



WORLD TRADE
ORGANIZATION

WORLD TRADE REPORT 2020

Government
policies to promote
innovation in the
digital age



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 2020 Report about?

The 2020 World Trade Report looks at the role of innovation and technology policies in an increasingly digitalized world economy, and explains the role of the WTO in this changing context.

Find out more

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Abbreviations and symbols

AD	antidumping	MERCOSUR	Southern Common Market
AI	artificial intelligence	MFN	most-favoured nation
APEC	Asia-Pacific Economic Cooperation	MNC	multinational corporation
ASEAN	Association of Southeast Asian Nations	MSME	micro, small and medium-sized enterprise
BEPS	base erosion and profit-shifting	OECD	Organisation for Economic Co-operation and Development
CARICOM	Caribbean Community	PPE	personal protective equipment
CPTPP	Comprehensive and Progressive Agreement for Trans-Pacific Partnership	R&D	research and development
CVD	countervailing duties	RTA	regional trade agreement
EAEU	Eurasian Economic Union	SCM	subsidies and countervailing measures
ECIPE	European Centre for International Political Economy	SEZ	special economic zone
EEA	European Economic Area	SME	small and medium-sized enterprise
FDI	foreign direct investment	SOE	state-owned enterprise
FTA	free trade agreement	STEM	science, technology, engineering and mathematics
GATS	General Agreement on Trade in Services	TBT	technical barriers to trade
GATT	General Agreement on Tariffs and Trade	TPR	Trade Policy Review
GBARD	government budget allocations for R&D	TRIMS	Agreement on Trade-Related Investment Measures
GDP	gross domestic product	TRIPS	Trade-Related Aspects of Intellectual Property Rights
GNP	gross national product	UNCTAD	United Nations Conference on Trade and Development
GPA	WTO Government Procurement Agreement	UNECE	United Nations Economic Commission for Europe
GPT	general-purpose technology	UNEP	United Nations Environment Programme
ICT	information and communication technology	UNESCO	United Nations Educational, Scientific and Cultural Organization
IEC	International Electrotechnical Commission	UNICEF	United Nations Children's Fund
IoT	Internet of Things	UNIDO	United Nations Industrial Development Organization
IP	intellectual property	USMCA	United States-Mexico-Canada Agreement
IPA	investment promotion agency	WHO	World Health Organization
ISO	International Organization for Standardization	WTO	World Trade Organization
ISP	internet service provider		
IT	information technology		
ITA	WTO Information Technology Agreement		
ITC	International Trade Centre		
ITU	International Telecommunication Union		
LDC	least developed country		
LLU	local loop unbundling		

Foreword by Deputy Directors-General Agah, Brauner, Wolff and Yi



In the digital age, a growing number of governments have adopted policies aimed at boosting growth through innovation and technological upgrading. The domestic economic fallout linked to the COVID-19 pandemic is leading countries to strengthen these policies. This report looks at these trends, and at how trade and the WTO fit in. It shows that there is a significant role for international cooperation to make countries' pursuit of such goals more effective, while minimizing negative spill-overs from national policies.

Historically, governments have sought to use policy to enhance long-term economic growth or societal welfare. These policies have always had to balance multiple objectives, from attempts to correct real or perceived market failures, to the dual task of managing change in mature sectors, while promoting emerging industries and technologies. Over the past two decades, countries have targeted these objectives with increasingly outward-oriented policies, in recognition that openness by access to larger markets and increased competition leads firms to innovate. Trade and trade policy have historically been important engines for innovation. The certainty and predictability in global market conditions fostered by the multilateral trading system has made a major contribution to innovation and technology diffusion globally, notably by underpinning the rise of global value chains. Countries have accessed advanced technology by importing capital goods, technologies and building knowledge through partnerships and global value chain participation. The economic literature and experience in many countries highlight that innovation, productivity and other key objectives of government policies are best served by broadly open global markets.

Today, a defining feature of government policies is to support the transition towards the digital economy. This transition has become the key objective of so-called "new industrial policies", whose conceptual basis and content have been partly reshaped by the distinct features of the digital economy. As data becomes an essential input, firms rely more on intangible assets than on physical ones. Digital firms are more scalable, reach global markets faster, and

large players may expand globally without the amount of physical investment previously necessary in other sectors. Success in the digital economy underscores the need for openness, for access to information and communications technology (ICT) goods and services, open-source technology, foreign markets, collaborative research projects, and in general for the diffusion of knowledge and new technology.

Spurring innovation in the digital field, whether "new in the world" or "new in the country", is at the core of many new industrial policies adopted in countries at all levels of development in recent years. Governments typically justify these interventions on the grounds of market failures in financing innovation and entrepreneurship, the existence of economy-wide spill-overs for general-purpose technologies, the public nature of knowledge, and the presence of network externalities. The Report finds that some of the policy instruments being employed are relatively new (data policies, some collaborative research and development support, knowledge diffusion through agglomeration, technological hubs) while others are more conventional (tariffs for infrastructural equipment, investment and tax incentives, innovation-based procurement and intellectual property policies).

The Report observes that many developing countries have adopted proactive policy frameworks to promote digital development and technological innovation, with a view, *inter alia*, to catching up on infrastructure, developing the digitization of production and building domestic capacity for a software/app economy which relies on open-source technologies. Innovation in the digital field is widely sought by countries at all development levels. Provided they continue to catch up on internet infrastructure and the right policy and business environment, least-developed countries stand to gain increasingly in digital service exports, participation in global value chains, and the economic inclusion fostered by affordable mobile services.

The Report notes that government policies retain "defensive" aspects, particularly in mature non-digital sectors subject to intense competition and technological transition. The greatest concentration


of “protective” policy instruments is seen in these sectors, aiming to manage the transition and address employment concerns.

In the digital field, the WTO and its existing rulebook already support innovation directly and indirectly in many ways: directly, by eliminating tariffs on internet and telecommunications infrastructure products through the Information Technology Agreement (ITA) and extending these benefits to non-ITA members, by liberalizing internet services through the telecommunications agreement, and by stimulating e-commerce with the moratorium on duties on cross-border digital flows, as well as by providing a robust and stable framework for the development of global and open standards, intellectual property protection and other critical rules based on the principles of non-discrimination, transparency and reciprocity; and indirectly, through the improved resource allocation and efficiency that come with open trade, which frees up resources that can be devoted to new cutting-edge pursuits.

The WTO agreements reached a quarter-century ago proved to be remarkably forward-looking in providing a framework that helped foster the development of an ICT-enabled economy in countries across all levels of development, while preserving policy space for countries to pursue different models of digital development.

Just as it has fostered broadly open, predictable and competitive markets in the wider global economy, the WTO can in the years ahead play an important role in reducing uncertainty in markets for digital goods and services. But this will mean updating the WTO framework to address new challenges and demands. For example, the rising importance of data leads to growing demands for shared international understanding on data transfer, localization and privacy. International cooperation would be useful to foster innovation and interoperability and to reduce tensions in ways that would make international markets function more predictably.

This report looks at how international cooperation – at the WTO, on Aid for Trade and elsewhere – can address these challenges and maximize the positive spill-overs from governments’ policies to promote innovation. While, in many instances, digital markets enhance competition and generate positive spill-overs for the rest of the economy, the Report also warns that the winner-takes-all characteristics of certain digital industries could lead to policy responses that raise tensions between countries and introduce unnecessarily high market barriers. Here, international cooperation could play a particularly valuable role in limiting negative spill-overs.



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Executive summary

A. Introduction

In the digital age, a growing number of governments have adopted policies aimed at boosting growth through innovation and technological upgrading. The domestic economic fallout linked to the COVID-19 pandemic is leading countries to strengthen these policies. This report looks at those trends, and at how trade and the WTO fit into them. It shows that international cooperation could play a significant role in making countries' pursuit of such goals more effective, while minimizing the negative spill-overs from national policies.

The shift towards digitalization and knowledge-based economies highlights the increasing importance of innovation and technology to economic growth. Under the so-called “new industrial policies”, government policies aim at shifting domestic production towards new, enabling digital technologies, while at the same time facilitating the modernization of mature industries.

At each phase of policymaking, governments have to balance multiple objectives, from attempts to correct real or perceived market failures, to the dual task of managing change in mature sectors, while promoting emerging industries and technologies. Over the past two decades, economies have met these objectives with increasingly outward-oriented policies, in recognition of the fact that openness – access to larger markets and increased competition – leads firms to innovate.

The digital age further underlines this need for openness. Trade and trade policy have historically been important engines for innovation. The certainty and predictability in global market conditions fostered by the multilateral trading system have made an enormous contribution to innovation and technology diffusion globally, notably by underpinning the rise of global value chains. Countries have accessed advanced technology by importing capital goods, by means of technologies, and by building knowledge through partnerships and global value chain participation.

Today, a defining feature of government policies is to support the transition towards the digital economy, which is one reason why more and more governments adopt knowledge-based strategies. However, international cooperation is necessary if outward-oriented policies are to be effective. In the context of

“new industrial policies” and related policies geared towards innovation, and the transition towards the digital economy, some of these strategies can have positive spill-overs for other countries – generating growth, creating new markets and encouraging technology diffusion. At other times, these strategies can have negative spill-overs – distorting trade, diverting investment, or promoting unfair competition.

The challenge for WTO members is to provide a framework of shared rules that encourages positive-sum outcomes and discourages zero- or negative-sum ones. This is not a new challenge. The system that was created after the Second World War was designed precisely to reconcile international rules with national policy space and flexibility.

B. Defining innovation-oriented government policies and their evolution in the digital age

In many countries, government policies attempt to improve the business environment or to tilt the structure of economic activity toward sectors, technologies or tasks that are expected to offer better prospects for economic growth or societal welfare than would occur in the absence of such intervention. Governments are generally motivated to implement policies at the sectoral level in order to boost long-term growth, increase incomes and productivity, and, in doing so, promote entrepreneurship, innovation, technology transfer, skill development and competition as specific policies to achieve these objectives.

Over time, there have been several phases of government policies, with considerable variance across economies. In the early days, industrial policies were narrowly defined as policies that aimed to build capacity mainly in the manufacturing sector. The 1980s marked a gradual shift away from policies based on import substitution, infant industry protection and direct intervention into the production process, towards more outward-oriented policies. Some countries anticipated that shift even earlier.

In the 1990s, industrial policies further embraced open economy requirements: skills upgrading, acquisition of technological capacity, reduction of business and trade costs, and infrastructure development, for example, as important medium-term objectives. Industrial and trade policies aimed

to improve the international competitiveness of firms and their integration into global value chains. Governments also introduced strong horizontal, or cross-sectoral, objectives aimed at providing the infrastructure for economic growth, although the horizontal focus did not completely displace sectoral policies, which remained a prominent feature of industrial policies.

By the turn of the millennium, the notion of industrial policy had shifted significantly, with the concept of “industrial” extending beyond the manufacturing sector and evolving towards a model of greater strategic collaboration between the private sector and governments, characterized by the relatively large presence of public-private partnerships and programmes to boost research and development (R&D).

Since the 2008-09 financial crisis, there has been an undeniable resurgence of government policies aimed at fostering change in the allocation of resources by economies, as reflected in the number of economies in which such policies have been developed and in the ambition of policy plans. “New industrial policies”, “Industrial 4.0”, “digital transition plans” have been designed in a context of profound industrial reorganization and parallel to the emergence of ground-breaking digital technologies and advanced manufacturing supply chains. For many countries, the principal aim is to modernize their economies, including their traditional manufacturing sectors, in a way that promotes the shift from mechanical and analogic production to digitally enabled production processes and services.

Hence a key and defining feature of “new industrial policies” is their prime focus on innovation, technological development and upgrading in the digital field.

Innovation can be understood as the transformation of an invention into marketable products and services, new business processes and organizational methods, as well as the absorption, adaptation and dissemination of novel technologies and know-how. Innovation-oriented government policies are therefore public interventions to support the generation and diffusion of innovation.

In practice, technological upgrading and the digitalization of production processes and services are embodied in the economic development plan of many countries, while in others, a specific digital development plan and an innovation plan complements an industrial strategy. Many developing countries have adopted proactive policy frameworks

to promote digital development and technological innovation with a view, for example, to catching up on digital and telecommunications infrastructure, developing the digitalization of production and building capacity for a software/app economy reliant, in the main, on open-source technologies.

Providing an overview of industrial and innovation policies in the digital space, this report examines how policy instruments evolve, distinguishing what is truly new from what simply adapts policy instruments already at use in “traditional sectors”. Certain policy tools and instruments are clearly integral to the digital economy: data policies, R&D support applied to digital technologies, skill and knowledge diffusion; other policy instruments such as investment incentives and intellectual property rights regimes are more “conventional” and need to adapt when applied to the digital sector.

“New industrial policies” can also display “defensive” aspects, particularly in non-digital sectors, which are the most mature, and which may be subject to competition and technological transition. A snapshot of the use of government policy tools, based on public sources including the WTO Trade Monitoring Database, complemented by the Centre for Economic Policy Research (CEPR)’s Global Trade Alert database, shows the relatively active use of industrial and trade policy instruments of a “defensive” nature in traditional sectors such as minerals, metals and chemical industries, and to a lesser extent in textiles and clothing, electrical machinery, and transport equipment. This is notably the case for new border measures including import tariffs, export duties and non-tariff measures, which account for one-third of the policy measures implemented since the 2008-09 financial crisis. The analysis of domestic support measures is less clear, as many of the domestic support measures are horizontal in nature. Where they are identifiable, sector-specific support measures tend to focus on sectors such as transport equipment, minerals and metals.

Investment policies, which are still at the heart of industrial strategies, are characterized by a trend to offer incentives and attract foreign direct investment (FDI), notably in increasingly popular special economic zones (i.e. areas in a country in which the business and trade laws differ from those of the rest of the country). Fiscal and financial incentives, such as tax or tariff exemptions and subsidized services, are the most prevalent investment promotion tools among economies of all development levels. Meanwhile, FDI policies adapt to the characteristics of the digital economy, in which firms no longer need to serve foreign markets by building large manufacturing capacity and

hence firms' criteria to invest abroad emphasize skills and the quality of digital infrastructure.

The novelty of government policies in the digital age is perhaps in the requirement for a better articulation of the various policies supporting the establishment of a new digital supply chain. While ambitions to innovate in digital technologies may vary from one economy to another, many countries – including least-developed countries – do have explicit digital strategies to make the most of the digital technologies, with a view to producing software, providing e-services and/or participating in e-commerce. The concept of innovation in some developing countries may differ somewhat from that of the few frontier countries in this field, as in these cases innovation indicates adopting existing technologies rather than inventing new ones. For these countries, their objectives include catching up with more technologically advanced economies and building alternative capacity for software/domestic “app” economies which can rely on open-source technologies.

Several features of the digital economy underline the evolution of this new phase of industrial and innovation policies. As data become an essential input in every aspect of economic activity, many digital technologies have the potential to alter economies and redefine innovation, and they are thereby considered to be general-purpose technologies. In particular, digital technologies foster collaboration and help to form innovative ecosystems. Firms in the digital economy rely less on physical assets and more on intangible assets. This makes firms much more scalable (i.e. capable of expanding), allowing them to reach global markets, and some market players have come to hold dominant positions in the digital sector.

As a result of these special features, government policies have been evolving in such a way as to encourage innovation in the digital space. Open and transparent data policies are an integral part of innovation policy, as actors need a clear framework for data use, transfer and protection. Government support in building and upgrading telecommunications infrastructure serves as an enabling condition to scale up digital services. Government policies also aim to foster innovation by supporting the promotion of science, offering specific mission-oriented or broad R&D support, developing innovation hubs, promoting digital literacy and skills, and encouraging e-government services as well as innovation procurement. Policy design has to be collaborative and adaptative to allow for the coordination of many more policy fields and favour more experimentation. Collaboration with the private sector is also being sought more systematically.

In the assessment of domestic policies surrounding digital technologies and related activities, a careful examination has to be made. Many national policies in the digital area, such as those which seek to improve the digital infrastructure, offer R&D support in general-purpose technologies, and develop digital skills, tend to be horizontal in nature, and hence are deemed, according to the economic literature, to be *a priori* less economically distortive than policies targeted at specific industries or firms. Policies which aim to create national champions and target specific industries may be more trade-distortive, and call for enhanced international cooperation.

Government policies today are increasingly oriented towards the promotion of innovation in the digital sectors. Over the past decade, R&D expenditure in services linked to information and communication technologies has grown from 10.8 per cent to 14.2 per cent of global R&D spending. Governments support innovation and the development of the digital economy through a mix of traditional policy instruments and new regulatory approaches. Traditional policy instruments range from direct and indirect public funding for R&D to the elimination of import tariffs (including under the WTO Information Technology Agreement), innovation- and digital-oriented public procurement, local content requirement measures, the development of standards and the promotion of high-tech clusters and tech hubs.

The specific features of the digital economy have also led numerous governments to broaden their policy toolboxes and develop new regulatory approaches. These new approaches aim to foster digital innovation through instruments like regulatory sandboxes (i.e. where businesses can draw on the expertise and advice of a regulator and test their products under less stringent regulatory requirements) and data-sharing schemes. They also aim to address digital challenges through interventions like data flow restrictions, data localization requirements and taxation.

C. Innovation policy, trade and the digital challenge

There are several arguments in the economic literature supporting the role of government in fostering innovation, some of which specifically apply to the digital economy. The report identifies five types of market failures in innovative activity that rationalize government intervention.

First, the outcomes of innovation have the characteristics of public goods. Public goods are supplied in inefficiently low quantities by the market

because private returns are lower than social returns. For example, like a public good, data can be used by several firms at the same time without experiencing any reduction in value. Thus, firms that collect and process data may not be able to fully capture the benefits, resulting in a disincentive for data collection and sharing. However, government policies can incentivize the collection, processing and sharing of data, while balancing these benefits with the protection of private information.

Second, digital innovation can generate large benefits for the whole economy by using and diffusing general-purpose technologies. Such technologies, like the steam engine and electricity, generate a growing range of applications and produce positive, economy-wide spill-overs, such as a greater availability of affordable computers and internet connections, which generate complementary innovation.

Third, innovative activity is characterized by asymmetric information between the potential innovator and the potential financier, because the innovator typically knows more about the activity than the financier. This can make it difficult for the latter to predict returns from a potential investment in innovative ventures. As a consequence, a lack of funding may inhibit firms from investing in innovation. However, governments can support projects with a high risk of no immediate result but potentially long-term outcomes, as well as improving financing for new firms and reducing their regulatory burden.

Fourth, complex activities, like innovation, are subject to coordination failures among the various stakeholders. Government action can help coordinate the different parties involved in the innovation process, ensuring that all the required complementary advances have been developed and are available in the market. For instance, to support the economic development of the digital economy, the government may need to intervene to coordinate the co-financing of communication infrastructures.

Fifth, digital technologies are also characterized by significant network externalities or effects, that is, the value of a network increases with additional users. In the presence of network externalities, governments may want to intervene because there can be a gap between the private and the social value of joining a network, limiting the size of networks in an inefficient manner. Government intervention can also address the risks of anti-competitive behaviour and of any single technology dominating the whole market.

The toolkit of policies to promote innovation is vast, because many factors affect innovation activity in

the economy. Innovation policies typically aim to enlarge market size and increase R&D, ensuring the appropriability of research investments by filling (or reducing) the gap between the social and private returns to innovation, and increasing innovation investment to above the inefficiently low levels delivered by the market. Policies also aim to ensure that markets are contestable (i.e. open to competition) and to prevent the abuse of dominant positions, anti-competitive behaviour and technology lock-in (i.e. when technologies that have become obsolete remain in place).

It is worth noting there is no one-size-fits-all approach to innovation policy. Different sets of policies are relatively more appropriate for countries at different levels of economic development. At early stages of development, governments may favour investment-based strategies, while home-grown innovation becomes more important as an economy grows and approaches the world technology frontier (i.e. the most recent technological innovations). Coupled with open and competitive markets, innovation policy can help countries to escape the middle-income trap by selecting and fostering the most innovative entrepreneurs.

Open and transparent trade policies contribute to innovation through improved access to foreign markets and increased competition, which provide firms with incentives to invest more in R&D. This is true for both developed and developing economies: a study of 27 emerging economies shows that both competition from foreign firms and linkages with foreign firms, through importing, exporting or supplying multinationals, increase product innovation, the adoption of new technologies and quality upgrading (Gorodnichenko, Svejnar and Terrell, 2010). Imports of capital goods and intermediate inputs improve productivity, product quality and diversity; the interaction between domestic and foreign firms, through backward and forward linkages, favours technological diffusion; face-to-face interactions within international production and research networks help the diffusion of tacit knowledge and promote knowledge spill-overs. Open and transparent data policies are also important contributors to innovation in the digital age.

Other government policies can be beneficial for innovation. The economic literature highlights that R&D tax credits tend to increase R&D spending and, in some cases, increase patenting activity. Government research spending and procurement have a generally positive impact on innovation. Recent research shows that public funding of university research leads to more patents being filed by private firms. Government

research grants allocated in a competitive way to private firms generally succeed in stimulating private R&D. The effect is particularly prevalent for small firms, which are more likely to experience external financial constraints. Governments can also have a large impact on innovation through procurement policies, especially those directed towards sectors and firms with high technological content.

To achieve desirable social goals, such as to share economic benefits widely and tackle climate change, there may be a role for government in developing radical innovation. Breakthroughs in technological developments are often achieved in the framework of mission-oriented innovation policies, in which the state is both the funder and the customer, with specific public agencies often performing the role of coordinators of vast R&D efforts. Although such policies are difficult to evaluate, they may be justifiable in and of themselves.

The importance of intellectual property rights (IPR) regulation is bound to increase in the digital age because many digital products are replicable at zero cost and are of a non-rival nature (i.e. one person's use of these products does not prevent other people from using them). Strict and enforceable IPRs are central and can increase the attractiveness of a country for digital firms. Recent studies show that patent protection increases the availability of innovation in the pharmaceutical industry. Open source software makes it possible to organize production in a decentralized manner among individuals who cooperate with each other and share resources and outputs, thus contributing to digital innovation.

Human capital fosters economic growth by increasing the productivity of existing technologies and providing an essential input into the innovation process, leading to the generation or diffusion of new technologies, particularly in the digital economy. Education, in particular in science, technology, engineering and mathematics (STEM), is associated with higher levels of innovation activities. Policies to increase the supply of STEM graduates and attract highly skilled immigrants have been shown to boost innovation, and highly skilled scientists and engineers from developing countries who have emigrated abroad to work can also generate net positive gains in their home countries when they go back to their home countries or when they connect with local entrepreneurs there.

Competition policy aimed at making markets contestable is generally beneficial to innovation. Studies have shown that product or service market regulation reduces the intensity or the efficiency of R&D in the same sector or in downstream sectors.

Several studies show that the removal of market entry barriers fosters innovation, including in digital sectors. Although it may be preferable to concentrate resources to foster growth at early stages of development, competition benefits long-term growth.

Other policies that create an innovation-friendly environment include building and maintaining telecommunications infrastructure and favouring agglomeration and early exposure to innovation. This report examines some insights into the wider economic implications of innovation policy, in particular in terms of overall impact on welfare and effects on inequality within countries.

Innovation policies in one country can, and do, have an impact on other countries. Such cross-border spill-overs can be both positive and negative. Innovation created in one country as a result of innovation policy tends, for instance, to diffuse internationally. This boosts foreign productivity and facilitates follow-up innovations abroad. However, innovation policy also improves the competitiveness of domestic producers. This lowers the intervening country's import demand in the targeted sector and increases global supply. As a result, the terms-of-trade of foreign competitors with a comparative advantage in this sector deteriorate.

The cross-border effects of innovation policy arise through a variety of channels from knowledge spill-overs, profit-shifting, supply-and-demand effects and competition for scarce resources. Many innovation policies benefit foreign countries, as they improve innovation, welfare and productivity not just at home but also abroad, for instance by enlarging the publicly accessible pool of knowledge or by boosting demand for foreign research. Assessments of the net effect of innovation policy are scarce, but experience suggests that policies are more beneficial if they are transparent and non-discriminatory. In the digital age, cross-border spill-overs are likely to intensify due to the knowledge intensity and network externalities associated with digital industries.

D. International cooperation on innovation policy in the digital age

Innovation policies, like other components of government policies, serve domestic policy objectives. They can generate both positive and negative international spill-over effects. In both regional and multilateral fora, governments have negotiated disciplines which regulate the use of policy instruments with a view to maximizing these positive cross-border spill-overs and to limiting the negative ones, without impeding the pursuit of legitimate public policy objectives.

