising importance of digital technologies may necessitate a restructuring and unification of these agreements within the WTO.

Staiger and Sykes (2016) offer an interpretation of the distinct design features of the GATT and the GATS from the perspective of the terms-of-trade theory of trade agreements. They suggest that a redesign of the GATS in line with the shallow integration design of the GATT might be possible and could be warranted. Greater harmonization of the WTO approach to rules for trade in goods and in services could be even more beneficial in the light of the blurring of the distinction between trade in goods and trade in services.

Turning to the second question above, it is indeed possible that digital technologies will create new forms of international externalities that can be addressed by the multilateral trading system. An example is the privacy issue associated with cross-border data flows. Just as firms' intellectual property rights (IPRs) can have trade effects, protection of consumers' data can also have trade impacts. Like IPR protection, cross-border privacy issues are not market access issues, i.e. the international externality associated with cross-border privacy issues does not take the form of a terms-of-trade externality. Accordingly, one would expect to look outside of the GATT and the GATS for solutions to the privacy issues raised by digital technologies.

The WTO TRIPS Agreement (i.e. the WTO Agreement on Trade-Related Aspects of Intellectual Property Rights) seems a natural forum for addressing the privacy issues raised by digital technologies. Since much digital trade takes the form of licensing arrangements over intellectual property, issues of IPR protection are central to digital technologies. Moreover, the privacy issues raised by digital technologies can be viewed as cross-border private property rights issues over one's own digital data. Viewed in this way, the international externality associated with these issues has a broadly similar structure to the non-market-access externality that the TRIPS Agreement is designed to address. (Rather than an agreement over reciprocal market access rights, TRIPS is an agreement on minimum standards for the protection and enforcement of IPRs, which are explicitly recognized in the TRIPS preamble as "private rights" – see Petersmann, 1996). This suggests that the broad design of TRIPS might also provide a platform for addressing the cross-border privacy issues raised by digital technologies.

gaps between the world of trade rules and other policy communities (UNCTAD, 2017a). Another theme that has been raised is how to strike the best balance between international rules to promote trade and ensure non-discrimination, and the pursuit of legitimate regulatory objectives of governments in areas such as online privacy and cybersecurity.[15]

(b) World Trade Organization

This subsection examines how certain WTO agreements cover digital trade, how they help economies to seize new trading opportunities arising from digital innovations, and how they address challenges. It also reviews discussions on related issues at the WTO.

(i) Work programme and new initiatives on e-commerce

Given the cross-cutting nature of e-commerce, the WTO Work Programme on Electronic Commerce adopted in 1998 tasked four WTO bodies (The Council for Trade in Services, the Council for Trade in Goods, the Council for TRIPS and the Committee for Trade and Development) to explore the relationship between existing WTO agreements and e-commerce. Since 1998, WTO ministerial conferences have considered the issue of e-commerce and decisions have been taken in that regard. In addition to agreeing to maintain the practice of not imposing customs duties on electronic transmissions, ministers have taken note of work done and have repeatedly called for the continuation and reinvigoration of the Work Programme on Electronic Commerce and for the General Council – the highest-level WTO body – to hold periodic reviews.

The period following the 10th WTO Ministerial Conference (which took place in Nairobi, Kenya, in December 2015) witnessed an increased interest among WTO members to deepen the discussion on e-commerce in the WTO. This increased momentum culminated in the circulation of ten submissions from members since July 2016. The submissions cover a wide range of issues including, among others, the definition of e-commerce, the applicability of customs duties to goods, transparency, the regulatory framework, and infrastructure gaps to enable e-commerce. Some members have shown a keen interest in pursuing e-commerce further, starting with looking at the existing WTO disciplines to determine what is currently addressed and what is not.

While discussions are still ongoing, the work programme has allowed consideration of how WTO rules apply to e-commerce. Most of the discussions to date have moved toward the notion that electronic commerce falls within the scope of existing WTO agreements, even when there is no specific reference to "electronic commerce" or "online trade". However, more recently, several members have been considering whether there is a need for new and improved multilateral rules, so as to respond to new challenges related to the changing nature of trade.

In the run up to the 11th WTO Ministerial Conference in Buenos Aires, Argentina, in 2017, 15 WTO members[16] created an informal group called the "Friends of e-Commerce for Development" (FEDs) with the objective of raising awareness about how e-commerce could become a vehicle for development. The FEDs acknowledged e-commerce as a tool to drive growth, narrow the digital divide and generate digital solutions for developing countries and LDCs, and they agreed to develop a comprehensive, long-term digital trade policy agenda.[17]

At the Buenos Aires Ministerial Conference in December 2017, members agreed to continue the work under the Work Programme on Electronic Commerce (WTO, 1998). They also agreed to maintain the current practice of not imposing customs duties on electronic transmissions until 2019.[18]

At the same time, however, in an initiative distinct from the work programme, ministers representing 44 members (counting the European Union as one member) issued a joint statement on electronic commerce. In this statement, they reaffirm the importance of global economic commerce and the opportunities it creates for inclusive trade and development. They state that they share the goal of advancing electronic commerce work in the WTO in order to better harness these opportunities and announce that they, as a group, will initiate exploratory work together toward future WTO negotiations on trade-related aspects of electronic commerce (WTO, 2017b).

(ii) Trade in services

Trade agreements have a role to play in overcoming the negative externalities brought about by restrictive policies affecting digital trade in services. Because a number of services sectors provide the basic infrastructure for e-commerce (e.g., telecommunications, financial and distribution services) and since, in addition, a wide array of services is supplied electronically, the GATS appears particularly relevant.

Scope and obligations

The scope of application of the legal obligations in the GATS is extensive. The GATS applies to all measures affecting trade in services and "measures" are defined broadly to include "any measure by a Member, whether in the form of a law, regulation, rule, procedure, decision, administrative action or any other form". The term "affecting" has been interpreted to cover not only measures which directly govern the supply of services but also measures which indirectly affect it.

The breadth of coverage of the GATS also results from the way in which the Agreement defines "trade in services", as encompassing services supplied through four modes of supply.[19] The four modes extend the definition of trade in services well beyond traditional notions of international trade. In addition, the term "supply" adds another important dimension, as it is also defined broadly, to include "the production, distribution, marketing, sale and delivery of a service". Whereas merchandise trade under the General Agreement on Tariffs and Trade (GATT) only begins post-production, trade in services encompasses the production process throughout the value chain of services. Therefore, all government measures affecting the supply of services, from their production to the final delivery, are covered by GATS obligations. With regard to sectoral coverage, the GATS applies to all services sectors, with the exception of governmental services (referred to as services supplied in the exercise of governmental authority) and most of the air transport sector.

It is important to note that the GATS makes no distinctions regarding the different technological means through which a service may be supplied. Therefore, the supply of services through electronic means (for example, via the internet) is covered by the GATS in the same way as all other means of supply. This also means that GATS disciplines apply to services supplied electronically and that the supply of a service across borders includes all means of delivery, including electronic delivery. In other words, the GATS is "technology-neutral". This has been confirmed by WTO jurisprudence (see Section D.3(b)(vii)). As a result, trade restrictions, as well as domestic regulations affecting electronic trade in services, are subject to the GATS.

All measures taken by governments with respect to the vast majority of the concerns usually identified in this context (e.g. network access, competition and interoperability, e-signatures, authentication, encryption, licensing, e-payments and standards, cybercrime, consumer protection, privacy of personal data, and data flow restrictions), to the extent that they affect trade in services, are covered by the GATS.

The GATS legal framework contains two types of provisions: general obligations and specific commitments. Some general obligations apply across the board to all services, whether or not commitments have been taken. Most notable of these are most-favoured-nation (MFN) treatment (whereby a member accords immediately and unconditionally to services and services suppliers of any other member treatment no less favourable than that is accords to like services and services suppliers of any other country) and transparency. Many other general obligations, however, apply only to sectors where a member has scheduled specific commitments. Specific commitments on market access (Article XVI), national treatment (Article XVII) and additional commitments (Article XVIII) are inscribed in schedules. The schedules list the sectors in which specified levels of liberalization are guaranteed. Unlisted sectors are, as a result, only covered by the general obligations that apply across the board.

Market access (Article XVI) is defined as the prohibition on a government to apply six types of restrictive measures unless they are explicitly inscribed in its schedule.[20] The first four are quota-type measures. These measures may be discriminatory or non-discriminatory, i.e. they may affect only foreign or both national and foreign services or suppliers. They may be explicit quotas, or be implemented in the form of an economic needs test (a test that conditions market access upon the fulfilment of certain economic criteria) or other measures having the same effect.

In the dispute DS285 "United States – Measures Affecting the Cross-Border Supply of Gambling and Betting Services" (also known as US – Gambling), the panel found that a member would not respect the market access obligation if it restricted any means of delivery under Mode 1 (see endnote 19) with respect to a committed sector in which no limitations were scheduled. Under the interpretation, a measure that bans the electronic transmission of a committed service would, in principle, be inconsistent with commitments in which no relevant limitation is listed.

National treatment (Article XVII) prohibits a government from applying measures that treat foreign services or suppliers less favourably than national services or suppliers of the same type, unless a limitation is explicitly entered in its schedule. Whether formally identical or not, treatment is considered less favourable if it modifies the conditions of competition in favour of national services or suppliers. For

example, forms of local data processing or storage requirements, or other restrictions on data flows, might infringe on a national treatment commitment under one of the modes of supply if they adversely affect the competitive opportunities of foreign services and suppliers relative to domestic services and suppliers.

Additional commitments may also be negotiated and inscribed in schedules by members (Article XVIII). These are legally binding positive undertakings with respect to measures that are not market access and national treatment limitations. In fact, additional commitments were designed to address possible gaps in existing rules that drafters might not have envisioned at the outset, e.g. to address unforeseen trade barriers or regulatory constraints. Thus, they can include undertakings that promote best practices, as was the case for telecommunications (see below). It is the first and only sector, so far, for which additional commitments have been taken on regulatory principles.

Annex on Telecommunications and Reference Paper

Of particular interest for e-commerce are two sets of obligations that focus on telecommunications services: the Annex on Telecommunications, which applies to all WTO members, and the Reference Paper on Regulatory Principles on Basic Telecommunications, which has been incorporated into the Schedules of Commitments by 103 WTO members. The Annex was concluded in recognition of the central role of telecommunications as a medium of transporting services. The Reference Paper aims to address the difficulty of effectively realizing commitments on liberalization in a sector typically characterized by dominant operators following the introduction of competition.

The Annex on Telecommunications ensures that suppliers of all scheduled services have access to and use of public telecommunications transport networks and services (i.e basic telecommunications) on reasonable and non-discriminatory terms and conditions.[21] The Annex on Telecommunications is of particular significance for e-commerce. It was drafted during the Uruguay Round (1986-1993) by negotiators who realized that, despite the competition-related provisions in Article VIII of the GATS, telecommunications operators were in the unique position of having sufficient market power potentially to undermine scheduled commitments in any service sector in which telecommunications were essential to doing business. Today, the use of communications networks and services has become even more integral to global business activity, especially online supply and sales of services, than it was when the Annex was first negotiated.

The Annex carries its own generally applicable non-discrimination disciplines on telecommunications service suppliers, notwithstanding whether specific commitments have been scheduled under telecommunications services. The term "non-discriminatory" is defined in the Annex as referring to both MFN and national treatment, as well as to sector specific usage of the term.[22] As a result, the suppliers of any service listed in a schedule, such as computer services, accountancy services or financial services or even other telecommunications, are thus assured of non-discrimination with respect to access and use. In terms of e-commerce, moreover, the Annex has the potential not only to afford internet access providers reasonable and non-discriminatory access to circuits and other internet backbone facilities obtained from operators; it can also ensure reasonable and non-discriminatory access by a range of suppliers of services over the communications networks.

It is of particular significance to online activity and the incumbent data flows involved that the Annex addresses information transfers.[23] It requires members to ensure that foreign service suppliers may use basic telecommunications for the movement of digitalized information both within and across borders, including for intra-corporate communications and for access to information contained in databases or otherwise stored in the territory of any member. All suppliers of committed services benefit from these obligations.

The regulatory principles embodied in the Reference Paper on Regulatory Principles on Basic Telecommunications govern the prevention of anti-competitive practices, the terms of interconnection, licensing criteria, transparency, the independence of regulators from suppliers, universal service, and other matters relevant to the prevention of abuse of dominant market positions with respect to basic telecommunications. These additional commitments were undertaken by 103 WTO members.

The Reference Paper, insofar as it promotes competitive conditions in the supply of telecommunications services, should help foster the extension of affordable and efficient infrastructure for e-commerce. It was developed because of the concern that, despite the commitments undertaken, telecommunications markets would still frequently be characterized by dominant suppliers, referred to as "major" suppliers in the text, that controlled bottlenecks or essential facilities and would be able to frustrate the effective realization of commitments if entirely free to decide how to treat their new competitors.

GATS exceptions

Concerns about online intrusions of privacy, the potential for fraud or other illicit activities (i.e. cybercrime), and the protection of transmissions against hacking (i.e. cybersecurity) have characterized discussions surrounding the internet since its inception. Such issues have gained greater prominence recently as the internet has become globally widespread and capable of more sophisticated business and personal activities thanks to broadband technologies.

Better understanding the general exceptions provisions of Article XIV and security exceptions of Article XIV *bis* of the GATS and how they operate therefore has considerable relevance to e-commerce. General exceptions permit members to take GATS-inconsistent measures if they are "necessary" to achieve certain public policy objectives. These objectives include the protection of public morals and the maintenance of public order, as well as securing compliance with laws or regulations – in themselves consistent with the GATS – for the protection of the privacy of individuals and the prevention of deceptive and fraudulent practices.

Article XIV is also subject to safeguards against abuse in that GATS-inconsistent measures taken under it must be "necessary". Put simply, this means that the inconsistent measures must themselves be necessary to achieve particular objectives. A measure would not be considered necessary, for example, if an alternative measure that is less trade-restrictive would achieve the same objective. The general exceptions also may not be applied in a manner which constitutes unjustifiable discrimination between members or used as a disguised restriction on trade in services.

Article XIV *bis* on security exceptions allows a member to take any action that the member considers necessary for the protection of its essential security interests relating to the supply of services for the provisioning of a military establishment, relating to fissionable and fusionable materials and the materials from which they are derived, or taken in time of war or any other international relations emergency. Article XIV *bis* does not convey the same standard of "necessity" as Article XIV.

Specific commitments relevant to e-commerce

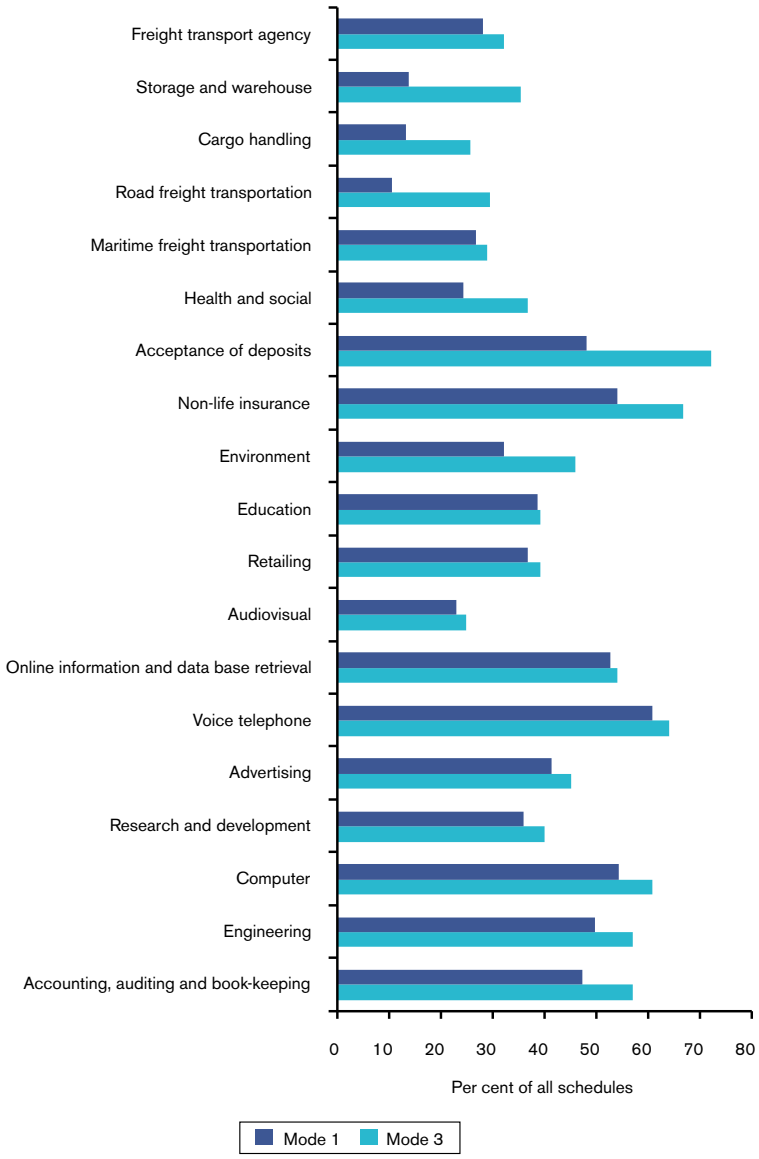
As a number of GATS disciplines apply only to committed services, the most advantageous conditions for digitally-enabled services are achieved when commitments exist and when those are as open as possible. The uncertainty stemming from the lack of multilateral bindings for services, in particular market access and national treatment measures, carries additional trade costs. Research has underscored that the predictability of market access conditions underpinned by the WTO system of disciplines has commercial value in itself (WTO, 2014b). In the case of goods, trade policy uncertainty measured as the gap between bound and applied tariffs (also known as tariff "water") is a significant trade impediment (Osnago et al., 2015).[24] Recent studies corroborate that services commitments in the GATS, as well as in regional trade agreements (RTAs), have a positive impact on services trade (cross-border or through commercial presence) when controlling for applied levels of openness. Further, services commitments that bind the *status quo* incite trade more than commitments that have "water" (Lamprecht and Miroudot, 2018).

In the WTO, some members have responded by taking commitments, in the Uruguay Round and in subsequent accessions, in a range of ICT-enabled sectors. Sometimes, such commitments, in the form of phasing-in commitments in telecommunications, have accompanied and encouraged further reforms. In other cases, commitments have bound the status quo. Members have also responded by negotiating and committing to the Reference Paper on Regulatory Disciplines for the Telecommunications Sector.

Overall, members have so far made uneven use of the GATS commitments to reduce trade barriers or guarantee existing levels of openness. The proportion of schedules that contain commitments on cross-border supply and commercial presence for such digital infrastructure services such as voice telephony, computer services, and online information and database retrieval, for example, is higher than in a number of other services sectors, but more than one-third of schedules provides no guarantees of treatment in these areas (see Figure D.1). Retailing services, which include online retailing services, are uncommitted in the majority of members' schedules. Further, the number of schedules containing commitments on Mode 1 is limited in relation to services, where the increasing performance of digital networks provide opportunities for cross-border electronic supply, such as accounting, engineering, research and development, advertising, audiovisual and educational services. The proportion of members' schedules that includes additional commitments in relation to the Reference Paper on Basic Telecommunications stands at 58 per cent (Roy, 2017).

As discussed in Section D.3(d), a number of governments have also responded by using services

Figure D.1: Percentage of schedules with commitments for Modes 1 and 3 in selected sectors



Source: Roy (2017).

Notes: The figure shows whether guarantees of a minimum level of market access and national treatment are provided for each sector and mode. It does not assess the level of openness guaranteed, how this level relates to the openness currently granted in practice, or whether it contains "water". (For definitions of Modes 1 and 3, see endnote 19).

RTAs, to a much greater extent on average than GATS commitments, to bind access conditions for the cross-border supply of services (including in some cases digital supply) as well as to guarantee levels of market access and national treatment for the establishment and operation of foreign entities wishing to provide, for example, digital infrastructure services.

Looking forward, the fact that most commitments under the GATS date from negotiations concluded 20 years ago represents the single most important gap in the coverage of e-commerce in services. Updating these commitments would be possible, should WTO members decide to do so, given the considerable levels of unbound liberalization in place.

(iii) Trade in goods

This section explains how the multilateral rules for trade in goods have remained relevant in the face of technological developments. It also shows that, notwithstanding the capacity of WTO rules to adapt, there have been instances where divergences of opinion have emerged on their interpretation, some of which have been solved through collective action or by plurilateral initiatives that promote specific outcomes.

Interpretation of existing trade rules in the context of new technologies

Situations may arise where new technologies lead to differences in opinion as to how the rules should be interpreted and understood, at least initially. This section will describe how the rules seem to apply to trade in 3D printed goods, including some issues that may become increasingly important, and how members have dealt with the interpretation of two cases derived from the "servicification" of manufacturing (when the manufacturing industry is increasingly relying on services as inputs into the production process, as well as producing and exporting more services along with goods).

3D printing

As explained in Section B, 3D printing refers to manufacturing processes in which a material (such as liquid molecules or powder grains) is joined or solidified under computer control to create a three dimensional object based on a digital model such as a 3D model, a computer-aided design (CAD) or an additive manufacturing file (AMF). Despite the advanced technology used, objects "printed" using this technique are not significantly different from those produced using traditional manufacturing techniques that rely on design works, plans, or sketches.

If an object is designed in one country and the instructions for its manufacturing are transmitted to another country, it is evident that what is being transmitted is not the object itself, but rather a design or plan that then allows a company to produce one or more units of that particular model. But what happens if the 3D printed good are then exported to another country? Under the existing rules, they would not be treated differently from goods manufactured based on designs developed in another country or the same country of exportation. There are, however, two sets of rules that may become increasingly relevant in determining such treatment.

The first one relates to Article 8 of the WTO Customs Valuation Agreement (CVA), which requires customs authorities to add certain additional payments to "the price actually paid or payable" of the imported goods.[25] Article 8:(1)(b)(iv) expressly requires customs to include in the customs value payments for "engineering, development, artwork, design work, plans and sketches, *undertaken elsewhere than in the country of importation* and necessary for the production of the imported goods" (emphasis added). Given the qualification in the provision, the country where these "engineering, development, artwork, design work, plans and sketches" are produced has an impact on the customs value of the imported goods. Thus, all things being equal, if a 3D printed object is imported into the country where the 3D model was developed – which would not occur in the event that the object was simply printed in the same jurisdiction in which the model was developed – the object would have a lower customs value. However, if goods are printed for export, it may be increasingly difficult for customs to take account of such costs, particularly in cases where these are not declared by the importer and there are no proper post-importation audit procedures in place.

A second exception relates to rules of origin (the criteria needed to determine the national source of a product), which vary depending on the specific methodology used to determine "substantial transformation" for a particular case. While the cost of the 3D model might be taken into account in the case of rules based on value addition (i.e. whether these works and plans are originating or non-originating), they will not play any role if, instead, origin is determined based on a change in the tariff classification (i.e. because only the tariff classification of the physical inputs incorporated into the final product are taken into account) or specific manufacturing processes. Since WTO members have not yet concluded the harmonization work programme, there are currently no product specific non-preferential rules of origin at the WTO, so each member can determine its own rules. In the context of preferential schemes, there is also a wide diversity in the types of rules of origin applied by members, which could make it increasingly difficult to determine which rule to apply in the case of 3D printed objects.

Although the issue has not been specifically discussed by WTO members, there does not seem to be a *prima facie* case for treating 3D models, CADs or AMF files differently from traditional engineering, development, artwork, design work, plans and sketches. The latter have been routinely developed and transmitted digitally over the past decades. Under

one view, 3D printing does not present anything essentially new in terms of current customs rules and procedures, which would suggest that the rules do not require an adjustment (Kafeero, 2016). However, as also discussed by Patrik Tingvall, Chief Economist and Magnus Rentzhog, Senior Adviser, National Board of Trade (Kommerskollegium) (see their opinion piece on page 158), this is not necessarily a consensus view. During a 2015 meeting at the World Customs Organization (WCO), some customs experts considered that it was necessary to discuss "the possible implications of 3D printing on origin, valuation, IPR and security" (WCO, 2016). Some of them also considered that, in addition to revenue-related issues, "there might be a need to redefine the term 'goods' in the future", which is "relevant for Customs responsibilities in 3D printing overall".

Servicification of manufacturing

The "servicification" of manufacturing refers to the situation in which the manufacturing industry is increasingly relying on services as inputs into the production process, as well as producing and exporting more services along with goods. Services are increasingly traded indirectly by being either embedded or embodied in goods exports, and not only directly (Drake-Brockman and Stephenson, 2012). The existing rules still apply to trade in *all* goods, without distinguishing whether they include embodied or embedded services. There are, however, some agreements that do take such aspects into account. For example, the CVA already prescribes the types of services that can, or cannot, be taken into account when determining the customs value of a good. As previously explained, the preferential and non-preferential rules of origin based on value addition also take into account certain services to determine the "substantial transformation" of a good.

On the valuation side, the Technical Committee on Customs Valuation (TCCV), which was established by the CVA and meets under the auspices of the WCO, has discussed two cases that have dealt with these issues. The first one involved a service contract with an engineering firm: a company in Country A entered into a service contract with an engineering firm in Country B, for a specific amount (e.g. US$ 1 million), for the construction of an industrial plant in Country A. Once the engineering firm completed the plans, it produced blueprints that were then exported in paper form from Country B to Country A. At the time of importation, customs authorities in Country A had problems determining the relevant customs value of the imported documents. In particular, it was not clear whether such value corresponded in full to the amount paid to the engineering firm. Was the customs value of those plans the amount paid to the engineering firm under the services contract (i.e. the US$ 1 million) or something else?

In 2009, the TCCV adopted by consensus Advisory Opinion 22.1, which notes that because the documents were "tangible", they should, therefore, "be regarded as 'goods' for which determination of the customs value is required" (WCO, 2016). However, since the payment to the engineering company had been for the services performed under a services contract (i.e. it had not been a payment as consideration for the documents themselves), it could not be taken into account in the customs value of the imported documents. One of the key elements to arrive at this conclusion was that the documents had not been "sold for export", which is one of the key requirements to apply the transaction value methodology. It was further acknowledged that the remaining valuation methods were also inapplicable to this particular case, in which case the "fall-back" method of Article 7 of the CVA would have to be used.[26] Under this provision, customs value must be determined in consultation with the importer in a flexible manner.[27] Beyond this advisory opinion, it is worth noting that, had the documents been transmitted electronically and printed in Country A, customs authorities would not have become acquainted with the engineering contract.

A second issue that was discussed by the TCCV between 2013 and 2016 involved the treatment of fees for unlocking a function of imported goods after importation. More specifically, it dealt with digital copiers that had incorporated a special locked application software (i.e. a security function), which was an optional component that could be unlocked by the final buyer after buying a code or password from a third party who owned the copyrights. In other words, the application software had not been developed and licensed by the manufacturer, but rather by a non related third party, in a manner akin to a smartphone app.

The manufacturer included the application software in all imported copiers for convenience, but the application could not be used without the code or password, which had to be bought by the final user as an internet download. The question was whether the customs value of those digital copiers should also include the value of that additional locked function, when it had been taken up by the buyer. During the TCCV discussions, several delegates were of the view that this type of voluntary fees for functions that could be unlocked post-importation should not be includable in the customs value, and proposed to adopt an instrument confirming this interpretation.