Multilateral and regional disciplines have contributed to shaping innovation policies for many years, with continued relevance in the digital age.

The WTO agreements reached a quarter of a century ago proved to be remarkably forward-looking in providing a framework that helped to foster the development of an ICT-enabled economy in countries across all levels of development, while preserving policy space for countries to pursue different models of digital development. Since its inception, the basic principles of the General Agreement on Tariffs and Trade (GATT) (and, today, those of the WTO), such as non-discrimination, transparency, reciprocity and the prohibition of unnecessarily trade-restrictive measures combined with the preservation of policy space for addressing important societal concerns, have promoted trade liberalization and innovation. These principles, although they pre-date the emergence of digitalization, continue to promote innovation in the digital world through the more sophisticated and detailed disciplines contained in the WTO agreements.

For example, the Information Technology Agreement (ITA) has applied a non-discriminatory, progressive elimination of tariffs on ICT goods, making essential technologies, tools and infrastructure equipment, notably internet infrastructures, more affordable.

The Technical Barriers to Trade (TBT) Agreement ensures that regulatory measures are transparent, non-discriminatory, and not unnecessarily trade-restrictive. It has contributed to the emergence of global, open source standards of digital technologies.

The Government Procurement Agreement (GPA) requires that domestic public procurement procedures be conducted based on principles of transparency, non-discrimination and procedural fairness, while allowing for innovation-based policies to operate under these principles.

The General Agreement on Trade in Services (GATS) has allowed WTO members to design and implement innovation policies, provided that they do so in a transparent and non-discriminatory manner, and within the confines of their specific commitments, stimulating the liberalization of telecommunications and internet-based services.

The Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) requires a common minimum level of intellectual property protection and enforcement, flanked by non-discrimination provisions, transparency requirements and binding dispute settlement. It ensures that

incentives for innovation and the creation of intangible assets are comparable across WTO members' economies.

These WTO agreements transcribe the fundamental principles of the multilateral trading system into detailed rules that affect innovation-related policies and, through those, decisions by public and private economic actors on how and where to invest in innovation. These rules have proved to be flexible enough to enable and promote innovation, while ensuring that all WTO members enjoy the benefits of free trade by providing certainty regarding trade rules.

Regional trade agreements (RTAs), too, address the new trade-related issues and challenges of innovation in the digital age. Although only a limited number of provisions in RTAs explicitly address industrial and innovation policy, these explicit provisions help to enhance the coordination of industrial and innovation policy, as well as scientific and technological cooperation. Many other provisions in RTAs can both constrain and support industrial and innovation policy in the digital age. While some of these provisions replicate or build on existing WTO agreements, other provisions establish new commitments. These new obligations cover various issues, including data protection and localization, competition and intellectual property in the digital era.

In addition, various international organizations play an important role in international cooperation on innovation by favouring harmonization and mutual recognition of standards and regulatory frameworks, addressing IP-related issues as well as tax and competition issues, tackling challenges in ICT infrastructure, and supporting digital inclusion and the participation of micro, small and medium-sized enterprises (MSMEs).

Digitalization and digital innovation policies are also creating new needs in the context of international cooperation. Just as it has fostered broadly open, predictable and competitive markets in the wider global economy, in the years ahead the WTO has an important role to play in reducing uncertainty in markets for digital goods and services. This will require new and updated international disciplines on innovation policy instruments.

For example, the increasing importance of data as an input in production and of the fluidity of data is leading to increasing demands for new international rules on data transfers, data localization and privacy. As digital equipment industries become pivotal by producing general-purpose technologies

and enabling downstream industries, international cooperation to encourage national governments to support innovation could bring benefits to the global economy. At the same time, the winner-takes-all characteristics of certain digital industries could lead to policy responses that raise tensions between countries and introduce unnecessarily high market barriers.

Building on this analysis and based on the limited evidence regarding cross-border spill-overs of innovation policies in the economic literature, this report examines more closely how international cooperation can address these challenges and maximize the positive spill-overs from governments' policies to promote innovation.

International cooperation in the WTO and RTAs can contribute to the promotion of digital innovation by helping governments open up and stimulate competition in their digital services sectors. The WTO and RTAs also have a role to play in preventing the introduction and possible spread of barriers to cross-border digital trade, and in making the latter an engine of development.

One question is whether, in the digital world, it makes sense to explore ways to expand the flexibility for governments to use R&D subsidies with important positive international spill-overs. International cooperation may help to design mechanisms to share the benefits arising from innovation policies between countries. In the absence of such mechanisms, national governments may not provide enough support for innovation, as they may fear that most of the benefits from the innovation they support will leak abroad.

International cooperation could help to promote innovation in the digital world by encouraging and facilitating investment in broadband infrastructure or digital industry. FDI promotes innovation in host countries through direct investments to develop R&D and backward and forward linkages. To reap the maximum benefits from FDI, a sound policy environment for investors, consistent with GATS obligations and commitments on commercial presence, is paramount. Ongoing discussions regarding the WTO's joint statement initiative on investment facilitation, aimed at expanding investment flows by simplifying and speeding up procedures, could further promote investment in broadband infrastructure or the digital industry.

Aid for Trade, too, can help governments to adopt more open trade and investment policies in the information and communications technology sector which, if supported by an adequate regulatory

framework, could help to attract FDI, develop digital infrastructure, and bridge the digital divide between poor and rich economies.

Empirical evidence suggests that highly skilled foreign workers positively contribute to innovation in the knowledge economy. Policies to attract highly skilled migrants have been put in place in both developed and developing countries. Commitments in the context of the WTO, RTAs or other international agreements could also help to open markets further to the supply of R&D services and other skilled professional services by suppliers from other WTO members, per mode 4 of the GATS (i.e. the presence of natural persons).

Data policies have become an integral part of innovation policies and a growing number of jurisdictions have passed new regulations to address data-related policy issues such as data privacy, consumer protection, and national security. It is important to examine the relationship between data policies and innovation further to understand what the long-term effects of such policies are. With enough information on the effects of data policies, international cooperation may help countries to share the benefits arising from international flows of data. Limitations on data flows or data localization policies often stem from privacy or security concerns, and therefore an effort to harmonize standards for data protection across countries or to develop mutual recognition criteria could build trust, and help prevent the spread of excessively restrictive data policies or a possible race to the bottom in privacy and security standards.

While, in many instances, digital markets can lead to enhanced competition, their potentially global reach can also result in dominant positions by market leaders, anti-competitive behaviour or mergers and acquisitions harmful to competition. International dialogue and cooperation on competition policies may help to enhance mutual understanding and awareness of policy effects.

Global markets have brought into focus the links between competition policy and industrial and innovation policies. Some tensions exist between, on the one hand, the desire to adapt competition and merger policy in order to provide more leeway to build and support companies large enough to contest global markets and create markets for innovative products, and on the other hand, concerns about using competition policy for strategic industrial policy purposes aimed at appropriating monopoly profits in the global market through the support of national champions.

In this context, international dialogue and cooperation can help to enhance mutual understanding and awareness of policy effects. Relevant cooperation and experience-sharing has taken and is taking place in various fora, such as, in particular, RTAs and organizations such as the International Competition Network (ICN), the United Nations Conference on Trade and Development (UNCTAD) and the Organisation for Economic Co-operation and Development (OECD).

Finally, the report discusses the economic arguments both in favour of and against more policy space for

developing countries to pursue innovation policies. The weight of these arguments depends on the context and the specific policies examined. Although, as already mentioned, there is little empirical evidence on the extent of the spill-over effects of innovation policies and thus of the consequences of granting developing countries more policy space to conduct innovation policies, it can be observed that some developing countries have displayed spectacular growth, suggesting that the cross-border spill-overs of their national policies may have similarly expanded.

A

Introduction

All over the world, governments are actively and openly intervening in economies to boost innovation, generate new technologies, and foster cutting-edge industries. These interventions can have positive or negative impacts, especially in today's hyper-connected global economy. On the one hand, they can expand knowledge, enhance productivity and spread the essential tools of global growth and development. But on the other hand, they can also distort trade, divert investment and benefit one economy at the expense of others. International cooperation and rules are needed more than ever to ensure that governments' new focus on innovation and technology policies maximizes positive spill-overs and minimizes negative ones – and to ensure that a race for technological leadership does not morph into a struggle for technological dominance. The *2020 World Trade Report* looks at the role of innovation and technology policies in an increasingly digitalized world economy, and explains the role of the WTO in this changing context.



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1. A new wave of government policies

Governments' motives for focusing on innovation and technological development often differ.¹ Some want to accelerate or leapfrog development. Others want to build greener and more equitable economies. Still others want to achieve – or hold on to – leadership in key strategic sectors. That governments want to help economies advance is not new. What is novel is the way in which today's increasingly digitalized, data-driven and technology-rich economies seems to have strengthened the case for state intervention, and broadened the scope for smarter, more proactive, more collaborative approaches (Ciuriak, 2018a; 2019b). The COVID-19 crisis has given further impetus to the drive for such government policies, by highlighting countries' vulnerabilities in key medical sectors and spurring governments to redouble efforts to develop new vaccines, improve treatments and strengthen national economic and technological resilience.

Government policies can have both positive and negative impacts or “spill-overs” in today's hyper-connected global economy. On the one hand, national efforts to boost innovation and technology can benefit everyone if they increase the global stock of knowledge and provide countries with the technological tools they need to scale up productivity, protect the environment or improve public health. On the other hand, these same national efforts can be harmful if they entail beggar-thy-neighbour policies that distort global competition or shift economic and social costs onto other partners. While a global race for technological leadership can fuel progress – since competition is often a powerful driver of innovation – it can also fuel conflict and delay progress if it morphs into a global struggle for technological dominance.

In a world where innovation policies and economic integration can drive technological progress, but where the two can also conflict, there is an even greater need for international cooperation and rules to ensure that modern industrial policies are designed and implemented in ways that encourage positive-sum outcomes (i.e. the expansion, exchange and cross-fertilization of knowledge) and discourage zero-sum ones (i.e. the promotion of one country's technological advance at the expense of others). To this end, an effective World Trade Organization could prove more important than ever.

2. Government policies redux

This new focus on state-led technological development is a relatively recent phenomenon. In past decades, the idea that governments should actively intervene in economies with the aim of promoting specific sectors or technologies had fallen out of favour in many countries. It was argued that governments lacked sufficient knowledge of complex economies to steer them successfully (Hayek, 1945; Nelson and Winter, 1982); that governments were susceptible to political capture and thus were more apt to protect losers than to pick winners; and that, often, the problems they sought to solve were a result of “government failures”, not “market failures”, so more government intervention could make matters worse (Bach and Matt, 2005; Miller, 1984). Although it was conceded that industrial policies had produced some modest successes in the past, more often they produced, as *The Economist* bluntly put it, “a crop of whopping failures” (*The Economist*, 2010). Better to let markets decide which industries succeed or fail, and to encourage government largely get out of the way (Krugman, 1994).

But in recent years, academics and policymakers have begun to take a second look at the role that governments play in economic development and growth (Aiginger, 2014; Ciuriak, 2013; Rodrik, 2010). They point out that, at a minimum, state institutions – financial systems, legal structures, and regulatory frameworks – provide the essential “operating system” for every economy, without which markets could not function, and that the quality of these institutions can significantly influence economic success. Another important evolution in recent decades is that industrial policies have become more outward-oriented, in recognition that openness, through access to larger markets and increased competition, can lead firms to innovate. The economic literature and the experiences of many countries highlight that innovation, productivity and other key objectives of industrial policies are best served by open markets.

Governments also supply a broad array of public goods, such as education, healthcare and employment policies, that are equally essential to economic growth, and which markets do not provide. These broad social policies may seem passive, untargeted and neutral, but in their basic design and structure, they can implicitly influence an economy's trajectory – including its technological capacity – often in powerful ways. Then there are the myriad ways in which more active and targeted government policies – such as procurement, subsidies, investment incentives and trade measures – steer capital and labour into activities that the markets might not choose, giving

an initial boost to strategic industries, encouraging “learning by doing” advantages, and potentially helping to accelerate economic development and higher growth (Lucas, 1993).

The shift towards more knowledge-based economies is perhaps the main reason why industrial policies are back in the spotlight. Ideas and information, the key resources in a knowledge-based economy, are different from commodities or capital, in that they resemble “public goods” (Haskel and Westlake, 2017; Romer, 1990). While everyone benefits from them – because they are freely available and infinitely consumable – few are willing to pay for them, because then others can “free-ride” on their investment (Arrow, 1972; Nelson, 1959). Since markets undersupply these critical resources – from higher education to basic scientific research, to digital infrastructure – it falls to governments to provide and pay for them.

Thus, high-tech industries often depend on access to other technologies or information sources to function – for example, Amazon’s reliance on the internet, or Google’s reliance on Big Data – and for this to occur, a level of coordination and shared access is required that only governments can provide. Then there is the fact that many digital technologies are characterized by network effects – for example, Facebook’s attraction to users increases the more users sign up – which gives governments a key role, not just in protecting networked industries in their infancy, but in preventing anticompetitive behaviour when these industries are fully grown (see Section C). While there are always going to be market failures, these are arguably bigger and more consequential in knowledge-based economies, so there is an even greater need for government intervention to correct them (Belli, 1999).

In short, economies, especially technologically advanced ones, do not operate in a vacuum; state policies inevitably shape them. Consciously or unconsciously, actively or passively, successfully or unsuccessfully, governments are continuously engaged in designing, executing, and fine-tuning what are effectively industrial policies (Greenwald and Stiglitz, 2012).

And since it is impossible for governments not to make choices about what direction the economy should take, how scarce resources should be allocated, and what measures are most likely to produce desired outcomes, it is important for governments to get their industrial strategies right. It has been argued that the need to guard against governments distorting markets or propping up failing industries should be balanced

against the need to ensure that governments make the right strategic choices about where new skills are needed, who wins or loses from trade agreements, how regulation shapes industrial development, and where to tax and invest.

Moreover, governments’ strategic economic choices often influence more than just economies. The goals, means and distributional outcomes of state intervention can have important and long-lasting social, environmental and political implications as well. Government efforts to foster advanced technologies and industries, for example, can have a major impact on everything from corporate concentration to labour markets to wealth inequality, presenting both opportunities and challenges. If societies are to adapt to and benefit from the economic changes that governments seek to engineer, then successful industrial policies would seemingly need to encompass a broad, complex, and mutually reinforcing range of measures to help manage difficult and often painful changes, and to build a political consensus around the need for structural reform. As Dani Rodrik has argued, “The real question about industrial policy is not whether it should be practised but how” (Rodrik, 2010).

3. Government policies are as old as industrialization

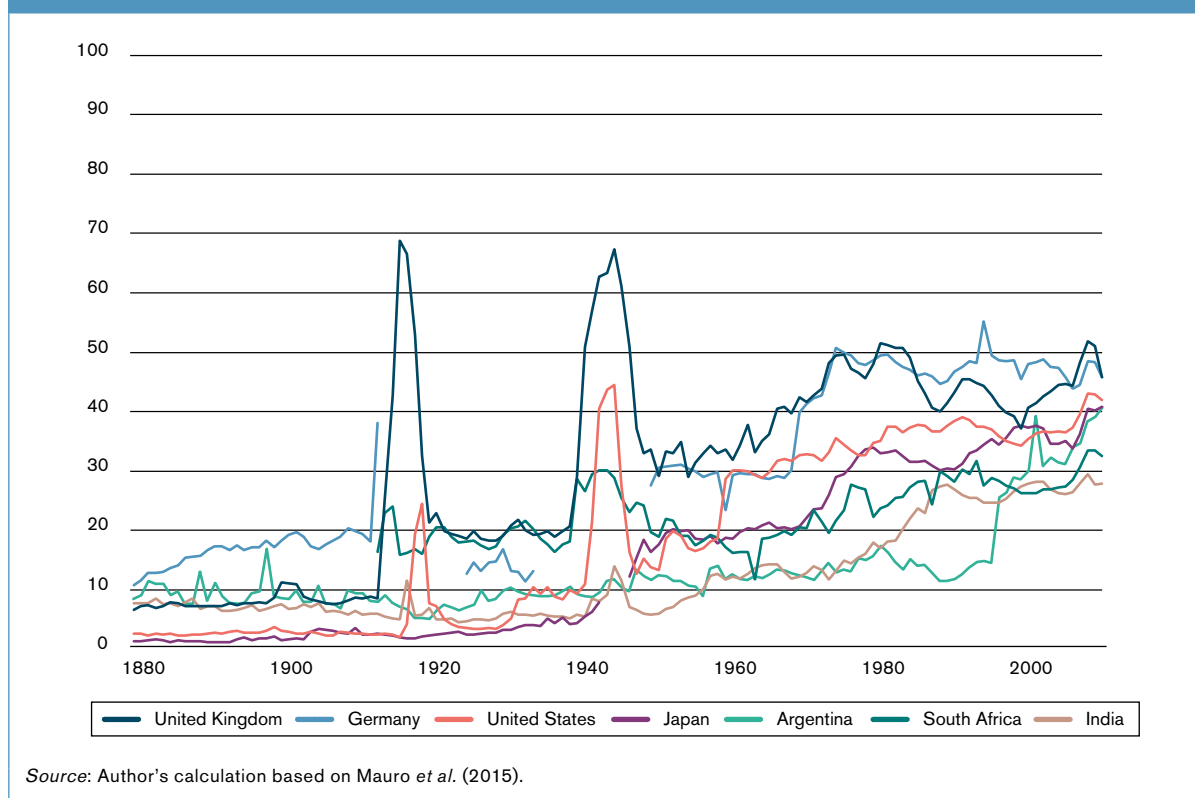
Governments have always intervened in economies,² but the nature and extent of their influence has changed over time. As economies have evolved from agrarian to industrial to post-industrial over the past century and a half, the state’s share of economic activity has steadily expanded (see Figure A.1).

While some of these rising expenditures, such as on defence or pensions, were not (or only tangentially) related to economic development, others, such as industrial subsidies, research and development (R&D) programmes or mass education clearly gave governments a greater role in shaping and steering economies, and allowed them to help determine which industries advanced, and which fell by the wayside. And the state’s economic role and policy “toolkit” expanded, industrial strategies arguably became more, not less, important, and their successes (or failures) more, not less, consequential.

Although the state’s role in 19th-century economies was extremely limited by modern standards, even the early industrializers in Western Europe and North America often used targeted policies to foster economic development, including infant-industry protection, pro-corporate legislation, intellectual

Figure A.1: Government's share of economic activity has steadily expanded

Total government spending as share of GDP



property protection and market-opening foreign policies (Chang, 2003; Shafaeddin, 1998).

However, it was the Second World War that marked the major turning point for the role of governments in the economy, subsequently sparking what has been described as a golden age of industrial policy. Governments played an unprecedented and largely successful role in mobilizing national economic resources for the war effort; this, combined with the social and economic changes that resulted from the war effort, helped to cement a broad post-war Keynesian consensus around the necessary role of governments in managing macroeconomic stability, securing full employment and encouraging industrial development. The Cold War, too, helped to reinforce support for industrial policies, as the both the United States and the Soviet Union used state power to mobilize industry and science for strategic advantage. Meanwhile, European governments increasingly turned to industrial planning to accelerate the development of strategic sectors and to narrow the perceived technology gap with the United States (Grabas and Nützenadel, 2014).

The rise of east Asian economies in the 1960s, 1970s and 1980s marked yet another turning point

for industrial policies. The vertiginous success of these economies was widely attributed not just to strong economic fundamentals, but to the state's central role in fostering public and private sector cooperation, mobilizing financial resources behind strategic industries, reallocating labour from low- to high-productivity sectors, and promoting export-led development. Indeed, perhaps their key policy innovation was to use state intervention, not to encourage inward-looking protectionism and import substitution, but to actively promote an increasingly outward-looking and export-led competitiveness strategy – in recognition of the fact that access to larger markets and increased competition would expose firms to new technologies and encourage them to innovate (Cherif and Hasanov, 2019a; Wade, 1990). Far from being antithetical to these Asian industrial policies, trade liberalization, economic integration and globalization were indispensable preconditions.

Indeed, it can be argued that many governments today do not need to “discover” new economic strategies so much as to “rediscover” old economic strategies that they had forgotten or consciously dismantled. For example, the fact that Western governments' spending on basic R&D has largely declined as a

share of GDP since the 1980s, even as emerging economies' spending has steadily increased (see Figure A.2), is both striking and potentially instructive.

4. Maximizing positive spill-overs while minimizing the negative ones – the critical role of international cooperation

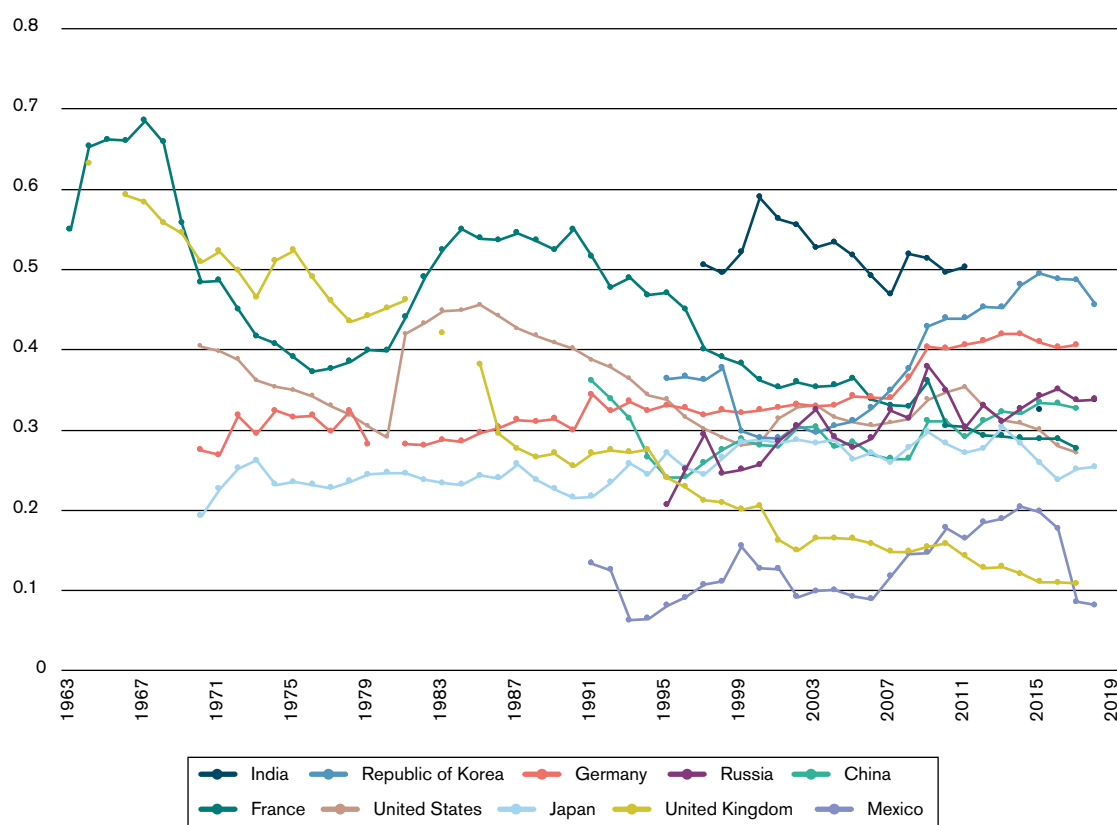
Yet government policies also have international repercussions or spill-overs – all the more so in today's increasingly integrated and digitalized global economy. Sometimes policies can have positive spill-overs for other countries, spreading knowledge, creating new industries or markets, and generating shared growth. But at other times they can have negative spill-overs – distorting trade, diverting investment or exacerbating adjustment costs in partner economies. The challenge is to provide an international economic framework that encourages positive sum outcomes and avoids zero-sum ones.

This is not a new challenge. The post-war system was designed precisely to reconcile international cooperation with national policy space and flexibility. On the one hand, the system sought to restore open world trade (by fixing exchange rates and binding tariffs) and on the other hand, it sought to restore domestic growth and employment (by preserving governments' freedom to manage interest rates, fiscal policies, and pro-employment and industrial strategies). As John Ruggie argued, it represented a system of "embedded liberalism" – a global balance between openness and regulation, capital and labour, markets and government intervention (Ruggie, 1982).

Today's multilateral trading system also aims to provide a framework of rules within which countries can advance their economic interests without compromising or harming the interests of others. The WTO's basic principles of non-discrimination, transparency and reciprocity, and the prohibition of unnecessarily trade-restrictive measures, combined with the WTO's recognition of countries' rights to maintain the policy space needed to address

Figure A.2: Emerging economies' spending on R&D has steadily increased

Government spending on R&D as share of GDP



Source: OECD Main Science and Technology Indicators (MSTI) database.

important economic, social or environmental concerns, have sought to balance the twin goals of national sovereignty and global trade integration since the WTO's inception.

At the same time, rapid and far-reaching economic and technological changes, together with governments' fast-evolving efforts to adjust to and benefit from these changes, are putting new pressure on this framework, calling into question the adequacy of existing multilateral rules, and fuelling demands for WTO modernization and reform. In particular, technology and digitalization seem to be increasing the incentives for state intervention even as they are simultaneously deepening global economic interdependence. These twin developments arguably make it both more challenging and more important to design modern industrial policies that are compatible with trade openness and to find new ways to balance countries' domestic and global interests.

This year's *World Trade Report* looks at the role of intertwined innovation and industrial policies in an increasingly digitalized world economy and explains where the WTO fits in. It looks at how an open and rules-based global trading system is relevant to ensuring that national policies can dovetail with growing global integration.

Section B explains how today's new industrial and innovation policies are truly "new" and different. It makes the point that digitalization has fundamentally changed the aim of government intervention, often in ways that make it compatible with – and not opposed to – open trade and economic integration.

Section C examines the various economic rationales for innovation policies and why the shift towards more knowledge-based economies seems to justify a larger, smarter and more proactive government role. It also looks at the wide range of instruments and policies that governments now use to boost innovation, digital adaptation and technological development, and assesses why some are more effective than others.

Finally, Section D examines how and where innovation strategies interact with global trade rules. It explains that the WTO's existing rules were designed to provide a framework – not a straitjacket – for the development and implementation of national economic policies, and suggests that the WTO's current rulebook may need updating and modernization if it is to remain relevant to the 21st-century economy.

Endnotes

- 1 The European Commission has proposed a “fresh approach to industrial policy”; Japan is exploring a new “Japan Inc.”; India has launched its “Made in India” strategy; China is advancing its “Made In China 2025” initiative; and US politicians are now openly calling for a new US industrial policy.
- 2 Although the term “industrial policy” dates from the 1970s, the arguments for its use go back as far as the 18th century. For example, prominent early arguments in favour of the selective protection of industries can be found in US Treasury Secretary Alexander Hamilton’s 1791 Report on the Subject of Manufactures, as well as in the influential work of the 19th century German economist Friedrich List.

B

Defining innovation-oriented government policies and their evolution in the digital age

Since the 2008-09 financial crisis, industrial employment in some economies has seen accelerated decline and international competition in mature industrial sectors has tightened; the evolution of productivity and wages has slowed; and a new economy enabled by digital technologies has emerged. In this context, industrial and innovation policies have undergone renewal, and these “new industrial policies” are reflecting a duality inherent to all government policy phases, as they aim to address the difficult modernization of traditional industries, while also aiming to bring about an adaptation of economies to digitalization.



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Some key facts and findings

- Spurring innovation in the digital field is at the core of many “new industrial policies” adopted in countries at all levels of development in recent years.
- In adopting “new industrial policies”, there is a general recognition among governments that trade and trade policy are important engines for innovation. Outward-oriented policies allow countries to access advanced technology by importing capital goods, technologies and building knowledge through partnerships and global value chain participation.
- As data become an essential input in economic activities, firms in the digital economy are coming to rely less on physical assets and more on intangible assets, allowing them to reach global markets faster.
- Governments continue to make a relatively active use of policy tools of a “defensive” nature in traditional sectors such as minerals, metals and chemical industries, and to a lesser extent in textiles and clothing, electrical machinery and transport equipment.
- Government policies are increasingly aiming to promote digital innovation and address digital challenges through a mixture of traditional policy instruments (such as tariffs, investment and tax incentives, innovation-based procurement and intellectual property policies) and new regulatory approaches.
- Many developing countries have adopted proactive policy frameworks to promote digital development and technological innovation. Provided that they continue to catch up with internet infrastructure and the right policy and business environment, least-developed countries stand to gain in digital service exports, participation in global value chains and economic inclusion fostered by affordable mobile services.

1. Introduction

Since the 2008-09 financial crisis, government intervention in the economy has undergone a process of renewal. These “new industrial policies” reflect a duality inherent to all industrial policy phases. On the one hand, they aim to address the difficult modernization of traditional industries, both in developed and developing countries; hence, in some of these traditional sectors, these policies may display “defensive” features, protective of the build-up or restructuring of traditional/downstream industries. On the other hand, new industrial policies are also clearly geared towards the adaptation of economies to digitalization, which means encouraging the adoption of digital processes in industrial sectors and spurring innovation to generate new activities (such as application-based services) in the digital space.

Section B.2 looks at how the characteristics of the digital economy modify the design of policy instruments, and how the push towards innovation in the digital economy has influenced the evolution of government policy and the ways in which instruments have been adapted. Some policy tools and instruments – for example, data policies and research and development (R&D) support measures, such as tax breaks to support specific digital innovation, skills and knowledge creation and diffusion – are clearly integral to the digital economy. Other instruments are more familiar, such as incentives for investment, or the promotion of intellectual property, even when they are applied to the digital sector.

Section B.3 offers a quantitative review of how governments have used policy tools over the past decade. The analysis is based on public sources, mainly the WTO trade monitoring tools, complemented by the Global Trade Alert database.¹ It shows that government policies continue to be widely used to support traditional sectors and to attract investment. However, increased focus is being placed on supporting innovation and the development of the digital economy through a mix of traditional policy instruments, such as support for R&D and tariffs, and new regulatory approaches to promote innovation and address digital policy issues raised specifically by the digital economy.

2. A new wave of government policies: when, where, what?

According to a United Nations Conference on Trade and Development (UNCTAD) global survey of industrial policies, presented in the context of its UNCTAD (2018a), 84 economies, accounting for

over 90 per cent of global gross domestic product (GDP), have adopted formal industrial development strategies since 2013, a number reaching 101 economies if counted since the financial crisis of 2008. Although such government policies never absolutely disappeared, they were less “in fashion” a decade or two ago, and their revival has been widespread enough to raise questions. The term “new industrial policies” has been used with relative frequency by countries to label their industrial policy plans, with a view to marking policy priorities linked to transformational changes in technology and economic activity.

This subsection will provide an overview of current trends in these policies. It will then discuss the special features of the digital economy and review how innovation and industrial policy evolve in the digital age.

(a) Definitions

(i) *New industrial policies*

There is no agreed or universal definition of industrial policy, in part because the very concept of industrial policy has been and still is subject to debate, and in part because it has adapted over time. Vanden Bosch (2014) notes that the term “industry” could be narrowly understood as “manufacturing industry” but the new industrial revolution, characterized by the growing utilization of digital technologies, has altered its meaning so that it now tends to include information technologies and services as well.

A key feature of current industrial policy (“new industrial policy”) is its focus on innovation, technological development and upgrading in the digital field. Innovation policies are public interventions to support the generation and diffusion of innovation, whereby an innovation is understood as the transformation of an invention into marketable products and services, the development of new business processes and methods of organization, and the absorption, adaptation and dissemination of novel technologies and know-how (Curtis, 2016; Edler *et al.*, 2016).²

Over time, a distinction has been made in the literature between narrowly defined, “vertical” policies, meant to support, by means of public policy tools, production in a particular sector or firm, as well as the technologies and tasks to build up that sector;³ and the wider concept of “horizontal” policies or strategies, which improve the business, cost, legal and infrastructural environment in which economic actors operate across sectors.⁴ Joseph Stiglitz, Justin

Yifu Lin and Celestin Monga, all former chief economists of the World Bank Group, have acknowledged the vertical/horizontal distinction but warned that the frontier between vertical and supposedly more neutral, “horizontal” policies was blurry, as vertical policies had to be supported or were impacted by horizontal ones (Stiglitz, Lin and Monga, 2013). Stiglitz, Lin and Monga wished to go beyond this distinction by suggesting that government action, through tax and fiscal policy, infrastructure development, the promotion of technology and of knowledge (including education spill-overs), was not “neutral” from the perspective of resource allocation, and that “industrial policy was not just about manufacturing”. They floated the controversial idea that “all governments were engaged in various forms of industrial policies – even those who advocated horizontal or neutral policies ended up taking actions that favoured certain industries more than others and therefore shaped the sector allocation of the economy”.

Nowadays many, if not most, economists opt for a definition sufficiently broad to reflect policy plans observed in countries or regions at different periods of times and levels of development.

(ii) Innovation policy

The defining feature of current government policies is their prime focus on innovation, technological development and upgrading in the digital field. Industrial and innovation policies have never been more intertwined than before. As Curtis (2016) puts it,

“the current debate and proposals on updated forms of industrial policy are less about market interventionism and more on technological innovation, productivity gaps, R&D, entrepreneurship, vertical specialization and agglomeration economies”.

Curtis notes that globalization and digital technologies have had a profound impact on the global innovation landscape. At the same time, innovation has become a crucial aspect of the development process, as policymakers in both high- and low-income countries increasingly see the development and adoption of advanced technologies, know-how and new business methods as key to stimulating productivity, competitiveness, employment and growth (Curtis, 2016).

Edler *et al.* (2016) define innovation policies as:

“public intervention to support the generation and diffusion of innovation, whereby an innovation is a new product, service, process or business model

that is to be put to use, commercially or non-commercially”.

While the Edler *et al.* (2016) definition focuses on the generation of new products and services, Li and Georghiou (2016) make a distinction by level of development. They acknowledge that “innovation” in the context of developed countries was often regarded as the creation of “non-existing” goods or services. By contrast, in some developing countries, innovation has not always been “new to the world”, but more often “new to the country”, in a way that means that innovation has been associated with catching up with world-level technological frontiers (Nelson, 2004). The World Bank (2010) embraces the view that:

“innovation means technologies or practices that are new to a given society. They are not necessarily new in absolute terms. These technologies or practices are being diffused in that economy or society. This point is important: what is not disseminated and used is not an innovation. Dissemination is very significant and requires particular attention in low- and medium-income countries”.

In this definition, innovation policy is not a single set of policy prescription to promote innovation but policy actions in several policy areas (education, science and technology, trade, entrepreneurship, investment and finance) constituting a framework for innovation to occur, but also for the innovation to be marketed and the underlying knowledge to be diffused.

The literature points to the tendency of innovation policies to become more complex, including not only an increasing set of policy areas, but also involving a range of actors and institutions. Innovation policies in the past were linked to specific policy objectives, designed and implemented by specific departments responsible for those specific missions (for example space travel and telecommunications). These innovation policies are often labelled as “mission-oriented” (Ergas, 1987; Mazzucato, 2013). This first phase of innovation policy evolved into more complex, “holistic” policies aimed at facilitating the interactions between the various actors and institutions involved in innovations processes, such as universities, research institutes, investors (including banks and venture capitals), and government agencies across various sectors. This intersects with new industrial policies, which promote a more horizontal approach to economic development, bringing together a vast number of actors and policy areas (World Bank, 2010).


 OPINION
PIECE

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Industrial policy revisited

The best-kept secret of economic policy may be the fact that every single economy in the world, either intentionally or not, pursues industrial policy. This is true not only for the usual suspects, such as Brazil, China, France and Singapore, but also for Chile, Germany, Great Britain and the United States. The news is only surprising if one forgets that industrial policy broadly refers to any government decision, regulation or law that encourages the ongoing operation or development of a particular industry. After all, economic development and sustained growth are simply the results of continuous industrial and technological upgrading, a process that requires public-private collaboration.

While industrial policy has had a bad reputation in economics for a long time, historical evidence shows that all countries that have successfully transformed from agrarian economies to modern advanced economies – the old industrial powers in Western Europe and North America as well as the newly industrialized economies in East Asia – had governments that played a proactive role in assisting individual firms in overcoming the coordination and externality problems that arose during the process of their structural transformation.

However, the sad fact is that while almost every government in the developing world has attempted, at some point in its development process, to play that facilitating role, most have failed. The economic history of the economies of the former Soviet Union, Latin America, Africa and even Asia have been marked by inefficient public investment and misguided government interventions that have resulted in many “white elephants” and costly distortions.

Looking carefully at these pervasive failures in developing economies, it appears that they are mostly due to the inability of governments to come up with good criteria for identifying industries that are appropriate for a given country's level of development. In fact, the propensity of governments to target industries that are too ambitious and are not aligned with a country's comparative advantage largely explains why their attempts to “pick winners” have often resulted in “picking losers.” In contrast, as I argued in “New Structural Economics” (Lin, 2010), governments in successful developing countries have typically targeted mature industries which have succeeded in countries with an endowment structure similar to theirs and with a level of development not much more advanced than theirs. The main reason is straightforward:

government interventions aiming at facilitating industrial upgrading and diversification must be anchored in industries with latent comparative advantage determined by their endowment structure, so that they enjoy low factor costs of production. In this way, once a government uses targeted policy to improve the hard and soft infrastructure needed to lower transaction costs, private firms in the new industries can quickly become competitive, both domestically and internationally.

In the case of advanced countries, most industries tend to be on the global frontier (i.e. having adopted the most recent innovations), which means upgrading requires an original innovation. In addition to *ex post* measures such as giving a patent to a successful innovation or supporting a new product through procurement, the government may also use *ex ante* measures such as supporting basic research needed for new product/technology development or impose a mandate for using a new product like the case of ethanol.

(b) Context

The rethinking of government policies since the global financial crisis of 2008-09 has been driven by a wide array of factors that vary from one country to another (Singh, 2016). These include:

- tightening competition between developing and developed economies, particularly in mature manufacturing sectors – as products and technologies mature and spread, catch-up phases are perceived to be shorter;
- the continuous decline in manufacturing employment in industrialized economies, and the relatively new phenomenon of a declining share of manufacturing production in the GDPs of the more advanced developing economies;
- the slower evolution of productivity and the stagnation, if not the decline, of real wages for mid- to low-income workers in many economies;
- influential public policy arguments, according to which economies with a stronger industrial base resist changes and shocks better;
- the desire to “move up the value chain”, i.e. for low-income economies to shift away from commodity exports and increase domestic value-addition, and for middle-income economies to achieve a technological “catch-up” with high-income economies; and,
- in line with the above, the emergence of disruptive technologies linked to the digital economy.

The socioeconomic context surrounding government policies has also changed: public demands on governments have become more complex in terms of defining economic policies to address sets of intertwined problems or longer-term crises, such as regional inequality, territorial impoverishment, health and food concerns, environmental protection, and even in some cases wage levels and redistribution.

Another element in the altered socioeconomic context is the recognition that the success of government policies cannot rely solely on manufacturing, given the level of servicification of manufactures and the spill-overs that incentives on one sector have on others. Cross-industry spill-overs are now widely acknowledged by the literature, so improving incentives for advanced manufacturing or the digital sector without making progress on internet connectivity and physical infrastructures, or promoting manufacturing activities without improving

the competitiveness of adjacent services activities, are recognised not to be effective. In other words, a better understanding of the notion of competitiveness implies the fulfilment of many other conditions other than just promoting output in manufacturing.

As described below, expectations from government policies differ according to levels of development, from the early stages in which sectoral industrial development is sought, to advanced levels in which ongoing technological change and its economic, social and territorial consequences must be addressed. Further, in countries at early levels of development, industrial and innovation strategies often pursue technology transfer and the domestication of international technologies, while later stages strive to push their technological frontiers outward.

(c) Trends in government policies

Policymaking is a process. Most government policies display elements of duality: simultaneously defensive (protecting the build-up or restructuring of traditional/downstream industries) and offensive (promoting exports, incentivizing innovations in “new” industries); vertical (aiming at sectoral development) and horizontal (coordinating actors and policies, improving the business environment, and reducing business and trade costs); combining domestic support and external measures. It is rarely one or the other, at each stage of development.

New industrial policies reflect this duality. On the one hand, these policies were designed during a period of profound industrial restructuring following the financial crisis of 2008-09 and were therefore aimed at addressing the difficult transitions of traditional industries in both developed and developing countries. On the other hand, new industrial policies focus on adapting the economy towards digitalization – which means encouraging the adoption of digital processes in industrial sectors as much as spurring innovation to generate new activities (such as application-based services) in the digital space. This push towards innovation in the digital economy is reflected in the evolution of policy instruments, as discussed in the following subsection, and in Table B.1, which shows how new themes and orientations have been incorporated in modern industrial policies over time.

The 1980s marked a gradual shift away from policies based on import substitution, infant industry protection and the direct intervention of states in the production processes, that were prevalent in the 1960s and 1970s in many economies, towards more

Table B.1: Evolution in government policies and new themes				
	Until the 1970s	1980s-90s	Modern industrial policies	
			2000s and ongoing	Recent/emerging themes
Key features/themes	Industrialization, structural transformation	Stabilization, liberalization Knowledge-based economy Participation in global value chains	Knowledge-based economy "Moving-up" the value chains	New industrial revolution. Push towards innovation and transition to the digital economy. Participation in digital supply chains. Sustainable development.
Policy goals	Creating markets, diversification	Market-led modernization	Specialization and increased productivity	Modern innovation ecosystem development.
Key elements	Import substitution Infant industry protection Sector development Gradual and selective opening to competition	More limited government involvement in many countries More horizontal policies Foreign direct investment (FDI) opening Exposure to international competition	Targeted strategies in open economies Enabling business environment Digital development (information technology – IT) and information and communication technology (ICT) diffusion Participation in global production networks FDI promotion combined with protection of strategic industries Micro, small and medium-sized enterprise (MSME) support (ongoing) Skills development (ongoing)	Innovative research, and technological development. Innovation in production. Learning economy. Public-private knowledge/tech development institutions. Acquisition or transfer of foreign technology. Entrepreneurship development.
Policy environment	Promotion of national development strategies	Less interventionist development strategies in many countries International commitments and disciplines	National development strategies complemented by other policies (technology, digital policies)	More emphasis on inclusiveness and coordination of various policies (industrial, innovation, digital transformation, environment)

Source: Authors, adapted from UNCTAD (2018a).

outward-oriented policies, as noted by Dornbusch and Park (1987). Some countries, for example in Asia, had anticipated that shift earlier, while others changed direction later.

In the 1990s, government policymaking embraced open economy requirements, such as skills upgrading, the acquisition of technological capacity, the reduction of business and trade costs, and infrastructure development, as important medium-term objectives. Industrial and trade policies aimed to improve the international competitiveness of firms and to integrate into global value chains. An important element of context has been the appearance of international (regional or multilateral) disciplines on the use of policy instruments that could generate negative spill-

overs internationally. For example, the combination of state aid and competition policies emphasized consumer interest in the European Union and aimed to limit the market powers of national champions in the European Union, and WTO binding disciplines and provisions have undoubtedly had an impact on WTO members' policy spaces (Bohanes, 2015).

Still, the introduction of strong horizontal objectives did not completely displace sectoral policies, which remained a prominent feature of government policies. Grabas and Nützenadel (2014) mentioned the 1990 European Commission's Communication on "Industrial Policy in an Open and Competitive Environment, Guidelines for a Community Approach" as a reflection of the new construct of policies of the 1990s.

At the turn of the millennium, academics such as Rodrik contributed to redefining the concept of industrial policies (Rodrik, 2004). Prominent among these shifts was a model of strategic collaboration between the private sector and governments, hence the relatively large presence of public-private partnerships and programmes to boost R&D. Rodrik made the point that one size did not fit all government policies, which had to be tailored to the specific context or institutions of a country, or, to use the terminology introduced by Hausmann, Rodrik and Velasco (2008), policies had to be sensitive to countries' "binding constraints". According to this view, different countries could adopt identical policies with very different results, since they had different sets of market failures. Also, policies aimed to be "more neutral" and targeted (for example toward micro, small and medium-sized enterprises (MSMEs)).

The idea of evaluating policies and instruments also grew in the 2000s. The related literature analysed instruments such as R&D subsidies (Hall and Van Reenen, 1999; Wilson, 2009), place-based policies targeting disadvantaged geographical areas, and environmental subsidies (e.g., renewable energy subsidies, as per Aldy, Gerarden and Sweeney (2018)). Aghion, Boulanger and Cohen (2011) argued that targeted, sectoral government subsidies work better when implemented in more competitive and high-skilled sectors. Instruments such as investment and R&D incentives induce more (and new) firms to enter competitive markets, and, in view of the higher level of competition in these markets, some will be encouraged to innovate in order to "escape" such competition. For these reasons, Aghion, Boulanger and Cohen suggest that sectoral aid that enhances within-sector competition by not focusing on one or a small number of firms is more likely to be growth- and productivity-enhancing than more concentrated aid.

The most recent inflexion is the current resurgence of governmental new industrial policies following the global financial crisis of 2008-09, in a context of a profound industrial reorganization and the emergence of ground-breaking digital and advanced manufacturing supply-chain technologies and digital services. Horizontal objectives are often associated with the vertical objectives of promoting specific industries or types of industries and with new concerns and objectives that aim to rely on greener sources of energy and on upgrading human capital and skills across the economy.⁵

As per the analysis in UNCTAD (2018), of the 114 new industrial policies issued since the global financial crisis, 30 emanated from developed countries and 84 from developing countries, of which 24 were

least-developed countries (LDCs). Three-quarters of these strategies have been adopted in the past five years. The coordination of various sets of policies is important, as industrial, environmental, investment and trade policies are called upon to meet the large number of objectives of today's industrial and development policies. New policy objectives are required to meet new socioeconomic challenges.

Several countries have adopted more than one policy; for example, they may have adopted a national industrial policy complemented by a policy on innovation, advanced manufacturing or digital economy (see Table B.2), all of which may eventually be part of an overall national development strategy. Industrial strategies reflect levels of development and concerns. UNCTAD (2019a) noted that high-income and upper-middle-income countries focused, for example, on advanced manufacturing development linked to the new industrial and digital revolution. LDCs had a higher number of industry-specific programmes and initiatives focusing on certain segments of their economies, such as MSMEs, consistent with the objective of promoting domestic value creation in downstream (and sometimes intermediate or upstream) sectors of the economy.

A defining feature of new industrial policies is the focus on innovation, technological development and upgrading, and the role of investment in promoting it. Investment policies may either be incorporated into broader industrial and development plans or be standalone policies establishing bridges with other policies. UNCTAD (2018) notes that foreign direct investment (FDI) policies have had to adapt to the characteristics of the new e-economy, in which firms no longer need to serve foreign markets by building locally large manufacturing capacity, but instead serve them with lower-scale non-equity investment and services; and in which the criteria used by firms to justify investing abroad change, for example from labour costs to skills, and from the quality of physical infrastructure to digital infrastructure.

Making the most of the digital economy is an overriding concern of countries at all levels of development. This means more than just adapting industrial and investment policies, as it implies a government-wide response to cross-sectoral, economy-wide challenges: among the topics that typically figure in countries' digital strategies are developing the right digital infrastructure, boosting research and science, upgrading skills and adopting retraining policies, promoting e-government services and cybersecurity, establishing a clear framework for data use, transfer and protection, and, in some countries, promoting the growth of national companies in digital services. Many

Table B.2: Examples of industrial and technological upgrading strategies adopted since the mid-2010's

New industrial policies (illustrative)	
Developed countries	
France	Industries du Futur Pacte Productif 2025
Germany	National Industrial Strategy 2030 High Tech Strategy 2025 Shaping the Course of Digitalization (Digitalisierungsgestalten)
Italy	National Industry Plan 4.0
Japan	Japan Revitalization Strategy and Industrial Competitiveness Enhancement Act; Initiatives for Promoting Innovation New Robot Strategy Fifth Science and Technology Basic Plan
Republic of Korea	Manufacturing Innovation Strategy 3.0
Singapore	Smart Nation Plan
Sweden	Smart Industries Strategy
United Kingdom	UK Industrial Strategy
United States	Strategy for American Leadership in Advanced Manufacturing Manufacturing Extension Partnerships
Developing countries	
Brazil	National strategy for Internet of Things Brazilian Strategy for Digital Transformation ("E-Digital")
China	Made in China 2025; "A policy to upgrade and integrate China's manufacturing sector with a modern service sector" (November 2019) Internet Plus
India	National Manufacturing Policy Digital India Make in India Strategy
Indonesia	Making Indonesia 4.0 (2017) Indonesia 2045
Malaysia	Industry4WRD: National Policy on Industry 4.0
Mexico	Industry 4.0 Roadmap
Morocco	Plan d'Accélération Industrielle du Maroc 2014-20
Philippines	Inclusive, Innovation-led Industrial Strategy (I-cube)
South Africa	National Industrial Policy Framework, and Industrial Policy Action Plan 2018/2019-2020/2021
Thailand	Thailand 4.0 National Strategy
Turkey	Medium Term Development Plan Industrial Strategy and Sector-specific industries 2019
Viet Nam	Five-Year Socio-Economic Development Plan (2016-2020) Industrial Development Strategy through 2025, vision 2015; Strategy on Cleaner Industrial Production 2020
Least-developed countries	
Bangladesh	Five-Year Plan 2016-21; National Industrial Policy 2016
Cambodia	Cambodia Industrial Development Policy 2015/25 National Broadband Planning Cambodia ICT Master Plan 2020
Myanmar	National Comprehensive Development Plan Industrial Development Vision and Industrial Policy Paper
Rwanda	National Industrial Policy; Made in Rwanda Policy (2017)
Zambia	National Industrial Policy (2018)

Source: Authors based on UNCTAD (2018a).

countries see the potential of the digital economy for generating economic growth. Digitally distributed or enabled services, such as (e-)banking and media, offer new opportunities for both domestic producers and consumers, and complement or replace less efficient physical distribution services.