OPINION PIECE

"Is the WTO 3D printing-ready?"

By Patrik Tingvall, Chief Economist and Magnus Rentzhog, Senior Adviser, National Board of Trade (Kommerskollegium)

New disruptive technologies are affecting firms' production decisions and reshaping global patterns of trade and investment. 3D printing, or additive manufacturing, is a perfect example. An article in the *Global Trade Review* suggests that 3D printing may wipe out as much as 40 per cent of world trade by 2040 (ING, 2017). The question asked here is: what challenges will the progress of 3D printing have on WTO and the multilateral trading system?

With 3D printing, computer-aided design (CAD) data is used to build physical objects by adding material layer by layer. 3D printing is already changing trade and production flows by moving production closer to customers, reducing transportation time, allowing for customized production, and lessening the need to stock products. We also see new types of firms emerging, such as CAD designers, CAD-file market places, and 3D-print shops. On the supply side, we see new "ink" producers challenging established firms. 3D printing is also bringing about labour market changes, from goods- to services-related occupations, such as CAD-design programmers and designers, post-production specialists, 3D material experts and consultants.

From a trade policy perspective, one can say that certain stages of the manufacturing production are merged into the 3D printing process, which in turn replaces trade in intermediate goods.

Even if it is difficult to make an exact prediction of the future landscape of trade and production, they appear to point toward increased trade in services, data, IPR and user rights.

The speed and magnitude of this transmission will partly depend on the regulatory environment governing trade and location of 3D printing activities.

Current WTO rules generally work well in the ongoing transition from trade in goods to trade in services, as concluded in a study by the National Board of Trade, Sweden. There are several reasons for this, including the fact that many WTO rules are flexible and technologically neutral.

Nevertheless, with the evolution of 3D printing and the shift from trade in intermediates to cross-border data flows, including IP content, we anticipate three ways in which 3D printing may challenge the multilateral trading system.

First, WTO rules on goods do not apply if there is no cross-border trade. Tariffs and trade facilitation are obvious examples. Additionally, agreements like the Anti-dumping Agreement become less relevant when there is no border crossing and when production can be easily moved out of the country facing anti-dumping duties.

Second, some agreements, or parts of them, gain importance at the expense of others. Most notably, services take centre stage, making GATS relatively more important. In other agreements, 3D printing changes how countries can use them. Under the Anti-dumping Agreement, questions arise on how to prove dumping and how to enforce an anti-dumping decision if production can be moved easily. For rules of origin, proof of origin must be shown in different ways.

Finally, some rules might need to be updated, for example:

- There is no horizontal rule on the right to transfer data, and if measures are not covered by commitments made, this opens up the possibility of protectionism and barriers on digital transfers.
- The increased degree of product differentiation complicates the use of rules of national treatment and the notion of a "like" product.
- Insufficient rules on export restrictions open the door for curbing exports of raw material and "ink".
- Differences in intellectual property rights between countries will become increasingly important in regard to where actual production will take place. In addition, current rules can be hard to apply to 3D printing.
- The GATS lacks detailed rules on issues such as subsidies. This makes WTO members less bound by trade regulations, meaning that companies that embrace 3D printing also move into less regulated territory.

In summary, the production and trade landscape is changing rapidly, with 3D printing as a key contributor. As shown, trade rules will not be a major barrier. However, some adjustments might be needed to ensure that WTO regulations do not stand in the way of progress. At the same time, it is also vital that the WTO is capable of providing clear and safe regulations for the multilateral trading system.

However, others disagreed with this view, commenting that the approach would risk creating an incentive for traders to design products to artificially reduce their customs value (e.g. by lowering the value of the device and increasing the value in locked functions for which consumers would almost certainly wish to pay) (WCO, 2009). The issue was discussed in several sessions of the TCCV, but they were not able to arrive at a consensus. As a result, if such circumstances arise, national customs authorities should interpret the rules of the CVA on a case by case basis, as they see fit.[28]

The two cases mentioned above illustrate the different stages with respect to some of these emerging challenges. In the case of exports of 3D printed goods, members do not yet seem to be facing any major challenges in the interpretation and implementation of the rules. However, this may change as the importance of the technology increases. In the case of the "locked functions" in apparatuses, members have discussed the correct interpretation of the rules, but have not been able to arrive at a common decision that would have harmonized the interpretation of the rules. Advisory Opinion 22.1 provides an interesting example of joint cooperation by members in clarifying the interpretation of the rules for a particular situation. One advantage of this outcome is that it results in increased transparency, security and predictability for traders, compared to the two other cases in which trade operators are likely to face different interpretations for identical situations.

How the legal texts have been adjusted to take digital technologies into account

Notwithstanding the capacity of existing WTO agreements to adapt to new technologies, there have also been situations in which GATT contracting parties and WTO members have decided to develop new provisions to tackle specific problems or take actions with a view to responding to emerging digital technologies.

Customs value of "carrier media bearing software"

In 1979, the Tokyo Round Code on Customs Valuation (the "Valuation Code") moved away from the notion of "normal value", under the Brussels definition of customs value,[29] in favour of the "transaction value", which was defined as "the price actually paid or payable for the goods, when sold for export to the country of importation". Under the then new rules, the value would be set on the amount that was "actually paid" for the imported goods, and not on the basis of the amount that the importer "should have paid" for the product. One year after its entry into force, participants to the Valuation Code faced a problem with regard to the valuation of software, which at that time was usually imported by means of punch cards, magnetic tapes, and discs (so-called "carrier media").[30] In particular, it was not clear how to apply the "transaction value" concept to the valuation of the software. Was the importer paying for the software (i.e. an "intangible") or for the carrier media bearing it (i.e. the "tangible" part that could be observed by customs officers)? The practice that had been followed by many countries prior to the entry into force of the Valuation Code was to calculate and collect import duties based exclusively on the carrier medium's value.[31]

Following almost two years of discussions, the Committee on Customs Valuation agreed on a decision on the valuation of carrier media bearing software, which reaffirmed the primacy of the transaction value and recognized that parties to the Valuation Code could choose between two options:[32] (1) parties could base the custom value on the price paid or payable for the software itself; or (2) parties could base the custom value on the cost of the carrier medium itself, excluding the cost or value of the software contained therein, provided that the two values had been differentiated on the invoice. In 1982, on the date of the adoption of the Decision, the Chairman of the Committee noted that:

> "In the case of imported carrier media bearing data or instructions for use in data processing equipment (software), it is essentially the carrier media itself, e.g. the tape or magnetic disc, which is liable to duty under the customs tariff. However, the importer is, in fact, interested in using the instructions or data; the carrier medium is incidental. Indeed, if the technical facilities are available to the parties to the transaction, the software can be transmitted by wire or satellite, in which case the question of customs duties does not arise. In addition, the carrier medium is usually a temporary means of storing the instructions or data; in order to use it, the buyer has to transfer or reproduce the data or instructions into the memory or database of its own system" (GATT, 1984b).

The so called "Carrier Media Decision" was subsequently readopted by WTO members after the conclusion of the Uruguay Round (GATT, 1995). To date, some 30 members have notified the WTO that they levy duties based exclusively on the cost of the carrier media and not on the value of the data or software (see Rev. 28 of GATT, 1984a). It is worth highlighting that the concept of carrier

media in this decision excluded "integrated circuits, semiconductors and similar devices or articles incorporating such circuits or devices", which eventually led to new interpretation challenges. This is because the Decision does not seem to apply to software imported by means of a USB flash drive, which contains integrated circuits. After discussing it, the TCCV was brought to the attention of the WTO Committee on Customs Valuation (2013a; 2013b). In November 2013, one delegation proposed to amend the Carrier Media Decision to take account of this technological development, but members have not to date reached consensus on this proposal (WTO, 2014a).

Liberalizing trade in information technology products

In 1996 a subset of 29 WTO members adopted the Information Technology Agreement (ITA) with a view to promoting faster technological change. This sectoral initiative eliminated tariffs on a number of essential information technology products, including computers, mobile phones, and most of the technological devices necessary to build and access the internet. Beyond the economic importance of these products, the main impetus for the negotiations derived from the positive impact that IT products could have on the economy and competitiveness of its participants, through improved business and manufacturing efficiency. The economic transformation towards a "global information society" required governments to promote affordable access to information technology which could be promoted by, for example, liberalizing trade in these products. Removing obstacles to trade in IT products would ensure that the new infrastructure would be built as quickly and as inexpensively as possible (WTO, 2012a).

In 2012, a group of WTO members submitted a "concept paper for the expansion of the ITA" (WTO, 2012b), which eventually led to concluding the "Expansion of the Information Technology Agreement" in December 2015 (see also GATT, 1995). Rapid changes in production methods, coupled with an increase in the speed of technological development, had transformed the sector and led to a series of new products that were not covered by the ITA. These included GPS systems, a new generation of medical devices, and an entirely new class of semiconductor chip called "multicomponent" semiconductors (MCOs) (Ezell, 2012). The ITA and the Expansion Agreement may play a key role in facilitating access to technology. In the right circumstances, they may also help firms in member countries integrate into global production networks and spur innovation in other sectors, thereby benefitting the economy as a whole (WTO, 2017a).

Digital technologies and the Trade Facilitation Agreement

The most recent example of multilateral trade rules being updated to take account of new digital technologies is the WTO Trade Facilitation Agreement (TFA), which entered into force on 22 February 2017.

Unlike the multilateral agreements that resulted from the Uruguay Round, which largely ignore the question of the technologies that may be used by members in order to comply with their obligations, the TFA makes explicit reference to a number of digital technologies. For example, Article 1.2 of the TFA goes well beyond the transparency provisions in Article X of the GATT by requiring members to make available "through the Internet" several categories of trade-related information. Article 7.1 requires members to allow for pre arrival processing of import documentation and includes provisions for the advance submission of documents in "electronic format". This is complemented by Article 7.2, which provides that members shall, to the extent practicable, allow for the option of "electronic payment" of duties, taxes, fees, and charges collected by customs. Article 10.2.2 requires government agencies to accept "electronic copies" when another government agency of the same member already holds an original of such document. Article 10.4 encourages members to implement a single window that will, to the extent possible and practicable, make use of "information technology" to support it. Finally, Article 12, which deals with international customs cooperation, envisages that communications (i.e. requests and answers between customs authorities in different countries) could take place through electronic means.

Although the TFA refrains from making similar references to specific technologies in other provisions, members are increasingly relying on digital technologies to implement most of its provisions, which is explained by the efficiency gains derived from relying on the interconnection of different electronic systems. This includes, for example, the provision in Article 7.4 concerning risk management, which in many countries has been designed as an electronic system that operates based on digital data shared with other systems, such as the information submitted for pre arrival processing, the database of authorized operators, and the availability of electronic copies of documents, much of which can be linked through an electronic single window.

Notwithstanding the capacity of WTO rules to be adapted to new situations, these three examples show that members have occasionally found it useful

to clarify specific aspects of the agreements or to adopt policy actions to promote specific outcomes.

(vi) Trade in agricultural products

The Agreement on Agriculture limits the use of trade-distorting support and permits unconstrained government spending on programmes that have no, or at most minimal, trade distorting or production effects. Annex 2 of the Agreement on Agriculture defines the scope of the latter and outlines detailed compliance criteria for granting such support. Several government policies permitted by Annex 2 would support digitalization and the introduction of innovative agriculture techniques and production practices.

This is particularly the case for "general services", a category of government support that accommodates policies that benefit the agriculture sector and rural communities as a whole. For instance, "pest and disease control" measures such as early-warning, quarantine and eradication systems could be computerized to minimize labour costs and enhance the accuracy of inspection, monitoring and traceability.

According to the Agreement, knowledge and skill-building to use digital data can be achieved through "training services" and "extension and advisory services", which include the provision of means to facilitate the transfer of information and the dissemination of results of research to producers and consumers. "Marketing and promotion services" include market information and advice and promotion relating to particular products. Digitalization can also be applied in "infrastructural services", including electricity reticulation (i.e. the provision of all equipment necessary to allow the delivery of electricity from the point of connection of a distribution network service provider's assets to sources of electricity supply, to the point of connection of an electricity consumer or of an electricity supply authority), water supply facilities and infrastructural works associated with environmental programmes. Government investments in these facilities are not subject to any limit, provided the expenditure is directed to the provision or construction of capital works only, and excludes the subsidized provision of on-farm facilities other than for the reticulation of generally available public utilities.

Disciplines contained within the Agreement on Agriculture relating to environmental or resource conservation policies contain adequate flexibility to promote comprehensive, innovative approaches to data, knowledge and technologies in agriculture. Innovative technologies including high-capacity sensors, and the massive data acquisition, storage, communication, and processing technologies to enable the development of new forms of knowledge, tools and services (Wolfert et al., 2017). However, in order for farmers to have access to data in a form that they can use, sophisticated and costly data-driven platforms to monitor and analyse the consumption of fertilizers, chemicals, energy and water in real-time may be required. Subject to benchmarks and conditions specified in Annex 2, agricultural producers may receive compensatory payments in the framework of such programmes in order to preserve agricultural ecosystems and spur the potential application of integrated digital solutions and innovative climate-smart technologies. The type of support may be particularly important for smallholder farmers who face significant hurdles in accessing new technologies (World Bank, 2017b).

Risk and uncertainty in agriculture stem from uncertain weather conditions, pests and diseases, and volatile market conditions and commodity prices. Managing agricultural risk is particularly important for farmers, and especially smallholders, because they lack the resources necessary to mitigate, transfer and cope with risk. Risk also inhibits external parties from investing in agriculture. Market inefficiencies and difficulties in coping with such risks by farmers may be used as a justification for introducing policies which could lead to market distortions.

However, as digital technologies offer cost-effective mechanisms for collecting, processing and disseminating data, they may help to reduce market inefficiencies resulting from poor and partial information and encourage recourse to policies covered by Annex 2 of the Agreement on Agriculture rather than to trade-distorting policies. More specifically, digital technologies can help farmers to mitigate against risks through tools like information services on weather (early warning systems) or prices (including through participation in spot commodity exchanges), as well as insurance mechanisms, including index insurance. However, factors like low levels of institutional development, the inability to customize products to meet smallholders' requirements, and poor financial literacy still hamper the widespread use of these mechanisms in developing countries (World Bank, 2017b). More complete and reliable data can also provide a better understanding of risk factors involved in the agricultural activity and encourage commercial lending and participation from multiple market and development stakeholders in agriculture (FAO, 2017).

Digital technologies can also improve the capacity of governments to monitor policy outcomes and re-invent policy design which could, in turn, contribute to reforms in the agriculture sector. Given the rapid changes and accompanying uncertainties in the global agricultural sector, policy-makers may need to experiment with new policies on a small scale before these policies are more broadly implemented (OECD, 2017b). Digital technologies for data acquisition, processing and analysis can effectively support this type of policy experimentation, allowing governments, for example, to identify individuals and groups that are at risk and do not have adequate social safety nets. However, while there is an increasing need for governments to be able to adopt nimble approaches to agricultural policies, challenges persist with respect to data gaps and measurement capacity. Creating the conditions that will support the evolution of policy priorities will require that policy-makers reflect on the implications of transformations in the agriculture sector beyond the short term, and that they adopt proactive thinking to anticipate where future opportunities and challenges will arise.

(v) Trade related aspects of intellectual property rights

The IP system interacts with and supports e-commerce in diverse and increasingly significant ways. Some forms of services trade transactions comprise IP as such, and, similarly, in the case of many digital downloads purchased by consumers, an IP license can actually define the nature of the underlying commercial transaction. IP facilitates various ways of trading in physical goods and in services using electronic means: for instance, the IP system enables the electronic flow of data and information necessary for e-commerce to function.

The WTO Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS Agreement) sets comprehensive minimum standards for the protection and enforcement of IP rights by incorporating pre-existing intellectual property conventions – administered by WIPO – into the WTO legal framework, and by adding and completing substantive standards over and above the level of previous conventions. This treaty technique means that the TRIPS obligations interact closely with the provisions of the WIPO conventions, and, consequently, that IP developments in the WIPO and the WTO form part of the multilateral IP system that strives to reconcile the meaning of different treaties and seeks to avoid conflict between them. (See WTO, 2000, *United States – Section 110(5) of the Copyright Act* at paragraph 6.70, which also takes into account WIPO treaties that were concluded after the TRIPS Agreement in order to avoid conflicts within this overall framework.)

The WTO TRIPS Agreement, and the integrated architecture of the multilateral IP system that it has created, thus constitutes a key component of the legal framework necessary for e-commerce and for international trade in intangible digital products. While TRIPS itself does not expressly address e-commerce or the digital environment as such, several of its provisions established a new international legal baseline that have supported and facilitated e-commerce. These include TRIPS disciplines on the non-discriminatory availability of IP rights, such as undisclosed information, copyright (including for software), patents and trademarks, balanced enforcement mechanisms, and the scope for competition safeguards. By establishing compatible domestic IP systems, the TRIPS Agreement helps build the legal structure in which rights to IP-protected digital products can be traded in the form of IP licenses, which in turn contributes to shaping commercial trans-border information flows.

General principles

Minimum standards and non-discrimination

Strict non-discrimination principles in the TRIPS Agreement, with fewer exceptions than those available under GATT and GATS,[33] ensure that any particular solutions individual members have implemented with regard to IP protection or enforcement in the digital environment (e.g. safe-guarding internet service providers from liability for IP infringement in user-generated content), or any additional IP protection they have made available in that regard (e.g. patent protection for software) – either in their national laws or in the context of RTAs – must be available to nationals from all WTO members, as a TRIPS obligation.

TRIPS flexibilities and development

The TRIPS Agreement contains elements of flexibility that allow members to seek appropriate policy responses to new issues raised by technological progress and the proliferation of e-commerce, and it has also enabled members to adapt the balance between IP rights and obligations in the online environment, where the operation of new business models such as search engines and information aggregator services contain new uses of IP-protected material.

Under the current TRIPS transition period regime, LDC members are exempt from applying the TRIPS Agreement – except for the non-discrimination principles – until 2021. Hence LDCs do not need to implement TRIPS IPR protection standards before

then, while their nationals can already enjoy the TRIPS standards for their own IP in other WTO members when engaging in online or offline commercial activity in their jurisdictions – a significant advantage as creative and innovative firms in LDCs seek effective access to global markets through e-commerce platforms.

Territorial nature of IPRs

IPRs are generally territorial in nature, which means that they are granted or arise separately in different jurisdictions, and the criteria for their validity or infringement are assessed separately according to the particularities of different territories. Trademarks or patents granted in one jurisdiction give rise to rights that are in principle only protected and enforceable in that country, and would not necessarily be infringed by activities in other territories. The TRIPS Agreement, and the provisions it incorporates from the Berne and Paris Conventions, are based on this understanding and provide various rules building on it, such as independence of protection in different jurisdictions.

Under the territoriality principle, IPR may differ considerably in scope from one member to another (and may be absent altogether in some members). This patchwork of distinct national IP rights poses challenges for the protection and enforcement of IPRs on the internet, as a global medium that straddles different jurisdictions. The extent of IP rights and their enforcement may vary significantly, and enforcement action by a right owner can, in many cases, involve costly multi-jurisdictional litigation and other procedures before numerous different national authorities. The TRIPS Agreement itself provides no specific rules on how its obligations on protection and enforcement of territorial IPRs could best be implemented in a space that transcends national boundaries.

However, over more than 20 years since the conclusion of the TRIPS Agreement, members' national jurisdictions have developed approaches and solutions to tackle these questions, which, in some areas, have settled into common practices that are now sometimes reflected in bilateral or regional agreements covering IPRs. The non-discrimination provisions in the TRIPS Agreement ensure that these national or regional solutions with regard to IPR protection in the digital sphere are available to nationals from all WTO members. A recent submission (WTO, 2016a) to the TRIPS Council suggested reaffirming the territoriality of copyright in the digital environment as a principle of the international trading system, in order to improve the business environment in the electronic copyright trade.

Substantive IPR standards

Given that the standards of IPR protection and enforcement provided for in the TRIPS Agreement create the very framework that is necessary to permit meaningful e-commerce and trade in digital products, it is clear that the vast majority of provisions are relevant for their operation. To highlight the pervasive significance of IPRs in this context, the following is a non-exhaustive selection of relevant substantive IPR standards that enable such trade to function smoothly.

Copyright and related rights

The implementation of TRIPS copyright standards by members provides the essential framework for e-commerce and international digital trade, as many digital products are defined in terms of the rights to use specific IPRs – often in the form of a license to use a copyrighted work. For instance, purchasing a video game, an app or a music file from an online retailer usually means obtaining a limited license from the rights-holder to use the copyright-protected software or sound recording, which can include the authorization to make a copy, and may include an authorization to obtain and use future updates of the game or software. That such a license can be legally traded and enforced is ensured by the TRIPS copyright standards on protectable works, including Article 10 on copyright protection for "Computer Programs and Compilations of Data", and their implementation into national law.

Similarly, the viability of new online business models such as search engines, news aggregator services or platforms for user-generated content rely to a large extent on exceptions and limitations which define to what extent copyright protected content can be used (e.g. displayed by search engines or aggregators) without authorization from the original rights-holder. A recent submission to the TRIPS Council calls members to assert the principle that "exceptions and limitations available in physical formats should also be made available in the digital environment" (WTO, 2016a). The criteria under which limitations and exceptions are permitted in the area of copyright are defined by the so-called three-step-test in Article 13 of the TRIPS Agreement (defining three cumulative criteria for legitimate exceptions), which has been interpreted in the panel report on the dispute *United States – Section 110(5) of the Copyright Act* (WTO, 2000).

The traditional principles of international copyright law as contained in the Berne Convention and the TRIPS Agreement have proven to be sufficiently

flexible to accommodate new categories of works, and ways of creating and using protected materials in the digital environment. The issues listed below are only some examples of how specific elements of the copyright standards have been interpreted and applied in the digital context.

Also relevant are the so-called "WIPO Internet Treaties", namely the WIPO Copyright Treaty and the WIPO Performances and Phonograms Treaty, described in Section D.3(c).

Right of reproduction

Article 9.1 of the Berne Convention, as incorporated into the TRIPS Agreement, provides that "authors of literary and artistic works protected by this Convention shall have the exclusive right of authorizing the reproduction of these works", and makes it clear that this right covers reproduction "in any manner or form".[34] In addition, Articles 11 and 14.4 of the TRIPS Agreement provide for rental rights in respect of computer programmes and phonograms and, in certain situations, cinematographic works, given that uncontrolled rental of such works, whether in digital or analogue form, may lead to widespread unauthorized copying.

The right of reproduction, enshrined in the Berne Convention and the TRIPS Agreement, is the very essence of copyright, both in the offline and online environments. Protected material embodied on digital media such as CDs and CD-ROMs have become increasingly vulnerable to piracy, given the ease and diminishing costs of digital copying, and the fact that digital information can be copied and transmitted over and over again without any loss of quality. The online environment involves risks of new forms of piracy, where websites can offer protected materials for download without the authorization of or any remuneration to the rights-holders. The initial unauthorized transmission of protected materials may be combined with traditional forms of piracy at the recipient's end. Therefore, the reproduction right and its effective enforcement are also essential in the new digital network environment.

The transmission of works and other protected materials over the internet or other electronic communications networks may involve a number of reproductions at various stages of the distribution chain. The first stage is the uploading of protected content to the host server at the point of transmission, and the final stage often involves downloading of that content by the end-user. The process of transmitting the content between these two points normally involves several intermediate and/or transient copies made by service providers. How to deal with such intermediate and transient reproductions has been a difficult issue in international discussions, in particular between content and service providers. These discussions have concerned the questions of the extent to which transient reproductions are or should be included in the scope of the reproduction right, and, to the extent they are included in the scope of that right, what type of limitations to that right should be applied in respect of such reproductions. A related question concerns what is the most effective point of control and enforcement of the reproduction right and the liability of intermediary service providers.

Right of communication

As regards the act of transmission of digital works, the right of communication is particularly relevant. The Berne Convention contains a number of provisions, incorporated into the TRIPS Agreement, that regulate this right.[35] A question discussed at the international level is whether these provisions concerning the right of communication adequately respond to the needs related to interactive online communications or whether clarifications or adaptations are necessary. This question was also raised in the course of the preparation of the WIPO Copyright Treaty. Article 8 of the final text of the Treaty, entitled "Right of Communication to the Public",[36] put the right of communication into a single provision containing two elements. First, it extends the right of communication to all categories of works. Second, it clarifies the application of the right in respect of interactive on-demand communications by confirming that the relevant acts of communication include cases where members of the public may have access to the works at different places and at different times.[37]

Trademarks

Standards concerning the availability, scope and use of trademarks are found in Articles 15-21 of the TRIPS Agreement which, together with provisions incorporated from the Paris Convention (1967) through Article 2.1, define the subject matter, minimum rights, permissible exceptions and term of protection. As with the rest of the TRIPS Agreement, the obligations regarding the protection of trademarks and other distinctive signs do not distinguish between the digital environment and the physical embodiment of goods or services. In e-commerce, the use and protection of trademarks and other distinctive signs is essential for rights-holders establishing their presence on a global scale through the internet. For example, in the globalized tourism sector, consumers purchasing goods or services at a distance, such as flights, hotel reservations and tour packages, increasingly rely on

the reputation and standardized quality associated with the trademark or other distinctive sign.

Trademark use on the internet

Article 15.1 of the TRIPS Agreement provides that any sign, or any combination of signs, capable of distinguishing the goods and services of one undertaking from those of other undertakings, must be capable of constituting a trademark. In order to obtain protection, a company generally files for the registration of a trademark in each country in which it operates.[38] Registration is made in respect of specified goods or services. Members may make registrability depend on use (Article 15.2), and require use to maintain registration (Article 19). The question that may arise as regards the application of these provisions concerns the conditions under which the use of a trademark on the internet satisfies such requirements, and when it does, in which countries. The TRIPS Agreement requires that the owner of a registered trademark be recognized to have an exclusive right to prevent others from using, in the course of trade, identical or similar signs for goods or services which are identical or similar to those in respect of which the trademark is registered, if such use would result in a likelihood of confusion (Article 16.1).

In this respect, the question that has arisen is under what conditions and in which jurisdiction(s) the use of a sign on the internet might constitute an infringement of a registered trademark, and whether the current territorially-based system of registration of trademarks is sufficient for the emerging borderless electronic marketplace. Identical or similar signs registered as trademarks for identical goods or services may be owned by different persons in different countries; thus, even in respect of identical goods or services, the use of such trademarks on the internet by one or more of the rights-owners may lead to conflicts. The question of relevant use has also been examined in members' domestic jurisprudence, to determine whether certain non-visible use of word trademarks – such as in coded website tags which trigger search results, or in advertisement keywords (i.e. online search terms which trigger the appearance of certain advertisements) – is considered infringing use, and if so, in which jurisdiction.

Issues relating to the use of trademarks on the internet have led to the adoption of a "Joint Recommendation Concerning Provisions on the Protection of Marks, and Other Industrial Property Rights in Signs, on the Internet" ("Joint Recommendation") (WIPO, 2001), by the Assembly of the Paris Union for the Protection of Industrial Property and the General Assembly of WIPO in September 2001[39] (see Section D.3(c)(v)).