MSMEs are also at the heart of the digital economy. Despite the high market shares of global platforms, many applications are locally produced and destined for local markets. The digital economy can reduce the need for intermediaries in certain activities and could encourage entrepreneurship by reducing the amount of start-up capital required. This is particularly true in developing countries. However, a digital economy becomes the focus of digital policies, and there are many challenges associated with the development of a competitive digital economy, including start-up funding, connectivity, skills and talent retention, data acquisition and storage, privacy, and other data-related issues.

LDCs have expressed concerns that, in view of the challenges and resources required to be competitive in the digital economy, they might lose their grip on the new economy before they even have a chance to catch up with traditional supply chains. Correa and Kanatsouli (2018) drew a mixed panorama of their industrialization in previous periods. Still, half of the LDCs had explicit objectives in the area of ICTs, for example to secure affordable and reliable connectivity, and to develop locally made applications. In many cases, local applications allow for significant cost reductions for consumers and improvement in the availability of services (for example in agricultural and remote areas). Several such countries have made significant headway already, including in remote and agricultural areas (UN-OHRLLS, 2018). In LDCs, exports of ICT services and services that can be delivered digitally accounted for an estimated 16 per cent of total services exports; they more than tripled from 2005 to 2018 (UNCTAD, 2019b).

Digital technologies help LDCs to improve the business environment and to reduce costs for MSMEs. For example, e-commerce is well suited to LDCs, which have a higher share of MSMEs than other economies. Apart from providing access to a broader range of buyers, some e-commerce platforms offer a range of services (customer service, shipping, payment, delivery and return handling) which are a source of significant savings for participating MSMEs (Songwe, 2019).

(d) Taxonomy of policy instruments

Table B.3 presents an illustrative taxonomy of the government policy tools most often found in the traditional goods sectors, and referenced by

institutions such as the Organisation for Economic Co-operation and Development (OECD), the United Nations Industrial Development Organization (UNIDO) and the United Nations Conference on Trade and Development (UNCTAD),⁶ as well as of instruments typically found in the digital space. Policies in digital sectors or digitally enabled sectors aim, to a large extent, to foster innovation and knowledge diffusion in these sectors, and from these sectors to others. The economic characteristics of digital sectors (the asset-light model, where a business owns relatively fewer capital assets compared to the value of its operations) and the objectives of government intervention (building the e-connectivity infrastructure, encouraging local innovation, even if it is only local software- and application-making, favouring certain data policies, encouraging knowledge diffusion, etc.), are shaping the nature and form of the instruments used in the digital space. For example, large capital infusions which may previously have been used to build capacity in capital-intensive sectors – such as metals, ship-building and others – may in part be “replaced” by more limited grants and tax incentives for R&D in the digital space, which is less intensive in terms of physical capital.

The question arises of what is really new and what is a simple adaptation of policy instruments already used in “traditional sectors”. The instruments presented in Table B.3 aim to support firms in participating in digital and digitally enabled supply chains. As reflected in Table B.3, certain policy tools and instruments are clearly integral to the digital economy: data policies, R&D support measures such as tax breaks to support specific digital innovation, and skills and knowledge creation and diffusion. Other instruments, even when applied to the digital sector, look somewhat more familiar, such as incentives for investment and the promotion of intellectual property. Perhaps the novelty is in the requirement for a better articulation of policies supporting the establishment of a new “digital” supply chain, which includes telecommunication and internet infrastructures and connectivity, the networks necessary to undertake electronic commerce and other digital services, and the skills set necessary to participate in the digital economy as a producer of local applications.

Several innovation-based policies are not new, but are now applied to spur innovation in the digital economy. For instance, there is a great emphasis on tax incentives and tax breaks in the digital field; tax reductions are available horizontally across several policy fields, for example upon investment, to foster patent and other intellectual property (IP) creation, to facilitate the adoption of digital processes in “traditional” industrial sectors, to create new software services, and to boost R&D.

Table B.3: Taxonomy of innovation and industrial policy tools			
Type of instrument	Traditional instruments	Instruments in the digital age	Examples in the digital age
Border measures	Import tariffs; export tariffs and other duties; quantitative restrictions; duty drawbacks		Elimination of tariffs for technical equipment, e.g. as per the WTO Information Technology Agreement (ITA) and the WTO Moratorium on Customs Duties on Electronic Transmissions.
Support measures	Tax incentives, exemptions, breaks, credit and any other favourable tax treatment (amortization); remission of indirect taxes.	(Tax) incentives for adoption of digital technologies.	France: Industries du Futur; Malaysia: tax incentives to the electrical and electronics industry to transition into the 5G digital economy and Industry 4.0.
	Direct transfers such as grants, direct payments and other production subsidies, equity financial and capital infusion, start-up capital for large investment projects.	Tax incentives for software development services, ICT-related services, data processing services and call centre services.	Australia; Belize; Canada; Djibouti; Egypt; India: IT/ITeS (i.e. Information Technology/ Information Technology-Enabled Services) Policy; Republic of Korea; Malaysia; Philippines: Investment Priority Plan; Slovak Republic; Sri Lanka; United States.
	Directed and preferential lending; subsidized interest rates and guarantees, favourable credit restructuring, forgiveness; export credit and guarantees.	R&D support, including R&D incentives, funding for basic research, research for dual goods; R&D grants and tax credits.	Germany: Digitalisierungsgestalten – direct funding for digital technologies and innovations; Federal funding of American Artificial Intelligence Initiative; Malaysia: Investment Tax Allowance (ITA) for R&D; Singapore: Research Incentive Scheme.
	Input or infrastructural subsidies (lower electricity prices); funding for basic and development research for dual goods.	Grants.	EU Research Council (grants for software and computing); US National Research Foundation.
		Mission-oriented R&D grants.	Canada: National Research Council Canada (NRC) Quantum Research & The Institute for Quantum Computing at the University of Waterloo; China: National Thirteenth Five-Year Plan for National Science and Technology Innovation; Quantum Research – United States: National Strategic Overview for Quantum Information Science.
		Equity financing for tech and digital sectors: public equity funds, fund of funds.	European Union: Connecting Europe Broadband Fund; Korea Fund of Funds; Sweden: Almi Invest (public venture capital company that invests in areas such as technology and industry).
		Accelerator and incubator programmes for early-stage businesses.	Poland: The Incubator Foundation; Canada Target Group: EntrePrism; US Small Business Administration: Growth Accelerator Fund.
		Patent boxes.	Ireland: Knowledge Development Box; France: reduced corporation tax rate on intellectual property income; Switzerland: tax exemption of patent income.
		Provide and extend digital infrastructure.	Cambodian ICT Masterplan 2020; Germany: DigitalPact School & Special Fund "Digital Infrastructure"; Japan: High Performance Computing Infrastructure (HPCI) programme; Malaysia: High-speed Broadband project (HSBB) & National Fiberisation and Connectivity Plan (NFCP); Nepal: National Broadband Policy & Rural Telecommunication Development Fund (RTDF).

Table B.3: Taxonomy of innovation and industrial policy tools (continued)

Type of instrument	Traditional instruments	Instruments in the digital age	Examples in the digital age
Local content requirements	Local employment quotas; use of local contractors; use of local supplies and services.	Technological transfer requirements; share of parts and components to be used in a product.	Indonesia: local content requirements for smartphones and tablets (30-40 per cent of 4G telecommunication devices sold in Indonesia are to be produced locally or need to include seven locally made applications or 14 locally created games, in addition to 10 per cent of locally sourced hardware and 20 per cent of local design and firmware development).
Government procurement	Preferential purchase schemes, preferential price margins for local producers.	Source and procure software only from local software development companies.	Russia: Issued decree 1236 and Order 155 restricting purchases by government entities and state-owned enterprises, based on not having an adequate local alternative for foreign producers of software; enforcement of a 15 per cent price advantage.
		Preferential purchase schemes covering digital products and services.	Turkey: Enforced local preference margin of 15 per cent for middle and high technology products; United States: provision in the "Consolidated and Further Continuing Appropriations Act, 2013-H.R.933" (Procurement of Chinese IT equipment contingent on FBI certification).
Agglomeration	Clusters; special economic zones; policies may include: free land, preferential input prices and access to utilities; infrastructural investment.	High-tech clusters; science parks.	Austria: Digital Innovation Hubs Initiative; Canada: Artificial Intelligence-Powered Supply Chains Supercluster (Scale AI); Cluster Excellence Denmark; EU Smart Specialisation Platform; Japan: The Industrial Cluster Initiative; Thailand Science Park; United States: National Network of Big Data Regional Innovation Hubs (BD Hubs).
		Special economic zones	China: High-Tech Development Zones (HTDZs); Turkey: technology development zones (TDZs).
		Accelerator and incubator programmes for early-stage businesses; tech hubs.	The Canada Accelerator and Incubator Program (CAIP); Turkey: International Incubation Center and Accelerator Support Programme.
Regulatory measures and standards	Technical regulations; product testing;	Standard development initiatives and regulatory measures related to digital technologies and advanced technologies (e.g. Blockchain, AI, 5G, autonomous vehicles).	Germany: Digitalisierungsgestalten –develop general compliance standards for telemedia; Germany: Road Regulations Amended to Allow Autonomous Vehicles; United States: Standardization Roadmap for Additive Manufacturing (i.e. 3D Printing).
		Standards for compatibility / interoperability.	European Telecommunications Standards Institute (ETSI) – interoperability standards for e-health, the Internet of Things and smart cities; European Committee for Standardisation (CEN) – e.g. Guidelines on interoperability of electronic invoices; United States: Federal Trade Commission – Internet of Things.
		Regulatory sandboxes.	Global Financial Innovation Network (GFIN); Monetary Authority of Singapore: The FinTech Regulatory Sandbox; United Kingdom: Financial Conduct Authority (FCA).
Investment (domestic and foreign)	Tariff and tax exemptions, incentives, and other support measures for domestic or foreign investment (see support measures), which may be granted inside or outside the context of particular economic zones or areas. Investment promotion measures and agencies; investment facilitation, screening, protection. Tax incentives by local authorities for establishment, linked or not linked to performance requirements.	Policies to attract FDI from high-tech companies.	Indonesia: tax holidays that include the digital economy sector; Republic of Korea: foreign investment zones for companies conducting R&D and companies that possess advanced technologies; Malaysia: customized investment incentives of RM 1 billion annually over 5 years to attract Fortune 500 & high-tech companies; Thailand: tax incentives for FDI for high-tech, including digital technologies.
		Special economic zones.	China – high-tech development zones (HTDZs); Turkey – technology development zones (TDZs).
		Immigration policies directed at bringing high-skilled labour in technology or other industries.	European Union: Blue Card; Japan: Highly Skilled Foreign Professional (HSFP) visa; Singapore: Employment Pass; United States: H1B visa.

Table B.3: Taxonomy of innovation and industrial policy tools (continued)			
Type of instrument	Traditional instruments	Instruments in the digital age	Examples in the digital age
Skills and learning	Training grants; training institutes for industry-specific skills; industry associations or skills councils; technical vocational education and training; education policies; government advisory services.	(Direct and indirect) government advisory services.	Czech Republic: CzechInvest- Business and Investment Support Agency; Germany: Mittelstand 4.0 (small and medium-sized business) competence centres.
		Technological knowledge transfer.	France: Industries du Futur – “multi-technology matrix”.
		Expansion of STEM (science, technology, engineering and mathematics) programmes.	US Department of Education investment for STEM education, including computer science, through discretionary and research grants.
		Accelerator and incubator programmes for early-stage businesses.	The Canada Accelerator and Incubator Program (CAIP); Turkey: International Incubation Center and Accelerator Support Programme.
		Skill development for digital technologies	Germany: DigitalPAct School & Vocational Training 4.0; Malaysia – Digital Social Responsibility (DSR); The Digital Personnel Development Institute for Public Sector; Thailand Digital Government Academy (TDGA).
Intellectual property	Patents, copyrights, trademarks.	Intellectual property (IP) incentives.	Malaysia: 10-year income tax exemption for IP-generated income from patents and copyright software based on the Modified Nexus Approach; ⁷ Singapore: Intellectual Property Development Scheme.
		Patent boxes.	Ireland: Knowledge Development Box; France: Reduced Corporation Tax Rate on IP Income; Switzerland: tax exemption of patent income.
Data policies		Personal data protection policies.	Australia: Personally Controlled Electronic Health Records Act (PCEHR); Malaysia: Personal Data Protection Act (PDPA); Russia: Federal Law no. 242-FZ “On Personal Data” (international transfer of personal data requires additional consent); Turkey: Data Protection Law; EU General Data Protection Regulation (GDPR);
		Data policies for addressing security issues, including data localization requirements and cross-border data flow policies.	China Cybersecurity Law- 2017 (requires operators of critical infrastructure (e.g. telecoms operators) to store personal data within China & requests for cross border data flows shall be submitted to a regulator); Guidelines for Nigerian Content Development in Information and Communications Technology (ICT); EU Cybersecurity Act;
		Open government data. ⁸	Mexico: La Política de Datos Abiertos.
		Data policies fostering data-sharing between companies (i.e. generally for addressing market competition issues).	Brazilian Good Payer’s Credit Act; European Payment Service Directive; UK Open Banking initiative.
		Data policies for ensuring government access to data for law enforcement and regulatory oversight purposes.	UK Investigatory Powers Act 2016.

Source: Authors.

A variety of grants also exists, for example when governments offer to match the paid-up capital of MSMEs, or provide funds to universities and national scientific institutes for research on advanced software and digital technologies (such as the

grants given to the European Research Council and the US National Science Foundation); in this context, individual grants may be limited in size. There are areas, however, which may mobilize larger direct funding resources from governments, such

as “mission-oriented” grants for the development of cutting-edge “quantum computing”, in the same style as the supercomputer projects of the 1980s. Government funding can also be made available to upgrade “enabling” telecommunications and internet infrastructures (broadband and connectivity plans), which require significant and multi-annual public and private sector investment.

While technological and science parks have existed for decades, digital tech hubs and other similar agglomerative formulae aim to maximize knowledge spill-overs by bringing together universities, start-ups and occasionally government research centres under individual or grouped projects. The agglomeration of talents and skills is a key component of the digital economy, and benefits in some countries from the support of specific immigration policies aimed at attracting highly skilled human resources.

An important category of policies is innovation-based government procurement. Such policies can take several forms (see Section D.2(a)(v)). Via government procurement, R&D contracts can be allocated to innovative firms or groups of firms, incentives can be provided for local firms to supply locally developed goods and services (such as software or digital applications), and/or markets can be created to develop local technologies.

National data policies are also at the heart of the digital economy. They generally aim to increase the accessibility and ease of data-sharing among users, as well as to regulate data availability for various purposes, including societal, scientific and economic purposes. Policies may provide guidance on charges for information, open data provision, collection, exchange and disclosure, licensing and privacy protection.

(e) How the digital economy changes government policy

Over the past few decades, the rapid developments of technologies such as AI, robotics, IoT, autonomous vehicles, 3D printing and nanotechnology have triggered a new wave of economic structural change, often termed the “Fourth Industrial Revolution” (Davis, 2016; Schwab, 2017). The current wave of technological breakthroughs can be distinguished from the first, second and third industrial revolutions in which technological developments in mechanical power, electricity and information technology (IT) powered industrial changes. In contrast, the driving force of the recent technological change is the shift from mechanical and analogue electronic technology to digital technologies.

Digital technologies, products and services have become core aspects of almost every sector, impacting production processes and business models, disrupting established sectors and altering the dynamics of the world economy. Although this revolution is still in its infancy, it is starting to bring about economic and social changes, requiring that institutional frameworks and government policies adapt. In particular, data and the digital economy affect business behaviour, redefine innovation, alter market outcomes and transform the way economies are organized.

(i) *Features of the digital economy*

The digital economy comprises ICT goods and services to provide digital infrastructure, online platforms, digitally enabled services and cross-border flows of data. The definition of ICT and the digital sector used in this report is the manufacturing and services sectors of which the main activities are linked to the development, production, commercialization and intensive use of digital technology.⁹

Several features of the digital economy underline this ongoing economic transformation. First, data have become an essential input in every aspect of economic activities, which are increasingly organized along digital supply chains. Second, many digital technologies have the potential to alter economies drastically, and they are thus considered to be general-purpose technologies (GPTs). Third, digital technologies redefine innovation, foster collaboration and help to form innovative ecosystems. Fourth, firms in the digital sectors are often highly scalable, resulting in higher market concentrations. Fifth, digital goods and services are increasingly integrated, resulting in a sustained shift of employment from manufacturing to services sectors. Finally, changes in the digital economy often take place much faster than in the traditional economy.

Data as a key input into the digital economy

The digital economy arose out of the extraordinary amounts of detailed machine-readable information that have become available about practically all personal, social and business activities and interactions. The internet has also allowed a massive amount of information to be carried by modern communication networks and transmitted instantaneously over any distance. The quantity of data flowing globally over the internet has grown exponentially over the past three decades. Global internet traffic, a proxy for data flows, grew from about 100 gigabytes per day in 1992 to more than 45,000 gigabytes per second in 2017. Today 3.9 billion people, or 51 per cent of the global population, use the internet, and it is predicted

that nearly two-thirds of the global population will have internet access by 2023 (Cisco Systems, 2020).

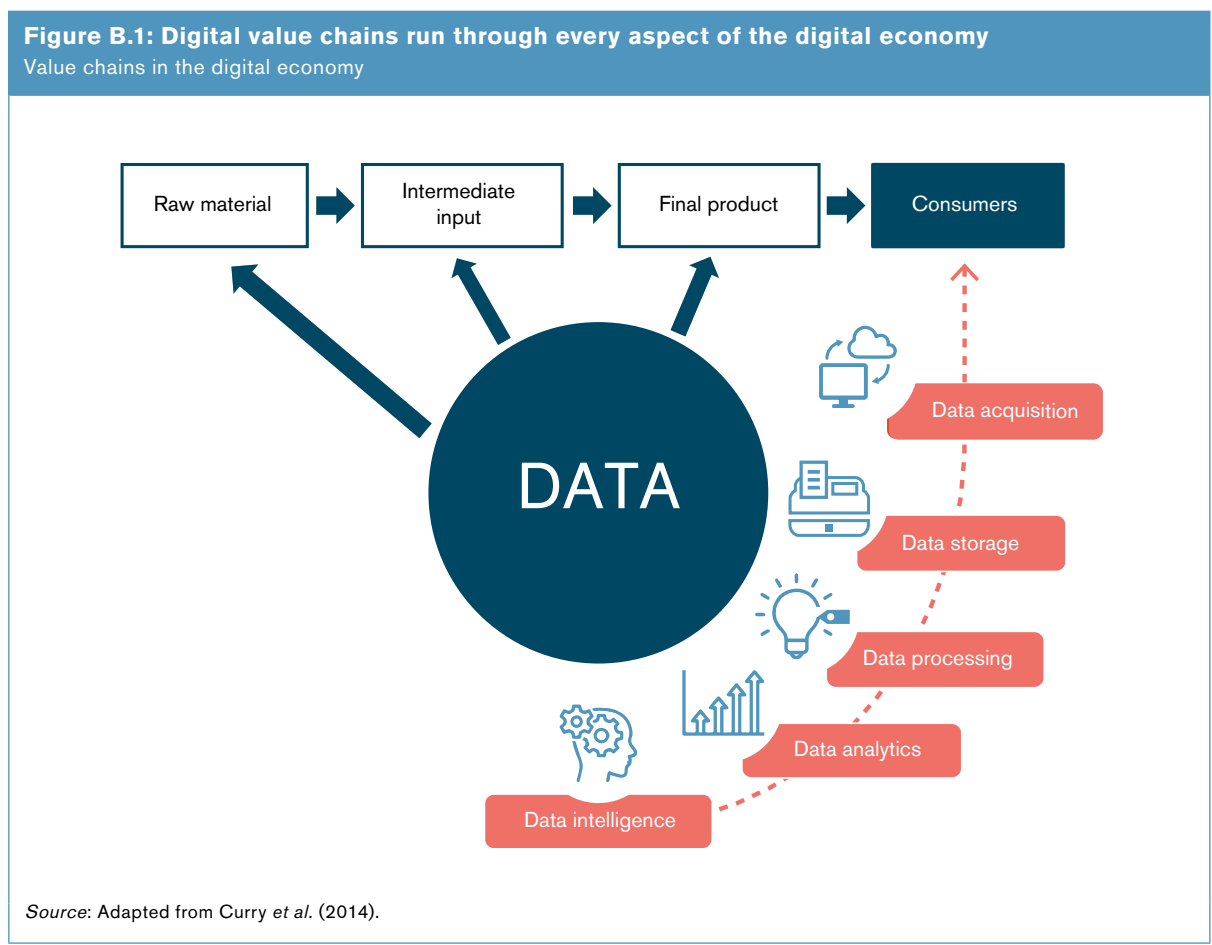
Currently 80 per cent of the processing and analysis of data take place in data centres and centralized computing facilities, and 20 per cent in smart connected objects such as cars, home appliances, manufacturing robots and computing facilities (Gartner, 2018). In the future, even more data are likely to be generated by smart connected objects and personal computing devices. Not only do digital technologies modify the functionalities of available goods and services, but the range and extent of such functionalities will depend on the quantity of data that can be transmitted. For example, the availability and diversity of data are crucial for training AI systems, which work by combining large amounts of data with fast, iterative algorithms to allow the software to learn automatically from patterns or features.

Although data are becoming ever more ubiquitous, creating value out of data requires complementary assets, individual skills, and data assessment tools, enabling those individuals and firms with the strongest capacities to take full advantage of the data (Guellec and Paunov, 2018). An entirely new value chain has

evolved around firms that support the production of insights from data, including data acquisition, data storage, data modelling and data analysis to generate data intelligence. This digital value chain runs through every aspect of the economy, enabling the efficient management of supply chains and increasing product diversity and in-depth insights about consumer preferences (see Figure B.1). In essence, the amount of data and the speed of data transmission enabled by data infrastructure are crucial for the functioning of the digital economy.

Digital technologies affect the entire economy

As mentioned above, many digital technologies are considered to be GPTs with the potential to alter economies and societies drastically. Just as the invention of steam engine, the electric motor and the semiconductor played essential roles in the first, second and third industrial revolutions, the development and wide adoption of digital technologies are the enablers for the Fourth Industrial Revolution. Technologies such as AI, IoT and Blockchain have the potential to be of benefit to the economy generally (Furman and Seamans, 2019).



GPTs can be identified as having three main characteristics, according to Bresnahan and Trajtenberg (1995). The first is pervasiveness – the technology should spread to most sectors. The second is improvement – the technology should get better over time, and therefore costs should keep falling for its users. The third is innovation generation – the technology should make it easier to invent and produce new products or processes. As we see below, digital technologies fulfil all three characteristics (Jovanovic and Rousseau, 2005).

Digital technologies spread across all sectors

Since the invention of computers and the internet, the spread of digital technologies has been rapid and has ranged well beyond the ICT sector. Figure B.2 shows the share of IT equipment and software in the net capital stocks of main sectors in the United States.

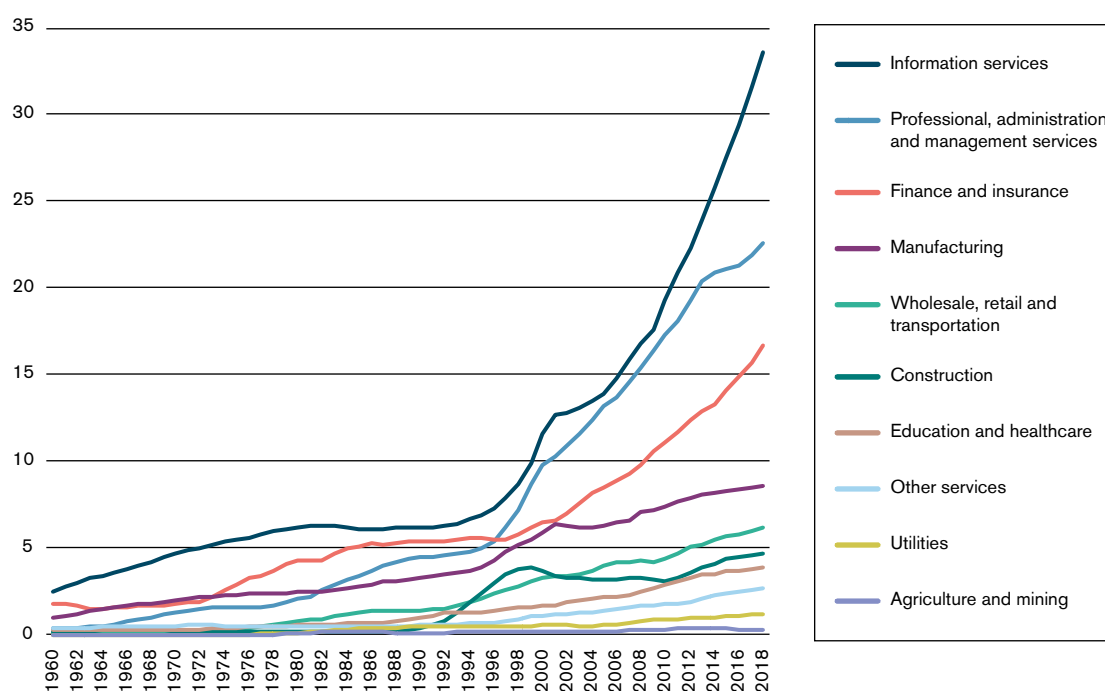
Some sectors adopted IT very rapidly – for example, the share of IT equipment and software in total capital stock in the information services sector reached over 30 per cent in 2018, followed by professional administration and management services, whose

share of IT equipment and software is over 20 per cent of its total capital stock. Other sectors, such as utilities, agriculture and mining, have not adopted IT technologies to the same extent, but their use of digital technologies has nonetheless increased over time. For example, ICT are used to provide localized weather forecasts and information on daily market prices to farmers. In resource-constrained environments especially, service providers use satellites or remote sensors to gather temperature data, the internet to store large amounts of data, and mobile phones to disseminate temperature information to remote farmers cheaply, to prevent crop losses and mitigate the effects of natural adversities (McNamara et al., 2011).

The pervasiveness of digital technologies is also demonstrated in their wide applications across different fields. AI, for example, is one of the most widely adopted digital technologies. It is increasingly driving important developments in technology and business, from autonomous vehicles to medical diagnosis to advanced manufacturing, transforming ways of living and working (WIPO, 2019b). The IoT, which allows everyday objects to communicate with

Figure B.2: Digital technologies spread rapidly to all sectors

Share of IT equipment and software in the capital stock in the United States by sector, 1960-2018 (percentile)



Source: Authors' calculation based on data from the US Bureau of Economic Analysis.

Note: The sectoral capital stocks are from the detailed non-residential fixed asset tables in constant 2012 US dollars made available by the US Bureau of Economic Analysis. The classification of sectors was changed in 2001.

one another and with other devices and services over the internet, also has wide applications: wireless IoT devices are becoming ubiquitous in business sectors such as manufacturing, healthcare and logistics.

Digital technologies improve over time

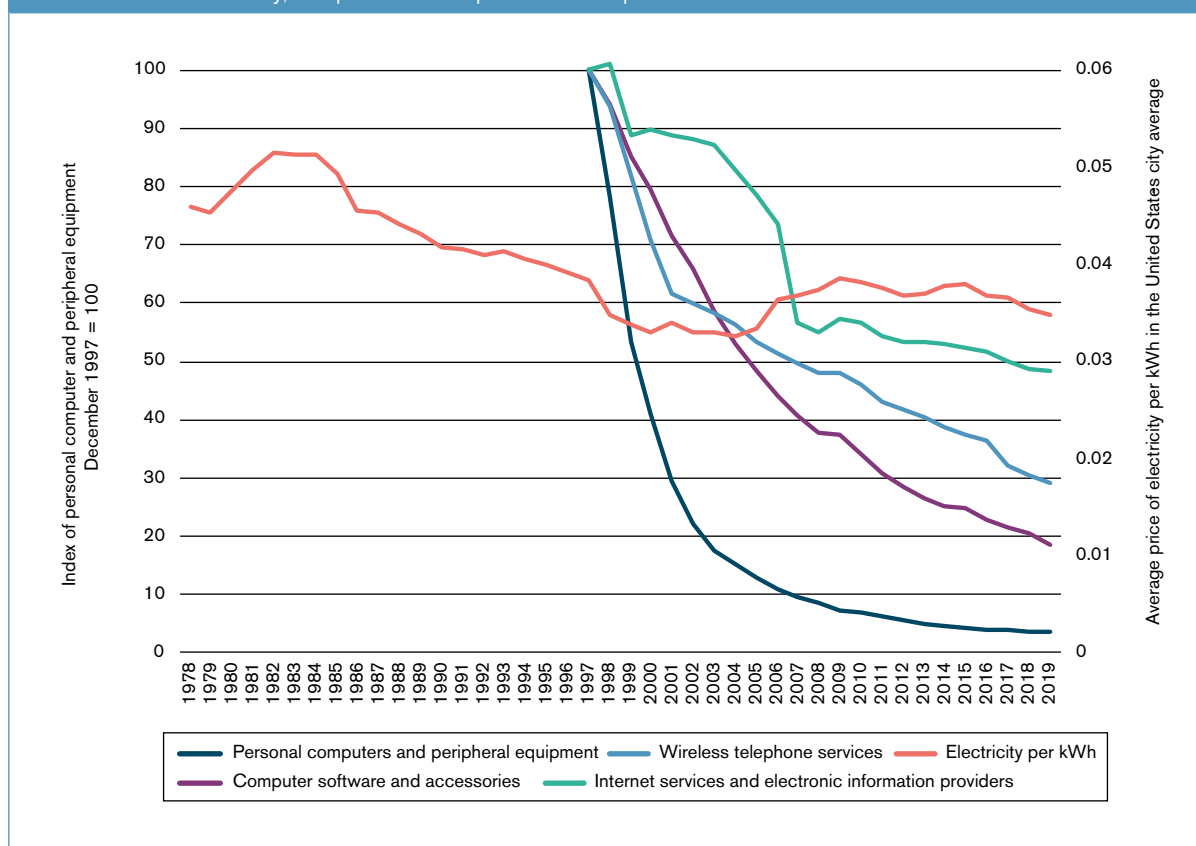
The second characteristic of a GPT is the improvement in efficiency over time, which can be shown in a decline in price and an increase in quality. This is certainly the case for digital technologies. Figure B.3 presents the price indices of personal computers, computer software, wireless telephone services and internet services relative to the aggregated consumer price index. The price of electricity – widely regarded as a GPT adopted in the 20th century – is also presented for comparison. While the relative price of electricity has remained stable since the late 1970s, the index of relative price of personal computers has fallen by a factor of 30 since 1997, and the price of computer software has fallen by more than 80 per cent. The relative price indices of wireless telephone

services and of internet services fell by roughly two-thirds and by half, respectively, over the same period.

While the price of digital technologies has drastically declined, the quality and speed of these technologies has improved. Take the example of computer memory chips: from the 1970s through the mid-1990s, a new generation of technology nodes – specific semiconductor manufacturing process and its design rules – was introduced roughly every three years. This three-year cycle coincided with the time interval between the introduction of next-generation dynamic random-access memory (DRAM) computer memory chips, which stored four times the quantity of data compared to the previous generation of chips. In the mid-1990s, the semiconductor manufacturing industry arrived at a significant technological inflection point and new technology nodes began arriving at two-year intervals. With smaller transistor sizes also came faster switching times and lower power requirements (Flamm, 2019).

Figure B.3: The relative price of computers has declined drastically in the past decades

Price indices for electricity, computer and computer software products



Source: Authors' calculation based on data from the US Bureau of Labor Statistics (<http://www.bls.gov>).
 Note: The prices indices are deflated by the US consumer price index. Electricity prices are US city averages per kilowatt-hour (kWh) (average yearly rate). The price indices of personal computers and peripheral equipment and of computer software are set to equal 100 in the first year of the sample (1997).

Digital technologies generate innovation

A third defining feature of a GPT is the ability to generate innovation. Digital technologies have not only radically improved processes, products and services, but have also changed the nature of innovation. We will discuss below how digital technologies foster innovation and innovative ecosystems as a distinct feature of the digital economy. In addition, measures to contain the spread of the COVID-19 pandemic

have further accelerated the adoption of digital technologies and fostered digital innovation (see Box B.1).

Digital innovation

In a narrow sense, digital innovation means the implementation of a new or significantly improved digital product, e.g. a semiconductor, a motion sensor or a piece of software. More broadly, digital

Box B.1: How COVID-19 has accelerated uptake of e-commerce and digital innovation

The COVID-19 pandemic is a public health crisis, but it has also acted as a catalyst for economic, social and behavioural changes. The measures to contain the spread of COVID-19 are likely to accelerate the shift to digital platforms and technologies significantly.

The enforcement of social distancing, lockdowns and other measures in response to the COVID-19 pandemic has led consumers to ramp up online shopping and use of social media and of other means of digital communication. Online e-commerce platforms have registered significant growth since the start of the pandemic. Amazon, a US-based e-commerce company, announced revenues of US\$ 75 billion in the first three months of the year, averaging US\$ 33 million an hour. MercadoLibre, Latin America's leading e-commerce technology company, reported a 70.5 per cent year-over-year increase in net revenue in the first quarter of 2020. The Chinese e-commerce giant Alibaba reported that its sales grew by 22 per cent in the first three months of 2020, despite virus-related restrictions denting activity.

Much of the digital innovation is taking place in developing countries. In Senegal, the Ministry of Trade is partnering with the private sector to facilitate delivery of essential goods and services through e-commerce. In Uganda, the Ministry of Information and Communications Technology and National Guidance has called to develop digital solutions in the fight against COVID-19 to support health systems and public service delivery (Kituyi, 2020).

Digital payments help people to avoid potential COVID-19 infection while keeping economies running, and they also help to put stimulus funds into consumers' hands more rapidly. For example, local governments in China have distributed vouchers through WeChat Pay to encourage immediate spending. The digital option also applies to the transfer of remittances, since restrictions to mobility during the COVID-19-related lockdowns limited the possibility of sending cash remittances (Bisong, Ahairwe and Njoroge, 2020). In addition, central banks have temporarily permitted companies and banks to lower or scrap transaction costs and fees on digital payments and mobile money transfers in order to encourage the use of mobile money in preference to cash (WTO, 2020).

Some small businesses were able to adopt digital technologies speedily, such as Indian food tech business Zomato, which used its platform to work with grocery start-ups to meet surging online orders (McKinsey & Company, 2020b). Governments also put in place measures to help businesses innovate and adopt digital technologies to strengthen their resilience against economic disruptions. For instance, the Distance Business Programme (Hong Kong, China) is a time-limited programme that provides funding support through fast-track processing for enterprises to adopt IT solutions for developing distance business.

Spurred by social distancing and stay-at-home requirements, digital services that can be delivered electronically have flourished. An average of 40 per cent of workers in the European Union and the United States have worked from home due to the pandemic (Berg, Florence and Sergei, 2020; Dingel and Neiman, 2020), although the rate of telework has been lower in developing economies. In particular, levels of remote work have significantly increased in sectors such as IT services, professional and business services, and financial activities (Hensvik, Le Barbanchon and Rathelot, 2020). To make teleworking possible, firms invested in digital transformations, especially in the services sector. Workers have learned to use collaborative software, access remote databases and participate in virtual meetings.

Box B.1: How COVID-19 has accelerated uptake of e-commerce and digital innovation (continued)

Although the measures to contain COVID-19 are temporary, they could trigger long-term shifts in customer habits and business operations. According to a consumer survey, 75 per cent of people using digital channels for the first time indicate that they will continue to use them when things return to “normal” (McKinsey & Company, 2020a). The digital transformations triggered by the pandemic are likely to have long-lasting effects.

Since the start of the pandemic, governments have introduced a wide range of digital technologies and services to mitigate the spread of COVID-19. These technologies and services are enabling policymakers to design and implement evidence-based policies and to enforce regulatory measures. They are also helping health professionals to treat patients and optimize hospital logistics.

For instance, in April 2020, the Government of Singapore was the first government in the world to introduce a Bluetooth-based mobile application which permits users to receive a notification when they have been in close contact with individuals who have been infected by the virus (Bay et al., 2020). The data are shared with public health authorities to analyse and predict epidemic spread. The application runs on a privacy protocol, and all data, which are stored on the user’s device (and are not retained by the application), are automatically deleted after a few weeks to ensure privacy. Several other governments have since developed similar applications.

Several governments are collaborating with telecommunications services providers to access telecommunications and geolocation data to track population movements, and in some cases, to enforce quarantine measures. According to Shendruk (2020), at least 29 governments are using data from mobile phones to monitor the spread of COVID-19. AI is also used to help front-line healthcare workers stay abreast with fast-changing COVID-19-related information.

technologies are used to develop new digital products and services, enhance existing or create new business processes, and modify existing business models. Digital innovation, in a broad sense, refers to the use of digital technologies to create a new product, process, marketing method, or organizational method, or to improve existing ones (Wiesböck and Hess, 2020; Nepelski, 2019).

Although the ICT sectors account for only a small share of value-added, digital technologies are the driving force in innovation. One way of measuring innovation is by the number of patent applications. The invention and wide adoption of computers worldwide coincided with a surge in the number of patent applications from both developed and developing countries since the mid-1990s. In particular, the number of ICT-related patent applications saw stronger growth compared with patent applications generally. Figure B.4 shows the share of patent applications in the ICT field as a percentage of total patent applications. In recent years this trend has been the strongest in China, although other economies have also seen increasing innovation in the ICT field.

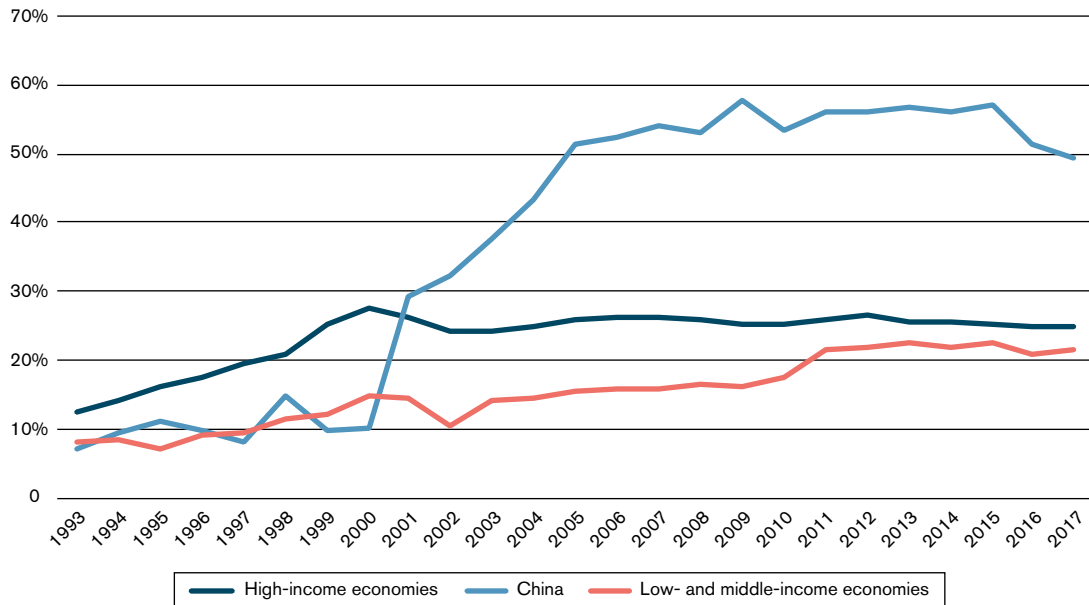
Some digital technologies, such as AI, have wide applications in many areas, generating innovation in a range of fields. Figure B.5 provides an overview

of AI patent applications, showing the top 20 companies and the economic fields designated in their applications. While IBM and Microsoft are the largest applicants of AI technology, most of the top 20 applicants are Japanese or Korean conglomerates. AI may be applied in many areas of economic activity, such as transportation, telecommunications and healthcare, and may thereby generate innovation and transform the economy as a whole.

Digital technologies also allow innovation to become more open and more collaborative, forming an innovation ecosystem. Despite frequent predictions that the internet will lead to the death of distance, the importance of spill-overs and synergies has in fact increased the importance of places where people come together to share ideas (see Box B.2). Innovation often happens where people congregate, especially in cities (Haskel and Westlake, 2017).

A proliferation of digital tools or digital components allows firms to build platforms not just of products but of digital capabilities to support different functions (Yoo et al., 2012). As firms leverage more standardized tools to design, produce and support products and services throughout their value chains, they are sharing more data and processes across organizational boundaries.

Figure B.4: The share of ICT patents has been surging
ICT-related patent applications as a share of total patent applications



Source: Authors' calculation based on data from OECD statistics.

Note: Patent applications under the Patent Cooperation Treaty (PCT)¹⁰ by origin of the inventor. ICT patents are defined as in Inaba and Squicciarini (2017).

Figure B.5: Innovations in AI are applied in a wide range of different fields
Top patent applicants by AI application field

	Agriculture	Arts and humanities	Banking and finance	Business	Cartography	Computing in government	Document management and publishing	Education	Energy management	Entertainment	Industry and manufacturing	Law, social and behavioural sciences	Life and medical sciences	Military	Networks	Personal devices, computing and human-computer engineering	Physical sciences and engineering	Security	Telecommunications	Transportation
IBM	17	150	93	935	184	81	1223	215	43	82	546	22	553	29	308	1050	112	486	759	424
Microsoft	17	209	42	780	218	96	944	151	22	236	192	9	319	25	332	1438	155	377	754	278
Samsung	29	176	17	183	42	44	265	73	140	62	131	5	595	64	135	922	165	446	755	538
Alphabet	4	163	29	463	361	38	521	67	18	55	61	6	119	13	241	709	53	206	593	333
Siemens	14	51	27	60	39	31	170	58	164	11	266	6	1127	16	58	268	323	293	458	415
Hitachi	18	98	65	168	23	37	270	90	141	13	199	2	447	18	61	306	256	297	338	735
Toyota	14	40	0	26	31	19	14	80	173	15	36	3	188	10	30	169	267	92	198	1987
Sony	13	267	10	194	67	32	196	106	34	314	46	5	372	14	88	495	85	299	538	209
SGCC	4	6	32	194	114	55	43	14	646	1	518	26	158	5	148	160	36	322	374	184
Panasonic	9	145	11	115	21	31	251	80	97	45	96	4	322	14	53	323	101	261	494	487
Toshiba	7	158	33	232	12	50	439	37	142	12	132	3	390	11	73	336	108	161	274	286
Bosch	39	9	8	14	21	3	17	25	155	10	58	1	129	4	13	137	230	184	185	1469
NEC	11	97	16	197	21	47	351	63	51	17	105	4	368	9	58	203	69	317	438	190
Fujitsu	12	73	47	173	8	34	326	66	25	22	110	3	401	8	54	200	55	351	253	299
LG Corporation	12	84	25	94	9	10	71	15	93	13	49	4	113	20	43	409	57	212	524	451
Canon	2	89	1	56	11	18	496	31	15	11	50	1	380	4	28	293	33	118	195	56
Mitsubishi	16	42	13	50	17	14	119	49	94	17	88	1	171	30	45	130	148	121	179	501
Ricoh	4	62	13	95	10	24	367	24	6	7	81	1	55	5	44	176	22	72	134	163
NTT	3	55	8	61	14	22	177	36	21	11	27	5	129	8	57	72	23	107	273	42
Sharp	5	74	3	21	7	16	203	35	7	8	28	0	92	7	14	153	33	54	142	88

Source: World Intellectual Property Organization (WIPO) (2019b).

Note: SGCC = State Grid Corporation China, NEC = Nippon Electric Company, NTT = Nippon Telegraph and Telephone. A patent may refer to more than one category.

Box B.2: Geographical agglomeration of industries

Firms within an industry tend to agglomerate (e.g. software companies in Silicon Valley, California) because there are benefits to having a large pool of skilled labour, easy access to local customers or suppliers and local knowledge spill-overs concentrated in one location. Until recently, the literature focused on the agglomeration of individual industries, and did not offer guidance on which types of effects mattered more. In a seminal paper, Ellison *et al.* (2010) propose a methodology to disentangle the strength of three different types of economic forces that result in industry agglomeration – consumer-supply relationships, labour market pooling and knowledge spill-overs. Using US data, they find that customer-supplier relationships have the strongest benefits, closely followed by labour market pooling. Knowledge spill-overs are found to be weaker than the other factors, but they are still statistically important.

The effects may also differ according to the industry. Whereas some industries require specialized workers with years of on-the-job training (labour linkages), other sectors often employ workers on short-term contracts through temporary work agencies. Similarly, some industries closely collaborate with their local suppliers (value chain linkages), while other industries operate according to anonymous exchanges with little need for buyer-supplier interaction. Knowledge spill-overs may be important catalysts for clustering for high-technology industries, but are less important in industries in which technology progresses less rapidly (Diodato, Neffke and O'Clery, 2018).

Using data from the United States, Diodato, Neffke and O'Clery (2018) show that services sectors, especially IT services, architecture, engineering, media and knowledge-intensive business services, are very much driven by agglomeration effects. The effects of labour linkages (i.e. the availability of a large pool of skilled labour) are particularly pronounced for services sectors. Conversely, manufacturing sectors are less likely to be clustered in one location, and their agglomeration is more likely to be driven by value chain linkages.

Faggio, Silva and Strange (2017) use data from the United Kingdom to show that the effects of agglomeration forces – in particular knowledge spill-overs – exist in new industries (i.e. sectors that are younger than the typical median industries) and for dynamic industries (i.e. sectors that have more new market entrants compared to the median entrants in a given year and industry). The effects of knowledge spill-overs are five to 10 times larger in new and dynamic industries than other industries. In particular, industries with high-technology components and high-education labour force tend to agglomerate due to knowledge spill-overs.

It has been suggested that the social distancing measures introduced during the COVID-19 pandemic and the rise of telework will lead to a decentralization of economic activities. Since the pandemic, some technology companies, including Facebook and Twitter, have committed to continuing remote work, citing benefits such as a more diverse hiring pool and reduced office space demands (Wittenberg, 2020). This trend has started to help spread economic activities from the top 15 most expensive cities in the United States to less expensive cities, generating higher earnings for professionals located outside metropolitan areas and lower costs for businesses (Ozimek, 2020). The dispersion of economic activities can also go beyond national borders: the accelerated adoption of digital technologies could allow companies to hire employees based in foreign countries teleworking from abroad, providing opportunities for workers in developing countries (Baldwin, 2020).

In addition, the evolution of transnational production networks and value chains has allowed an expansion of global innovation networks. The reduction of communication and coordination costs as a result of IT has led to a geographical dispersion of innovation activities. Multinational enterprises can establish one or more affiliate facilities at different locations around the world, allowing business activities such as R&D, design, production, marketing and the provision of services to be increasingly dispersed in multiple geographical

locations. R&D management, specialization decisions and exchanges of information take place among regional R&D facilities and the parent company. Different market participants such as networks of multinational enterprises, high-technology start-ups, universities and public research laboratories, venture capitalists, specialized technology brokers, standard-setting organizations and government agencies increasingly recognize the gains from research specialization and collaboration (Maskus and Saggi, 2013).