Anti-competitive practices in the digital environment

As with the paper-based trading environment, anti-competitive issues are potentially raised by e-commerce, particularly in relation to intellectual property licensing arrangements. Article 40.1 of the TRIPS Agreement notes that "some licensing practices or conditions pertaining to intellectual property rights which restrain competition may have adverse effects on trade and may impede the transfer and dissemination of technology". The need for the intellectual property system to function effectively as a means of promoting transfer and dissemination of technology is vitally important in relation to e-commerce technology, as for other forms of technology, especially considering the infrastructure concerns of developing countries.

There are possible instances of anti-competitive behaviour in relation to some online licensing arrangements. For example, a click-through license for the use of a website could be anti-competitive according to national law implemented consistently with Article 40 of the TRIPS Agreement. Such a license may also seek through contractual means to remove the effect of permitted exceptions intended to balance rights and obligations in a TRIPS framework. Competition considerations regarding abuse of IPRs are also relevant to address situations where issues of interoperability of devices or networks involve IP protected technologies or standards. Particular difficulties may arise where exceptions to exclusive rights in TRIPS compliant domestic legislation differ in some respects across jurisdictions.

The framework created by Article 40 recognizes the importance of competition policy for IP systems and creates a consultative basis on which members can exchange specific concerns in this area, including where they relate to e-commerce and trade in digital products.

Enforcement

The TRIPS provisions on enforcement, Articles 41-61, require members to ensure that enforcement procedures are available under those members' laws so as to permit effective action against any act of infringement of IPR covered by the TRIPS Agreement, including expeditious remedies to prevent infringements and remedies which constitute a deterrent to further infringements. The provisions on enforcement are not specific to infringements in any particular technological environment. Consequently, nothing suggests that these provisions would not be applicable to IPR infringements in the digital network environment covered by the TRIPS Agreement,

although it does not appear to be possible to apply certain provisions, in particular those on special requirements related to border measures, to online distribution. The speed and geographical scope of damage that illegal activities can cause, for example to holders of copyrights and related rights, emphasize the need for expeditious remedies, including injunctions ordered as part of a final decision or on an interim basis, to prevent infringements from occurring.

On the one hand, the use of new ICTs may be helpful in modernizing judicial procedures consistently with the objectives referred to in Article 41, in particular by making them more rapid and less complicated and costly. On the other hand, these technologies also create new challenges for the application of these procedures.

Jurisdiction and choice of law

As IP has traditionally been regulated, administered and enforced on a territorial basis, the "borderless" nature of the internet raises difficulties in determining the appropriate jurisdiction in respect of activities carried out on a global network. On the whole, the TRIPS Agreement is silent on this issue, although it appears to have been drafted on the presumption that the right to take action should be available in the jurisdiction in which the infringing act takes place. Articles 44.1 and 50.1 of the TRIPS Agreement contain explicit references to this effect.

As regards the choice of law applicable to copyright infringements, guidance is given in Article 5(2) of the Berne Convention, as incorporated into the TRIPS Agreement, which provides that "the extent of protection, as well as the means of redress afforded to the author to protect his rights, shall be governed exclusively by the laws of the country where protection is claimed". A characteristic feature of the internet is that, once a work is put on the network in one country, it can be accessed anywhere in the world. This has led to discussions on the choice of law to be applied to a work posted on a website. Under traditional copyright concepts applied to the exploitation of works embodied in hard copies, the applicable law would appear to be that of the jurisdiction in which an act falling under copyright takes place. However, the problem with applying this approach to the internet is that if a website makes a posted work available worldwide, this potentially gives rise to the application of the laws of all jurisdictions in which the work can be accessed and liability under them. It has been argued that it would be preferable to apply to such exploitation of a work only the law of the jurisdiction from which the transmission originates. On the other hand, this approach has been seen as having an obvious limitation, in that the relevant acts leading to worldwide exploitation of a work could be governed by the law of a country with low standards of protection.

Applying remedies for internet infringement

A related question is what remedies should be available if subject matter posted on a website is considered to infringe IPR, in particular when the transmission originates from another jurisdiction. For example, should injunctive relief (a remedy compelling a party to refrain from specific acts) be available in respect of a transmission that originates from another jurisdiction and, if so, would such an injunction be enforced by the authorities of that country? Or should damages be calculated on the basis of injury in the country where the action against the infringement was taken, or on a worldwide basis?

Even though questions concerning jurisdiction and related matters have already arisen in the context of traditional ways of exploiting IP, such questions are likely to become more common given the global reach of the internet. The question appears to be whether the existing rules of public and private international law, including international treaties relating to mutual recognition and enforcement of judgements, adequately address these types of situations, or whether additional clarifications are needed.

In applying TRIPS enforcement standards in the context of e-commerce and trade in digital products, members' national jurisdictions have developed certain responses to specific practical challenges, some of which have also been reflected in other international or in bilateral agreements.

While digital reproduction and communication technologies create new risks of piracy, they also provide possible technical solutions to many problems faced by holders of copyright and related rights. Technological measures that can be used to facilitate the protection of copyright and related rights include copy protection (limiting the number of copies that can be made from an original reproduction), encryption (controlling access to online, satellite or other services) and watermarking (indicating within the material itself the original source of material, which can be used in tracking down piracy). The effective operation of such solutions may require that legislators provide adequate legal protection and effective legal remedies against the circumvention of the technological measures that are used by the holders of copyright and related rights to protect their rights. Given that this issue was not yet widely

discussed at the time of the negotiations that led to the conclusion of the TRIPS Agreement, it was not raised in the negotiations and no specific provisions concerning technological measures were taken into the TRIPS Agreement. However, the more recent WIPO Copyright Treaty and WIPO Performances and Phonogram Treaty recognize the role that technological measures used by rights-holders have in facilitating effective protection.

In conclusion, the standards for IPR protection and enforcement set out in the TRIPS Agreement are technology-neutral and apply regardless of whether the relevant criteria triggering an obligation are fulfilled on a digital network or in the physical world. Members' measures that affect use or protection of IPRs on the internet are subject to TRIPS obligations and disciplines. By defining the subject matter and the use-rights with respect to IPRs, the TRIPS Agreement provides much of the legal and conceptual framework necessary for e-commerce to function and for digital products to be traded in their intangible form. Its relevant provisions include substantive minimum standards relating to individual IPRs, the national treatment and MFN obligations, and transparency and cooperation obligations. Governments and businesses might nevertheless find value-added in an explicit recognition and affirmation of the applicability of the TRIPS Agreement to e-commerce.

While the traditional principles of international IP law have proven to be sufficiently flexible to accommodate both new technologies and ways of creating and using protected materials in the digital environment, technology and trade practices have developed significantly in the 20 years since the adoption of the TRIPS Agreement. As illustrated above, this has led members to develop specific approaches to how to apply TRIPS standards in the context of e-commerce and digital trade, which are reflected in many national laws and a number of international and bilateral treaties.

The non-discrimination principles of the TRIPS Agreement already ensure that any additional or more specific IP rights and advantages that members may implement in response to the above developments also benefit the nationals of all other WTO members. Beyond that, during the TRIPS-related discussions of the Work Programme on Electronic Commerce, several members considered the merits of clarifying the relationship of the TRIPS Agreement with some of these subsequent developments.

(vi) Aid for Trade

E-commerce development-related challenges are well known and range from infrastructure to capacity constraints particularly in developing countries and LDCs. As such, many have stressed the need to bridge the digital divide and address the related challenges as part of any effort to advance work on e-commerce. Technical assistance and capacity-building are key pillars of the WTO's work and play a fundamental role in furthering the understanding of the WTO Agreements and of other topics of discussion, including e-commerce. However, the WTO would not be able, on its own, to address all the challenges related to e-commerce.

To bridge the digital divide, additional finance must be mobilized to support the development of network infrastructure, dynamic ICT services markets, and adequate regulatory environments. Financing is essential to help develop affordable, reliable ICT infrastructure, and build up related services offerings, especially for under- or unserved populations.

Given the importance of services for connectivity, the Aid for Trade initiative, a WTO-led multi-stakeholder programme launched in 2005 to help developing countries, and in particular LDCs, to build the trade capacity and infrastructure they need to benefit from trade-opening, can play an important role in supporting the governments of developing countries in their efforts to enhance connectivity by adapting their policies to provide an enabling environment for investment, competition and innovation in digital infrastructure services. Roy (2017) sees two areas in which Aid for Trade could make a difference: by helping to improve foreign investment policy for services, and by providing assistance in reforming trade-related service sector policies and associated regulatory frameworks.

Improving foreign investment policy for services is key to attracting the foreign private investment needed to develop the digital infrastructure and thereby to contribute to achieving the United Nation's Sustainable Development Goals (SDGs) in developing countries. As emphasized by UNCTAD (2014), the contribution of the private sector is indispensable for many developing countries, as public financing alone will not suffice to meet SDG-related financing requirements. This is particularly true for the ICT sector, where private investment in public infrastructure, including land-based and submarine cables, dwarfs official development assistance: the former totalled US$ 702 billion between 2004 and 2015, a hundred times more than official development assistance for communications (US$ 6.8 billion) over the same period (Roy, 2017).

Improving trade-related service sector policies and associated regulatory frameworks is another area where Aid for Trade can make a difference. This assistance might consist in helping interested governments to design and implement policies in favour of connectivity services, involving, for example, the introduction of competition in monopolized segments of the telecommunications market or relaxing limits on the supply of certain key digital infrastructure services. It might also involve adapting and reinforcing regulatory regimes in services sectors subject to trade-related reforms. Introducing competition in telecommunications services, for example, typically involves changes in domestic policies regarding cross-subsidization and anti-competitive practices, interconnection, universal service obligations or the set-up and functions of an independent regulator.

Beyond the support in the services area, Aid for Trade plays an important role in assisting with trade facilitation. The TFA is a powerful tool to reduce trade costs. Trade facilitation tops the Aid for Trade priorities of both developing countries and their development partners, albeit in a broader conception that also includes physical connectivity, such as transport corridors, and digital connectivity too. There is also growing evidence of the positive impact of Aid for Trade in tackling border bottlenecks and contributing to inclusive trade outcomes.

As discussed in Section D.3(c), the Aid for Trade initiative is part of a broader effort to bridge the digital divide. The United Nations' 2030 Agenda for Sustainable Development includes targets for universal and affordable access to the internet, and several international organizations are undertaking initiatives that aim to bridge the digital divide.

(vii) Disputes before the WTO involving goods, services and digital technologies

The extraordinary development and diversification of digital technologies over the last couple of decades has made itself felt in the arena of WTO dispute settlement. As international trade increasingly involves both digital products and digital methods of transmission and delivery, the WTO dispute settlement has increasingly found itself tasked with resolving disputes related to aspects of the digital economy. These disputes often raise interesting and sometimes difficult legal questions.

Most WTO rules were drafted prior to the current digital revolution, and their application to new and innovative products and delivery systems can therefore be challenging. But the WTO dispute settlement system is required to adjudicate disputes efficiently and effectively regardless of the products at issue. Dispute settlement panels and the Appellate Body have therefore had to resolve, within the existing legal framework, disputes relating to technologies that in some cases did not exist when the WTO agreements were being drafted.

One important digital economy-related issue that has arisen in dispute settlement related to the GATT is the tariff treatment of new technologies. All WTO members have "schedules" of concessions, legal instruments setting out in list form the maximum import tariffs (i.e. bound duties) that can be levied by members on different products. Relating to the GATS, WTO members have schedules of commitments detailing bound levels of market access and national treatment. Both GATT and GATS schedules are "binding", meaning that members are legally prohibited from imposing tariffs or limitations above their scheduled levels.

Problems can arise, for example, when new technologies do not clearly fit into any of the product categories listed in a member's schedule, or when they appear to fall under more than one category. This challenge existed even before the emergence of digital technologies. In the 1950s, the Government of Greece decided to impose an import duty of 70 per cent on "long-playing gramophone records" (33 1/3 and 45 revolutions per minute), much higher than the specific bound duty for "gramophone records, etc.". When challenged by Germany in the GATT, Greece justified its decision on the basis that such records had not existed at the time that the Greek Government had granted that particular concession during the Annecy and Torquay Rounds, and that they were technologically different from the new ones (i.e. they contained a volume of recordings up to five times that of the old records, were lighter and made of a different material). For Greece, those "new products" were not covered by the scope of the concession.

However, this interpretation was rejected by a Group of Experts in "Greek increase in bound duty" (GATT, 1956), who recalled that "the practice generally followed in classifying new products was to apply the tariff item, if one existed, that specified the products by name, or, if no such item existed, to assimilate the new products to existing items in accordance with the principles established by the national tariff legislation". Because the concession had not placed any qualification upon the words "gramophone record", the Group of Experts concluded that the new long-playing gramophone records were also covered by the scope of this concession.

In the WTO, panels and the Appellate Body have considered variations of this problem in a number of cases. For example, in *EC – Computer Equipment*, the issue in dispute was whether certain types of LAN (i.e. local area network) equipment that had not existed at the time when the European Communities' schedule had entered into force were covered by the concessions on "telecommunications equipment" or "Automatic Data Processing Machines". This seemingly technical question had important consequences for the applicable tariff rate. In resolving this dispute, the Appellate Body confirmed that schedules are an integral part of the WTO treaty system, and must therefore be interpreted according to the ordinary rules of treaty interpretation and thus on the "basis of the ordinary meaning of the wording of the respective Schedules". On this basis, the Appellate Body found the panel's legal reasoning to be erroneous and thus reversed the panel's finding that the European Communities had violated its commitment of concessions for LAN equipment under the GATT.

In practice, this means that the proper tariff treatment of goods, including new digital equipment, does not depend on the subjective understanding of the scheduling member, but on the proper interpretation of the scope of the concession in a member's schedule in accordance with the various interpretive tools that exist in customary international law. Moreover, the meaning and coverage of the words actually used is not frozen in time at the moment when the schedule entered into force. Rather, as the scope and content of words change over time, such changes may be reflected in the coverage of the schedule. Following the same logic as that in the Greek gramophone records case, the question of whether a new product is covered by a commitment in a schedule of concessions is ultimately determined by properly interpreting the terms of the concession in accordance with the rules of customary international law.

The same approach was subsequently taken in *China – Publications and Audiovisual Products*, where the question at issue was whether a GATS commitment in China's services schedule concerning "sound recording distribution services" covered network music services, i.e. the distribution of music over electronic networks, such as the internet. Contrary to China's view that network music services constituted an entirely new type of service that did not come under any of the commitments made in China's services schedule, the Appellate Body, applying the rules of treaty interpretation and focusing on the "plain meaning" of the words used in China's schedule, found that the words "sound recording distribution services" were "sufficiently generic that what they apply to may change over time" (WTO, 2009). Confirming its approach in *EC – Computer Equipment*, the Appellate Body explained that, from a legal perspective, what matters is not the subjective understanding of the scheduling member but the meaning and coverage of the specific words used in the particular commitment at issue. Having interpreted China's commitment on "sound recording distribution services" according to the customary rules of treaty interpretation, the Appellate Body found that network music services fell within the scope of the relevant commitment. Neither China's own understanding of the commitment nor the range of existing music distribution services at the time the commitment was made were determinative in this respect. Thus, as the range of existing "music distribution services" expanded and diversified due to technological innovation, so did China's generically-worded commitment cover those newly developed methods of distributing music – including distribution over the internet.

Disputes may arise not only when new digital equipment enters the market, but also when existing products are modified or improved and take on additional capabilities or functions. For example, during the 1990s, computer and video monitors used to be distinct products with different technical characteristics, and one could not be used to replace the other because they used different connection interfaces. The version of the Harmonized System used in the Uruguay Round Schedules established separate categories, so members could levy different duty levels on them. However, technology eventually evolved to a point where multifunctional monitors entered the market, including flat panel display devices (FPDs), i.e. certain types of monitors or screens that can be connected both to a computer and other video sources thanks to the inclusion of multiple connection interfaces (e.g. DVI – digital visual interface – and HDMI – high-definition multimedia interface). But should these be treated as computer monitors or video monitors?

A WTO dispute settlement panel faced exactly this situation in *EC – IT Products*. That dispute concerned the tariff treatment of FPDs that were capable of receiving and reproducing video signals both from automatic data-processing machines (e.g. computers) and other sources (e.g. DVD players). So, were they subject to the 12 per cent bound duty for video monitors or to the duty-free concession for computer monitors?

The panel once again applied the same interpretative approach taken by the Appellate Body in *EC – Computer Products*. Looking at the words

actually used in the relevant parts of the European Communities' schedule, the panel acknowledged that the schedule explicitly excluded from duty-free treatment FPDs that were solely capable of receiving signals from sources other than automatic data processing machines. However, the FPDs at issue were capable of receiving signals from multiple sources, including automatic data-processing machines. Thus, the panel held that the European Communities could not deny the duty-free treatment to FPDs that were units of automatic data-processing machines simply because they were also capable of displaying signals from other sources. Thus, although the products and their multifunctionality were new, some of them nevertheless fitted into an existing category of the European Communities' schedule, and that category governed the applicable tariff rate.

These disputes show that new products do not necessarily fall outside of the scope of members' scheduled concessions. Rather, the proper tariff treatment of new products, including new digital and technological products, depends upon a proper interpretation of the scope of the relevant scheduled concessions as well as the applicable provisions of the relevant treaty or treaties.

Other technology-related issues have also arisen in WTO dispute settlement relating to digital methods of transmission or delivery in trade in services. According to the GATS, services trade is affected through one of four different methods or "modes" (see endnote 19 for a definition of the four modes). As the internet has increasingly overcome the physical barriers of time and distance and enabled international communication, engagement, and transaction with unprecedented ease and speed, and through an ever-increasing range of devices, disputes have arisen about the extent to which the provision of services over the internet, as opposed to more traditional technologies such as the telephone or the fax machine, are covered by members' services schedules. For example, in *US – Gambling*, it was found that gambling services provided over the internet were covered by a commitment in the United States' services schedule concerning the provision of gaming services. In that same report the panel noted that "this is in line with the principle of 'technological neutrality', which seems to be largely shared among WTO Members".[40] This means that the technologies used to enable Mode 1 trade have no bearing on whether the service(s) in question are covered by WTO rules. In other words, a service delivered over the internet is, for WTO purposes, to be treated no differently than the same service provided over the telephone – for example, the provision of French language lessons from France to students in, for example, Brazil, is to be treated the same regardless of whether the lessons are provided over the phone or via an internet voice call (WTO, 2004).

Accordingly, although new technologies are making the provision of services across borders both easier and more common, the mechanism or method by which such services are provided should not have an impact on their treatment under WTO law. This provides meaningful predictability and stability. It means that, although the constantly changing digital environment means that services are continually constantly being provided in new and innovative ways, their provision continues to be governed by the framework of rules and commitments made by members upon their entry into WTO.

(c) International organizations

As discussed in the preceding subsections, unilateral measures undertaken by governments may not be sufficient to fully capitalize on the opportunities offered by digital innovation and digital trade. In particular, there is scope for international cooperation and multi-stakeholder engagement at the supranational level. This subsection provides an illustrative list of key initiatives undertaken by other multilateral organizations to help governments realise the benefits and address the challenges related to digital trade.

While the focus of this section is on multilateral programmes, regional actors also play an important role. Regional developments banks, such as the African Development Bank (AfDB), the Asian Development Bank (ADB), the European Bank for Reconstruction and Development (EBRD), and the Inter-American Development Bank (IADB), as well as regional organizations like the African Union (AU), the Asia-Pacific Economic Cooperation (APEC), the Association of Southeast Asian Nations (ASEAN), and the various regional organizations active in Latin America, all have programmes in place in one area or another to accompany governments in their efforts to address the risks and reap the benefits of digital trade.

(i) Facilitating investment in human capital and addressing knowledge gaps

As already discussed in Section D.2(a), the lack of adequate infrastructure, coupled with low levels of human capital, is one of the key challenges faced by developing countries in reaping the gains from digital trade.

Several international organizations have developed programmes to help developing countries' governments build the skills needed for individuals and businesses

to maximize the benefits of digital trade, including the Internet Society (ISOC), the International Trade Centre (ITC), the International Telecommunications Union (ITU), the United Nations Commission on International Trade Law (UNCITRAL), UNCTAD, the Universal Postal Union (UPU) and the World Bank, as well as UN regional commissions. The ITU Academy, for example, provides face-to-face and online courses to equip individuals with the ICT skills they need to find their way around a fast-evolving digital environment. UNCTAD's TrainForTrade programme is another initiative that offers face-to-face technical assistance and skills training, as well as distance-learning courses to developing countries in multiple languages, customized according to the specific needs of the country. The programme also supports developing countries in formulating e-commerce and investment policies and implementing institutional frameworks for e-commerce-related issues at the national level.

Some programmes, such as the "Digital Skills for Decent Jobs for Youth" campaign launched in June 2017 by the International Labour Organization (ILO) in partnership with the ITU, focus on young people. The campaign aims to forge partnerships with the aim of mobilizing investment to equip 5 million young people with digital skills conducive to decent jobs by 2030.

The lack of information about market access and potential opportunities is another major challenge faced by developing countries in the context of digital trade. In view of this, many international organizations have undertaken initiatives to offer technical assistance and policy advice to developing countries, in addition to sharing information about best practices and trends in e-commerce.

UNCTAD, for example, launched a comprehensive multi-stakeholder initiative called "eTrade for all" in July 2016 to address existing knowledge gaps and maximize synergies between developing countries, donors and partners. Under this initiative, 29 international organizations (including the WTO) have come together to promote greater transparency in the supply of capacity-building efforts in support of eTrade readiness. The "eTrade for all" online platform serves as a one-stop information hub for developing countries to identify potential sources of assistance, connect with potential partners and benefit from currently some 25 different "development solutions", related, for example, to infrastructural support, skills-building, payment solutions, regulatory frameworks and trade facilitation (https://etradeforall.org).

Similarly, the WCO has launched an e-commerce web corner to serve as a single reference point for all e-commerce related information including policy support, technical assistance and capacity-building (see https://etradeforall.org/developmentsolution/e-commerce-web-corner-world-customsorganization/).

Another key initiative in this area is the Rapid e-Trade Readiness Assessments of Least Developed Countries implemented by UNCTAD to assist LDCs in assessing their e-commerce readiness by identifying critical readiness gaps in different policy areas (including ICT infrastructure, electronic payment systems, trade logistics, access to finance and skills development), and proposing concrete actions to address the gaps through collaborative public and private partnerships (see http://unctad.org/en/Pages/Publications/E-Trade-Readiness-Assessment.aspx). As of May 2018, seven such assessments had been completed,[41] three of which were funded through the Enhanced Integrated Framework (EIF), a multilateral partnership dedicated to assisting LDCs. The EIF's institutional and productive capacity-building projects also assist participating LDCs in developing e-commerce strategies and small infrastructure for online business and governance, with digital/e-commerce skills training being in many cases an integral part of such projects. Finally, the EIF is working with the United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP) to support the implementation of an Asia-Pacific paperless trade framework agreement through legal analysis and capacity-building.

Finally, the ICT Policy Review Programme (ICTPR), implemented by UNCTAD, serves as a broad-based initiative to offer technical assistance, strategic advice and diagnostics on e-commerce-related issues to governments (see http://unctad.org/en/Pages/DTL/STI_and_ICTs/ICT4D-Policies.aspx). The ICTPR aims to encourage inclusive policy dialogue by identifying bottlenecks and proposing solutions to reform ICT policies at the national level.

Various regional actors have also launched technical assistance initiatives to build digital skills at the regional level. The African Union, for example, has developed, as part of its Agenda 2063 framework – which, among other things, aims at developing ICT – a programme to support digital entrepreneurship and promote integration of ICT in education and training. ASEAN, for its part, adopted a work programme on e-commerce for the period 2017 to 2025, which includes human capacity development programmes on digital technologies and e-commerce. Another example is the IADB, which organizes training activities for customs officials and regional agencies on digital certification and electronic single windows, and is one of the driving

forces behind the ConnectAmericas Platform, a free social media platform that aims at facilitating firms' internationalization through online learning activities, information sharing and networking opportunities.

(ii) Addressing challenges related to trade facilitation and ICT infrastructure

Several international organizations are actively involved in initiatives that aim to support governments in using digital technologies to reduce the cost of doing business by simplifying and standardizing trade-related procedures, in particular customs procedures and the logistics of cross-border e-commerce.

One of the key programmes in this area is the UNCTAD Automated System for Customs Data (ASYCUDA), which was initiated in the early 1980s to automate the operations of customs administrations (see http://www.asycuda.org/). The main objective of the programme is to facilitate trade by strengthening the customs administrations' operational capacity to carry out their fiscal and control missions through automation. The ASYCUDA software has contributed to modernizing and streamlining customs transit and clearance procedures in more than 90 countries worldwide.

Another key actor in this field is the World Bank through its Trade Facilitation Support Program, which supports countries in implementing the WTO's TFA (see http://www.worldbank.org/en/programs/tradefacilitation-support-program). The ITC has also set up a trade facilitation programme to promote the inclusion of business perspective in trade facilitation reforms through the enhancement of public-private dialogue and increased collaboration between key stakeholders (see http://www.intracen.org/itc/trade-facilitationprogramme/). Among the ITC's clusters of intervention, the modernization and automation of cross-border procedures aims to respond comprehensively to the needs of businesses – including e-traders – through enhanced transparency and improved access to information and documentation. The ITC also assists MSMEs in overcoming physical and procedural barriers to online commerce by strengthening their capacity to meet border requirements.

The United Nations Centre for Trade Facilitation and Electronic Business (UN/CEFACT), for its part, has issued 40 recommendations to facilitate cross-border trade and electronic business by simplifying, standardizing and harmonizing trade-related procedures and information flows. Recommendation 26, for instance, encourages the "use of interchange agreements between commercial parties using Electronic Data Interchange (EDI) for international commercial transactions". The same recommendation also includes The Model Interchange Agreement for the International Commercial Use of EDI to "ensure the harmonization of interchange agreements in international trade and to develop an internationally accepted version for optional use". Many of these recommendations are now international standards of the International Organization for Standardization (ISO).

In addition, challenges raised by the parcellization of trade (see Box C.3) led the World Customs Organization (WCO) to establish a Working Group on E-commerce in July 2016 to develop proposals for practical solutions to facilitate the clearance of low value shipments, including duty/tax collection mechanisms and control procedures. A recommendation that outlines guiding principles to simplify clearance of such shipments while ensuring appropriate revenue collection was adopted in December 2017, and a framework of standards is being developed with the aim of providing a globally harmonized approach to ensure the speedy delivery of parcels across borders.

Other projects are specifically aimed at supporting the development of ICT infrastructure in developing countries. The World Bank's Transport and ICT Global Practice, for example, helps governments harness and promote new and innovative technologies through infrastructure lending, technical assistance and advisory services (see http://www.worldbank.org/en/topic/transport/brief/connections). Overall, more than three-quarters of World Bank projects include an ICT-related component. The Telecommunication Development Sector programme of the ITU is another example of a programme on ICT infrastructure, which aims at fostering international cooperation in the delivery of technical assistance and in the creation, development and improvement of telecommunications and ICT equipment and networks in developing countries (see https://www.itu.int/en/ITU-D/Pages/default.aspx).