Firms are more scalable in the digital economy

The consumption of data and information by one person does not reduce the amount of data and information available to others, and this is considered to be non-rivalry by economists. The non-rival nature of data makes them ubiquitous and reusable without further costs, and also results in cost advantages, which companies obtain with an increasing scale of operation (“the economy of scale”). While economies of scale are observed in traditional sectors such as telecommunications and electricity supply, there are often limits to the cost advantages due to the finite supply of raw materials or saturation of regional markets. Creating and expanding a company in the digital age, however, requires much less physical capital. Although the initial investments in fixed assets are high, the cost of producing one additional unit of a digital product (e.g. producing an additional copy of a software) is almost zero and average costs rapidly decrease with scale.¹¹

As firms in the digital economy no longer need the equipment and inventories to process physical goods, the major assets of a company are often intangible assets such as knowledge, brand recognition and intellectual property (patents, trademarks and copyrights), which are highly scalable. Consequently, we observe increasing incidences of “scale without mass” in the digital economy, which allow firms to scale up to serve entire markets much more rapidly. A number of start-up companies have reached very high percentages of international revenues within a few years of their inception, even when these “born global” companies were quite small and unknown at home.¹²

Table B.4 categorizes 20 large global companies in digital or digital-enabled sectors, ranging from internet platforms and digital content providers to telecommunication companies. In comparison to traditional multinational corporations, such as those in the telecommunications sector, large digital companies possess fewer foreign assets even though they derive a significant portion of their sales abroad.

The digital economy is also characterized by economies of scope, where the value of data increases when cross-referenced with other data sources. The competitive advantage that data provide is precisely the insight into markets or production processes that are not accessible without it (Ciuriak, 2018b). In addition, the digital economy features network effects, whereby the value of a network increases with additional users. This self-reinforcing mechanism often strengthens the dominant market positions of existing firms. As the co-founder of

PayPal, Peter Thiel, points out, commercial success is built on network effects and economies of scale: “Twitter can easily scale up but a yoga studio cannot” (Thiel and Masters, 2014).

Consequently, dominant market players are widely seen in the digital economy. For example, Google has some 90 per cent of the market for internet searches. Facebook accounts for two-thirds of the global social media market. Amazon boasts an almost 40 per cent share of the world’s online retail activity. In China, Alibaba has been estimated to have close to 60 per cent of the Chinese e-commerce market, while WeChat (owned by Tencent) has more than one billion active users, and together with Alipay (Alibaba), is offering mobile payment solutions for virtually the entire Chinese market (UNCTAD, 2019b). In terms of market structure, the data-driven economy gives rise to superstar firms, resulting in high market concentration across a wide swath of industries and a low share of labour in value-added and sales (Autor *et al.*, 2020).

Integration of goods and services

Another special feature of digital technologies is that they allow goods and services to be increasingly integrated. As digital technologies allow for reduced costs and greater fluidity in reaching and interacting with consumers and in tracking their behaviour, the digital transformation moves manufacturing towards mixed models for providing goods and services and creates opportunities for innovation.

This servicification process comes through several channels. First, the services component of manufacturing, such as R&D, product design, branding, advertising and retail, is increasing and becoming more profitable than the manufacturing and assembly process (Timmer *et al.*, 2014). Digitalization allows these services to be unbundled either as separate business entities or outsourced. Second, the rapidly changing technology and service requirements make it more common for firms to unbundle capital equipment into a service, thus turning capital expenditure into operation expenditure. This model means that some manufacturers no longer own their production equipment but pay either a fixed subscription cost or a variable fee to use and maintain the equipment (Mussomeli, Gish and Laaper, 2016). Third, entirely new services have emerged, such as predictive maintenance services using IoT, on-demand transportation services and web-based business services. The customization of products to adapt to individual customers’ specific needs has also become a service.

Table B.4: Sales and assets of top digital companies globally						
Category	Company name	Total sales (billion US\$)	Total assets (billion US\$)	Share of foreign sales (%)	Share of foreign assets (%)	Ratio between share of foreign sales and assets
Internet platforms	Alphabet (Google)	75	147.5	54	24	2.3
	Facebook	17.9	49.4	53	21	2.5
	eBay	8.6	17.8	58	7	8.3
	Average	11.3	26.4	50	19	2.6
Digital Solutions	Automatic Data Processing	11.7	43.7	15	10	2.3
	First Data Processing	11.5	34.4	14	11	1.3
	Paypal	9.2	28.9	50	7	7.1
	Average	4.2	9.7	32	17	1.9
E-Commerce	Amazon.com	107	65.4	36	32	1.1
	Priceline.com	9.2	17.4	80	17	4.7
	Expedia	6.7	15.5	44	11	4.0
	Average	9.9	13.5	42	38	1.1
Digital Content	21 st Century	27.3	48.2	29	10	2.9
	Fox Liberty Global	18.3	67.9	61	65	0.9
	Sky	16.1	23.5	30	7	4.3
	Average	11.1	19.3	36	32	1.1
IT devices and components	Apple	215.6	321.7	65	39	1.7
	Sony	72	148	71	24	3.0
	Flextronics	24.4	12.4	70	20	3.5
	Average	31.5	36.3	75	39	1.9
IT Software and Services	Microsoft	85.3	193.7	52	43	1.2
	Qualcomm	23.6	52.4	98	18	5.4
	Adobe Systems	5.9	12.7	47	21	2.2
	Average	19.5	32.2	63	46	1.4
Telecom	AT&T	146.8	402.7	4	5	0.8
	Vodafone	59	192.6	85	90	0.9
	Telecom Italia	21.5	77.6	25	12	2.1
	Average	31.3	74.8	42	46	0.9

Source: UNCTAD (2017) based on data from the Orbis – Bureau Van Dijk database.

As a result, services are gradually being integrated into manufacturing firms' business activities. Many manufacturing companies are moving toward an "as-a-service" model, enabled by software, connectivity, and intelligent supply chain capabilities. For instance, Siemens, a producer of consumer and industrial appliances, installs sensors on many of its appliances that are monitored by software, allowing for more effective maintenance services for customers.

Conversely, services firms are also entering manufacturing activities, further blurring the frontier

between manufacturing and service. Retailers and logistics companies are gaining greater control over their supply chains by investing in next-generation digital logistics, empowering them to meet increasing consumer demand for fast and accurate delivery. Amazon is an illustration of this move. The company has its own private brands and owns a patent for an on-demand clothing manufacturing warehouse that enables the firm to quickly produce tailored clothing once customer orders are placed (Del Rey, 2017).

As a consequence of digitalization, a sustained shift in employment have been taking place from

the manufacturing sector to the services sector in developed countries and in an increasing number of developing countries. Automation, industrial robotics and better production technologies allow manufacturing activities to be more productive without requiring the same amount of workforce. Current technological progress, especially the use of computers and digital technologies in the workplace, has led to a higher relative demand for skilled workers and a lower relative demand for workers performing routine activities (WTO, 2017). As illustrated in Figure B.6, while manufacturing output increase in the United States, Germany and Japan, the share of manufacturing employment continues declining. In the meantime, the share of employment in services is increasing and requires higher skills. The shift of employment opportunities away from the manufacturing sector calls for policy adjustments to provide social safety net and opportunities for workers to acquire new skills.

The speed of change

A final defining feature of the digital economy is the sheer speed of change. As predicted by the co-founder and Chairman Emeritus of Intel Corporation, Gordon Moore, computing power has been doubling every two years since the dawn of the electronic age (“Moore’s Law”). The result is exponential growth in the price performance of computation at a much faster speed. Similarly, author George Gilder predicted that the carrying capacity of communication systems (the bandwidth) grows at least three times faster than computing power, which meant that the communications power doubles almost every six months (“Gilder’s Law”).

Such exponential growth of digital technologies implies that dramatic changes often take place rapidly, without any clear indication given by past experience. For example, smartphones appeared about a decade ago, but it could not have been predicted that over 5 billion people would come to own a mobile device today and that they would use these devices to exchange data, purchase products and share information. Innovation can also be more frequent, as the internet and platforms make it possible to launch new products and processes at lower costs. For example, in the automotive industry, new car models are launched once a year, whereas software updates (i.e. innovations that modify the models concerned) can be issued at a high frequency¹³ (Guellec and Paunov, 2018). It has been argued that machine-learning has further accelerated the pace of innovation, as computer algorithms are trained on large amount of data to optimize discovery, refine production processes, and improve product quality

(Ciuriak, 2019). Within the short period of time since the COVID-19 outbreak, advanced machine learning techniques have been used for rapid classification of COVID-19 genomes, predicting survival rates of severe patients, and discovering potential drug candidates against the virus (Alimadadi *et al.*, 2020).

The speed of change in the digital economy has allowed major industry players in the digital sector to emerge within a short period of time. Compared with companies in the traditional economy that took decades or centuries to establish their brand reputations, the digital economy has allowed new business models and rapidly expanding lead firms to become established within a matter of years. As new business models challenge incumbents in novel ways and rapidly render skills obsolete, the fast pace of transformation requires societies to adapt and calls for agile government policies that stay ahead of the curve.

(ii) The digital economy requires changes in policymaking

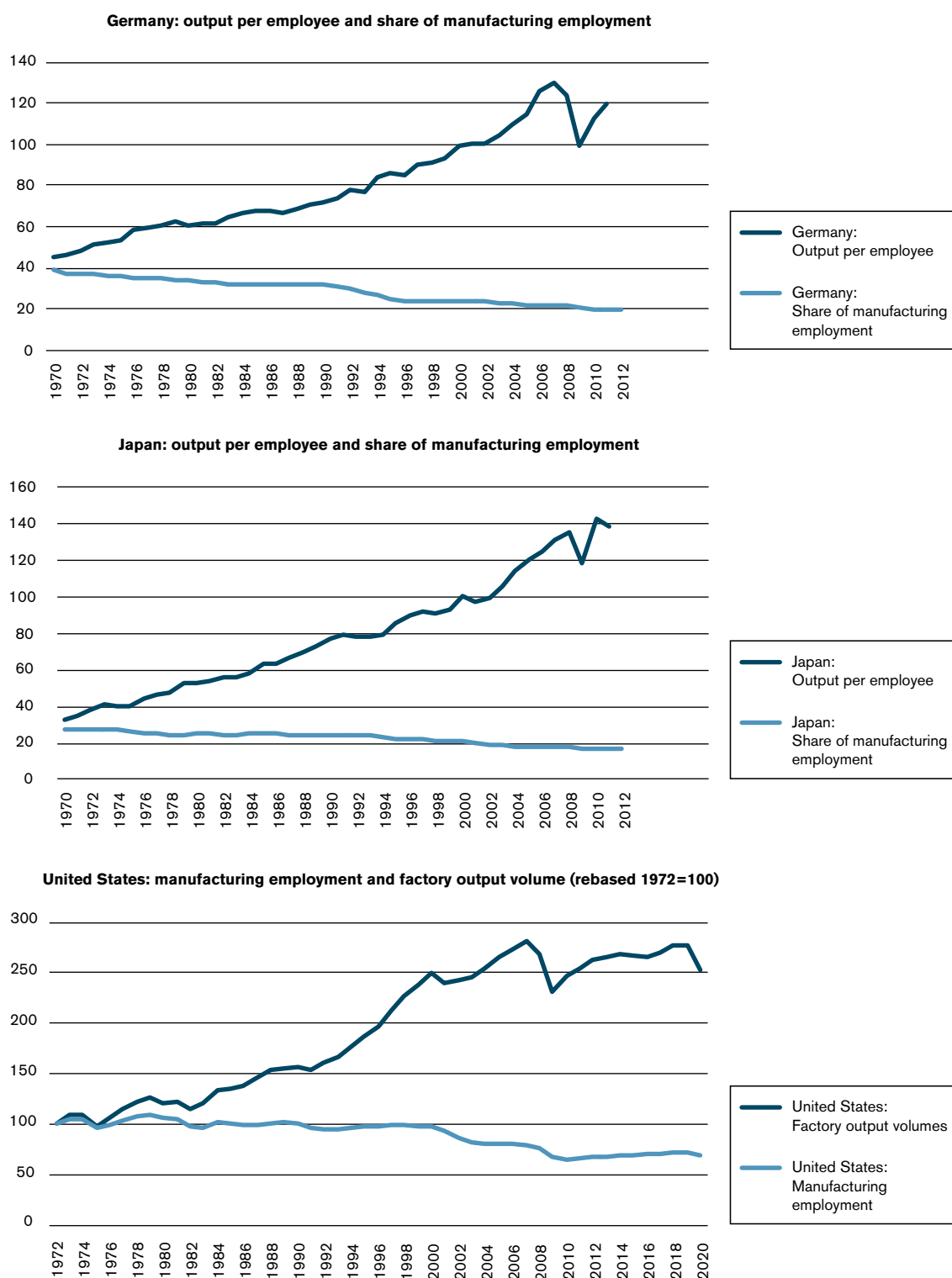
The special features of the digital economy affect market outcomes and influence the effectiveness of innovation-based government policies, thus calling for new thinking in government priorities. In what follows, we describe several broad trends of how innovation and industrial policy in the digital age may evolve or break from previous generations of policy. A closer examination of specific policy tools to foster innovation and promote the digital economy is provided in Section B.3.

In the digital economy, data policies are an integral part of innovation and industrial policy. Support in internet and telecommunication infrastructure has become a key priority for many economies. Government policies also aim to foster innovation through R&D support and by developing innovation hubs and promoting digital literacy. Government policies need to be broad and agile to keep up with the pace of change, and policies to address market concentration and encourage competition are an integral part of government policies.

First, as data and digital intelligence become key inputs in the digital economy, data policies become an integral part of innovation and industrial policy. On the one hand, governments recognise the importance of data and digital intelligence in production and innovation, and therefore aim to create an attractive policy environment to support access to and use of data. On the other hand, data generation, collection, storage, capture and analysis by private firms have triggered concerns about privacy and security for

Figure B.6: Factory jobs have declined but industrial production has continued to grow

Factory output and manufacturing employment in Germany, Japan and the United States



Source: Authors' calculation. The data for Germany and Japan are based on the US Bureau of Labour Statistics' International Labor Comparisons (ILC) program. The figure for the United States is based on data from US Bureau of Labour Statistics.

Note: The figures for Germany and Japan reflect manufacturing output per employee and the share of employment in manufacturing. The figure for the United States reflects factory output volumes and manufacturing employment; the data have been adjusted with both indices equal to 100 in January 1972.

both individuals and governments. Government policies thus aim to serve the twin purpose of fostering data-based innovation while mitigating the risks of digital technologies.

Second, support in building and upgrading telecommunication infrastructure has become a key priority for many economies, as digital connectivity offers the preconditions for market participants to access and utilize data. For example, 5G mobile telephone networks are expected to be a game-changer in digital sectors, as many new digital technologies such as the IoT depend on a fast and stable telecommunication network. Some 50 telecommunications operators are scheduled to start new 5G services by the end of 2020, requiring new investment in underwater cabling and in upgrading network capacity (Grijpink *et al.*, 2018).

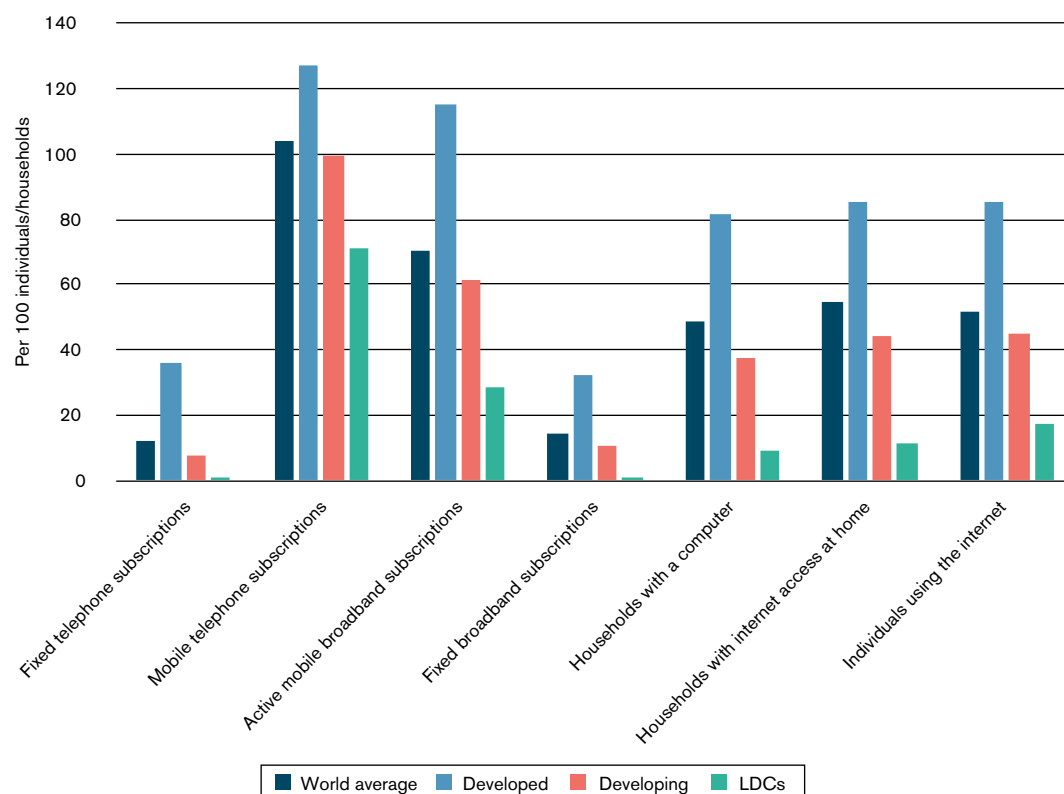
Notwithstanding the progress in enhancing digital connectivity, a major digital divide exists between advanced economies, developing countries and

LDCs. Figure B.7 illustrates the digital divide across countries of different development levels. While almost every individual in advanced economies owns one or more mobile devices and has access to mobile broadband, the number of mobile telephone and mobile broadband subscriptions in LDCs stand at 71 and 29 per cent respectively. The ratio of fixed broadband subscriptions in LDCs is even lower, at about 1 per 100 inhabitants. This gap in access to ICT infrastructure is compounded by the fact that internet connections in some low-income economies are slow and relatively more expensive. In some African countries, 1 gigabyte (GB) of internet data costs over 20 per cent of the average monthly income, which makes it unaffordable for all but the wealthy few (Alliance for Affordable Internet, 2019).

African LDCs have been able to leapfrog in certain digital services. For instance, African firms have become world leaders in mobile money transfer and payment services, which help bring affordable financial services such as banking, micro-payments

Figure B.7: LDCs are still behind in access to digital infrastructure

Indicators of ICT access per 100 inhabitants, 2018



Source: Author's calculation based on data from International Telecommunications Union (ITU).

and remittances transfer to consumers, particularly in remote areas. Mobile money services have improved significantly in low-income countries, particularly in sub-Saharan Africa: the share of the population aged 15 years and older having a mobile money account reached 21 per cent by 2017, the highest share in the world (Figure B.8). Such technologies provide an alternative and cost-effective way to deliver services when traditional institutions are less efficient.

While it is acknowledged that LDCs are still lagging behind in ICT infrastructure equipment and access, the relatively high rates of mobile telephony equipment and growing internet penetration are already allowing certain countries to find areas of comparative advantage, notably in business processing outsourced activities enabled by the internet such as accounting, call centre services, transportation and delivery, in which tens of thousands of jobs have already been created in Africa (Songwe, 2019).

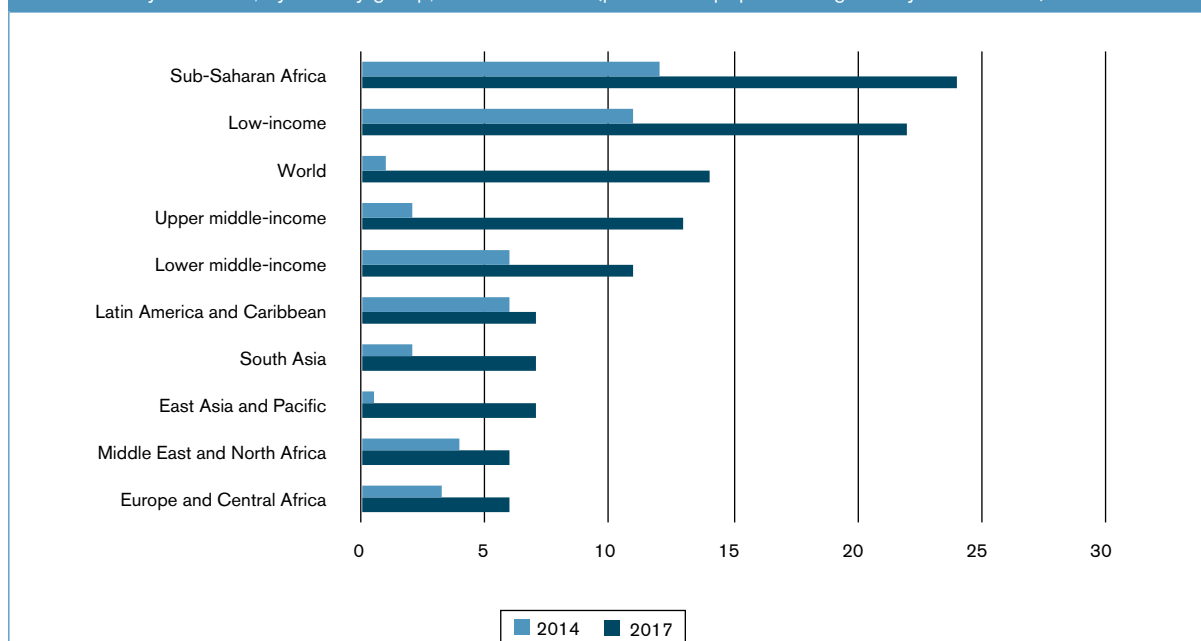
Third, the close connection between digitalization and innovation suggests an ever-closer alignment of government policy and building appropriate innovation ecosystem (Ciuriak, 2018a; Sampath, 2018). Table B.5 provides an illustrative list of the major changes to innovation policy motivated by the digital economy. Policies to spur innovation include reforming

the patent system, providing support for more GPTs, encouraging collaboration between universities and the business sector, ensuring access to data, and supporting innovation and entrepreneurship. As will be discussed in the following subsection, government policies to foster innovation include R&D support, capital market interventions, government procurement and the development of innovation hubs.

Finally, the changing dynamics of innovation requires governments to adapt their policies at a much faster pace. As it is practically impossible to foresee the applications and socioeconomic ramifications of digital technologies, government policies cannot provide guidance or regulations beforehand, but instead need to be flexible and agile to respond to the requirements of ever-emerging new technologies and business models. Policymaking in the digital age thus need to be broad and agile, refrain from overly detailed regulations, and follow an adaptive approach that favours experimentation, iteration and differentiation. For example, mechanisms such as regulatory sandboxes are used by policymakers to allow start-ups and other innovators to conduct live experiments in a controlled environment under a regulator’s supervision, thus helping policymakers to improve their understanding of regulatory needs (see Section B.3)

Figure B.8: Sub-Saharan Africa is leading in mobile banking

Mobile money accounts, by country group, 2014 and 2017 (per cent of population aged 15 years or older)



Source: Author’s calculation based on World Bank Global Financial Inclusion Database.

Note: Country groups are those of the source.

Table B.5: Major changes to innovation policy called for by digitalization

Policy area	Change required
All domains	Use digital tools to mobilize more information, implementation and monitoring of policies. Engage with the public. Frame national policies in view of the global market.
Access to data	Ensure access to data for innovators, taking into account diversity of data. Develop appropriate data access schemes, differentiating by types of data. Explore the development of markets for data.
Support for innovation and entrepreneurship	Ensure that policies are responsive and agile. Support more service innovations. Adapt the IP system. Facilitate access to data while preserving rights and incentives. Support the development of multi-purpose digital technologies.
Public research	Promote open science (access to data, publications). Support interdisciplinary collaboration. Develop co-creation with industry. Support training in digital skills for science. Invest in digital infrastructure for science.
Competition and collaboration	Review the conceptual framework of competition policies as needed from the perspective of innovation in the age of platforms and easier entry (e.g. new rules regarding takeovers, standards, access to data, etc.). Adapt the IP system (protection of data, AI challenges). Support the transition of MSMEs and opportunities for diverse regions. Foster collaborative innovation.
Education and training	Have innovation agencies support improvement of assessments of skills required for the digital transformation, ensuring that young people and students are properly equipped with these as well as skills for lifelong learning. Support proper management and organizational structures in firms for digital innovation. Support wider involvement in innovation by disadvantaged groups, through engagement and training.

Source: Guellec and Paunov (2018).

3. Mapping government policy instruments in the digital era: old tools, new tools

As noted in Section B.2, government policies are a complex mix of tools and objectives that evolve over time to adjust to new economic developments and priorities. With the rise of the digital economy, recent years have been characterized by a shift towards innovation to accelerate the transition into the digital age. This section reviews the specific policy tools used by governments over the past decade. Our analysis, based on WTO trade monitoring activities and complemented by the Global Trade Alert database (<https://www.globaltradealert.org>), shows that government policies continue to be widely used to support traditional sectors and to attract investment. However, there is increased focus on supporting innovation and the development of the digital economy through a mixture of traditional policy instruments, such as support for R&D and tariffs, and new regulatory approaches that promote innovation and address digital policy issues raised specifically by the digital economy.

Analysis is unfortunately hampered by the lack of specific information on key policy instruments (e.g. subsidies) and the existence of various sources of

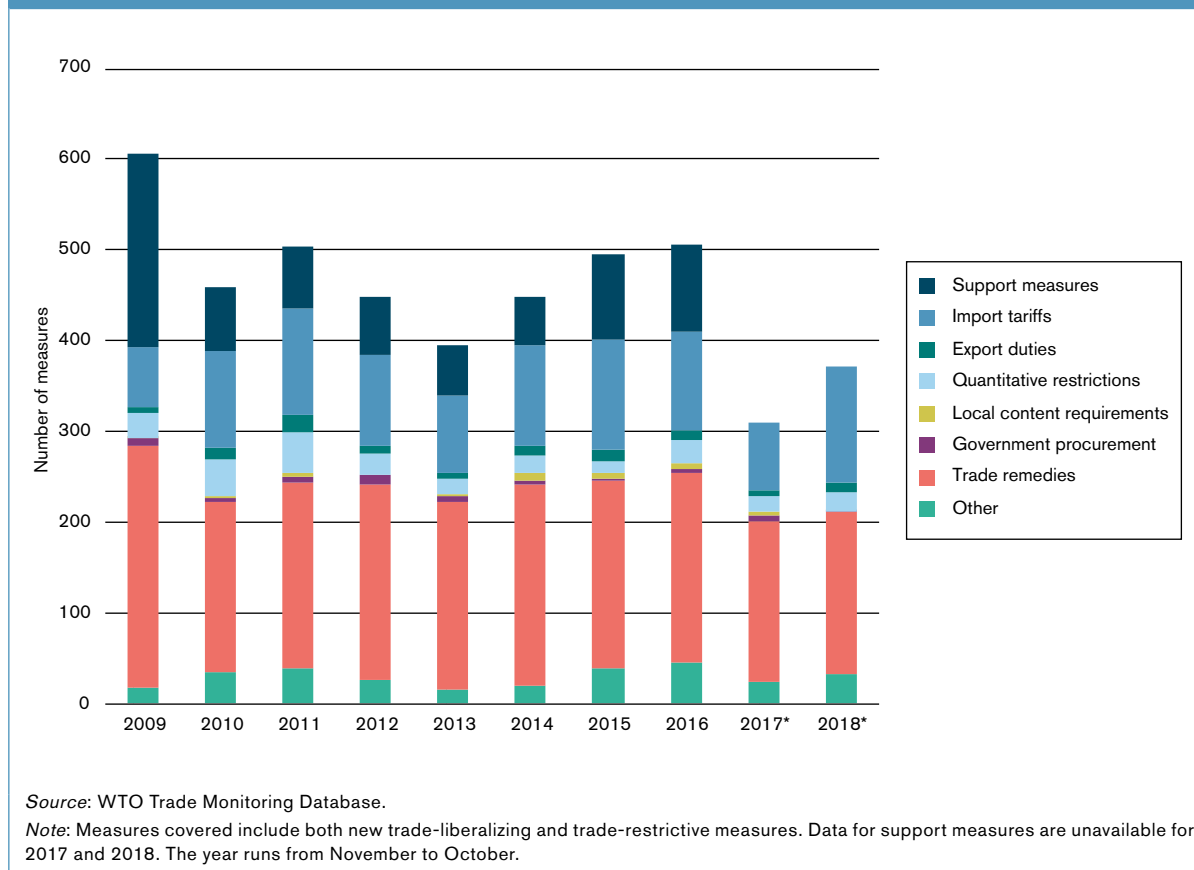
information that are not necessarily comparable. In spite of these shortcomings, the data available provide a glimpse into the types of measures commonly applied.

Figure B.9, which is based on WTO trade monitoring activities, shows a relatively active use of various policy instruments over the past decade. The implementation of new measures by WTO members fluctuated over the period from 2009 to 2018, declining from a peak of 600 new measures during the 2009 financial crisis to a low of 400 new measures in 2013, to rise again to more than 500 in 2016.¹⁴ Another sharp decrease could be observed in 2017. Although the number of new measures varied over the period, the number of policy instruments used, by type, remained relatively constant until 2017, which saw a decrease in the number of import tariff measures.¹⁵ Trade remedies accounted for a large and steady number of new measures over the period, followed by import tariffs and support measures. Support measures, which represented more than one-third of the number of measures examined in 2009 owing to the financial crisis, decreased significantly between 2010 and 2014. A slight increase in the use of support measures can be observed thereafter.

These numbers, which cover both trade-liberalizing and trade-restrictive measures, do not capture

Figure B.9: Trade remedies, import tariffs and support measures are the most widely used policy measures

Number of measures over time, by type of measure (2009-18)



the incidence of such measures on global trade flows. They only provide a general idea of the type of measures used by governments. Further analysis conducted in the context of the trade monitoring process finds that approximately two-thirds of import tariff measures taken throughout this period are liberalizing measures, including agreements such as the Information Technology Agreement (ITA) or other bilateral free trade agreements (FTAs). Interestingly, the incidence on global trade flows of trade remedies, which are trade-restrictive by nature, increased sharply in 2017 and 2018, a period which also saw growing trade tensions (WTO, 2019b).

(a) Policy tools are widely used to support traditional economic sectors

The following analysis shows that a relatively high density of policy tools apply to the minerals, metals and chemical industries, textiles and clothing, electrical machinery and, to an extent, transport equipment. These sectors face globalized competition, a large degree of cyclicity, and

reduced profit margins. Market pressure to adapt, incorporate new technologies and mobilize capital explains the continued focus of industrial policy on these industries.

(i) Border measures

Regarding average unweighted most-favoured-nation (MFN) (i.e. non-discriminatory) applied tariffs, the general trend over the past decade has been one of overall tariff reduction at the global level. Average unweighted MFN applied tariffs, calculated from the WTO World Tariff Profiles database (which encompasses 94 economies), declined for developed economies from 3.14 per cent in 2009 to 2.35 per cent in 2018, and from 8.57 per cent to 7.94 per cent for developing economies. Even when tariffs were trade-weighted, the average applied duty changed very little over the period. The industrial sector with the highest average tariffs is clothing (garments), followed by textiles – although even these tariffs, which have historically been high, also experienced a modest decline between 2009 and 2018.

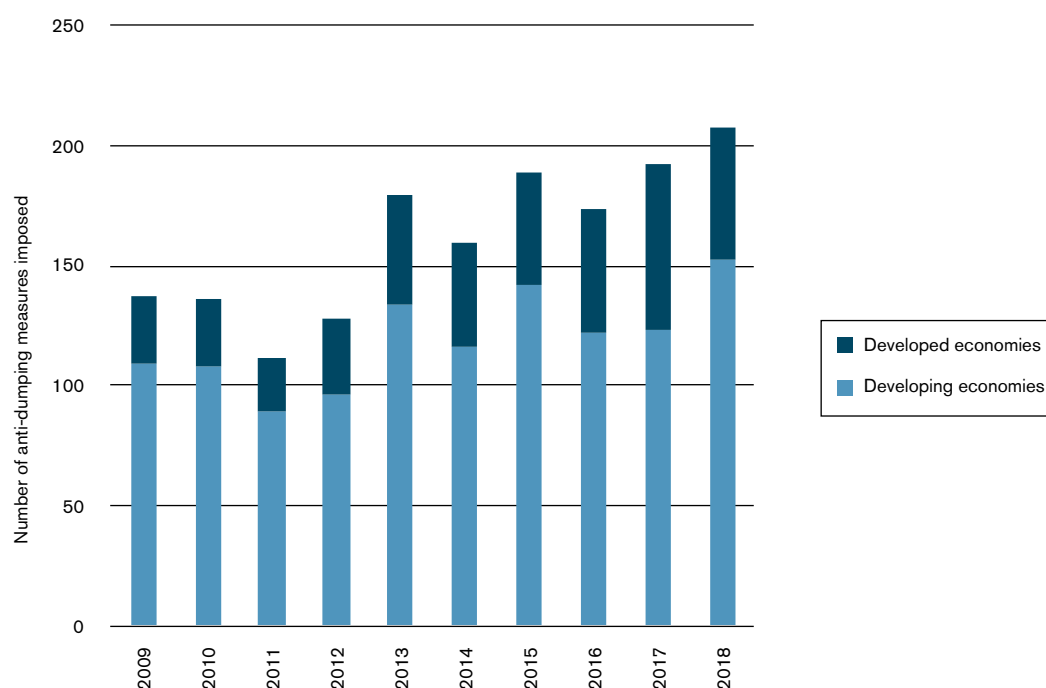
Average MFN applied tariffs, however, do not capture import tariffs imposed bilaterally in the context of anti-dumping or countervailing measures. Looking at these trade remedy measures provides a different picture. Trade remedies are a widely used policy tool. Although trade remedies are not directly an industrial policy tool, they are used to counter other members' policies and are examined in the context of the WTO monitoring reports, which found a growing stockpile of import-restrictive measures over the 2009-2018 period.¹⁶ Minerals, metals and chemicals are the main sectors subject to these types of policies, in both developed and developing economies, and measures include anti-dumping and countervailing duties, and other "temporary" regulations to limit imports from specific trading partners. The most frequently used import-restrictive measure in terms of numbers implemented was anti-dumping duties, with more than 200 implemented in 2018. The use of these measures climbed substantially following a low in 2011 of roughly 110 new anti-dumping measures (see Figure B.10).

Comparing the distribution of anti-dumping measures by product category, roughly 60 per cent of measures imposed by developed economies focus on minerals and metals, for example steel and aluminium products (see Figure B.11). For developing economies, chemicals, which includes items from pigments and dyes all the way to plastics, is the product category with the highest number of anti-dumping measures (about one-third), followed closely by minerals and metals. Textiles are also important for developing economies, with 12 per cent of anti-dumping measures imposed on this sector. It is important to note that few LDCs have their own investigating authorities for trade remedies, meaning that this tool is not frequently used by these economies.

Finally, an analysis of export duties and quantitative restrictions provides a similar picture to the analysis of trade remedies, namely that they are primarily applied to the minerals, metals and chemicals industries. However, whereas for anti-dumping duties these sectors are targeted because of market segmentation, export duties mostly stem from governmental financial

Figure B.10: Anti-dumping measures have seen a resurgence in recent years

Number of anti-dumping measures imposed over time (2009-18)

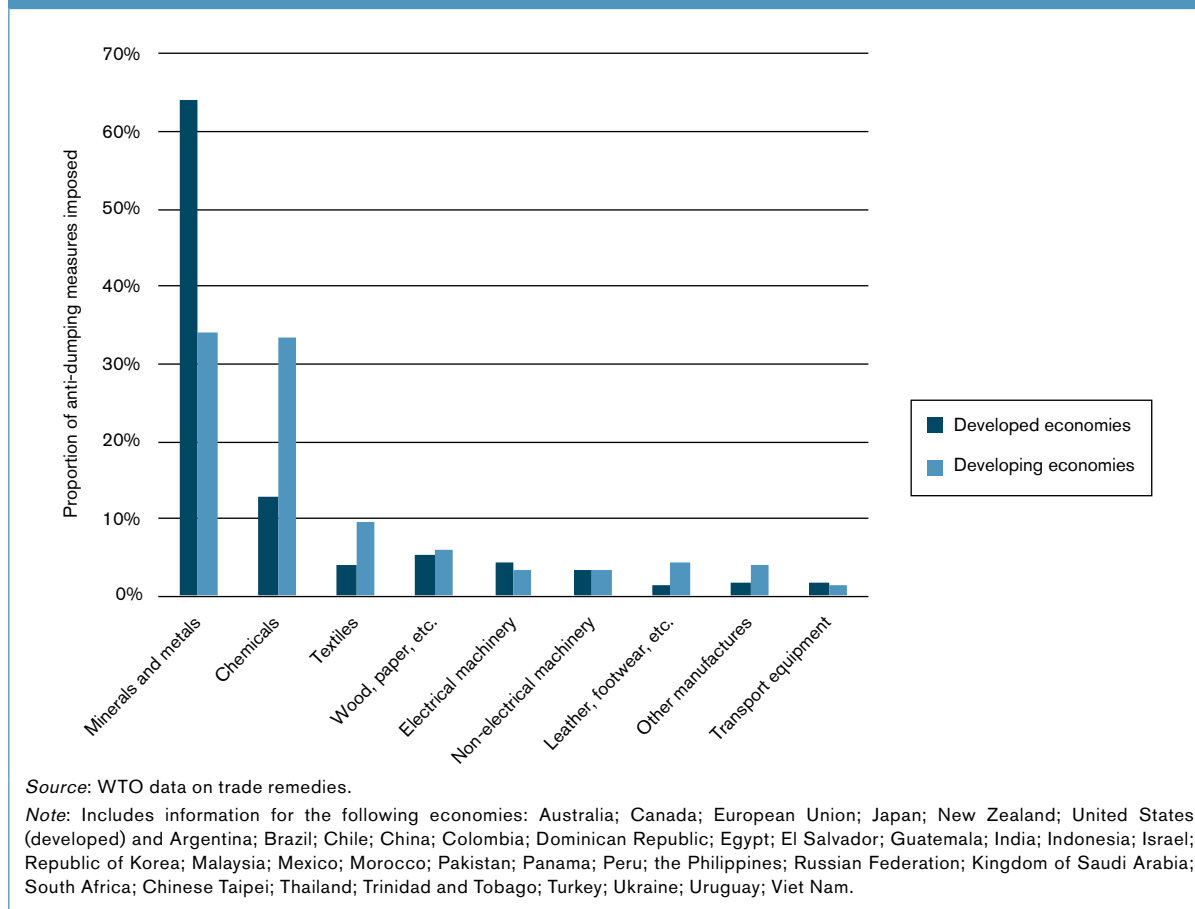


Source: WTO data on trade remedies.

Note: Includes information for the following economies: Argentina; Australia; Brazil; Canada; Chile; China; Colombia; Dominican Republic; Egypt; El Salvador; European Union; Guatemala; India; Indonesia; Israel; Japan; Republic of Korea; Malaysia; Mexico; Morocco; New Zealand; Pakistan; Panama; Peru; Philippines; Russian Federation; Kingdom of Saudi Arabia; South Africa; Chinese Taipei; Thailand; Trinidad and Tobago; Turkey; Ukraine; United States; Uruguay; Viet Nam.

Figure B.11: Minerals, metals and chemicals are the sectors most targeted by anti-dumping measures in both developed and developing economies

Anti-dumping measures by product categories (2009-18)



motivations. As noted in WTO (2010), the possibility of deriving large incomes from natural resources can incentivize exporting and importing economies to appropriate these incomes through trade restrictions.

Export duties as documented in the WTO trade monitoring database are exclusively applied by developing economies, almost two-thirds of which are applied to minerals and metals, followed by chemicals and textiles.¹⁷ Similarly, quantitative restrictions are a tool mostly used by developing economies, with nearly 40 per cent of these measures applied to minerals and metals, followed by chemicals and textiles.¹⁸

(ii) *Local content and government procurement*

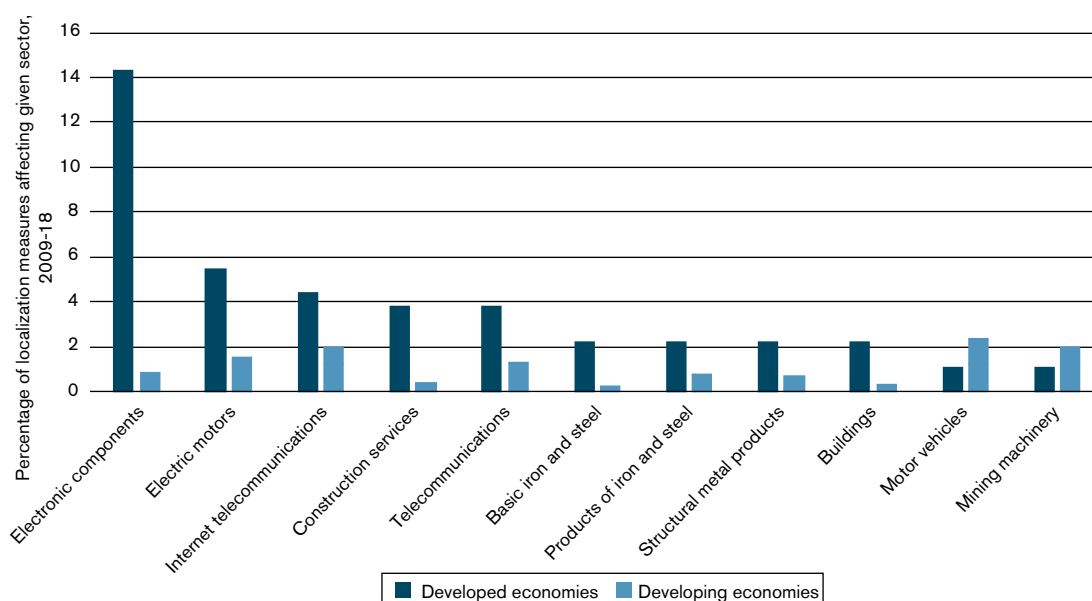
Whereas trade remedies and border measures are used chiefly on primary and intermediate goods, local content and government procurement measures tend to apply to final goods, such as electrical machinery and transport equipment. These tools account for only a small part of total adopted support measures:

between 3 per cent and 6 per cent of the annual totals of new policy interventions each year according to the Global Trade Alert database, but these percentages probably understate the true totals.

Sectors targeted by local content and government procurement measures vary somewhat according to whether an economy is developed or developing. In developed economies, most local content measures¹⁹ were used for electronic components between 2009 and 2018 (Figure B.12). This was in contrast to government procurement, measures for which taken by developed economies primarily targeted minerals and metals in 2009-18, although largely by a single economy (Figure B.13). In contrast, developing economies, which often have objectives to protect infant industries (Hufbauer *et al.*, 2013) target a much broader range of sectors for both local content measures and government procurement (figures B.12 and B.13). Only one LDC reported a “buy local” government procurement measure in the Global Trade Alert database.

Figure B.12: Local content measures focus on electrical and non-electrical machinery

Local content measures by product categories (2009-18)

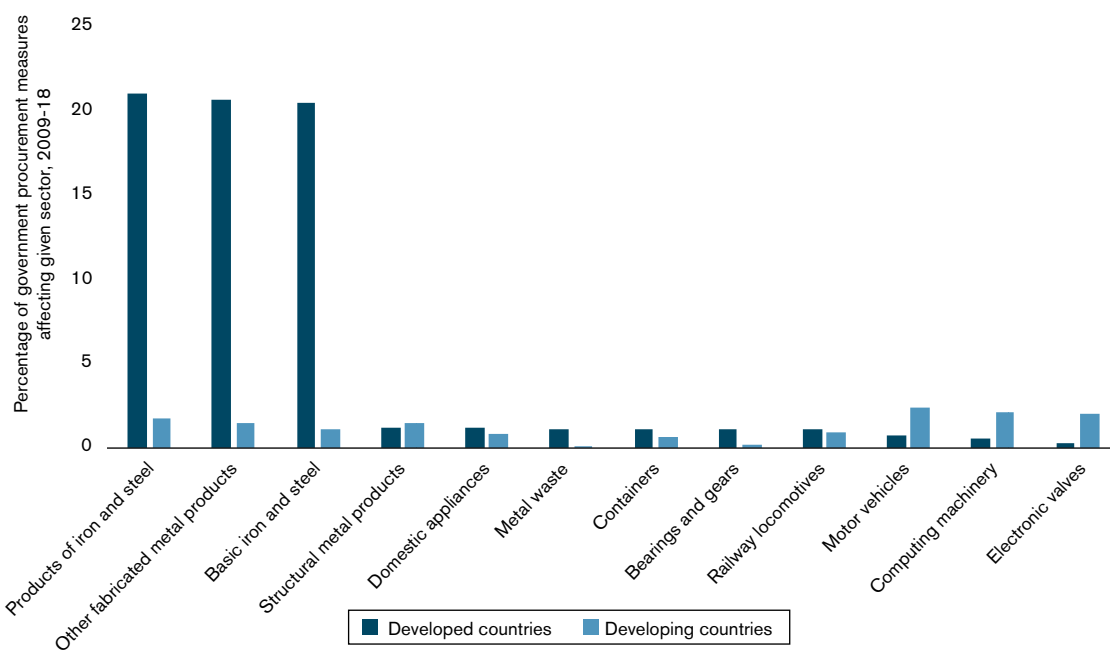


Source: Global Trade Alert (<https://www.globaltradealert.org>).

Note: Includes submissions from the following economies: Australia, Austria, Belgium, Bulgaria, Canada, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Monaco, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, United Kingdom and United States.

Figure B.13: Government procurement measures are mostly in minerals and metals and non-electrical machinery

Government procurement by product category (2008-18)



Source: Global Trade Alert (<https://www.globaltradealert.org>).

Note: Includes submissions from the following economies: Australia, Austria, Belgium, Bulgaria, Canada, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Monaco, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, United Kingdom and United States.

(iii) Support measures

While there is a plethora of descriptions and information on subsidies in the economic literature, there is no agreed definition and comprehensive database of support measures for domestic industries around the world. WTO (2006) discusses various definitions and forms of support that may be associated with subsidies, a discussion this report still considers to be relevant in 2020. The Global Trade Alert database uses its own concept. It tracks, in its own way, financial grants, state loans, and tax or social insurance relief, which would generally qualify as economic subsidies under the broad definitions used for analytical purposes. The Global Trade Alert database tends to confirm the trend observed for other policy instruments, i.e., that the number of support measures slightly declined after the 2008-09 financial crisis, and that, after a “plateau”, the use of support measures has been recently increasing, a trend that the COVID-19 pandemic is likely to magnify further. In 2018 alone, more than 400 new support measures were accounted for in the database, the most recorded during the entire 2009-18 period (see Figure B.14).

Types of support measures range from tax holidays to grants, and can cover specific industries or entire economies. Looking at the distribution of support measures by product category in both developed and developing economies, a large share are unclassified measures that are horizontal in nature, i.e., not

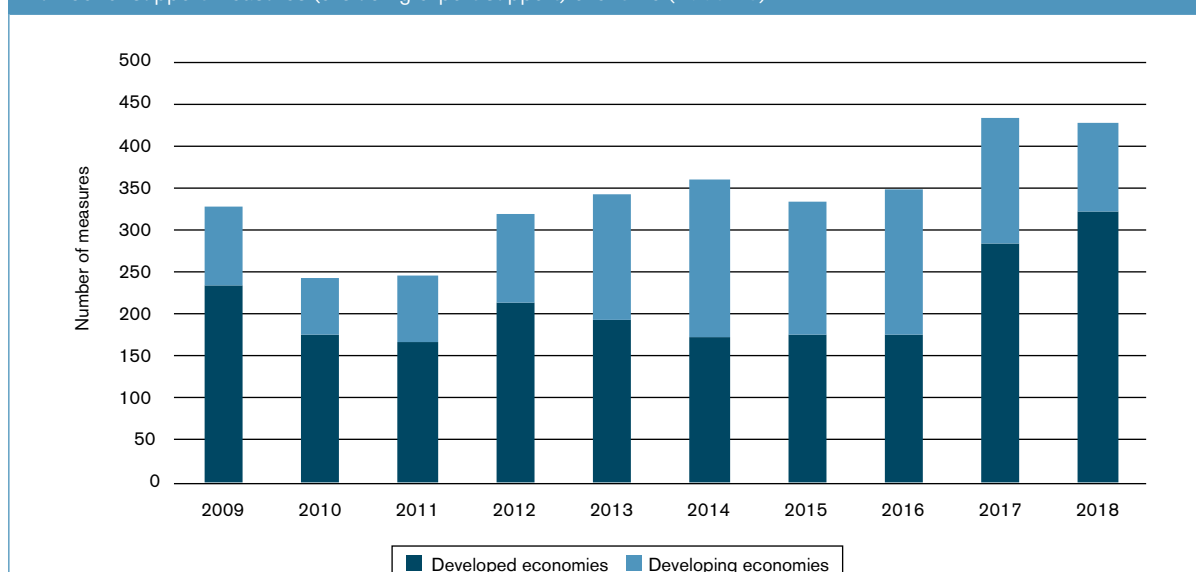
attributed to a specific sector. Electrical energy and motor vehicles are the most frequently affected sectors, followed by iron and steel and mining machinery.