Finally, a number of regional organizations, as well as the various regional development banks, have programmes in place to facilitate trade and support the development of infrastructure, many of which with a digital component. The APEC Internet and Digital Economy Roadmap, for example, identifies the development of digital infrastructure, the promotion of interoperability, and the achievement of universal broadband access as key focus areas. The IADB, for its part, actively supports the use of digital technologies as part of its trade facilitation activities (through, for instance, the promotion of electronic single windows).

(iii) Facilitating a favourable legal and regulatory framework

The lack of a robust legal and regulatory framework for the governance of digital trade can not only hinder technological advances; it can also pose serious challenges for consumers and businesses alike by increasing the risk of fraud, cybercrime and abuse of privacy. International organizations can play a crucial role in fostering technological innovation while mitigating such risk by helping countries develop a legal environment that promotes secure online business.

UNCTAD's E-Commerce and Law Reform Programme, for example, offers developing countries access to expert reviews of e-commerce legislation and provides expert advice to policymakers regarding effective laws governing e-commerce. Areas covered under this programme include consumer protection, cybercrime, data protection and privacy, intellectual property and electronic signatures. The ITU, for its part, supports the development of transparent and forward-looking legal and regulatory frameworks to stimulate ICT investment and promote universal, ubiquitous, affordable and secure access to ICTs through its Infrastructure, Enabling Environment and E-Applications Department.

Given the ever-evolving nature of digital trade, a number of international organizations have taken steps to discuss, conceptualize and implement suitable frameworks for regulation and governance of various aspects of digital technologies and digital transactions. UNCITRAL, for example, which is responsible for formulating modern and harmonized rules on commercial transactions, has developed Model Laws on Electronic Commerce and on Electronic Transferable Records, which now provide the basis for national legislation in over 150 jurisdictions across 70 countries. The UNCITRAL Model Law on Electronic Commerce was the first legislative text to adopt the fundamental principles of non-discrimination, technological neutrality and functional equivalence that are widely regarded as the founding elements of modern electronic commerce law (UNCITRAL, 2018).[42] Building on the UNCITRAL Model Laws on Electronic Commerce and on Electronic Transferable Records, the United Nations Convention on the Use of Electronic Communications in International Contracts aims to facilitate the use of electronic communications in international trade by assuring that contracts concluded and other communications exchanged electronically are as valid and enforceable as their traditional paper-based equivalents. Additionally, the UNCITRAL Secretariat offers technical assistance and expert advice to lawmakers in drafting and reviewing legislation based on UNCITRAL texts.

Another example is the World Economic Forum (WEF)'s Digital Trade and Cross-Border Data Flows project, which leverages public-private collaboration to define and implement digital trade policy frameworks (https://www.weforum.org/projects/digital-tradepolicy). This project is closely linked to the WEF's Centre for the Fourth Industrial Revolution and aims to steer and shape policy developments related to e-commerce, generating global thought leadership and developing practical solutions to advance inclusive growth and sustainable development in digital trade (see https://www.weforum.org/centre-for-the-fourthindustrial-revolution).

In the area of trade finance, the International Chamber of Commerce (ICC) Banking Commission has established a working group to identify strategies to overcome the challenges of digitalizing trade finance by evaluating ICC rules to assess their "e-compatibility", develop a set of minimum standards for the digital connectivity of service providers, and examine the practical issues related to the legal validity of data and documents in digitalized form.

The rising interest of businesses and governments in blockchain technology has also led some organizations, such as ISO, to set up new initiatives to explore legal and regulatory issues related to the implementation of this technology. A new ISO technical committee consisting of experts from over 30 countries was established recently to study the priority areas for standardization and develop future standards to "stimulate greater interoperability, speedier acceptance and enhanced innovation in [the] use and application" of blockchain technology.

In addition, various international organizations, such as the United Nations (UN), the OECD and the WCO, have adopted resolutions and issued recommendations and guidelines to help countries develop regulatory frameworks in specific areas such as consumer protection, data privacy and cybersecurity. For instance, the Guidelines for Consumer Protection in the Context of Electronic Commerce, approved on 9 December 1999 by the OECD Council, are designed to help ensure that consumers are no less protected when shopping online than they are when they buy from their local store or order from a catalogue. By setting out the core characteristics of effective consumer protection for online business-to-consumer transactions, the guidelines are intended to help eliminate some of the uncertainties that both consumers and businesses encounter when buying and selling online.

In the area of data privacy, the OECD's Guidelines on the Protection of Privacy and Transborder Flows of Personal Data represent a consensus on basic principles which can serve as the basis for national legislation to be adopted at the country level. These guidelines aimed to harmonize privacy legislation across different countries, preventing undue barriers to the cross-border flows of data and ensuring that there is no unfair discrimination against data subjects. The UN, for their part, adopted a first resolution on the right to privacy in the digital age in 2013, which has been followed by several others since then. The resolutions underscore that any legitimate concerns states may have with regard to their security should be addressed in a manner consistent with obligations under international human rights law. The resolutions also express concern about the sale of personal data for commercial purposes without the individual's consent. In 2015, UN member states went one step further by appointing a special rapporteur on the right to privacy, responsible for gathering relevant information, including on international and national frameworks, national practices and experience, to study trends, developments and challenges in relation to the right to privacy, and to make recommendations (HRC, 2014).

The need for international cooperation to enhance cybersecurity is widely accepted and has given rise to a large number of initiatives in different fora.[43] Of particular importance is the work that has taken place in the United Nations Governmental Groups of Experts on Developments in the Field of Information and Telecommunications in the Context of International Security ("UN GGE"), the first of which was established in 2004. The mandate of the UN GGE was to identify existing and potential threats arising from the use of information and communication technologies and possible cooperative measures to address such threats. The UN GGE reports issued in 2013 included specific recommendations with respect to: (i) non-legally binding norms rules and principles for responsible behaviour of states;[44] (ii) confidence-building measures; (iii) international cooperation and assistance in cyberspace security and capacity-building; and (iv) how international law applies to the use of ICTs. The GGE process reached an impasse in 2017 when the fifth UN GGE was unable to reach consensus on a report, mainly because of disagreement concerning the application of how certain international laws[45] applies to cyberspace.

Various other UN bodies and organizations are also actively involved in issues related to cybersecurity. The Economic and Social Council (ECOSOC), one of the principal organs of the UN, has been dealing increasingly with cybercrime. The issue of cybersecurity has also been discussed in the UN Congress on Crime Prevention and Criminal Justice (UNCPCJ), which plays a major role in international standard-setting and policy-making in crime prevention and criminal justice. The work of the UNCPCJ resulted in the adoption by the UN General Assembly of a resolution calling for an open-ended intergovernmental expert group to study the problem of cybercrime and international responses to it. The report was produced by the UN Office on Drugs and Crime (UNODC) in 2013 and led to the launch of the UNODC Global Programme on Cybercrime. This programme is intended to assist member states in their struggles against cyber-related crimes through capacity-building and technical assistance. Another UN organization active in this field is the ITU, which has developed a Global Cybersecurity Index (see https://www.itu.int/en/ITU-D/Cybersecurity/Pages/GCI.aspx), and in May 2017 it launched the Global Cybersecurity Agenda (GCA – see https://www.itu.int/en/action/cybersecurity/Pages/gca.aspx), a framework for international cooperation on cybersecurity.

Another important initiative is the Resolution of the Policy Commission of the WCO on the Guiding Principles for Cross-Border E-Commerce, which outlines the guiding principles for cross-border e-commerce on issues such as risk management, safety and security, and legislative frameworks. The Resolution aims to help customs and other government agencies, businesses, and other stakeholders in the cross-border e-commerce supply chain to understand, coordinate and better respond to the current and emerging challenges.

Some regional organizations have also launched initiatives to coordinate and support regional efforts to develop a robust legal environment to promote digital trade. The APEC Electronic Commerce Steering Group (ECSG), for example, coordinates e-commerce activities for APEC and promotes the development and use of e-commerce by supporting the creation of legal, regulatory and policy environments in the APEC region that are predictable, transparent and consistent. The ASEAN, for its part, has made modernizing the e-commerce legal framework and enhancing the security of electronic transactions two of the key objectives of its 2017-2025 work programme on e-commerce. As for the African Union, in 2014 it adopted the African Union Convention on Cyber Security and Personal Data Protection to create a legislative framework for cybersecurity and data protection in the African region.

(iv) Competition-related issues

As discussed in Section D.2(c), the cross-border activities of digital firms can result in spill-overs, for example, in the case of varying stances across different jurisdictions towards abuses of dominant positions and their impact across national markets (Epstein and Greve, 2004).[46] Concerns regarding such potential spill-overs form the rationale for the work of the International Competition Network (ICN), the OECD, UNCTAD and other international organizations (including also WIPO in the context of its Development Agenda and, in the past, the WTO) active in the field of competition policy (Anderson et al., 2018a). These organizations have already promoted a significant degree of convergence in national competition policies generally, through their extensive and informative analytical, policy development and advocacy work (Hollman and Kovacic, 2011).[47]

While international coordination in the more specific subject area of competition policy as it relates to digital markets is, perhaps, in a relatively early phase, some WTO members have already recognized the importance of cooperation in this area[48] and called for forward-looking discussions in relevant international fora.[49]

(v) Intellectual property-related issues

International regulatory cooperation

While the existing technology-neutral intellectual property rules in place in the 1990s provided, for the most part, a robust regulatory environment for the digital exchange of licenses and protected subject matter, the operation of the digital technologies making up the internet, and the latter's transnational nature, raised a number of specific problems for intellectual protection. Some of the more immediate issues quickly triggered regulatory responses at the international level which have now become widely accepted standards, including through RTAs (see Section D.3(d)).

The protection of well-known trademarks

It has long been established in trademark law that particularly famous trademarks should enjoy special protection, and the TRIPS Agreement further consolidated the conditions and contours of this trademark protection, not only broadening the scope of this protection to include service trademarks, but also clarifying that, when determining whether a trademark is "well-known", besides its actual use, members should also take into consideration how well-known the trademark is in the relevant commercial sector, including through advertising. However, despite these clarifications, considerable differences in the interpretation prevailed in different jurisdictions about the definition of the term "well-known" trademarks.

These differences were put into sharp focus when, after the fall of the ''Iron Curtain'' and the dissolution of the Soviet Union, a number of new market economies emerged which enacted trademark laws and established their own registration authorities. It was not uncommon during that period for fortune-seekers to register famous trademarks like "Dior" or "Cartier" in order to extract money from the true proprietors when the latter tried to get a foothold in the same market (Kur, 2013). This situation was exacerbated by the global reach of the newly established internet, which meant that situations permitted under different national regulatory systems could – and often did – collide, thereby multiplying multi-territorial conflicts.

This resulting need for international cooperation to harmonize the interpretation of the term "well-known" led to discussions at the WIPO Standing Committee on Trademarks, Industrial Designs and Geographical Indications (SCT), which concluded with the adoption of the Joint Recommendation Concerning Provisions on the Protection of Well-Known Marks in 1999. These non-binding joint recommendations contain detailed provisions for the determination of a "well-known" trademark, taking into account the internet phenomenon, and establish remedies for conflicts between well-known marks and other marks, business identifiers and domain names.

The internet and trademark use

The global and borderless nature of the internet also challenged the concept of trademark use, which, in trademark law, is significant in determining whether use requirements for registration have been fulfilled, whether distinctiveness has been acquired, and what constitutes infringement in a particular jurisdiction. Driven by increasingly pressing questions on how to resolve these inherently international challenges, discussions in multilateral fora have sought to accelerate the development of international harmonized principles (Croze, 2000) in this regard. The resulting discussions aimed to harmonize the interpretation and meaning of "trademark use" which was not specifically dealt with in the existing legal frameworks of the time (the Paris Convention and TRIPS Agreement) and was causing increasing difficulties for trademark owners with the propagation of internet and the rise of new business models and online commerce. The resulting

Joint Recommendation Concerning Provisions on the Protection of Marks, and Other Industrial Property Rights in Signs, on the Internet (2001) was established in order to help the authorities and courts involved in such conflicts and in all other questions arising from the contradiction between the principle of territoriality of rights and the global nature of the Internet (WIPO, 2004).

The 2001 Joint Recommendation contains detailed provisions that allow members to determine whether the use of a sign on the internet can be considered as use in their territory by providing a list of relevant factors that allow the identification of whether such use can constitute a "commercial effect".[50] It also establishes best practice for avoiding conflicts of rights-holders of identical or similar rights granted in different countries and their use over the internet. It further provides that remedies should be limited, as far as possible, to the territory in which the right is recognized, and they should only be available if the allegedly infringing use of the sign can be deemed to have taken place in that territory.

While these recommendations were conceived as non-binding "soft law" rules they now enjoy widespread factual adherence, and compliance with their substance is now frequently included in the intellectual property obligations in bilateral international treaties.

The "Internet Treaties": copyright and neighbouring rights

The rules governing copyright and neighbouring rights were established by the Berne Convention, the Rome Convention and the TRIPS Agreement, signed in 1994.

These normative bodies were conceived in the early stages of internet proliferation, and even though their provisions remain technology-neutral, there were big concerns from countries with strong cultural and creative industries about how these rules could apply for enforcing IPR in the digital environment.

The principal purpose of the "Internet Treaties" – the WIPO Copyright Treaty and the WIPO Performances and Phonograms Treaty – was to adapt international rules for the protection of copyright and the rights of performers and producers of sound recordings to the digital revolution, in particular, the distribution of copyright material over the Internet (WTO, 2015a).

The WIPO Copyright Treaty and the WIPO Performances and Phonogram Treaty do not constitute amendments to the Rome Convention or the Berne Convention respectively, nor are they part of the TRIPS Agreement. They are independent treaties that build on the provisions of the aforementioned agreements and further clarify the rights conferred, for example the rights of reproduction and making available for application in the digital environment, among others.

These updates served at the time of adoption to support enforcement actions against emerging forms of piracy, such as mass pirated optical disk production, and the use of early versions of peer-to-peer (P2P) technology to make unauthorized copies of copyrighted material available online (Wilson Denton, 2015).

Technical assistance

Beyond the regulatory responses described above, WIPO is actively providing technical assistance to help countries harness the use of digital technologies in the IP area and enhance their participation in the global innovation economy.

WIPO's programme of assistance to IP offices helps such offices in developing countries and LDCs to deliver better services to their stakeholders through efficient automated and standardized business processes for IP administration, online services, including search, registry and filing systems, and integration into regional and international systems to enable the electronic exchange of data and documents.

(vi) Supporting MSME participation in digital trade

As discussed in Section D.2(e), digital trade has opened up a world of opportunities for MSMEs in terms of increased access to international markets. However, given their small scale of operation and limited skills, MSMEs, especially in developing countries may require technical assistance and advisory services to maximize the potential benefits of digital trade.

In view of this, some international organizations, such as the ITC, have actively focused on supporting the participation of MSMEs in digital trade. ITC's E-Solutions Programme, for example, aims to facilitate online trading for MSMEs through initiatives such as creating a common collaborative structure for technology and services. In this way, MSMEs are able to share the costs of exporting goods, handle foreign payments and generate awareness in foreign markets. The programme also helps countries to build an international legal structure and international logistics to reduce barriers to e-commerce. Finally, it promotes market access for MSMEs through special

events, promotional activities and partnerships with international platforms. In association with the World Bank, ITC has also undertaken a Virtual Market Places (VMPs) project which aims to unlock the untapped economic growth potential of MSMEs in the Middle East and North Africa region in order to generate employment and more inclusive social and economic development. This project supports MSMEs in adopting new business models to improve their competitiveness and enable them to penetrate new markets.

Another example is the "Enabling E-commerce" initiative, launched by the WTO, in partnership with the WEF and the Electronic World Trade Platform (eWTP), during the 11th WTO Ministerial Conference in Buenos Aires in December 2017. This initiative aims to bridge the gap between global e-commerce policy and practice by facilitating dialogue on the practical challenges faced by MSMEs.

The Easy Export Programme undertaken by the Universal Postal Union (UPU), for its part, capitalizes on national postal infrastructure to develop a simplified and harmonized export service for MSMEs. The UPU Easy Export Programme is adapted from Exporta Fácil, a postal export project implemented in Brazil and other Latin American countries. The UPU also provides support in legal, regulatory, and technical framework and sets the global postal strategy, regulations, and standards.

It is often argued that MSMEs are disproportionately affected in the international trade arena by, among other things, a lack of access to information (ITC, 2016). They are often unaware of potential foreign markets and do not have the resources to navigate sometimes complex trading procedures. Small business owners often lack the time and in house expertise to deal with trade roadblocks, which puts them at a disadvantage and may even prevent them from participating in world trade.

Several international organizations have launched initiatives to redress this situation and to improve access to trade related information. For example, the WTO makes publicly available all notified information through different platforms, such as the "Integrated Trade Intelligence Portal" (WTO, 2018a), which provides frequent updates on a wide range of trade measures, including tariffs and regulatory changes to standards. The Transparency in Trade (TNT) initiative (TNT, 2018), for its part, is a partnership by UNCTAD, the AfDB, the ITC, and the World Bank that aims to facilitate the collection of tariffs and non-tariff measures and other trade data, and at providing free and open access the data collected. In December 2017, the ITC, UNCTAD and the WTO also launched the Global Trade Helpdesk, an online portal with relevant and up-to-date market information to support MSMEs to make fully informed trade and investment decisions that could lead to greater international trade activity. The Global Trade Helpdesk provides a unique entry point to existing trade-related information.

(vii) Promoting digital inclusion and making digital trade an engine of development

As discussed in Section D.2(a), one of the most important dimensions of the digital divide is that between developing countries that are not very technologically advanced and developed countries that are. Bridging the digital divide is one of the key objectives of the UN SDGs, which were launched in 2016 and have been guiding multilateral work in this area since then. Goal 9.C, in particular, calls on the international community to "significantly increase access to information and communications technology and strive to provide universal and affordable access to the Internet in least developed countries by 2020". In view of the critical importance of promoting digital inclusion, the Aid for Trade initiative has made digital connectivity and inclusiveness the main focus of its recent work. The 2017 *Aid For Trade at a Glance* publication (OECD and WTO, 2017) examined how and why connectivity is critical for inclusiveness and development, with a view to informing policy discussions and helping governments, donors and the private sector to focus their development efforts.

Various international organizations are active in this area. In 2016, for example, the World Bank launched a multi-donor trust fund, the Digital Development Partnership, based on the findings and recommendations provided by its World Development Report (World Bank, 2016). The programme supports developing countries in strengthening analogue complements to digital technologies, such as regulations that create a vibrant business climate and skills that let firms leverage digital technologies to compete and innovate.

In association with UNCTAD's "eTrade for all" initiative, the World Bank has undertaken an "eTrade for Development" programme to assist developing countries in expanding digital entrepreneurship, to diagnose a country's performance on e-trade and assess its main limitations, to improve developing countries' regulatory environments for digital markets based on international best practices, and to facilitate the adoption of customs procedure and logistics condition to reduce costs related to the movement of goods through e-commerce.

Some organizations, such as the Food and Agriculture Organization (FAO), have also undertaken digital inclusion initiatives to address the barriers to mobile internet adoption through infrastructure and policy, affordability, digital literacy and availability of local content. FAO's "Mobile Apps for Local Content" project, for example, focuses on the development of four apps that will help improving agricultural services and availability of local content. It aims to provide easy and affordable access to useful data, information and statistics to the rural poor. This project is part of a broader initiative that leverages the knowledge of FAO and its strategic partners in the mobile world, promoting digital inclusion for smallholders and family farmers.

(viii) Supporting collection and dissemination of reliable ICT statistics

In order to help economies to develop and implement better policies, some international organizations are supporting the collection of reliable statistics on the access to and use of ICTs and their impact on development. In association with UNCTAD's "eTrade for all" initiative, the International Telecommunications Union (ITU) has undertaken an ICT statistics programme that offers developing countries support in collecting and disseminating data about ICTs. The programme offers technical support for data collection and training for staff of National Statistical Offices and other national institutions responsible for ICT statistics and household surveys.

In a similar vein, the "Partnership on Measuring ICT for Development" is an international, multi-stakeholder initiative that was launched in 2004 to improve the availability and quality of ICT data and indicators, particularly in developing countries. The Partnership helps developing countries to collect ICT statistics, particularly through capacity-building and hands-on training for national statistical offices, and collects and disseminates information society statistics. The Partnership's work is coordinated by a steering committee made up of the ITU, UNCTAD and the United Nations Educational, Scientific and Cultural Organization (UNESCO) Institute for Statistics.

The importance of reliable data to foster informed and evidence-based policy-making also led the Group of Twenty (G20) to initiate work on ways to measure digital trade. In 2017, the German Presidency tasked the OECD, the UNCTAD, the World Bank and the WTO to work together to identify opportunities, challenges and the way forward in the measurement of digital trade. Discussions on this issue now take place in the context of the G20 Trade and Investment Working Group (TIWG). The G20 Digital Economy Task Force under the Argentinian Presidency in 2018 also began work to develop a toolkit for measuring the digital economy.

(d) Regional trade agreements

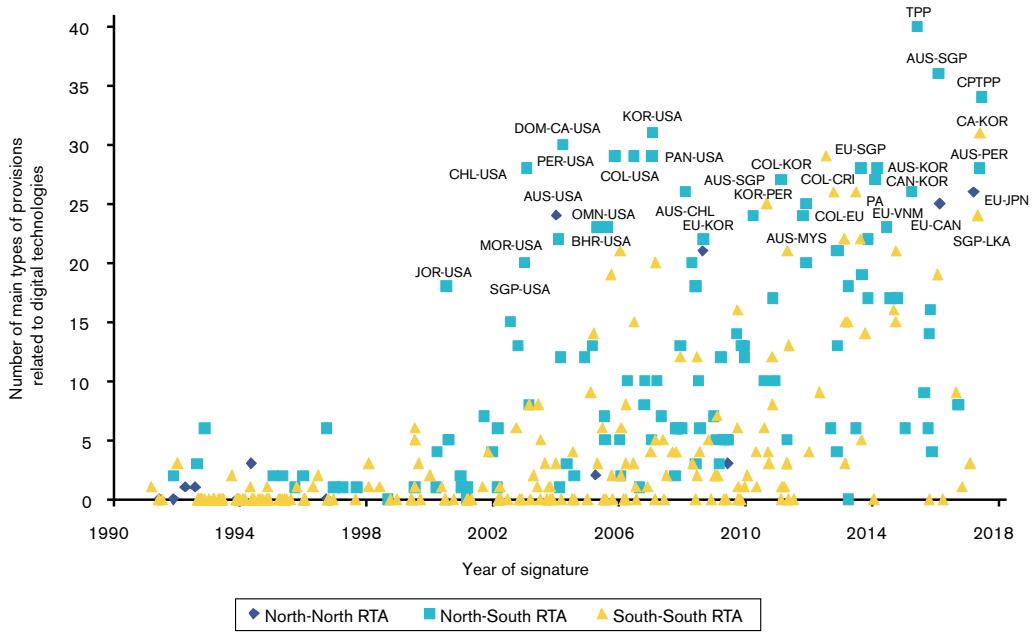
RTAs have often been dubbed laboratories in which some economies establish new types of provisions in order to address recent trade-related issues and challenges. A detailed analysis of 362 RTAs, including 286 agreements currently in force and notified to the WTO (as of August 2018), shows that issues related to digital technologies are explicitly found in different chapters of an increasing number of RTAs – currently 217.[51] Although, the inclusion of such provisions is not a recent phenomenon, the number and scope of provisions related to digital technologies incorporated in a given RTA have tended to increase in recent years, as highlighted in Figure D.2. These provisions can be found throughout the agreement, and not only in the chapter on e-commerce, highlighting the complexity of the different issues related to digital technologies and trade. These issues can be broadly grouped as related to: (i) trade rules and market access; (ii) telecommunications regulatory framework; (iii) specific digital regulatory challenges; (iv) intellectual property; (v) electronic government management and (vi) cooperation.

While some provisions related to digital technology clarify certain existing provisions and/or commitments established under the WTO, other provisions expand commitments or establish new ones (Burri, 2017; Monteiro and Teh, 2017; Wu, 2017; Tuthill and Sherman, 2008). In addition, provisions related to digital technologies often complement other relevant provisions found in RTAs, even though they do not make explicit reference to digital technologies, as highlighted in Section D.3(b) in the case of the WTO agreements. Overall, provisions related to digital technologies remain particularly heterogeneous, sometimes specific to a single or couple of RTAs.

(i) Trade rules and market access in relation to digital trade

A broad set of provisions on digital technologies found in RTAs is explicitly related to trade rules and market access. As highlighted in Figure D.3, the scope of these provisions ranges from the applicability of WTO and RTA rules to e-commerce, to the non-discriminatory treatment of like digital products, as well as commitments not to impose custom duties on digital products and to liberalize digital trade in services. Other relatively more recent provisions address the cross-border transfer of information by electronic means, the use and location

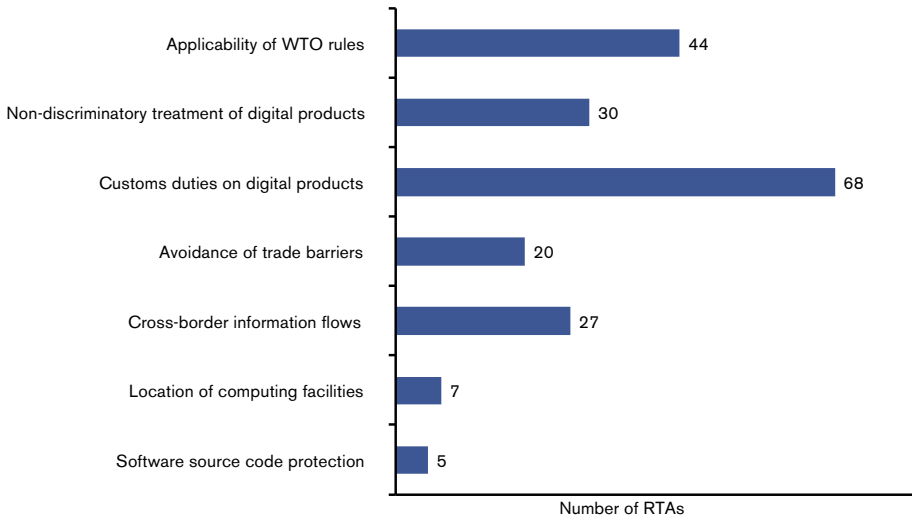
Figure D.2: Evolution of RTAs with provisions related to digital technologies



Source: Updated and extended from Monteiro and Teh (2017).

Note: See Appendix D.1 for the complete list of main types of provisions related to digital technologies in RTAs. Original and amended RTAs are analysed separately.

Figure D.3: Provisions related to digital technologies on trade rules and market access



Source: Updated and extended from Monteiro and Teh (2017).

of computing facilities, and the transfer of and access to software source code.

Applicability of WTO rules to e-commerce

An increasing number of RTAs with an e-commerce chapter include a provision referring to the applicability of WTO rules to e-commerce, which recognizes, as discussed in detail in Section D.3(b), that e-commerce falls within the scope of existing WTO agreements. Although the language of this type of provisions differs across agreements, the two most common provisions specify that the parties recognize (where relevant) the applicability of WTO rules to e-commerce or to measures affecting e-commerce, respectively.

Scope of the e-commerce chapter

Comprehensive e-commerce chapters in RTAs sometimes include provisions specifying their scope, namely measures affecting e-commerce or trade conducted by electronic means. When defining the scope, several RTAs incorporate a provision confirming the applicability of the other chapters to the e-commerce chapter, such as those related to cross-border trade in services, investment, financial services and/or telecommunications.[52] Generally, e-commerce provisions, especially in so far as they relate to the electronic supply of services, are subject to any relevant reservations for non-conforming measures in annexes (negative list RTAs) or limitations entered in schedules, or unscheduled services (positive list RTAs). While a few agreements confirm that electronic transmissions are considered to be a provision of services, other RTAs explain that the e-commerce chapter has been incorporated without prejudice to the parties' respective views on the question.

A limited number of RTAs explicitly limit the scope of the e-commerce chapter (or some provisions) by excluding certain types of measures from the disciplines therein, such as those related to government procurement, subsidies and taxation. Other excluded measures include those affecting broadcasting and information held by or on behalf of a party or measures related to such information.

Non-discriminatory treatment of digital products

A limited but increasing number of RTAs incorporates specific provisions, often worded differently across agreements, referring to the principle of non-discrimination of digital products. Subject to reservations for non-conforming measures and commitments and limitations scheduled in relation to, typically, the chapters on cross-border trade in services, investment and financial services, these provisions prohibit a party from adopting measures that accord less favourable treatment to digital products of the other party than it accords to its own like digital products. Most RTAs that incorporate a clause of national treatment of digital products also extend the non-discrimination provisions to the principle of most-favoured-nation treatment, namely the prohibition of measures that accords less favourable treatment to digital products of other parties to the RTA than it accords to like digital products of non-parties to that RTA.

A complementary provision, only found in a couple of relatively recent RTAs, requires each party to endeavour to eliminate any measure not complying with the non-discrimination principle and adopted before the agreement's entry into force that the other party identifies. A related provision further requires the parties to determine, in good faith and in a transparent, objective, reasonable and fair manner, whether a digital product is of the party, of the other party or of a non-party. The parties also commit to cooperate in international organizations and fora to foster the development of criteria for the determination of the origin of a digital product, with a view to considering the incorporation of such criteria into the RTA.

Customs duties on digital products

It is not only in the context of the WTO that countries have agreed not to apply customs duties on digital products. Most RTAs with a specific article or chapter on e-commerce include a provision referring to the practice of not imposing customs duties on electronic transmissions or digital products. The language of this type of provision differs across agreements, ranging from the recognition by the parties of the importance of maintaining the current practice of not imposing customs duties on electronic transmissions, to firmer commitments to not impose any customs duties on electronic transmissions or digital products.

The scope of the practice of not imposing customs duties differs also across agreements. Most provisions apply to digital products by electronic transmission, while others refer more generally to electronic transmissions. Similarly, some provisions refer only to customs duties, while others explicitly cover customs duties as well as fees or charges. Several RTAs further clarify that nothing prevents the parties from imposing (directly or indirectly) internal taxes or charges on digital products delivered electronically or on content transmitted electronically, as long as such taxes or charges are imposed in a manner consistent with the agreement.

A very few other provisions refer explicitly to the WTO Ministerial Decisions on the Work Programme on Electronic Commerce regarding not imposing customs duties on electronic transmissions. Unlike in the WTO where the decision on the moratorium on customs duties on electronic transmissions is renewed at every ministerial conference, the practice of not imposing customs duties on electronic transmissions in RTAs is often a permanent one. In that context, one relatively recent but idiosyncratic provision commits the parties to cooperate to make this practice binding within the WTO framework, with a view to considering its incorporation into the RTA. A related provision further specifies that the parties (may) reserve the right to adjust the practice of not imposing customs duties, consistent with any changes to the WTO Ministerial Decision.

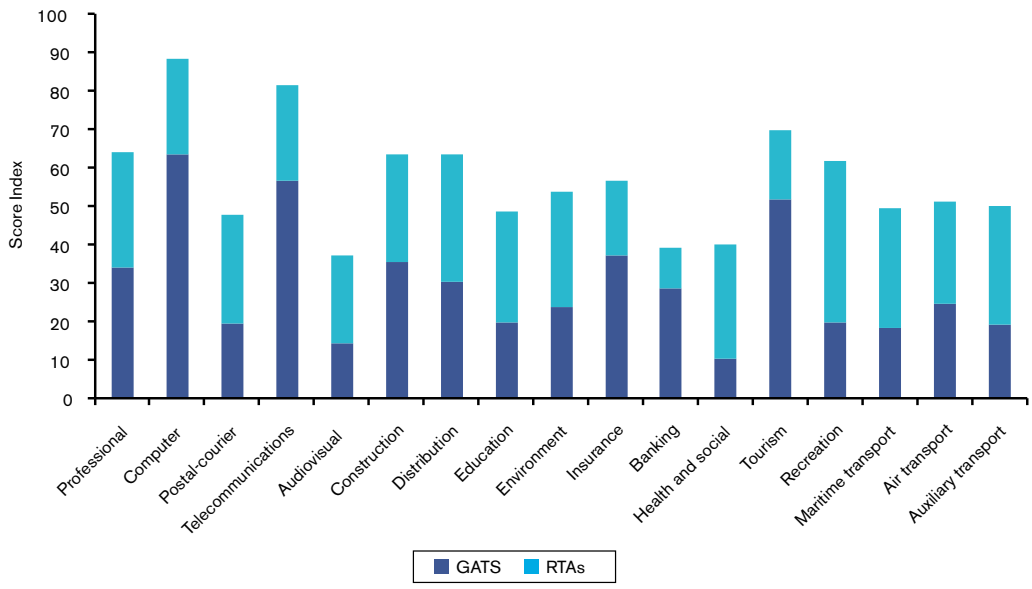
Avoidance of trade barriers faced by e-commerce

While many RTAs incorporate a provision recognizing the importance of avoiding (unnecessary) barriers to the use and development of e-commerce, a limited number of agreements include specific provisions referring explicitly to (unnecessary) trade barriers faced by e-commerce.[53] Aside from the provision recognizing the importance of avoiding unnecessary barriers to trade conducted by electronic means, a few other provisions, often complementary, call on the parties to the RTAs in question to endeavour to prevent or guard against measures that unduly hinder trade conducted by electronic means.

Liberalization commitments in relation to digital services

As discussed in Section D.3(b), trade in services plays an important role in enabling digital trade. While RTAs tended initially to cover only trade in goods, trade in services has become a major component of RTAs in the last 15 years. Overall, services commitments established under RTAs tend to guarantee greater levels of market access and non-discrimination than under the GATS. As highlighted in Figure D.4, the sectors of telecommunications and computer services attract, overall, the highest levels of bindings in RTAs (Gootiiz et al., 2018; Roy, 2014; Tuthill and Sherman, 2008). Several RTAs go beyond the GATS by expanding the sectoral coverage of commitments or by reducing or eliminating limitations. A number of countries have also, in RTAs, gone beyond their obligations in relation to the Reference Paper on Regulatory Principles on Basic Telecommunications (see also Section D.3(b)(ii)).

Figure D.4: Average sectoral index score for GATS and RTA commitments



Source: Roy (2014) based on Roy and Marchetti (2008).

Note: Based on commitments undertaken by 53 WTO members (counting the European Union as one) on Modes 1 and 3 in 67 services RTAs. The index score is brought within a scale of 0 to 100 for each sector, with 100 representing full commitments (i.e., without limitations) across all relevant sub-sectors. "GATS" reflects the index value for both GATS commitments and services offer in the Doha Development Agenda. "RTA" reflects the index value for a member's "best" RTA commitments across all its RTAs. The score for the European Union commitments is for the 1995 enlargement of the European Union (EU-15).

The Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP) is, to date, the only RTA to create new disciplines on electronic payment card services, requiring the parties to allow the cross-border supply of electronic payment services subject to certain conditions (such as registration with the relevant authorities).

Cross-border information flows

The ability to transfer data across borders by electronic means is often an essential component of trade, including digital trade. A limited number of RTAs includes specific, often idiosyncratic, provisions related to cross-border information flows in the context of e-commerce. These provisions range from the importance of maintaining cross-border flows of information, to cooperation and commitments to allow cross-border electronic transfer of information by electronic means, including personal information.

Besides recognizing the importance of the free flow of information in facilitating trade, including through cooperation, some RTAs commit the parties to endeavouring to refrain from imposing or maintaining unnecessary barriers to electronic information flows across borders. A few other more recent and specific provisions require the parties to allow the cross-border transfer of information by electronic means, including personal information, for the exercise of the business of a covered person, while recognizing that the parties may have their own regulatory requirements concerning the transfer of information by electronic means.

In parallel, an increasing number of RTAs include provisions on the cross-border transfer of financial information by electronic means. The provisions, which prohibit the adoption of measures preventing the processing of financial information, including transfers of data by electronic means, typically confirm that each party conserves the right to adopt or maintain measures to protect personal data, personal privacy, and the confidentiality of individual records and accounts as long as such measures are not used as a means of avoiding commitments. Some of these provisions also refer to the right to require financial service suppliers to obtain prior authorization from the relevant regulator to transfer such information, based on prudential consideration.

Location of computing facilities

Closely related to the issue of free flows of information across borders is that of disciplining data localization requirements. Only a couple of relatively recent RTAs incorporate specific provisions on the use and location of computing facilities. In particular, the main provision calls on or requires the prohibition of bilateral measures that require service suppliers, investors and investments to use or locate computer facilities in the other party's territory as a condition for the exercise of its business activity. A complementary provision explains, however, that the parties are not prevented from adopting or maintaining measures affecting the use or location of computing facilities in order to achieve a legitimate public policy objective, provided that such measures are not applied in a manner that would constitute a means of arbitrary or unjustifiable discrimination or a disguised restriction on trade.

Software source code protection

Another issue addressed in a couple of relatively recent RTAs refers to the protection of the confidentiality of software source code. Source code refers to the list of programming commands necessary to understand and modify how software works. In that context, the main provision on source commits each party not to require the transfer of, or access to, software source code owned by a person of the other party, as a condition of the import, distribution, sale or use of such software, or of products containing such software, in their respective area. This commitment is, however, limited to mass-market software or products containing such software, and explicitly excludes software used for critical infrastructure.

A complementary but less common provision further confirms that the parties are not precluded from including or implementing terms and conditions related to the provision of source code in commercially negotiated contracts. The parties are also not prevented from requiring the modification of source code of software necessary for that software to comply with laws or regulations which are not inconsistent with the RTA. Similarly, requirements related to patent applications or granted patents are not affected, subject to safeguards against unauthorized disclosure under the party's law or practice.

(ii) Telecommunications regulatory issues

As discussed previously, telecommunications services, including internet, mobile telephony, and data transmission services, provide the basic infrastructure and transmission capacity enabling the electronic supply of other services and trade in goods and services through digital networks. An increasing number of RTAs includes a chapter or section dedicated to telecommunications, establishing

specific regulatory principles, including with respect to anti-competitive behaviours. These provisions are complemented in some RTAs with specific provisions on the access to and use of the internet, as well as on internet interconnection charge-sharing.

Domestic telecommunications regulatory framework

Provisions on telecommunications regulatory principles found in RTAs usually draw extensively on the provisions of the WTO Annex on Telecommunication and the Reference Paper on Regulatory Principles on Basic Telecommunications. However, in a similar manner to other types of provisions found in RTAs, the scope of these regulatory provisions tends to differ across agreements. Some RTAs offer some enhancements in either substance or clarity over GATS disciplines (Tuthill and Sherman, 2008).

A number of RTAs broaden the scope of the Reference Paper obligations beyond basic telecommunications, to cover all telecommunications services, thereby promoting fair and transparent competition for all forms of wire-based and wireless services, including mobile, satellite and internet delivery, and other internet-based services, unless otherwise specified in the schedule of the party in question to the RTA. Another area in which some RTAs expand on GATS provisions concerns the requirements for major suppliers to provide leased circuit services at "capacity-based, cost-oriented prices", which goes beyond "reasonable and non-discriminatory" terms and conditions required under the WTO Annex on Telecommunications. Similarly, some RTAs specify the preferred regulatory approach to be taken by authorities, while neither the Annex nor the Reference Paper dictates any particular regulatory approach.

Several other regulatory issues not addressed, at least explicitly, in GATS disciplines have been addressed in a limited but increasing number of RTAs. In particular, some RTAs contain provisions requiring major telecommunications suppliers to lease network portions to other operators, to enable the latter to extend their network and services directly to customers without having to duplicate the existing facilities or to pay call-by-call interconnection fees in order to pass traffic through the dominant operator's network. A complementary provision related to co-location further requires major suppliers to allow suppliers of public telecommunications transport networks or services to locate on major suppliers' premises the equipment which is essential for interconnection or access to unbundled network components or facilities.[54]

Other new issues related to the anti-competitive behaviours of major suppliers include number portability and dialling parity. Provisions on number portability guarantee the ability of end-users of public telecommunications services within a territory to retain the same telephone numbers when switching between like suppliers of telecommunications services. Similarly, provisions on dialling parity guarantee the ability of end-users to use an equal number of digits to access a like public telecommunications service, regardless of the public telecommunications service supplier chosen by the end-user. The promotion of reasonable and non-discriminatory access to facilities owned or controlled by major suppliers and needed to supply telecommunications services, including submarine cables, satellites, and pols and ducts, has also been addressed in some RTAs.

International mobile roaming is another relatively more recent issue that has been addressed in a limited number of RTAs. Certain agreements require major suppliers to provide specified services needed to ensure interoperability of roaming on mobile networks. Other relatively more common provisions encourage: (i) cooperation to promote transparent and reasonable rates for international mobile roaming services, including by ensuring that information on roaming rates is accessible to consumers; (ii) minimizing impediments to the use of technological alternatives to roaming; and/or (iii) exchanging information on the retail rates for international mobile roaming services. RTAs with such provisions often also require that a party's regulated rates and conditions on wholesale international roaming services are provided to the other parties' telecommunications service suppliers on a reciprocal basis. Such provisions are intended to enable end users to use their home mobile handset or other device for voice, data or messaging services while outside their territory at reasonable cost.

Access to and use of the internet

While some e-commerce chapters recognize the importance of the telecommunications chapter's article on "access to and use of public telecommunications transport networks or services" in enabling trade conducted by electronic means, a few RTAs include explicit provisions recognizing a set of principles of access to and use of the internet. According to these principles, consumers should be able to access and use the digital products and services they choose, unless prohibited by the parties' respective laws. Consumers should also be able to run the applications and services of their choice, subject to the needs of law enforcement, as well as be able to connect their choice of devices to

the internet, provided that such devices do not harm the network and are not prohibited by the parties' respective laws. In addition, consumers should be able to have the benefit of competition among network providers, application and service providers, and content providers.

Internet interconnection charge-sharing

The cost distribution between network providers, application and service providers, content providers and internet users may affect, among other things, access to and use of the internet. In that context, only a couple of very recent RTAs, including the CPTPP, incorporate a specific provision related to internet interconnection charge-sharing. This provision recognises that a supplier seeking an international internet connection should be able to negotiate with another party's suppliers on a commercial basis issues, such as compensation for the establishment, operation and maintenance of facilities of the respective suppliers.

(iii) Domestic regulatory framework for e-commerce

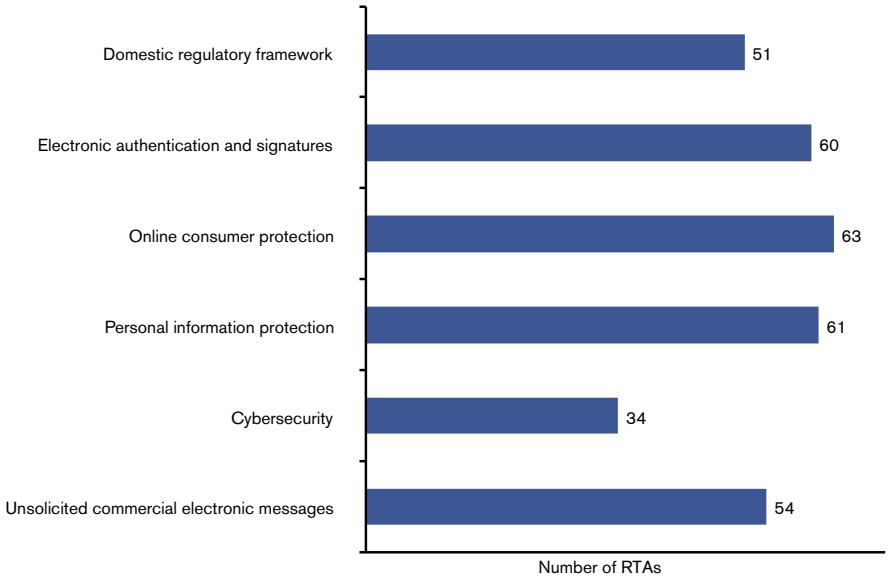
Besides provisions related explicitly to international trade rules, an increasing number of RTAs includes provisions addressing regulatory issues with a view to creating an environment of trust and confidence in the development and use of e-commerce. While some provisions refer to the general domestic regulatory framework, other provisions address, often in a complementary manner, various specific regulatory aspects or concerns related to e-commerce. As highlighted in Figure D.5, some of the most common regulatory issues related to e-commerce covered in RTAs include online consumer protection, electronic authentication and personal information protection. Unsolicited commercial electronic messages and cybersecurity are some of the other issues and concerns addressed in a relatively more limited number of RTAs.

Domestic regulations

A growing number of RTAs include provisions related to the general domestic legal framework in which e-commerce takes place. Similar to other types of e-commerce provisions, the language and scope of these provisions differ significantly across agreements. These provisions range from the recognition of different regulatory principles, such as transparency, interoperability and technological neutrality, to cooperation and commitments to adopt or maintain domestic laws regulating e-commerce and to minimize regulatory burden.

One of the most distinctive provisions refers to the adoption of a general regulatory framework, often referring explicitly to the principles of the 1996 UNCITRAL Model Law on Electronic Commerce.

Figure D.5: Provisions on domestic regulatory framework for e-commerce



Source: Updated and extended from Monteiro and Teh (2017).

As discussed in Section D.3(c), the principles of the UNCITRAL Model Law on Electronic Commerce include, among other things, non-discrimination, technological neutrality and functional equivalence. A couple of more recent RTAs make also an explicit reference to the principles of the 2005 UN Convention on the Use of Electronic Communications in International Contracts.

Electronic authentication and signatures

As explained in Section D.1.(c), electronic authentication plays an important role in the promotion of confidence in e-commerce. An increasing number of RTAs include a broad set of provisions explicitly addressing electronic authentication and signatures of transactions. These provisions range from cooperation to commitments to adopt measures related to electronic authentication and promote mutual recognition and interoperability of digital certificates.

A relatively common provision requires the adoption and maintenance of measures permitting participants in electronic transaction to (i) establish before judicial or administrative authorities that their electronic transaction complies with any legal authentication requirement; and/or (ii) determine the appropriate authentication technologies and implementation models. The provision often clarifies that the parties may require certain security authentication standards and certification by an accredited authority for transactions where a high degree of reliability and security is required. Other relevant provisions call on the parties to work towards the mutual recognition of digital certificates and electronic signatures at government level, or to promote the interoperability of digital certificates.

Online consumer protection

Part of the success of e-commerce hinges on consumer trust and the extent to which consumers' rights are adequately protected. In that context, an increasing number of RTAs include various provisions on digital consumer protection, many of which are only found in a couple of recent RTAs.[55] These provisions range from the importance of digital consumer protection to cooperation to commitments to adopt consumer protection measures and promote fair business practices and cross-border consumer settlement mechanisms.

A limited number of RTAs either calls on the parties to endeavour or requires them to adopt transparent measures to protect consumers engaged in e-commerce from fraudulent and deceptive commercial practices. A complementary but less common provision further requires the protection for consumers using e-commerce to be at least equivalent to that provided for consumers of other forms of commerce.

A few more recent provisions, found in a couple of RTAs, refer to fair business practices by calling upon or requiring the parties to standardize the information to be provided to consumers in e-commerce, including regarding the terms, conditions of use, prices, additional charges if applicable, and secured forms of payment. Several other provisions, not referring specifically to consumer protection, also establish specific commitments to encourage the adoption by the private sector of self-regulation, including codes of conduct, model contracts, guidelines and enforcement mechanisms (based on international standards). Some of these RTAs also commit the parties to promoting alternative transboundary dispute settlement mechanisms relating to consumer protection in cross-border electronic transactions.

Personal information protection

As discussed in Section D.2(c), a large part of the data being collected, stored and transferred in relation to electronic business transactions is personal data, the collection of which raises concerns about privacy and confidentiality. An increasing number of RTAs has established specific provisions on personal digital information protection. These provisions range from the importance of personal information protection to cooperation to commitments to adopt measures to protect personal data and take into account international standards.

In particular, one of the most common provisions on personal information protection requires the parties to either endeavour to adopt and maintain, or to adopt and maintain laws, regulations or measures ensuring the protection of e-commerce users' personal data. A complementary but less common provision also refers to the importance or commitment to take into account international standards, practices or criteria established by relevant international organizations in the development of standards or measures on personal information protection.

Although not referring explicitly to personal digital information, a limited number of RTAs includes a chapter or article dedicated to the protection of personal data establishing different content principles, such as purpose limitation, data quality and proportionality, transparency, security, and right of access, rectification and opposition. These RTAs also require the establishment of appropriate enforcement mechanisms and coherence with international commitments. More generally, and as

discussed above, the right to protect personal data and privacy is also recognized in the chapter on services and/or financial services of many RTAs, including within the scope of application of general exception clauses in trade in services.

Cybersecurity

The development and use of digital technologies have raised a number of concerns, including regarding cybersecurity, as discussed in Section D.2(c). Only a few RTAs include cooperation provisions on cybersecurity and cybercrime, mainly through the exchange of information and experiences, including on related laws, regulations and best practices. A couple of recently signed RTAs, including the CPTPP, incorporate an article dedicated to cooperation on cybersecurity matters, which recognizes the importance of building the capabilities of the parties' national entities responsible for computer security incident response. The article further recognizes the importance of using existing collaboration mechanisms to cooperate in order to identify and mitigate malicious electronic intrusions or dissemination of malicious code.

Unsolicited commercial electronic messages

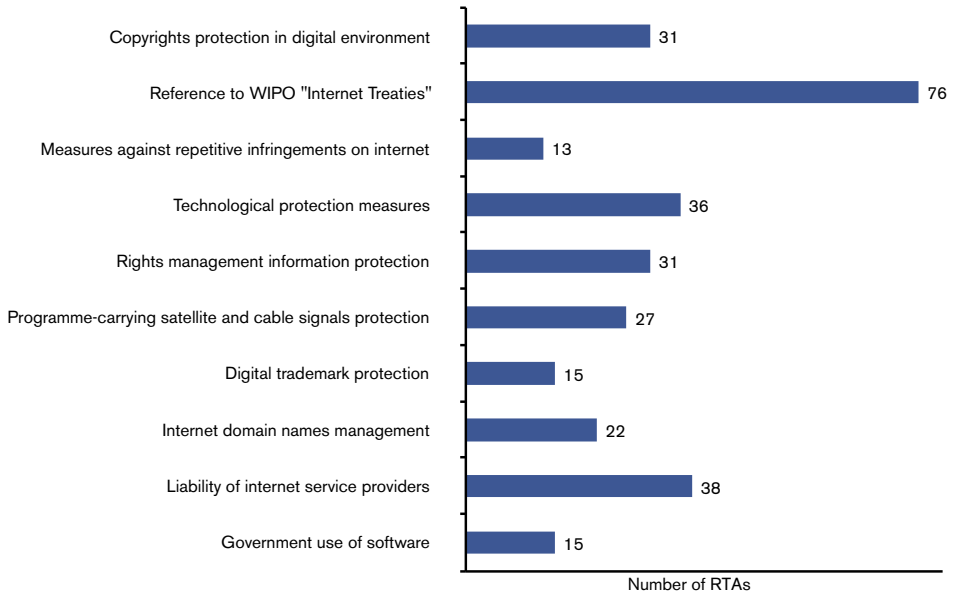
Protection against unsolicited commercial electronic messages, often referred to as spam, has been addressed in a limited but increasing number of RTAs. These provisions take different forms ranging from the importance to address spam to cooperation, including in international fora, to commitments to adopt appropriate measures regulating and minimizing spams.

(iv) Intellectual property issues in the digital environment

While the regulatory issues discussed above remain relatively broad in scope, an increasing number of RTAs have explicitly addressed a broad range of different specific digital regulatory issues related to IP, in particular copyright and trademarks.[56] As with other types of provisions, the language and scope of IP provisions vary widely across RTAs (Valdés and McCann, 2014).

Several IP provisions related to digital technologies cover the protection and enforcement of copyrights and related rights, including through technological protection measures, and rights management information protection, as highlighted in Figure D.6. Other issues covered include programme-carrying satellite and cable signals, digital trademark protection, internet domain names management, liability of internet service providers and government use of software.[57]

Figure D.6: Provisions on intellectual property issues in the digital environment



Source: Updated and extended from Monteiro and Teh (2017).

Copyrights and related rights protection and enforcement

An increasing number of RTAs explicitly recognize the impact of digital technologies on the use of literary and artistic works, such as books, computer programmes, films, musical compositions, and on the use of artistic performances, phonogram productions, and broadcasts.[58] However, the language and scope of the provisions on protection and enforcement of copyright and related rights in the digital environment differ across agreements, with some provisions relatively more common than others.

Several RTAs recognize the importance of IP in promoting economic and social development, particularly in the new digital economy. Several other agreements confirm that existing IP rights, including reproduction rights, continue to apply to the digital environment. Similarly, an increasing number of RTAs include provisions referring to WIPO Copyright Treaty and WIPO Performances and Phonogram Treaty, commonly known as the "WIPO Internet Treaties".[59] As discussed in Section D.3(c), both treaties require the parties to provide a legal framework ensuring adequate IP protection of authors, performers, and other rights-holders when their works are disseminated through new technologies. Provisions referring to the WIPO Internet Treaties range from the affirmation of the existing obligations pursuant to these treaties to commitments to adhere and/or accede to and comply with them. A couple of more recent RTAs also call on or require the accession/ratification to or compliance with the Beijing Treaty on Audiovisual Performances, which regulates copyrights for audiovisual performances and expands performers' rights, including in the digital environment.

In parallel, some RTAs explicitly refer to authors' and performers' exclusive rights to authorize or prohibit their literary and artistic works, and performances or phonograms, in any manner or form, permanent or temporary, including temporary storage in electronic form.[60] Similarly, several RTAs include provisions on the rights of broadcasting organizations, including the prohibition from retransmitting television signals (whether terrestrial, cable or satellite) on the internet without the authorization of the rights-holder(s), if any, of the content of the signal and of the signal itself. A couple of recent RTAs include also specific provisions on the protection of computer programmes and databases, including with respect to authorship, restricted acts, exceptions to restricted acts and decompilation.[61]

Some recent RTAs further require the adoption and implementation of special measures against repetitive infringements of copyrights and related rights on the internet and over other digital networks in a manner that avoids the creation of barriers to legitimate activity, including e-commerce, and that preserves fundamental principles, such as freedom of expression, fair process and privacy. In that context and as discussed below, some of these RTAs refer to the possibility of limiting the liability of, or the remedies against online service providers.

Technological protection measures

With the increasing use and consumption of digital content, efficient protection of copyrighted works, phonograms and performances is particularly challenging. As discussed in Section D.2(e), technological protection measures (TPMs) have been developed to deter piracy and encourage rights-owners to use digital media. TPMs can take various forms, including access control technology (such as encryption or password protection), and copy or use control measures (such as serial copy management system) to prevent unauthorized copying, transmission and use. The WIPO Internet Treaties require that legal protection and remedies against the circumvention (i.e. hacking) of TPMs be applied to protected works, phonograms and performances.

Besides provisions referring to the WIPO Internet Treaties, a limited but increasing number of RTAs incorporate specific provisions, sometimes very detailed, on TPMs requiring legal protection and remedies, including administrative, civil or criminal procedures in some agreements, against: (i) the unauthorized circumvention of effective TPMs; and (ii) production, sale or rental of circumventing devices promoted or marketed for circumvention purpose.[62] Some provisions further detail the limitation and exception conditions for which these criminal procedures and penalties do not apply to infringers, such as non-profit library, educational institution or public non-commercial broadcasting entity. A complementary but less common provision further clarifies that the provisions on TPMs do not require the ITC industry to design devices, components or services corresponding to certain TPMs.

Rights management information protection

The online distribution of digital content presents important challenges for the management of creative content and identification of users and copyright-owners (authors or performers). Rights management information (RMI) of a work provides data identifying the copyrighted content, its rights-owners and its terms and conditions of use. RMI is increasingly used in digital rights management for licenses and

royalties, often in the form of an electronic watermark placed in the protected content. The WIPO Internet Treaties require effective legal protection of RMI that accompanies protected works, phonograms and performances.

In addition to provisions referring to the WIPO Internet Treaties, a limited but increasing number of RTAs incorporate specific provisions, often worded differently, on RMI requiring legal protection and remedies, including criminal procedures and penalties in some agreements, against: (i) the removal or alteration of any RMI; and (ii) distribution or broadcasting of works with altered RMI. Some RTAs also specify the limitation and exception conditions for which criminal procedures and penalties do not apply to infringers, such as non-profit library and educational institutions. A complementary but less common provision also clarifies that the provisions on RMI do not require RMI to be attached to copies of a work.

Programme-carrying satellite and cable signals protection

With the ever-increasing use of satellites and cable, including for broadcasting and the reception of copyrighted television programming, the risk of the unauthorized interception of signals and the unauthorized rebroadcasting of programme material, sometimes referred to as "signal piracy", increases. A limited number of RTAs incorporate several provisions, often worded differently, on the protection of programme-carrying satellite and cable signals.[63] Several RTAs either require accession to/ratification of, or recognize, the existing rights and obligations under the Convention Relating to the Distribution of Programme-Carrying Signals Transmitted by Satellite. The Convention establishes, among other things, the obligation to take adequate measures to prevent the unauthorized distribution on or from the parties' territories of any programme-carrying signal transmitted by satellite.

Other more specific provisions focus on encrypted signals. Several RTAs requires the provision of legal protection and remedies, including criminal or civil procedures in some agreements, against: (i) the production or sale of decoding encrypted programme-carrying satellite (and cable) signals system; and (ii) the reception or further distribution of decoded encrypted programme-carrying satellite (and cable) signals. While most RTAs with such provisions cover only satellite signals, a couple of RTAs extend the obligation to cable signals. Some RTAs also extend the provision of remedies to any person injured by these activities, including any person holding an interest in the encrypted programming signal or its content.

Digital trademark protection

The rapid development of new digital technologies and the expansion of the internet and social media platforms make trademark protection more challenging. A trademark is any sign that individualizes the market products and services of a given enterprise and distinguishes them from its competitors. Provisions related to digital trademark protection have been incorporated in a limited number of RTAs. Some of these provisions recognize or reaffirm the importance of the principles contained in the WIPO Joint Recommendation Concerning Provisions on the Protection of Marks, and other Industrial Property Rights in Signs, on the Internet (WIPO Joint Recommendation). As discussed in Section D.3(c), this WIPO Joint Recommendation proposes a legal framework for trademark owners wishing to use their trademarks on the internet and to participate in the development of e-commerce. Some RTAs further establish commitments to either endeavour to apply the WIPO Joint Recommendation or be guided by the principles contained in the WIPO Joint Recommendation.[64] A couple of RTAs also explicitly forbid, as unfair competition, acts of providing, through an electric telecommunications line, products using an indication, including a trademark, of a product or business which is identical or similar to another person's famous indication of products or business.

Internet domain names management

As discussed in Section D.3(c), unlike other IP rights, the registration of internet domain names is global. The registration of domain names is usually not managed by national IP authorities but by organizations accredited by the Internet Corporation for Assigned Names and Numbers (ICANN). The successful registration of a domain name in one part of the world prohibits the registration of that domain name in any other part of the world. In that context, and in order to address the problem of trademark cyber-piracy, a limited number of RTAs include provisions related to internet domain names, many of which are specific to one or several agreements. These provisions range from cooperation to commitments regarding unfair competition and dispute settlement relating to domain names.

Only a couple of relatively recent RTAs forbids and requires the provision of appropriate remedies against registering or holding, with the intention of gaining unfair profit or of causing damage, a domain

name that is identical or confusingly similar to a trademark. Some RTAs list possible remedies, such as revocation, cancellation and transfer of registered domain names. Other relatively more common provisions require the management of each party's country-code top-level domain (ccTLD) to establish an appropriate dispute settlement procedure, consistent with the international principles recognized by ICANN, for cases related to the bad-faith registration of domain names in violation of trademarks. These principles include expeditious, low-cost, fair, equitable and not overly burdensome dispute resolution procedures, without precluding a resort to judicial proceedings. A complementary provision also requires the management of each party's ccTLD to provide online public access to a reliable and accurate database of domain name registrant contact information. Other idiosyncratic provisions include participating in ICANN Governmental Advisory Committee or supporting endeavours to develop international policies or guidelines governing the resolution of disputes relating to domain names and trademarks.

Liability of internet service providers

As highlighted in Section D.2(e) and D.3(b), as part of their efforts to enforce copyrights in the internet and to fight against cyber-piracy, a number of countries have established a domestic legal framework requiring internet service providers (ISPs) to cooperate with authorities in the elimination and/or prosecution of IP violations by internet users, limiting, in exchange, the liability for or remedies against ISPs for IP infringements by the users of their online services (e.g. online video platform) or facilities. The liability of intermediary service providers, sometimes referred to as "safe harbour", has been addressed in a limited but increasing number of RTAs in order to promote the legitimate digital trade of books, movies, series, music and software. These provisions range from cooperation, including with the business community, to specific commitments limiting the liability of providers acting as mere conduit, caching, hosting or linking digital services.

In particular, several RTAs call on or require the establishment of legal incentives for ISPs to cooperate with copyright owners in deterring the unauthorized storage and transmission of copyright materials. These agreements and several others also call on or require the parties to ensure that the intermediary service providers are not held liable for third-party illegal content, provided they meet conditions specific to whether they are mere conduits or provide hosting and caching (storing). Some RTAs extend the limitation of liability to ISPs referring or linking online content through hyperlinks and directories. RTAs with such provisions often define in detail the conditions for which the liability of ISPs can be limited.[65]

A complementary but less common provision specifies that provisions limiting the liability of ISPs do not affect the possibility of a court or administrative authority requiring ISPs to terminate or prevent an infringement. A related provision further commits the parties not to impose a general obligation on ISPs to: (i) monitor the information they transmit or store when offering mere conduit, hosting and caching; and (ii) actively seek facts or circumstances indicating illegal activity. The provision, however, specifies that parties may establish obligations for ISP to inform promptly, upon request, the competent public authorities of alleged illegal activities or information. In that context, several RTAs require the establishment of a notice and takedown system, according to which ISPs expeditiously remove or disable access to material in response to court orders or allegations that its content infringes copyrights. Certain RTAs also require ISPs to adopt and implement policy that provides, in appropriate circumstances, for the termination of the account of repeated infringers.

Government use of software

Efforts to fight software piracy within governmental institutions are also addressed in a limited number of RTAs. The most common provision, often worded differently, requires the parties to issue appropriate laws, orders, regulations, or administrative or executive decrees actively regulating the acquisition and management of computer software at the central level of government in order to confirm that all central government agencies use legitimate software. The most detailed version of this provision lists possible type of measures, such as procedures preparing and maintaining inventories of software on agency computers and inventories of software licenses. A complementary but less common provision also commits each party to encourage its respective regional and local governments to adopt similar measures.

(v) Electronic government

Although there is no internationally agreed definition of electronic government (e-government), it typically encompasses the use of ICT to deliver services in the public administration. A large and increasing number of RTAs include a broad range of provisions related to e-government that can be found in the chapters on e-commerce, government procurement, intellectual property, rules of origin, sanitary and

phytosanitary measures, technical barriers to trade, trade facilitation, and trade in services, among others. While some provisions refer to paperless trading administration in general, other provisions apply to specific areas, such as rules of origin, customs operation systems, IP registration, and government procurement, as shown in Figure D.7. Many RTAs also establish transparency commitments with the possibility or obligation to publish electronically, including on the internet, relevant information. Similarly, many RTAs promote the use of ICT to administer specific institutional arrangements, such as committees established under the agreements.

Paperless trading administration

Paperless trading refers to the process of making trade administration documents submitted by importers and exporters available and accepted electronically. An increasing number of RTAs includes specific provisions on paperless trading, ranging from cooperation, including in international fora, to commitments to make available and accept electronic trade administration documents and take into account international standards in developing paperless trading.

Electronic certificate of origin system

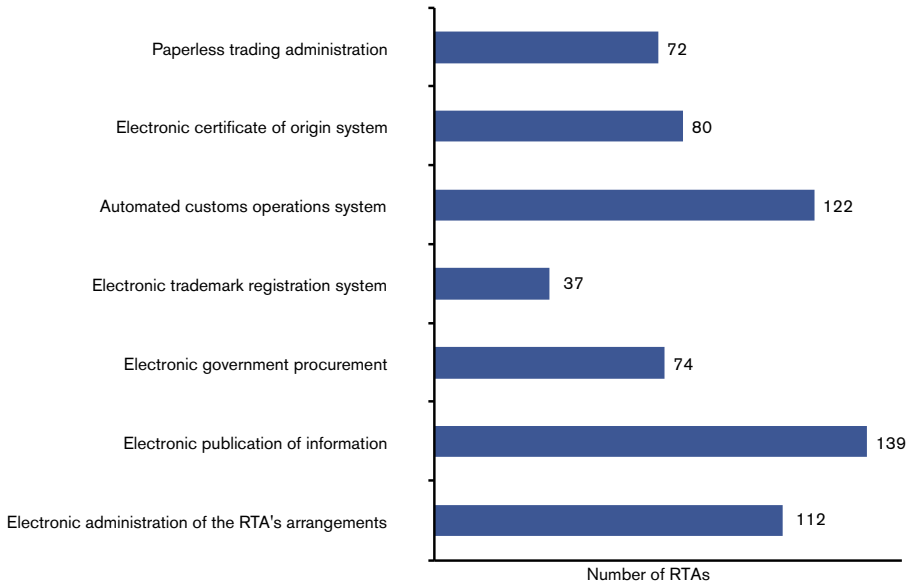
Rules of origin correspond to the criteria established to determine the national source of a product. These rules are needed to determine whether a product is qualified to receive preferential tariff treatment under a RTA. Several RTAs include specific provisions considering the possibility of applying an electronic certificate and verification system, or at least developing or using electronic certificates of origin or electronic declarations of origin. The record-keeping requirements related to the certificate of origin procedure often also mention the possibility of keeping electronic or digital records.[66]

Automated customs operations system

The number of RTAs with trade facilitation provisions has not only increased very rapidly since the 1990s, but the coverage of trade facilitation measures has also expanded in the last 10 years (WTO, 2015b). Similarly, the chapters on customs procedures or trade facilitation in an increasing number of RTAs include at least one provision related to the application of ICT to simplify and automate customs procedures (Duval and Mengjing, 2017). These provisions, often formulated differently, range from cooperation to commitments to promote or apply automated customs systems.

In particular, some RTAs promote or require the creation of an electronic system of information exchange between the customs administration and the trading community, if possible based on international standards. These agreements further

Figure D.7: Provisions on electronic government management



Source: Updated and extended from Monteiro and Teh (2017).

promote the development of compatible electronic systems between the parties' customs administrations to facilitate the exchange of international trade data. In that context, these agreements also promote the development of a set of common data elements and processes (for instance in accordance with the WCO Customs Data Model and related recommendations and guidelines). Other more specific provisions refer to the application of electronic systems for the advance submission of the information necessary for the release of imported goods at the border (including for express shipments in some agreements), express shipments, payment for duties, risk management and single windows. A limited number of RTAs further require the introduction of ICT be carried out, to the extent possible, in consultation with all relevant parties directly affected.

Electronic trademark registration system

Only a few relatively recent RTAs include provisions related to electronic trademark registration systems. A couple of agreements refer to the importance of, accession to/ratification of, or compliance with the 2006 Singapore Treaty on the Law of Trademarks. This WIPO treaty covers administrative trademark registration and licensing procedures and addresses, among other things, the use of modern communication technologies to process and manage trademark rights. Several RTAs foresee the possibility of establishing an electronic system for the registration of trademarks, or at least providing the applicant with an electronic communication of the reasons for a refusal to register a trademark.[67]

Electronic government procurement

Government procurement is another area increasingly covered in RTAs. Many of the most detailed chapters on government procurement found in RTAs include provisions, sometimes worded differently, addressing the use of electronic means for conducting government procurement.[68] Some of these provisions replicate the WTO's revised Government Procurement Agreement's provisions regarding, among other things, the general principles related to the use of electronic means and the requirements related to electronic auction. Other more specific provisions on government procurement related to digital technology are found in an increasing number of RTAs.

Some agreements require the parties to seek to provide opportunities for government procurement to be undertaken through electronic means, including the internet. A limited number of relatively recent RTAs also call upon or require the parties to adopt policies and procedures for the use of electronic means in procurement that: (i) protects documentation from unauthorized and undetected alteration; and (ii) provides appropriate levels of security for data on the procuring entity's network. As discussed below, several agreements also commit the parties to endeavour to use electronic means of communication to disseminate information on government procurement efficiently. In that context, some of these agreements call upon or require the adoption or maintenance of a single electronic portal for access to comprehensive information on government supply opportunities as well as information on measures relating to government procurement.[69] A couple of recent RTAs include similar provisions promoting the use of ITC aimed specifically at facilitating the participation of MSMEs in government procurement.

Electronic publication of information

Enhancing the transparency of trade policy is an important component in a large number of RTAs. Many of these agreements include different provisions referring to the possibility or obligation to publish electronically, including on the internet or through different electronic means, specific information and documents.[70] These provisions, particularly heterogeneous in terms of scope and language, can be found throughout the agreement. Some provisions refer to the electronic publication, including through the internet, of broad information, such as proposed and existing laws, regulations and information related to trade in goods, services, government procurement, intellectual property, customs procedure, competition or MSMEs. Conversely, other provisions focus on the electronic publication of specific information, such as visa requirements, new import licensing procedures, tariff-rate quota, fees and charges, advance ruling decisions, notices of intended government procurement and tender documentation. The electronic notification of proposed technical barriers to trade or sanitary and phytosanitary measures is also explicitly foreseen in some agreements, including the publication of responses to comments received. Similarly, several RTAs encourage or require the publication of electronic IP databases on trademarks, domain names, plant variety protection and geographical indications.

Electronic administration of the RTA's institutional arrangements

An increasing number of RTAs establish specific institutional arrangements, such as focal points or committees, in order to review and monitor the implementation and operation of the agreement, or of specific chapters such as those on technical barriers to trade, sanitary and phytosanitary measures and the environment. Although the nature and structure

of these arrangements differs across RTAs, some of these agreements include provisions referring to the possibility of using electronic means to implement specific commitments. Some RTAs mention the possibility of using any technological means, including ICT, available to the parties to conduct committee meetings. Similarly, some RTAs detail the dispute settlement procedure and mention the possibility of sending written submissions electronically and of organizing the panel work by electronic means, including consultations via videoconference.

(vi) Cooperation and technical assistance

As highlighted above, many provisions related to digital technologies refer to cooperation. Some provisions identify science and technology, ICT or more specifically e-commerce as a cooperation area without providing any additional details or defining any actions. Conversely, other provisions specify the form(s) and/or topic(s) of cooperation. In most cases, the issues identified are part of a non-exhaustive list of potential cooperation areas.

Cooperation on science and technology and ICT cover different specific issues, such as broadband access, network security, IP, statistics or trade facilitation. Other cooperation provisions apply to specific sectors, such as the broadcasting and software industries. Many issues covered by these cooperation provisions are only specific to a couple of RTAs, such as cultural heritage digitalization, intelligent transport systems, virtual reality and digital cinema.

Cooperation provisions on e-commerce also cover a broad range of issues, many of which were discussed previously in this subsection. Promoting and enhancing the development of e-commerce, including by improving its effectiveness and efficiency, is one of the most covered cooperation issues. Other commonly addressed issues include the domestic legal and policy framework of e-commerce, electronic authentication, consumer protection and personal data protection. Several RTAs also include cooperation provisions promoting the use of e-commerce by MSMEs, including, in some agreements, by identifying and overcoming the obstacles faced by MSMEs engaged in e-commerce (Monteiro, 2016).

The most common form of cooperation is exchanging relevant information and sharing experiences on regulations, policies and programmes regarding specific issues related to e-commerce. Other types of cooperation include policy dialogue, participation in international fora, training, research, best practices-sharing, joint projects and exchange of professionals.

In some cases, the negotiation of cooperation provisions related to digital technologies in RTAs takes place in a broader context in which the parties have previously negotiated cooperation agreements on ITC or e-commerce. For instance, before concluding their RTA, Japan and Australia negotiated a framework for cooperation in the information economy and ICT industries covering various issues, such as the digital divide and personal data privacy.

(vii) Upcoming provisions related to digital technologies

Over the last 25 years, issues related to digital technologies have been explicitly addressed in an increasing number of RTAs. In parallel, the scope of many of these provisions has tended to increase in recent years and are likely to continue to increase in the future. These provisions cover a broad range of issues: trade rules and market access commitments; telecommunications regulatory issues; digital regulatory issues; intellectual property protection; e-government management; and cooperation. Most provisions related to digital technologies do not follow a specific and unique template, even in some agreements negotiated by the same country. As a result, provisions related to digital technology remain particularly heterogeneous in terms of structure, language and scope.

The most common types of provisions related to digital technologies refer to e-government, cooperation and the moratorium on customs duties on electronic transmissions. Other issues covered in an increasing number of RTAs include the general domestic legal framework of e-commerce, as well as more specific issues, such as electronic authentication, consumer protection, personal information protection and intellectual property. Other issues addressed in a relatively more limited number of mostly recent agreements include cross-border information flows and data localization.

Overall, while many RTAs have recognized or adapted their commitments to the evolution of digital technologies, most detailed and comprehensive provisions related to digital technologies are often incorporated in a limited number of mostly recent RTAs. In fact, only a limited number of RTAs includes provisions addressing most of the issues related to digital technologies identified above. The approach to addressing some of these issues also differs in some agreements, likely reflecting, at least in part, different political sensitivities. That being said, given the dynamic nature of RTAs, provisions related to digital technologies are likely to keep evolving with new and more comprehensive types of provisions.

(e) Proposals from recent studies on how to promote digital trade

Several studies argue that conventional trade barriers are a significant obstacle to the expansion of digital trade and that the reduction and elimination of such barriers should therefore be viewed as a key component of a digital trade agenda. One example often mentioned in this respect is the reduction of tariffs on high-technology products and, closely related to this, the expansion of the product coverage of, and increase in the number of countries participating in, the WTO Information Technology Agreement. The simplification of customs procedures is another important example often referred to in the literature of how conventional trade policy can support the expansion of digital trade. Proposals have been made to increase the minimum value of imports below which no duty, tax or other administrative fee is charged, and allow for the digital submission of customs forms.

In addition, an emerging literature has also proposed developing new or enhancing existing WTO disciplines in light of what has been achieved in some recent RTAs, for example as regards the cross-border transfer of information, data localization requirements, e-signatures and e-authentication, protection of the personal information of users of e-commerce, or protection of consumers online (see the opinion piece by Anupam Chander, Georgetown University Law Center, on page 194, as well as Chander, 2013; Meltzer, 2016; and Cowhey and Aronson, 2017). A number of observers have suggested that a dedicated instrument be negotiated to incorporate such new rules, while others have emphasized the extent to which existing WTO agreements already cover and allow for addressing such matters.[71]

In addition, as discussed above, WTO rules on trade in services already apply to services supplied electronically, and cover, in particular, key measures affecting foreign investment and competitive conditions in such enabling sectors as telecommunications. A number of studies emphasize the importance of GATS obligations, as well as of an expansion of members' market access and national treatment commitments to enhance digital trade.[72] These studies suggest that digital trade can be supported through actions that could be taken within the framework of the GATS, including by groups of members improving commitments in their schedules on most-favoured-nation basis, without requiring the creation of a new standalone body of rules, as was done for the Information Technology Agreement.[73]

4. Conclusions

This section has discussed the domestic and international policy dimensions of the digitalization of international trade and identified certain aspects of policies that may warrant international cooperation.

Several aspects of the current policy and regulatory context of digital trade have been highlighted. First, digital trade is becoming a more complex and debated aspect of international trade relations, notably as a consequence of the possible scope for strategic trade rivalry and heightened concerns regarding various policy aspects, including security. Second, digital trade raises issues at the intersection of trade governance, such as market access and non-discrimination, on the one hand, and certain aspects of internet governance, such as online privacy and consumer protection, on the other. Third, the effects of digitalization on international trade rules are of a horizontal, cross-cutting nature.

Because existing WTO trade rules on goods, services and the protection of intellectual property rights are technologically neutral, in the sense that they apply irrespective of the particular mode of delivery of a good or service, digital trade is, in principle, covered by those rules. Rules on trade in services are especially relevant. The question that arises is whether further actions should be taken in this context to support digital trade, such as the expansion of market access and national treatment commitments, and the development of horizontal rules on matters such as consumer protection.

Specific provisions addressing digital trade have been adopted in an increasing number of RTAs. Their structure, scope and language have evolved over the years, with recent provisions often more comprehensive and detailed.

While the expansion of digital trade will entail considerable benefits, it is important to ensure that this expansion takes place under conditions that adequately address certain regulatory challenges. Issues concerning privacy protection and cybersecurity are likely to figure prominently in debates on the future governance of digital trade.

Although not specific to digital technologies, privacy protection has been addressed in trade agreements in different ways.[74] Some agreements, including WTO rules on trade services, include privacy protection within the scope of application of general exception clauses. Other agreements, including certain RTAs, establish substantive principles of personal data protection and enforcement mechanisms, or require

OPINION PIECE

Enabling and regulating the digital economy

By Anupam Chander, Georgetown University Law Center

The internet is the twenty-first century's Silk Road, powering trade across the globe in ways heretofore impossible. The internet arrived on many nations' shores without much prior preparation by governments, and it would take time to see how the internet would transform every part of life – from socializing, to learning, to creating. Regulators were often left struggling to catch up, eager to embrace the opportunities the digital economy offered for their citizens, yet concerned about the disruptions and other challenges that accompanied it. The regulatory framework for the digital economy developed at both the international and national levels, proceeding from an initial, largely enabling, phase to the recent more regulatory phase.

The first phase of internet regulation focused largely on enabling new forms of electronic commerce. At UNCITRAL in 1996, the nations of the world agreed to recognize electronic contracts and records in their domestic law. The United States led the world in removing legal risks for internet enterprises for the actions of their users, including for users' copyright infringement or defamation. At the WTO in 1998, the Ministerial Council agreed on a moratorium on customs duties on electronic transmissions, spurring cross-border trade in digital products.

Although they were conceived at the dawn of the internet age, the WTO's foundational agreements addressed telecommunications and other electronic networks, including the internet. The General Agreement on Trade in Services (GATS) recognized four modes of supply, including cross-border trade, in which the supplier and the consumer transact from their respective home economies across a border. Many members made specific commitments to liberalize cross-border trade in database services, data-processing services, computer services, telecommunications services, as well as other services, such as financial services and travel agency services, to name a few, that could now be provided across borders electronically. Indeed, in its first decade, the WTO would face a dispute where a member state complained that another member state's ban on internet gambling was inconsistent with its commitments on cross-border supply (*US – Gambling*).

Even during this early period, governments enacted laws to address some growing concerns. The European Union promulgated a directive to regulate the automated data-processing of personal information. A 1996 WIPO treaty promoted national laws that would strengthen efforts to protect copyrighted works through encryption and other technological tools. Some countries extended existing censorship from print and broadcasting media to the internet, often barring controversial information and even entire internet platforms from abroad as a result.

As the digital economy has grown, governments have sought to impose greater control over the internet. In this second, regulatory phase of governmental intervention, national governments have contended more deeply with issues such as free expression, data privacy, algorithmic decision-making and taxation. Even local governments have found themselves grappling with taxi and hotel regulations and, on occasion, smart city deployment. As data has emerged as the lifeblood of the digital economy, governments have sought to protect privacy amidst global flows, as evidenced in the European Union's strengthened data privacy regime, the General Data Protection Regulation.

The rise of cloud computing, in which the storage and processing of information are provided as a service from remote computers, gives individuals and companies access to powerful computers that they could not otherwise afford on their own. Cloud computing, however, increases jurisdictional complexities. The United States recently adopted the "Cloud Act" to promote regulated data-sharing across borders. Governments have become increasingly concerned about the movement of data across borders, but national measures mandating that data be localized at home by their very nature disfavour foreign providers. Eleven Pacific states have adopted a free trade agreement – the CPTPP – that ensures that restrictions on cross-border data flows will be justified by legitimate public policy interests, rather than used to discriminate against foreign suppliers. Privacy, cybersecurity and traditional consumer protection have become critical components of international trade, and trade agreements will have to assure these values.

The regulatory framework will find new challenges in the latest technological innovations. The internet undergirds the most revolutionary technologies of this century, including smart cities, the sharing economy, virtual and augmented reality, artificial intelligence, and robotics. Such technologies will require both enabling and regulatory interventions, both at the national and international levels.

the adoption of measures to protect e-commerce users' personal data, taking into account relevant international standards. It is important to ensure the interoperability of different privacy regimes.

Cybersecurity has emerged as a source of concern regarding its effects on digital trade. Recent international efforts towards progress on common norms have stalled. Indeed, the very meaning of the concept of cybersecurity or information security is a matter of debate. A limited but increasing number of RTAs includes provisions specifically addressing cybersecurity and cybercrime through cooperation.

The evidence suggests that there has been an increase in data localization measures in recent years. These measures are typically applied for a variety of policy reasons. A number of studies point to the adverse economic effects of such policies. Only a couple of recent RTAs, including mega-regional agreements, establish specific provisions on the use and location of computing facilities.

Finally, an important normative consideration with respect to future international initiatives to promote the expansion of digital trade is how they will contribute to make trade more inclusive. Several dimensions need to be considered. A first question relates to the digital divide, its consequences and the measures that can be taken to bridge it. These include the use of international agreements, such as the GATS, to make commitments that enhance policy credibility and thereby help attract foreign direct investment. A second question concerns the participation of MSMEs and the extent to which digital innovation will level the trading field. A related question is whether digitalization will bring with it more or less competition. If winner-takes-all dynamics prevail, national competition authorities are likely to play a prominent role, which, given the cross-border nature of digital firms, will highlight the need for international cooperation.

Appendix D.1: Main types of provisions related to digital technologies in RTAs

(i) Trade rules and market access in relation to digital trade

- Applicability of WTO rules to e-commerce
- Scope of e-commerce chapter
- Non-discriminatory treatment of digital products
- Customs duties on digital products
- Avoidance of trade barriers faced by e-commerce
- Liberalization commitments in relation to digital services
- Cross-border information flows
- Cross-border financial information flows
- Location of computing facilities
- Software source code protection

(ii) Telecommunications regulatory issues

- Domestic telecommunications regulatory framework
- Access to and use of internet
- Internet interconnection charge-sharing

(iii) Domestic regulatory framework for e-commerce

- Domestic regulations
- Electronic authentication and signatures
- Online consumer protection
- Personal information protection
- Cybersecurity
- Unsolicited commercial electronic messages

(iv) Intellectual property issues in the digital environment

- Copyrights and related rights protection and enforcement in the digital environment
- Reference to WIPO "Internet Treaties"
- Protection of computer programmes and databases
- Television signal retransmission on the internet
- Special measures against repetitive infringements on internet
- Technological protection measures
- Rights management information protection
- Programme-carrying satellite and cable signals protection
- Digital trademark protection
- Internet domain names management
- Liability of internet service providers
- Government use of software

(v) Electronic government

- Paperless trading administration
- Electronic certificate of origin system
- Automated customs operations system
- Electronic trademark registration system
- General principles of use of electronic means in government procurement
- Electronic auction requirements in government procurement
- Use of electronic communication to disseminate information on government procurement
- Single electronic portal for information access on government procurement
- Use of electronic communication to undertaken government procurement
- Measures for documentation and data protection on government procurement
- Limited tendering for technical reasons
- Electronic publication of information
- Electronic administration of the RTA's institutional arrangements

(vi) Cooperation and technical assistance

- Cooperation and technical assistance on science
- Cooperation and technical assistance on ICT
- Cooperation and technical assistance on e-commerce

Endnotes

1 See for example https://www.healyconsultants.com/blog/haiti-area-of-interest-for-foreign-direct-investment/ and https://www.export.gov/article?id=Rwanda-Openness-to-Foreign-Investment

2 http://www.ictacademy.in/pages/Digital-Empowerment.aspx; https://changingthepresent.org/collections/committee-for-democracy-in-information-technology/education_technology-access

3 https://www.pmgdisha.in/; http://www.bus.umich.edu/kresgepublic/journals/gartner/research/109700/109759/109759.html

4 As observed in ITU (2017), significant gaps persist between developing and developed economies with respect to internet access and even more with regard to broadband access. In developed economies in 2016, fixed and mobile broadband subscriptions covered, on average, 30.1 per cent and 90.3 per cent of the population, respectively; in developing economies, these figures stood at 8.2 per cent and 40.9 per cent (ITU, 2016). The cost of mobile broadband is also much higher in a number of developing countries.

5 The European Centre for International Political Economy's (ECIPE) Digital Trade Restrictiveness Index (DTRI) maps and measures policy restrictions to digital trade in 64 countries. The index covers many trade policy restrictions in the digital economy varying from tariffs on digital products, restrictions on digital services and investments, restrictions on the movement of data, and restrictions on e-commerce. See ECIPE (2017).

6 Local content requirements may also be inconsistent with the obligations in Article III:4 of the GATT 1994 and Article 2.1 of the Agreement on Trade-Related Investment Measures (TRIMs Agreement), which prohibit measures that require the purchase by firms of products of domestic origin or from any domestic source. The obligations in the TRIMs Agreement apply to measures related to trade in goods only.

7 The weight of the ICT sector in the total EU economy reaches 3.9 per cent, behind China and India (4.7 per cent), the United States (5.3 per cent) and Japan (5.4 per cent). The ICT services subsector, which includes computer and related activities and telecoms, is the leading subsector, representing 73.1 per cent of the total value added of the ICT sector globally, while the manufacturing sub-sector constitutes the remaining 26.9 per cent. In the European Union, ICT services represent more than 90 per cent of total ICT value-added in 2014. See European Commission (2017g).

8 ECIPE (2017) provides a snapshot of tariff and non-tariff measures affecting imports of digital products in 64 countries.

9 Based on Goldfarb and Trefler (2018b) and Agrawal et al. (2018).

10 Guided by similar concerns to promote "bibliodiversity", Germany and Belgium have also followed suit with fixed-price laws for e-books.

11 One possible alternative suggested by the OECD is to use a small but non-transitory decrease in quality (SSNQ) test.

12 One argues that services commitments in international trade agreements provide a credible instrument for anchoring unilateral policy reforms and limiting policy substitution. Another sees the process of services trade-opening as part of government responses to changes in the nature of production towards international supply chains. See the discussion of economic theories of the GATS in WTO (2012c).

13 A number of studies provide taxonomies and purport to provide empirical estimates of the existence of such barriers to digital trade (Ciuriak and Ptashkina, 2018a; Chander and Le, 2015; UNCTAD, 2017a).

14 Policy and regulatory divergencies exist with regard to several aspects of data policies, including in respect of the protection of privacy and personal data, which is now widely seen as one of the critical aspects of the regulatory environment that needs to be addressed in order to construct "a trusted digital environment". Domestic data protection laws differ with regard to how to define the information to be protected as private or as personal data, whether the protection of privacy and personal data is treated as a matter of consumer protection or as a matter of protection of fundamental human rights, and whether such protection is provided for in generic or sector-specific laws (de Terwangne, 2009; Kuner, 2011; Schwartz, 2013; Schwartz and Solove, 2014; Cowhey and Aronson, 2017; Yakovleva, 2017). See also Section D.3(c)(iii).

15 For different views on this matter, see, for example, Cowhey and Aronson (2017) and Greanleaf (2016).

16 Argentina; Chile; China; Colombia; Costa Rica; Guatemala; Kazakhstan; Kenya; Mexico; Moldova; Montenegro; Nigeria; Pakistan; Sri Lanka; and Uruguay.

17 See http://unctad.org/en/pages/newsdetails.aspx?OriginalVersionID=1477

18 At the WTO in 1998, the Ministerial Council agreed on a moratorium on customs duties on electronic transmissions, which entails that WTO members should not impose customs duties on electronic transmissions. At the 11th WTO ministerial meeting in Buenos Aires in December 2017, the Indonesian Delegation circulated a statement regarding the scope of the application of the moratorium on customs duties on electronic transmissions (in the context of e-commerce discussions). The statement explains that it is Indonesia's understanding that this moratorium shall not apply to electronically transmitted goods and services and that the extension of the moratorium applies only to the electronic transmissions and not to products or contents which are submitted electronically (see WTO document WT/MIN(17)/68) dated 20 December 2017).

19 The Agreement defines the modes for trade in services as follows: Mode 1: cross-border supply – whereby the service is supplied from the territory of one member into that of another; Mode 2: consumption abroad – whereby a consumer in one member purchases a service delivered in the territory of another member; Mode 3: commercial presence – whereby a service supplier in one member

establishes a subsidiary or a branch in the territory of another member in order to supply services; Mode 4: presence of natural persons – whereby an individual from one member is temporarily present in the territory of another to supply a service.

20 They relate to: the number of service suppliers; the value of service transactions or assets; the number of operations or quantity of output; the number of natural persons supplying a service; the type of legal entity or joint venture; and the participation of foreign capital.

21 In terms of the definitions in the Annex, "Public telecommunications transport service" means any telecommunications transport service required, explicitly or in effect, to be offered to the public generally and typically involving the real time transmission of customer supplied information without any end to end change in its form or content, while "Public telecommunications transport network" means the public telecommunications infrastructure permitting telecommunications between and among network termination points.

22 Meaning, "Terms and conditions no less favourable than those accorded to any other user of like public telecommunications transport networks or services under like circumstances".

23 See paragraph 5c of the Annex.

24 In the case of trade in services, even when barriers are low, there is often no certainty that these may not rise in the future as a result of pressures for protection. The perceived benefits of increased bindings on services in RTAs likely explains, much of the proliferation of such accords over the past 15 years.

25 These relate to certain goods and services supplied directly or indirectly by the buyer free of charge or at reduced cost, for use in connection with the production and sale for export of the imported goods, to the extent that such additional payments had not been included in the declared customs value.

26 Customs administrations must try to determine the customs value based on the transaction value of the goods. When this is not possible (e.g. because there was no sale), customs administrations will then try to apply alternative valuation methods in a pre-determined sequence: transaction value of identical goods; transaction value of similar goods; the deductive method; and the computed method. Only if one valuation method is not applicable they can move to the next one. If none of these methods can be applied, Article 7 of the CVA provides for a residual or "fall-back" method, according to which customs will try to apply the methods but in a more flexible manner. In all cases, the value must be fair and reflect commercial reality.

27 Advisory Opinion 22.1 notes that it could be determined "on the basis of the cost directly incurred in transcribing the engineering designs and development plans onto the paper and printing of such documents". In other words, the value of the documents could be based on the cost of producing the paper version of those engineering plans.

28 A 2013 ruling in the United States determined that the license fees paid by the importer to the manufacturer for a license key and download of firmware that expanded the capabilities of a machine were not dutiable as part of the price actually paid or payable, nor were they additions to value as royalties or proceeds of subsequent resale (WCO, 2015).

29 Under the Brussels Definition of Value, a normal market price, defined as "the price that a good would fetch in an open market between a buyer and seller independent of each other," was determined for each product, according to which the duty was assessed. Factual deviations from this price were only fully taken into account where the declared value was higher than the listed value. Downward variations were only taken into account up to 10 per cent.

30 See United States Government (US Customs and Border Protection, 2013).

31 Under the Brussels Definition of Value, there is a distinction between hardware-related software, usually called "operating software" (i.e. the one integrated in an apparatus), and "user application software" (i.e. which can be loaded into the memory of an apparatus temporarily).

32 See GATT document VAL/8.

33 TRIPS non-discrimination principles, found in Articles 3, 4 and 5, do not contain any general exceptions for economic integration equivalent to the exceptions in Article XXIV of the GATT 1947 or Article V of the GATS.

34 The Diplomatic Conference held in December 1996 adopted the following Agreed Statement concerning Article 1(4) of the WIPO Copyright Treaty, which incorporates by reference the substantive obligations of the Berne Convention: "The reproduction right, as set out in Article 9 of the Berne Convention, and the exceptions permitted thereunder, fully apply in the digital environment, in particular to the use of works in digital form. It is understood that the storage of a protected work in digital form in an electronic medium constitutes a reproduction within the meaning of Article 9 of the Berne Convention".

35 Article 11(1)(ii) of the Berne Convention provides that authors of dramatic, dramatico-musical and musical works shall enjoy the exclusive right of authorizing any communication to the public of the performance of their works. Similarly, authors of literary works enjoy the exclusive right of authorizing any communication to the public of the recitation of their works (Article 11ter(1)(ii)). Article 14(1)(ii) provides authors of literary or artistic works with the exclusive right of authorizing the public performance and communication to the public by wire of their works if adapted or reproduced by means of cinematography, and Article 14bis(1) grants the same right to the owner of copyright in a cinematographic work. Article 11bis(1)(i) and (ii) provides that authors of literary and artistic works shall enjoy the exclusive right of authorizing: (i) the broadcasting of their works or the communication thereof to the public by any other means of wireless diffusion of signs, sounds or images; and (ii) any communication to the public by wire or by rebroadcasting of the broadcast of the work, when this communication is made by an organization other than the original one.

36 Article 8 of the WIPO Copyright Treaty reads: "Without prejudice to the provisions of Articles 11(1)(ii), 11bis(1)(i) and (ii), 11ter(1)(ii), 14(1)(ii) and 14bis(1) of the Berne Convention, authors of literary and artistic works shall enjoy the exclusive right of authorizing any communication to the public of their works, by wire or wireless means, including the making available to the public of their works in such a way that members of the public may access these works from a place and at a time individually chosen by them".

37 As regards the scope of this right in respect of intermediaries who provide physical facilities for communication without actively initiating it, the Diplomatic Conference adopted the following Agreed Statement: "It is understood that the mere provision of physical facilities for enabling or making a communication does not in itself amount to communication within the meaning of this Treaty or the Berne Convention".

38 Certain countries have a common system for the protection of trademarks or a common procedure for the filing and registration of trademarks. The Madrid Agreement concerning the International Registration of Marks, and the Protocol thereto, provide for the international application of registration of trademarks at the International Bureau of WIPO.

39 These governing bodies decided to "[r]ecommend that each Member State may consider the use of any of the provisions […] as guidelines concerning the protection of marks, and other industrial property rights in signs, on the Internet". Article 1(i) of the Joint Recommendation defines that a "'Member State' means a State member of the Paris Union for the Protection of Industrial Property, of the World Intellectual Property Organization, or of both".

40 According to paragraph 4 of the *Work Programme on Electronic Commerce – Progress Report to the General Council*, adopted by the Council for Trade in Services on 19 July 1999 (official WTO document number S/L/74, 27 July 1999): "It was also the general view that the GATS is technologically neutral in the sense that it does not contain any provisions that distinguish between the different technological means through which a services may be supplied."

41 The seven LDCs assessed were Bhutan, Cambodia, Lao People's Democratic Republic, Liberia, Myanmar, Nepal and Samoa.

42 The principle of non-discrimination ensures that a document would not be denied legal effect, validity or enforceability solely on the grounds that it is in electronic form. The principle of technological neutrality mandates the adoption of provisions that are neutral with respect to technology used. In light of the rapid technological advances, neutral rules aim to accommodate any future developments without further legislative work. The functional equivalence principle lays out criteria under which electronic communications may be considered equivalent to paper-based communications. In particular, it sets out the specific requirements that electronic communications need to meet in order to fulfil the same purposes and functions that certain notions in the traditional paper-based system – for example, "writing," "original," "signed," and "record" – seek to achieve.

43 The Carnegie Endowment for International Peace has created a Cyber Norms Index that provides an overview of the various international fora in which cybersecurity issues are being or have recently been discussed (https://carnegieendowment.org/publications/interactive/cybernorms). Proposals made by some economies since the late 1990s for the negotiation of a global treaty on cybersecurity issues have failed to attract support. The only international legally binding instrument in this area is the Convention on Cybercrime, also known as the Budapest Convention, which was concluded within the framework of the Council of Europe and entered into force in 2004.

44 The 2013 UN GGE established several basic norms, including that "International law, and in particular the Charter of the United Nations, is applicable and is essential to maintaining peace and stability and promoting an open, secure, peaceful and accessible ICT environment" and that "States must meet their international obligations regarding internationally wrongful acts attributable to them. States must not use proxies to commit internationally wrongful acts. States should seek to ensure that their territories are not used by non-State actors for unlawful use of ICTs" (United Nations, 2016a). The 2015 UN GGE significantly expanded and elaborated on the norms set out in the 2013 report (United Nations, 2016b). For example, it agreed that "A State should not conduct or knowingly support ICT activity contrary to its obligations under international law that intentionally damages critical infrastructure or otherwise impairs the use and operation of critical infrastructure to provide services to the public".

45 Especially international laws concerning state responsibility, self-defence and humanitarian law.

46 In addition to negative spillovers (e.g. one jurisdiction or its enterprises being adversely affected by enforcement decisions taken in other jurisdictions), there can of course be important positive spillovers from competition law enforcement (e.g., anti-cartel enforcement in one jurisdiction also benefitting consumers in other jurisdictions in which the same cartels have been active).

47 See also diverse examples of relevant inputs on the websites of the ICN, OECD and UNCTAD.

48 For instance, in 2017, the Federal Antimonopoly Service (Russia's competition agency) suggested discussing and reconsidering the new approaches to antimonopoly regulation and economic analysis tools in the digital economy at the Fifth BRICS Competition Conference (Federal Antimonopoly Service of the Russian Federation, 2017a).

49 On 22-23 March 2018, during the ICN Conference representatives of several competition agencies emphasised the role of competition in the current economy, placing an emphasis on competition in the digital world. It was highlighted that, due to digitalization and globalization, competition agencies increasingly have to deal with different types of markets and changing business models. All speakers agreed on the need to conduct market studies to understand digital markets better (ICN, 2018).

50 There is no definition of "sign" in the Joint Recommendation Concerning Provisions on the Protection of Marks, and Other Industrial Property Rights in Signs. However, under TRIPS Article 15, signs refer to "words including personal names, letters, numerals, figurative elements and combinations of colours".

51 The analysis presented in this subsection updates and extends the scope of analysis of Monteiro and Teh (2017). Besides RTAs notified to the WTO, the analysis also covers newly signed RTAs that have not entered into forced yet and/or not been notified to the WTO, such as the Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP) and the Amended Singapore-Australia, European Union-Japan, Colombia-Panama, European Free Trade Association-Gulf Cooperation Council, European Free Trade Association-Philippines, and Republic of Korea-Central America RTAs. Other RTAs analysed include agreed but not signed text, such as the European Union-Singapore, European Union-Viet Nam, and European Union-West Africa

RTAs. The main text of the RTAs, but also side documents, such as protocols, annexes, communication letters and other documents associated with the RTAs, have been included in the review. Accessions to an existing RTA are excluded from the analysis. Original and amended RTAs have been reviewed separately. The following set of keywords was used to identify provisions related to digital technologies: artificial (intelligence); audio; automat(ion); broadband; computer; cyber; digital; distance; domain; e-(commerce); electronic; emerging; hardware; ICT; Internet; network; on-line/online; paperless; server; software; spam; technical; technolog(y); telecom(munication); web; and wireless.

52 Most e-commerce chapters are also covered by the RTA's chapters on general exceptions and on dispute settlement (Monteiro and Teh, 2017).

53 Although they are not reviewed here, the schedules of concessions on ICT-related goods, including those covered in the WTO Information Technology Agreement, established in RTAs also participate in the promotion of digital economy by reducing the cost of goods and equipment necessary to power and use the internet. Similarly, several RTAs include a provision requiring each party to grant duty-free temporary admission of professional equipment, including software, necessary for carrying out the business activity, trade, or profession of a person who qualifies for temporary entry pursuant to the laws of the importing party.

54 Several RTAs also include provisions on standard-related measures relating to the attachment of terminal or other equipment to public telecommunications transport networks. Some of these agreements and a few others establish a committee on telecommunications, sometimes dedicated only to telecommunications standards.

55 Although not reviewed here, a few RTAs include specific provisions on cross-border consumer protection that are not specific to e-commerce. These provisions are often found in a chapter on competition and consumer policy in the relevant RTA.

56 Although not reviewed here in detail, many RTAs include provisions referring more generally to technology, science and innovation. Some provisions address the promotion of technological innovation and transfer and dissemination of technology. Similarly, several cooperation provisions on science, research and technology development require an adequate and effective protection of IP resulting from these cooperative activities.

57 Although not referring explicitly to digital technologies, several recent RTAs incorporate provisions related to collective management societies for copyright and related rights in charge of collecting and distributing royalties. These collective management societies are particularly relevant in the development of digital marketplace for book, music or movie content. Other provisions relevant to digital technologies include provisions related to the legal protection and remedies against camcording (i.e. unauthorized copying of a cinematographic work from a showing in a cinema). A few RTAs also include provisions referring to trade secrets held in computer system.

58 Many RTAs with an IP chapter include a provision defining the scope of IP, which explicitly encompasses copyright in computer programmes and databases.

59 Certain RTAs with an IP chapter do not refer explicitly to any of the "WIPO Internet Treaties" but mention the "agreements administered by WIPO".

60 Many RTAs with an IP chapter include provisions on copyrights and related rights, providing for the exclusive right to authorize or prohibit all literary and artistic works and performances reproductions by wire or wireless means.

61 Software decompilation refers to the process of converting executable programme code into some form of higher-level programming language so that it can be read by a human.

62 Provisions on technological protection measures and right management information have also been negotiated in the Anti-Counterfeiting Trade Agreement (ACTA). Other provisions related to the digital economy include cooperation with the business community and the disclosure of information by online service providers identifying alleged IP infringers. ACTA was signed by Australia, Canada, the European Union, Japan, the Republic of Korea, Mexico, Morocco, New Zealand, Singapore, Switzerland and the United States in 2011. It requires the ratification of at least six signatory parties to enter into force.

63 Several RTAs to which the European Union is a party require the other party to commit to harmonizing its legislation with the EU acquis in the audiovisual field, paying particular attention to matters relating to the acquisition of IP rights for programmes and broadcast by satellite, cable and terrestrial frequencies.

64 A couple of RTAs refer also to the need for a clear legal framework for geographical indications (GI) owners wishing to use their GI on the internet.

65 The original TPP included comprehensive provisions, not included in the final version of the CPTPP, many of which idiosyncratic, detailing the framework of legal remedies and safe harbours in respect of online services that are ISPs. Similarly, the parties to the CPTPP have also agreed to suspend the articles on technological measures of protection, information on rights management and protection of satellite signals encrypted cable programme carriers.

66 Although not referring explicitly to digital technologies, several RTAs include a provision committing the parties to review the rules of origin, taking into account the effect on the rules of technological developments, among other factors, which could require amendments to the rules of origin.

67 More generally, the EU-Japan RTA is to date the only agreement to require the establishment of electronic systems for the management of applications for customs actions on goods infringing intellectual property rights, including trademarks.

68 The provision establishing the scope and coverage of the government procurement chapter specifies in several RTAs that covered procurement includes the procurement of digital products.

69 Many RTAs include different provisions specifying the minimum information to be included in notices of intended procurement, tender documentation and post-award notices published electronically.

70 Many other RTAs include provisions on transparency that do not mention the possibility or obligation to publish the information electronically. For instance, several RTAs include

provisions requiring the parties to publish or otherwise make publicly available their respective laws, regulations and other measures of general application pertaining to e-commerce. A complementary but less common provision further commits each party to respond promptly to request by the other party for specific information on any of its measures of general application pertaining to, or affecting the operation of the e-commerce chapter.

71 See Crosby (2016).

72 See section D.3(b). See also Burri (2017), Wu (2017), Singh et al. (2016), Wunsch-Vincent and Hold (2012) and World Economic Forum (2018a).

73 See Hoekman and Mavroidis (2017), Crosby (2016), and Adlung and Mamdouh (2018).

73 Substantive harmonization of privacy protection has been the subject of several international arrangements adopted outside the context of trade agreements and which are generally of a non-legally-binding nature.

E. Conclusions

The world trading system has always been shaped by technological progress. Not only is technology a determinant of trade costs, but it also defines what products can be traded across borders, and it affects patterns of comparative advantage.

Today's digital revolution has come about because of the shift from mechanical and analogue electronic technology to digital technologies, which have been rapidly adopted in the information and communication sectors in particular, and accompanied by sweeping economic and even social changes. All of this started with one fundamental innovation: the internet.

The internet economy has remodelled many facets of our lives, from how we interact with each other, to what we buy and how we work. As new digital technologies leverage the internet to process and analyse big data, computers, automation and data analytics are coming together in an entirely new way that is transforming the global economy and global commerce. Increasingly, trade in goods and services now includes large data and intellectual property contents, and new markets, products and business models are emerging.

This report has examined four digital technologies that are likely to affect trade significantly in the years to come: the Internet of Things, artificial intelligence, 3D printing and Blockchain. The effects of these digital technologies on international trade have been analysed from both a qualitative and a quantitative perspective.

One of the most significant effects of digital technologies is the extent to which they reduce various trade costs, such as transport and logistics costs, the cost of crossing borders, information and transaction costs, and the costs of cross-border payments. Transport and logistics costs combined account for more than half of the variation in trade costs in agriculture and manufacturing, and for more than 40 per cent of the variation in trade costs in services. Thus, the application of artificial intelligence, the Internet of Things and Blockchain to reduce transport and logistic costs are likely to have the largest effects on overall trade costs.

Digital technologies are also blurring the distinction between goods and services and are increasing the importance of data flows and intellectual property. For example, a 3D printed object is also a "3D traded object" – a good that is produced on the basis of a design protected by intellectual property that is transmitted by electronic means as a service.

The Report has also discussed four ways in which digital technologies affect the composition of trade. First, digital technologies increase the services component of trade, because of the ease of supplying services digitally, because new services emerge and replace trade in goods, and because international production networks increase the services content of manufacturing goods. Second, digital technologies foster trade in certain type of goods (time-sensitive, certification-intensive and contract-intensive goods), while at the same time reducing trade in digitizable goods. In addition, the "sharing economy" business model may affect trade in certain consumer goods, such as housing and transport services. Third, digital technologies affect the complexity and length of global value chains, reducing the costs of coordinating geographically dispersed tasks, but at the same time providing increased incentives to (re)locate production near large markets or near centres of innovation. Fourth, digital technologies change patterns of comparative advantage by increasing the importance of factors such as the quality of digital infrastructure and market size, as well as institutional and regulatory determinants of comparative advantage, including intellectual property protection.

These broad qualitative patterns are largely confirmed by quantitative analysis. The WTO's Global Trade Model (GTM) shows that future technological changes are expected to increase trade growth, especially the growth of trade in services. Global trade is projected to grow by around 2 percentage points more than the baseline growth rate, and the share of services trade is projected to grow from 21 per cent in 2016 to 25 per cent in 2030. Moreover, the share of imported intermediate services in manufacturing is projected to increase.

All of these changes seem likely to open new opportunities for developing countries and smaller firms. However, the digital divide, in its various aspects, remains a reality. Quantitative analysis suggests that developing countries will gain an increasing share of global trade, but the extent of that share will depend on their ability to catch up in the adoption of digital technologies. As the *World Trade Report 2017* outlined, technology adoption and diffusion hinge on a number of factors, including feasibility, affordability and managerial culture, as well as legal and regulatory frameworks and public acceptance.

The digital divide is only one among several challenges raised by the advent of digital technologies. Issues related to market concentration, the loss of privacy and security threats increasingly dominate policy agendas in many economies. While digitalization can have significant pro-competitive effects, it can also potentially limit competition by enabling exclusionary or collusive behaviour. Digital technologies make it easier to generate, collect and store personally identifiable data. While this offers private, social and business benefits, concerns about individual data privacy have also become widespread. In addition, cyberattacks can seriously threaten the security of individuals, firms and governments, and can have disruptive economic effects.

Given the cross-cutting nature of digital technologies, as governments progressively develop regulation to take into account the growing digitalization of their economies, the set of policies that have an impact on international trade expands. When it comes to regulating consumer protection in online transactions, data privacy, cybersecurity, competition policy for digital markets, and intellectual property protection, this report shows that governments follow very diverse approaches – reflecting the diversity in public policy objectives across countries.

The global nature of the current transformation suggests that international cooperation is necessary, and the evolving nature of trade that new "policy dynamics" are required. As the distinction between goods and services is increasingly blurred, and the role of intellectual property in international trade increases, policies related to trade in services and intellectual property become increasingly relevant. If trade is increasingly fuelled by cross-border data flows, mercantilist approaches to trade policy cooperation are rendered less relevant than regulatory cooperation. The challenge for governments is to find the right balance between principles and policies that promote technological progress and international market integration on the one hand, and principles and policies that ensure that they retain the ability to pursue legitimate objectives while regulating the digital economy, on the other. The principle of legitimate objective – which aims to ensure that government policies do not represent disguised restrictions on trade and that they are not more trade-restrictive than necessary – is an integral part of WTO legal texts. The question is whether this principle, as currently embodied in WTO texts, is sufficient to address the challenges raised by the expansion of digital trade.

The way we do business is going to change dramatically over the coming years, in ways that are likely to pose new challenges to the trading system as it exists today. WTO members will have to consider how they want to respond to these challenges.

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Technical notes

Composition of regions and other economic groupings Regions				
North America				
Bermuda	Canada*	Mexico*	United States of America*	
Other territories in the region not elsewhere specified				
South and Central America and the Caribbean				
Antigua and Barbuda*	Chile*	El Salvador*	Panama*	Trinidad and Tobago*
Argentina*	Colombia*	Grenada*	Paraguay*	Uruguay*
Aruba (the Netherlands with respect to)	Costa Rica*	Guatemala*	Peru*	Venezuela, Bolivarian Republic of*
Bahamas**	Cuba*	Guyana*	Saint Kitts and Nevis*	
Barbados*	Curaçao	Haiti*	Saint Lucia*	
Belize*	Dominica*	Honduras*	Saint Vincent and the Grenadines*	
Bolivia, Plurinational State of*	Dominican Republic*	Jamaica*	Saint Martin	
Brazil*	Ecuador*	Nicaragua*	Suriname*	
Other territories in the region not elsewhere specified				
Europe				
Albania*	Czech Republic*	Iceland*	Montenegro*	Slovenia*
Andorra**	Denmark*	Ireland*	Netherlands*	Spain*
Austria*	Estonia*	Italy*	Norway*	Sweden*
Belgium*	Finland*	Latvia*	Poland*	Switzerland*
Bosnia and Herzegovina**	France*	Liechtenstein*	Portugal*	The former Yugoslav Republic of Macedonia*
Bulgaria*	Germany*	Lithuania*	Romania*	Turkey*
Croatia*	Greece*	Luxembourg*	Serbia**	United Kingdom*
Cyprus*	Hungary*	Malta*	Slovak Republic*	
Other territories in the region not elsewhere specified				
Commonwealth of Independent States (CIS), including associate and former member States				
Armenia*	Georgia*	Moldova, Republic of*	Turkmenistan	
Azerbaijan**	Kazakhstan*	Russian Federation*	Ukraine*	
Belarus**	Kyrgyz Republic*	Tajikistan*	Uzbekistan**	
Other territories in the region not elsewhere specified				
Africa				
Algeria**	Congo*	Ghana*	Mauritius*	Somalia**
Angola*	Côte d'Ivoire*	Guinea*	Morocco*	South Africa*
Benin*	Democratic Republic of the Congo*	Guinea-Bissau*	Mozambique*	South Sudan**
Botswana*	Djibouti*	Kenya*	Namibia*	Sudan**
Burkina Faso*	Egypt*	Lesotho*	Niger*	Tanzania*
Burundi*	Equatorial Guinea**	Liberia*	Nigeria*	Togo*
Cabo Verde*	Eritrea	Libya**	Rwanda*	Tunisia*
Cameroon*	Eswatini*	Madagascar*	São Tomé and Príncipe**	Uganda*
Central African Republic*	Ethiopia**	Malawi*	Senegal*	Zambia*
Chad*	Gabon*	Mali*	Seychelles*	Zimbabwe*
Comoros**	The Gambia*	Mauritania*	Sierra Leone*	
Other territories in the region not elsewhere specified				

*WTO members
**Observer governments

Middle East				
Bahrain, Kingdom of*	Israel*	Lebanese Republic**	Saudi Arabia, Kingdom of*	United Arab Emirates*
Iran**	Jordan*	Oman*	Syrian Arab Republic**	Yemen*
Iraq**	Kuwait, the State of*	Qatar*		
Other territories in the region not elsewhere specified				
Asia				
Afghanistan*	Hong Kong, China*	Malaysia*	Papua New Guinea*	Timor Leste**
Australia*	India*	Maldives*	Philippines*	Tonga*
Bangladesh*	Indonesia*	Mongolia*	Samoa*	Tuvalu
Bhutan**	Japan*	Myanmar*	Singapore*	Vanuatu*
Brunei Darussalam*	Kiribati	Nepal*	Solomon Islands*	Viet Nam*
Cambodia*	Korea, Republic of*	New Zealand*	Sri Lanka*	
China*	Lao People's Democratic Republic*	Pakistan*	Chinese Taipei*	
Fiji*	Macao, China*	Palau	Thailand*	
Other territories in the region not elsewhere specified				
Regional trade agreements				
Andean Community (CAN)				
Bolivia, Plurinational State of	Colombia	Ecuador	Peru	
AFTA (Association of Southeast Asian Nations (ASEAN) Free Trade Area)				
Brunei Darussalam	Indonesia	Malaysia	Philippines	Thailand
Cambodia	Lao People's Democratic Republic	Myanmar	Singapore	Viet Nam
CACM (Central American Common Market)				
Costa Rica	El Salvador	Guatemala	Honduras	Nicaragua
CARICOM (Caribbean Community and Common Market)				
Antigua and Barbuda	Belize	Guyana	Montserrat	Saint Vincent and the Grenadines
Bahamas	Dominica	Haiti	Saint Kitts and Nevis	Suriname
Barbados	Grenada	Jamaica	Saint Lucia	Trinidad and Tobago
CEMAC (Economic and Monetary Community of Central Africa)				
Cameroon	Chad	Congo	Equatorial Guinea	Gabon
Central African Republic				
COMESA (Common Market for Eastern and Southern Africa)				
Burundi	Egypt	Kenya	Mauritius	Sudan
Comoros	Eritrea	Libya	Rwanda	Uganda
Democratic Republic of the Congo	Eswatini	Madagascar	Seychelles	Zambia
Djibouti	Ethiopia	Malawi	South Sudan	Zimbabwe
ECOWAS (Economic Community of West African States)				
Benin	Côte d'Ivoire	Guinea	Mali	Senegal
Burkina Faso	The Gambia	Guinea-Bissau	Niger	Sierra Leone
Cabo Verde	Ghana	Liberia	Nigeria	Togo
EFTA (European Free Trade Association)				
Iceland	Liechtenstein	Norway	Switzerland	
European Union (28)				
Austria	Denmark	Hungary	Malta	Slovenia
Belgium	Estonia	Ireland	Netherlands	Spain
Bulgaria	Finland	Italy	Poland	Sweden
Croatia	France	Latvia	Portugal	United Kingdom
Cyprus	Germany	Lithuania	Romania	
Czech Republic	Greece	Luxembourg	Slovak Republic	

GCC (Gulf Cooperation Council)				
Bahrain, Kingdom of	Oman	Qatar	Saudi Arabia, Kingdom of	United Arab Emirates
Kuwait, the State of				
MERCOSUR (Southern Common Market)				
Argentina	Brazil	Paraguay	Uruguay	Venezuela, Bolivarian Republic of
NAFTA (North American Free Trade Agreement)				
Canada	Mexico	United States of America		
SADC (Southern African Development Community)				
Angola	Eswatini	Malawi	Namibia	Tanzania
Botswana	Lesotho	Mauritius	Seychelles	Zambia
Democratic Republic of the Congo	Madagascar	Mozambique	South Africa	Zimbabwe
SAFTA (South Asia Free Trade Agreement)				
Afghanistan	Bhutan	Maldives	Pakistan	Sri Lanka
Bangladesh	India	Nepal		
WAEMU (West African Economic and Monetary Union)				
Benin	Côte d'Ivoire	Mali	Senegal	Togo
Burkina Faso	Guinea-Bissau	Niger		
Other groups				
ACP (African, Caribbean and Pacific countries)				
Angola	Côte d'Ivoire	Guinea-Bissau	Namibia	Solomon Islands
Antigua and Barbuda	Cuba	Guyana	Nauru	Somalia
Bahamas	Democratic Republic of the Congo	Haiti	Niger	South Africa
Barbados	Djibouti	Jamaica	Nigeria	Sudan
Belize	Dominica	Kenya	Niue	Suriname
Benin	Dominican Republic	Kiribati	Palau	Tanzania
Botswana	Equatorial Guinea	Lesotho	Papua New Guinea	Timor-Leste
Burkina Faso	Eritrea	Liberia	Rwanda	Togo
Burundi	Eswatini	Madagascar	Saint Kitts and Nevis	Tonga
Cabo Verde	Ethiopia	Malawi	Saint Lucia	Trinidad and Tobago
Cameroon	Fiji	Mali	Saint Vincent and the Grenadines	Tuvalu
Central African Republic	Gabon	Marshall Islands	Samoa	Uganda
Chad	The Gambia	Mauritania	São Tomé and Príncipe	Vanuatu
Comoros	Ghana	Mauritius	Senegal	Zambia
Congo	Grenada	Micronesia	Seychelles	Zimbabwe
Cook Islands	Guinea	Mozambique	Sierra Leone	
Africa				
North Africa				
Algeria	Egypt	Libya	Morocco	Tunisia
Sub-Saharan Africa				
Western Africa				
Benin	The Gambia	Guinea-Bissau	Mauritania	Senegal
Burkina Faso	Ghana	Liberia	Niger	Sierra Leone
Cabo Verde	Guinea	Mali	Nigeria	Togo
Côte d'Ivoire				

Central Africa				
Burundi	Central African Republic	Congo	Equatorial Guinea	Rwanda
Cameroon	Chad	Democratic Republic of the Congo	Gabon	São Tomé and Príncipe
Eastern Africa				
Comoros	Kenya	Mayotte	Seychelles	Sudan
Djibouti	Madagascar	Reunion	Somalia	Tanzania
Eritrea	Mauritius	Rwanda	South Sudan	Uganda
Ethiopia				
Southern Africa				
Angola	Eswatini	Malawi	Namibia	Zambia
Botswana	Lesotho	Mozambique	South Africa	Zimbabwe
Territories in Africa not elsewhere specified				
Asia				
East Asia				
China	Japan	Korea, Republic of	Mongolia	
Hong Kong, China	Korea, Democratic People's Republic of	Macao, China	Chinese Taipei	
Southeast Asia				
Brunei Darussalam	Lao People's Democratic Republic	Myanmar	Singapore	Timor-Leste
Cambodia	Malaysia	Philippines	Thailand	Viet Nam
Indonesia				
South Asia				
Afghanistan	Bhutan	Maldives	Pakistan	Sri Lanka
Bangladesh	India	Nepal		
Oceania				
Australia	Tuvalu	Kiribati	New Zealand	Solomon Islands
Nauru	Fiji	Marshall Islands	Papua New Guinea	Tonga
Palau	Indonesia	Micronesia	Samoa	Vanuatu
APEC (Asia-Pacific Economic Cooperation)				
Australia	Hong Kong, China	Mexico	Russian Federation	Thailand
Brunei Darussalam	Indonesia	New Zealand	Singapore	United States
Canada	Japan	Papua New Guinea	Chinese Taipei	Viet Nam
Chile	Korea, Republic of	Peru		
China	Malaysia	Philippines		
BRIC				
Brazil	Russian Federation	India	China	
Developed economies				
North America (except Mexico)	European Union (28)	EFTA (Iceland, Liechtenstein, Norway, Switzerland)	Australia, Japan and New Zealand	
Developing economies				
Africa	South and Central America and the Caribbean, Mexico	Europe except the European Union (28) and EFTA; Middle East	Asia except Australia, Japan and New Zealand	

LDCs (least-developed countries)				
Afghanistan	Comoros	Kiribati	Nepal	Tanzania
Angola	Democratic Republic of the Congo	Lao People's Democratic Republic	Niger	Timor-Leste
Bangladesh	Djibouti	Lesotho	Rwanda	Togo
Benin	Equatorial Guinea	Liberia	São Tomé and Príncipe	Tuvalu
Bhutan	Eritrea	Madagascar	Senegal	Uganda
Burkina Faso	Ethiopia	Malawi	Sierra Leone	Vanuatu
Burundi	The Gambia	Mali	Solomon Islands	Yemen
Cambodia	Guinea	Mauritania	Somalia	Zambia
Central African Republic	Guinea-Bissau	Mozambique	South Sudan	
Chad	Haiti	Myanmar	Sudan	
Six East Asian traders				
Hong Kong, China	Malaysia	Singapore	Chinese Taipei	Thailand
Korea, Republic of				
Pacific Alliance				
Chile	Colombia	Mexico	Peru	

WTO members are frequently referred to as "countries", although some members are not countries in the usual sense of the word but are officially "customs territories". The definition of geographical and other groupings in this report does not imply an expression of opinion by the Secretariat concerning the status of any country or territory, the delimitation of its frontiers, nor the rights and obligations of any WTO member in respect of WTO agreements. The colours, boundaries, denominations and classifications in the maps of the publication do not imply, on the part of the WTO, any judgement on the legal or other status of any territory, or any endorsement or acceptance of any boundary.

Throughout this report, South and Central America and the Caribbean is referred to as South and Central America.

Aruba; the Bolivarian Republic of Venezuela; Hong Kong Special Administrative Region of China; the Republic of Korea; and the Separate Customs Territory of Taiwan, Penghu, Kinmen and Matsu are referenced as: Aruba, the Netherlands with respect to; Bolivarian Rep. of Venezuela; Hong Kong, China; Korea, Republic of; and Chinese Taipei respectively.

The data supplied in the World Trade Report 2018 are valid as of 31 July 2018.

Abbreviations and symbols

ACTA	Anti-Counterfeiting Trade Agreement
ADB	Asian Development Bank
AfDB	African Development Bank
AI	artificial intelligence
AMF	additive manufacturing file
APEC	Asia-Pacific Economic Cooperation
ASEAN	Association of Southeast Asian Nations
ASYCUDA	UNCTAD Automated System for Customs Data
AU	African Union
AWS	Amazon Web Services
B2B	business-to-business
B2C	business-to-consumer
BOP	balance of payments
CAD	computer-aided design
CEPII	Centre d'études prospectives et d'informations internationales
CGE	computable general equilibrium
CPC	Central Product Classification
CPI	consumer price index
CPTPP	Comprehensive and Progressive Agreement for Trans-Pacific Partnership
CVA	WTO Customs Valuation Agreement
DAO	Decentralized Autonomous Organization
DEA	US Drug Enforcement Administration
DLT	distributed ledger technology
DRM	digital rights management
DVI	digital visual interface
EBOPS	Extended Balance of Payments Services Classification
EBRD	European Bank for Reconstruction and Development
ECIPE	European Centre for International Political Economy
EDI	Electronic Data Interchange
EIF	Enhanced Integrated Framework
ESW	Electronic Single Window
EU	European Union
EUR	Euros
eWTP	Electronic World Trade Platform
FAO	Food and Agriculture Organization of the United Nations
FDI	foreign direct investment
FPD	flat panel display
GATS	General Agreement on Trade in Services
GATT	General Agreement on Tariffs and Trade
GCA	Global Cybersecurity Agenda
GCI	Global Cybersecurity Index
GDP	gross domestic product
GDPR	EU General Data Protection Regulation
GI	geographical indication
GPS	Global Positioning System
GTAP	Purdue University's Global Trade Analysis Project
GTM	Global Trade Model
GVC	global value chain
HDMI	high-definition multimedia interface
IADB	Inter-American Development Bank
IAPP	International Association of Privacy Professionals
ICANN	Internet Corporation for Assigned Names and Numbers
ICC	International Chamber of Commerce
ICN	International Competition Network
ICT	information and communication technology
ILO	International Labour Organization
IMF	International Monetary Fund
IoT	Internet of Things
IP	intellectual property
IPR	intellectual property rights
ISIC	International Standard Industrial Classification of All Economic Activities
ISO	International Organization for Standardization
ISP	internet service provider
IT	information technology

ITA	WTO Information Technology Agreement
ITC	International Trade Centre
ITO	International Trade Organization
ITU	International Telecommunication Union
LAN	local area network
LDCs	least-developed countries
MaGE	Macroeconometrics of the Global Economy
MAU	monthly active user
MFN	most-favoured nation
MOOC	massive open online course
M-Pesa	"Mobile"-Pesa
MSMEs	micro, small and medium-sized enterprises
NASA	US National Aeronautics and Space Administration
NRI	Network Readiness Index
OECD	Organisation for Economic Co-operation and Development
OLS	ordinary least squares
P2P	peer-to-peer
PPML	Poisson pseudo-maximum likelihood
PTA	preferential trade agreement
R&D	research and development
RCM	remote container management
RFID	radio-frequency identification
RMI	rights management information
RTA	regional trade agreement
SDGs	United Nation's Sustainable Development Goals
SEC	US Securities and Exchange Commission
SPS	sanitary and phytosanitary measures
STDF	Standards and Trade Development Facility
SWIFT	Society for Worldwide Interbank Financial Telecommunication
TBT	technical barriers to trade
TCCV	Technical Committee on Customs Valuation
TFA	WTO Trade Facilitation Agreement
TPMs	technological protection measures
TPP	Trans-Pacific Partnership Agreement
TRIMS	Trade-Related Investment Measures
TRIPS	Trade-Related Aspects of Intellectual Property Rights
UN/CEFACT	United Nations Centre for Trade Facilitation and Electronic Business
UNCITRAL	United Nations Commission on International Trade Law
UNCTAD	United Nations Conference on Trade and Development
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNSD	United Nations Statistics Division
UK	United Kingdom
UPU	Universal Postal Union
US	United States
US BEA	US Bureau of Economic Analysis
USITC	United States International Trade Commission
WCO	World Customs Organization
WEF	World Economic Forum
WIOD	World Input-Output Database
WIPO	World Intellectual Property Organization
WTO	World Trade Organization

The following symbols are used in this publication:

…	not available
0	figure is zero or became zero due to rounding
-	not applicable
EUR	Euro
US$	United States dollars
£	UK pound

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WTO members

(As of 1 August 2018)

Afghanistan
Albania
Angola
Antigua and Barbuda
Argentina
Armenia
Australia
Austria
Bahrain, Kingdom of
Bangladesh
Barbados
Belgium
Belize
Benin
Bolivia, Plurinational State of
Botswana
Brazil
Brunei Darussalam
Bulgaria
Burkina Faso
Burundi
Cabo Verde
Cambodia
Cameroon
Canada
Central African Republic
Chad
Chile
China
Colombia
Congo
Costa Rica
Côte d'Ivoire
Croatia
Cuba
Cyprus
Czech Republic
Democratic Republic of the Congo
Denmark
Djibouti
Dominica
Dominican Republic
Ecuador
Egypt
El Salvador
Estonia
Eswatini
European Union
Fiji
Finland
France
Gabon
The Gambia
Georgia
Germany
Ghana
Greece
Grenada
Guatemala
Guinea
Guinea-Bissau
Guyana
Haiti
Honduras
Hong Kong, China
Hungary
Iceland
India
Indonesia
Ireland
Israel
Italy
Jamaica
Japan
Jordan
Kazakhstan
Kenya
Korea, Republic of
Kuwait, the State of
Kyrgyz Republic
Lao People's Democratic Republic
Latvia
Lesotho
Liberia
Liechtenstein
Lithuania
Luxembourg
Macao, China
Madagascar
Malawi
Malaysia
Maldives
Mali
Malta
Mauritania
Mauritius
Mexico
Moldova, Republic of
Mongolia
Montenegro
Morocco
Mozambique
Myanmar
Namibia
Nepal
Netherlands
New Zealand
Nicaragua
Niger
Nigeria
Norway
Oman
Pakistan
Panama
Papua New Guinea
Paraguay
Peru
Philippines
Poland
Portugal
Qatar
Romania
Russian Federation
Rwanda
Saint Kitts and Nevis
Saint Lucia
Saint Vincent and the Grenadines
Samoa
Saudi Arabia, Kingdom of
Senegal
Seychelles
Sierra Leone
Singapore
Slovak Republic
Slovenia
Solomon Islands
South Africa
Spain
Sri Lanka
Suriname
Sweden
Switzerland
Chinese Taipei
Tajikistan
Tanzania
Thailand
The former Yugoslav Republic of Macedonia
Togo
Tonga
Trinidad and Tobago
Tunisia
Turkey
Uganda
Ukraine
United Arab Emirates
United Kingdom
United States of America
Uruguay
Vanuatu
Venezuela, Bolivarian Republic of
Viet Nam
Yemen
Zambia
Zimbabwe

Previous World Trade Reports

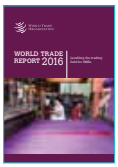
Trade, technology and jobs

2017

The *World Trade Report 2017* examines how technology and trade affect employment and wages. It analyses the challenges for workers and firms in adjusting to changes in labour markets and how governments can facilitate such adjustment to ensure that trade and technology are inclusive.

Levelling the trading field for SMEs

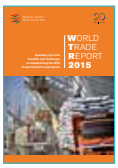
2016



The *World Trade Report 2016* examines the participation of small and medium-sized enterprises (SMEs) in international trade. It looks at how the international trade landscape is changing for SMEs and what the multilateral trading system does and can do to encourage SME participation in global markets.

Speeding up trade: Benefits and challenges of the WTO Trade Facilitation Agreement

2015



The WTO Trade Facilitation Agreement (TFA), agreed by WTO members at the Ministerial Conference in December 2013, is the first multilateral trade agreement concluded since the establishment of the WTO in 1995. This Report is the first detailed study of the potential impacts of the TFA, based on analysis of the final agreement text.

Trade and development: Recent trends and the role of the WTO

2014

This Report looks at four major trends that have changed the relationship between trade and development since the start of the millennium: the economic rise of developing economies, the growing integration of global production through supply chains, the higher prices for agricultural goods and natural resources, and the increasing interdependence of the world economy.

Factors shaping the future of world trade

2013

This Report looks at what has shaped global trade in the past and reviews how demographic change, investment, technological progress, developments in the transport and energy/natural resource sectors, as well as trade-related policies and institutions, will affect international trade.

Trade and public policies: A closer look at non-tariff measures in the 21st century

2012

Regulatory measures for trade in goods and services raise challenges for international cooperation in the 21st century. This Report examines why governments use non-tariff measures and services measures and the extent to which these measures may distort international trade.

The WTO and preferential trade agreements: From co-existence to coherence

2011

The ever-growing number of preferential trade agreements (PTAs) is a prominent feature of international trade. This Report describes the historical development of PTAs and the current landscape of agreements. It examines why PTAs are established, their economic effects, the contents of the PTAs, and the interaction between PTAs and the multilateral trading system.

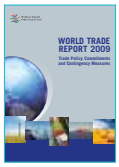
Trade in natural resources

2010

This Report focuses on trade in natural resources, such as fuels, forestry, mining and fisheries. It examines the characteristics of trade in natural resources, the policy choices available to governments and the role of international cooperation, particularly of the WTO, in the proper management of trade in this sector.

Trade policy commitments and contingency measures

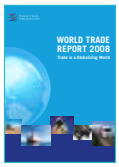
2009



This Report examines the range and role of contingency measures available in trade agreements. It aims to analyse whether WTO provisions provide a balance between supplying governments with the necessary flexibility to face difficult economic situations and adequately defining these in a way that limits their use for protectionist purposes.

Trade in a globalizing world

2008



This Report provides a reminder of the gains from international trade and highlights the challenges arising from higher levels of integration. It addresses the question of what constitutes and drives globalization, the benefits and challenges it brings, and the role trade plays in this world of ever-growing inter-dependency

Sixty years of the multilateral trading system: Achievements and challenges

2007

On 1 January 2008 the multilateral trading system celebrated its 60th anniversary. The *World Trade Report 2007* celebrates this landmark anniversary with an in-depth look at the General Agreement on Tariffs and Trade (GATT) and its successor, the WTO – their origins and achievements, the challenges they have faced, and what the future holds.

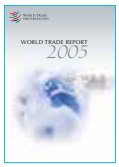
Exploring the links between subsidies, trade and the WTO

2006

This Report focuses on how subsidies are defined, what economic theory can tell us about subsidies, why governments use subsidies, the most prominent sectors in which they are applied and the role of the WTO Agreement in regulating subsidies in international trade.

Trade, standards and the WTO

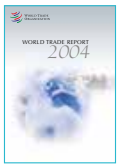
2005



This Report seeks to shed light on the various functions and consequences of standards, focusing on the economics of standards in international trade, the institutional setting for standard-setting and conformity assessment, and the role of WTO agreements in reconciling the legitimate policy uses of standards with an open, non-discriminatory trading system.

Coherence

2004



This Report focuses on the notion of coherence in analysing interdependent policies: the interaction between trade and macroeconomic policy, the role of infrastructure in trade and economic development, domestic market structures, governance and institutions, and the role of international cooperation in promoting policy coherence.

Trade and development

2003

This Report focuses on development. It explains the origin of this issue and offers a framework within which to address the question of the relationship between trade and development, thereby contributing to more informed discussion.

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World Trade Report 2018

Trade has always been shaped by technology but the rapid development of digital technologies in recent times has the potential to transform international trade profoundly in the years to come. Computing, automation and data analytics are coming together in entirely new ways that deeply impact what we trade, how we trade and who is trading. What will be the consequences of the "new digital revolution" on the world economy, and in particular on international trade?

The *World Trade Report 2018* examines how digital technologies – and in particular the Internet of Things, artificial intelligence, 3D printing and Blockchain – affect trade costs, the nature of what is traded and the composition of trade. It provides an analysis of the changes at play and estimates the extent to which global trade may be affected over the next 15 years. The Report discusses the opportunities arising from the development of digital technologies, in particular for developing countries and smaller firms, but also the challenges. It also examines how international trade cooperation can help governments both seize these opportunities and address the challenges.

The Report finds that one of the most significant impacts of digital technologies is the extent to which they will reduce trade costs. It also highlights that digital technologies will affect the composition of trade by increasing the services component, fostering trade in certain goods such as time-sensitive products, changing patterns of comparative advantage, and affecting the complexity and length of global value chains. A number of simulations outlined in the Report show that future technological changes are expected to increase trade growth, especially in trade in services, and that developing countries are likely to gain an increasing share of global trade. The expansion of digital trade is likely to entail considerable benefits but international cooperation is needed to help governments ensure that digital trade continues to be an engine of inclusive economic development.

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