Financial grants (e.g. R&D for clean transportation or other infrastructure support) and state loans are the two most widely used types of support measures. According to Global Trade Alert data, developed economies primarily used financial grants until 2014-15, but figures from recent years show a high and increasing use of state loans. Large developing economies seem to resort primarily to direct intervention through financial grants, while other developing economies seem to favour state loans.²⁰ State loans are consistently the second-largest proportion of support measures employed by developing economies.

(b) Investment policies: a central piece of government policies

Investment policies have always been an important part of government policy and continue today as a key measure to promote economic development and competitiveness. According to UNCTAD (2018a), 90 per cent of new industrial policies include investment policy tools targeting all areas of the economy. There has been a growing focus on increasing FDI in recent decades, reflected by the explosion of investment promotion agencies (IPAs) and bilateral investment treaties in the 1990s (UNCTAD, 2000; WAIPA, 2019).

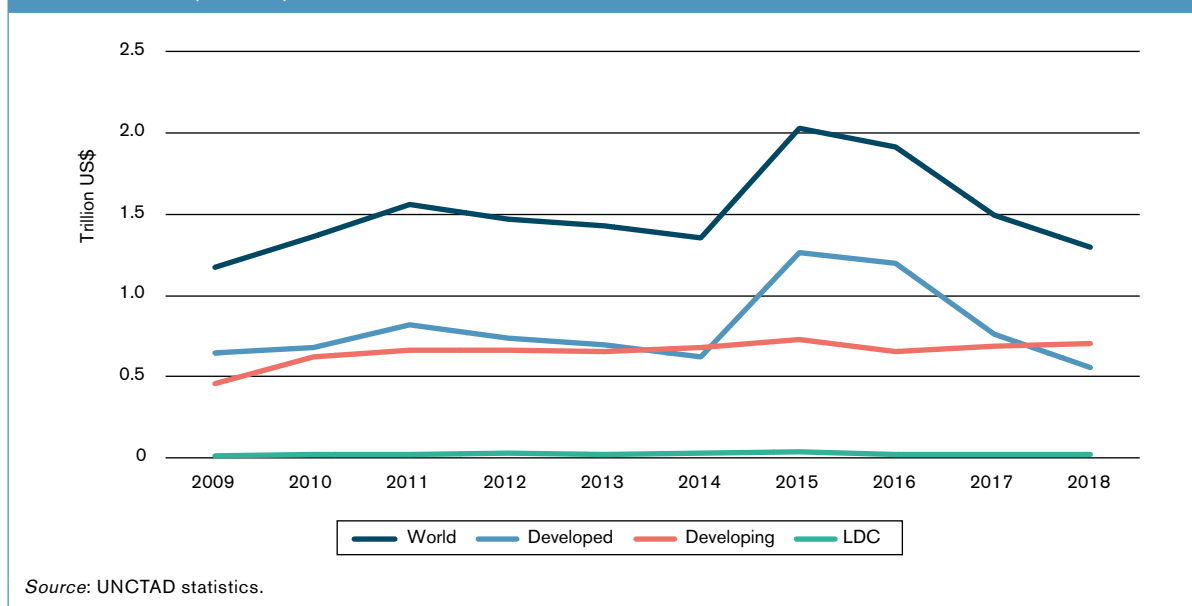
Figure B.14: Support measures have increased over the 2009-18 period
 Number of support measures (excluding export support) over time (2009-18)



Source: Global Trade Alert (<https://www.globaltradealert.org>) (data from February 2020).

Figure B.15: Inward FDI flows reflect investment's shift towards intangible assets

Inward FDI flows (2009-18)



However, global economic changes have seen the value of FDI fluctuate in recent years (see Figure B.15). Although inward FDI was worth nearly US\$ 1.2 trillion in 2018, this represented a decline from a high of more than US\$ 2 trillion in 2015. Significantly, although in value terms investment has primarily targeted developed economies, developing economies have steadily attracted more investment dollars, surpassing developed economy FDI in 2014 and 2018. In fact, the recent decline in FDI flows is mainly attributable to three factors principally affecting developed economies, including tax reform in the United States, a decline in the average rates of return on FDI, and a systematic change in the source of production value from physical to intangible assets, such as IP and royalties, which has accompanied the growth of the digital economy (Omic, 2018).

Investment policy is used both to attract foreign investment and to regulate that foreign investment, including the conditions of establishment, issues of protection of assets and repatriation of profits.

A variety of tools are used for these purposes, although fiscal and financial incentives are the most prevalent investment promotion tools among economies of all development levels (see Table B.6) (UNCTAD, 2018). Incentives include tax or tariff exemptions and subsidized services or employee training programmes. Investment facilitation, be it regulatory exemptions or re-designed procedures, is another widely used investment promotion tool with broad horizontal coverage of an economy. Location requirements and incentives for investment, especially incentives to invest in special economic zones (SEZs), are also used to bring finance and development to a specific region or sector (see Box B.3

Table B.6: Survey of investment policy tools in industrial development strategies, by economic grouping

Economic grouping	Entry and establishment					
	Incentives	Special zones/ incubators	Investment facilitation	Liberalization	Restriction	Performance requirements
Developed economies	97	83	67	3	0	3
Developing economies	92	78	82	18	5	20
LDCs	96	92	88	17	8	25

Source: UNCTAD (2018).

Note: From an UNCTAD survey of industrial policies including 30 strategies and 84 policies issued by economies across all regions. Some economies are covered by more than one industrial policy, and one industrial policy includes more than one investment promotion tool.

Box B.3: Special economic zones

One of the key features of investment policies in the past two or three decades has been the expansion of SEZs. Their number increased ten-fold in 25 years to nearly 5,400 in 2018 (UNCTAD, 2019a), and about 500 new SEZs are currently in preparation. Many economies wish to replicate the success of some of these zones in terms of economic expansion and innovation, as well as aim to fulfil economic development and industrial policy objectives. In some SEZs, economic activity has mutated in less than two decades from the production of low value-added manufacturing products to cutting-edge digital industries or services.

As with investment policies more generally, a variety of tools are used to attract investment into SEZs. These tools include fiscal incentives such as tax holidays, preferential border measures including import tariff exemptions, business-friendly regulations like faster permitting, real estate laws including ownership rights, and infrastructure support (see Figure B.16).

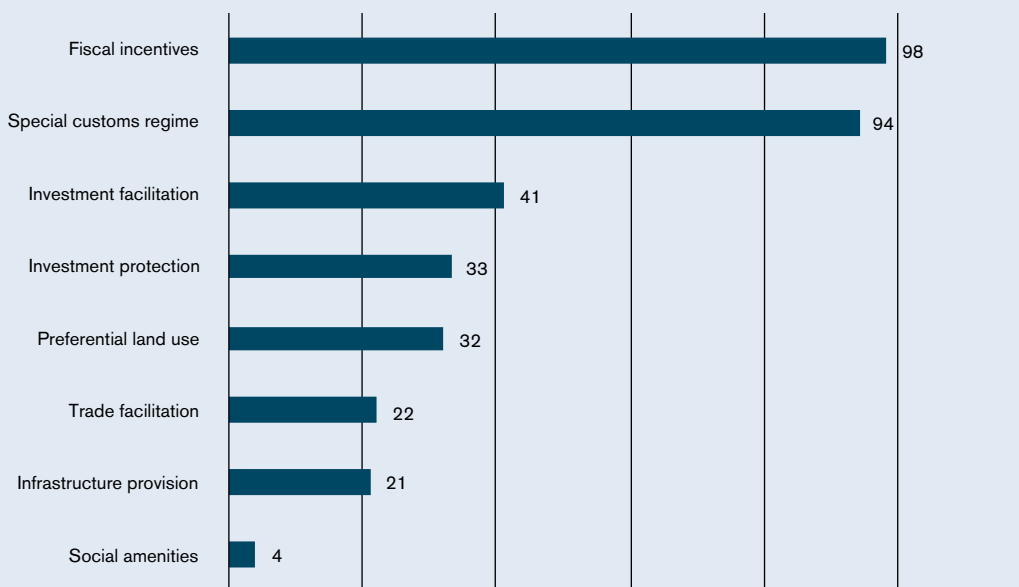
SEZs have had a particularly large role for many economies' trade, being a facilitator of both imports, especially of intermediate goods, and exports of value-added products. Trade data reveals that a large share of some economies' total manufacturing exports originate from SEZs and an estimated 20 per cent of global exports come from export zones, including an estimated 40 per cent of developing country exports (OECD and EUIPO, 2018). In addition, SEZs have been shown to play a key role in global value chain participation for processing intermediate goods, given that their customs exemptions generally prevent tariff accumulation (UNCTAD, 2019a).

Unfortunately, the central role of SEZs in many global value chains has been disadvantageous to them in the current COVID-19 pandemic. According to a survey conducted by the Kiel Institute and the World Free Zones Organization, nearly every free zone in the world has been affected by domestic measures to contain the virus, drops in demand, supply chain disruptions or losses of trade financing (Gern and Saskia, 2020).

Analysis by UNCTAD reveals that most SEZs no longer target specific economic activities and manufacturing and services. SEZs are increasingly moving into new areas, including high-tech sectors, and targeting objectives beyond exports. Additionally, SEZs are more and more often becoming a means for cross-border cooperation, for example when they straddle more than one economy (UNCTAD, 2018).

Figure B.16: Fiscal incentives are the tools most frequently used in SEZs

Tools used by SEZs



Source: UNCTAD (2019a).

Note: 127 SEZ laws from 115 countries were reviewed.

for more information on SEZs). Importantly, performance requirements may be tied to investment incentives to ensure that objectives like employment levels, exports or technology dissemination are achieved.

IPAs themselves are also a tool economies use to promote investment, both nationally and within specific sectors. Although investment policies often apply horizontally to all parts of a given economy, the majority of IPAs (94 per cent) target specific sectors (WAIPA, 2019). Sectors targeted by IPAs also vary by income level. Developed economies focus efforts on a range of sectors, most importantly ICT (70 per cent target this sector) followed by tourism, life science and renewable energy, compared to developing economies which focus on agriculture and fishery investment, followed by ICT and tourism (WAIPA, 2019). Beyond investment, economies target specific sectors to try to push development objectives, for example to move into higher technology sectors, particularly through SEZs.

While in the past two decades, the direction of investment policies had been to attract increased foreign investment under more liberal terms, a renewed emphasis has recently been placed on restrictive “investment screening procedures”, which require that governments investigate more deeply when considering whether to approve investment in sensitive sectors, such as energy and critical infrastructure, including infrastructure related to the digital economy (UNCTAD, 2018). In addition to traditional national security concerns such as those related to the acquisition of land and natural resources, new concerns related to the digital economy, such as access to citizens’ data or developing domestic capabilities related to new digital infrastructure, have become more prominent in investment policies.²¹ In addition, concerns about domestic capacity and capability with respect to the digital sector, particularly with regards to telecommunications, are increasingly being considered by governments prior to allowing certain types of foreign investment (ECIPE, 2020).

Although some restrictions may be appearing, attracting investment remains an important tool used by economies for growth and development, especially with the growth of the digital economy. Just as IPAs are increasingly focused on bringing investment to ICT, the focus of economies’ investment measures more generally has turned to the digital economy. Ensuring that an economy has adequate access to high speed internet or to the latest mobile technology is becoming more critical for integration into the global economy, and economies are taking measures to invest in this infrastructure themselves.

(c) Old tools, new tools: supporting innovation and the development of the digital economy

Although government policy tools continue to support traditional economic sectors, an increasing focus is being placed on broader policy objectives, including the promotion of innovation and the development of the digital economy.

As many economies gradually move towards a knowledge-driven economy, the use of policy tools has evolved to facilitate new technological developments and innovation. This subsection provides insights on the evolution of policy tools used by economies across different levels of development to promote innovation and development of the digital economy. It discusses public efforts to support R&D, policy interventions implemented on trade in ICT goods (as enablers of digitalization), measures and regulations applied to trade in ICT-enabled services (i.e. cross-border services provided in digitized form), and the rising use of high-tech clusters and tech hubs to foster innovation.

(i) *R&D as an engine of innovation*

R&D plays a critical role in the innovation process. R&D essentially consists of an investment in technology and future capabilities that is transformed into new products, processes and services. Companies, governments, universities and non-profit organizations around the world have made substantial investments in R&D.

Gross R&D expenditure has been increasing, but R&D intensity gaps persist across income groups and regions

R&D expenditures have grown significantly over the last two decades, but gaps in R&D intensity persist across income groups. Total global R&D expenditures, including both private and public investments, nearly tripled in current dollars since 2000, from US\$ 676 billion to US\$ 2.0 trillion (UNESCO, 2020b).

From a historical perspective, global R&D expenditures have undergone important shifts over the last three decades. Today, it is not only high-income economies that are conducting R&D in earnest; middle-income economies represent a significant and rising share of global R&D expenditures. While in 1996 high-income economies accounted for 87 per cent of global R&D, in 2017 they only represented 64 per cent of total investments — the lowest share registered in the last 30 years. Middle-income economies represented 35 per cent of total R&D expenditures in 2017. Asian R&D powerhouses, such as China, India, Japan and the Republic of Korea, contributed to as much as 40

per cent of the world's R&D in 2017, up from 22 per cent in 1996 (WIPO, 2019a).

R&D intensity, defined as global R&D expenditures divided by global GDP, allows a comparison of the degree of importance given to R&D for spurring innovation. R&D intensity has been relatively stable, increasing from 1.4 per cent in 1996 to 1.7 per cent since 2013 (UNESCO, 2020b). As Figure B.17 illustrates, most of the growth in R&D intensity has been registered among upper middle-income economies, with intensities rising from 0.6 per cent in 1996 to 1.5 per cent in 2017. Growth in R&D intensity is concentrated in a few countries, notably China, where R&D intensity grew from 0.6 per cent in 1996 to 2.1 per cent in 2017, and Malaysia, where R&D intensity grew from 0.2 per cent to 1.3 per cent over the same period. In contrast, R&D intensity only improved marginally among middle-income economies, excluding China, from 0.5 per cent in 1996 to 0.6 per cent in 2017, and in low-income economies, from 0.2 per cent to 0.4 per cent.

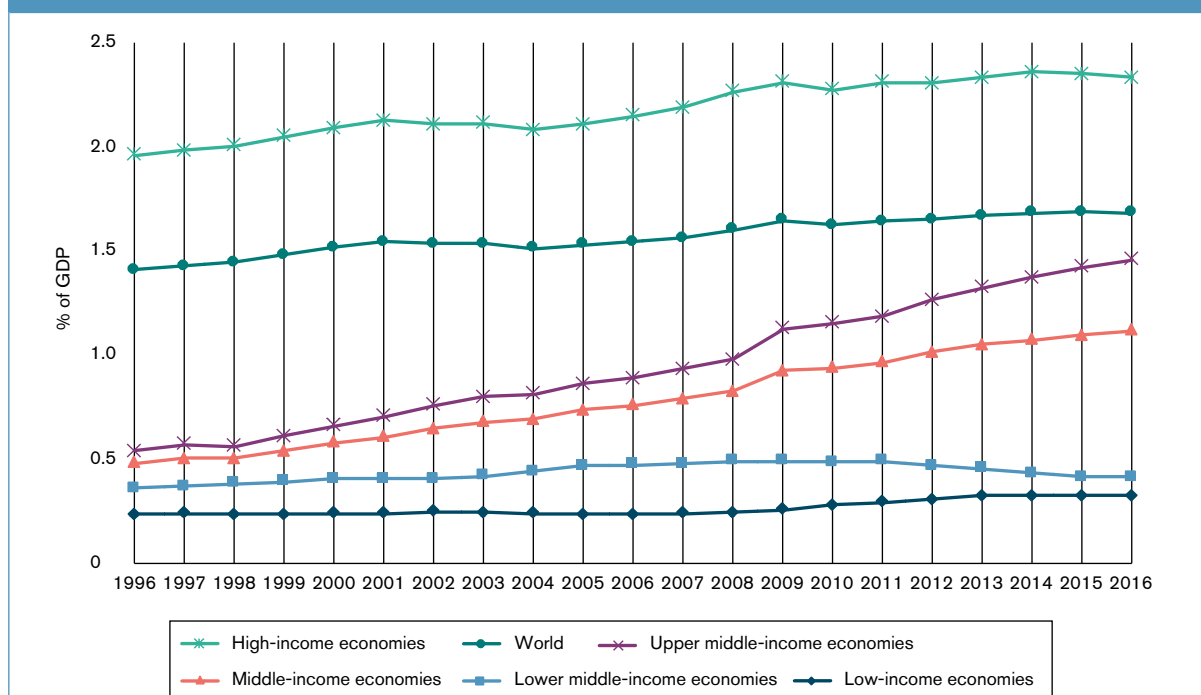
Figure B.18 presents the distribution of R&D intensity by region and R&D intensity trends between 1996 and 2016. North America and Western Europe have been leading total global R&D expenditures. However, East Asia and the Pacific countries have experienced the most significant growth rate (50 per cent) in the

last three decades, followed by the Arab States (30 per cent), Latin America and the Caribbean (29 per cent) and sub-Saharan Africa (19 per cent).

In many economies, direct government funding and tax incentives are key policy instruments to promote R&D and innovation.

Investment in R&D is an important driver of innovation and economic growth. The primary source of funding for R&D varies across economies, with governments playing a leading role in low-income economies. Figure B.19 illustrates the evolution of R&D expenditure by source of funding (business, government, higher education or private non-profit organizations, and funds from abroad – i.e. rest of the world) across different economies and income levels. Although the period for which data are available is limited (2012-17), interesting trends emerge: governments appear to play a significant role as a source of direct funding for R&D in low-income and lower middle-income economies and act as the second primary source of funding in high-income countries and upper middle-income economies with a consistent level of spending at around 22 per cent and 30 per cent respectively. Direct government support typically takes the form of subsidies and grants to research institutes and firms, including MSMEs. In contrast, the business sector acts as a

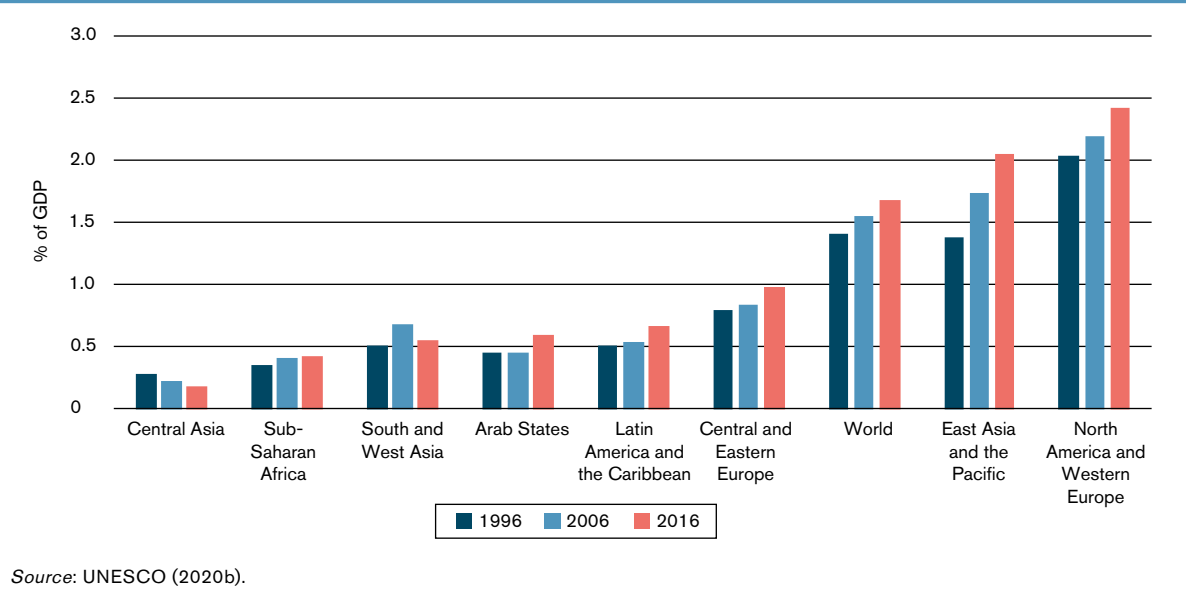
Figure B.17: R&D intensity increased in all economies except lower middle-income economies
Evolution of R&D intensity by level of development (1996-2016)



Source: UNESCO (2020b).

Figure B.18: North America, Western Europe, and East Asia and the Pacific have the highest R&D intensity

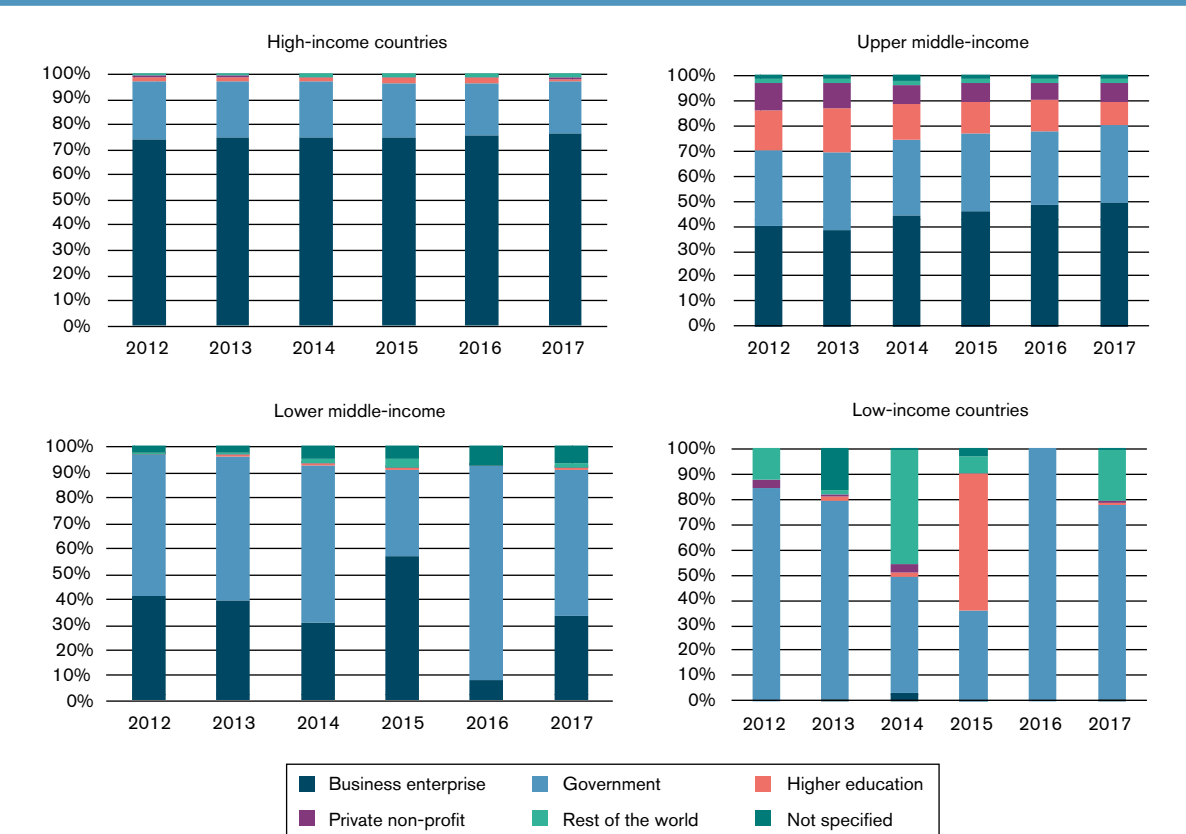
R&D intensity by region, 1996, 2006 and 2016 (R&D expenditure as a percentage of GDP)



B. DEFINING INNOVATION-ORIENTED GOVERNMENT POLICIES AND THEIR EVOLUTION IN THE DIGITAL AGE

Figure B.19: Government funding plays a key role in lower middle-income and low-income economies

Source of funding for R&D across various levels of development (2012-17)



primary source of funding for R&D in high-income countries, accounting for around 75 per cent over the 2012-17 period.

Direct government funding is also increasingly being used to promote innovation and R&D in MSMEs. Data from the European Commission and the OECD Compass on science, technology and innovation policy (STIP Compass) reveals that direct funding support for R&D is the most common policy instrument used to support MSME innovation in the 51 economies considered²² and that such support grew significantly over the period between 2000 and 2017 (see Figure B.20). Grants are the most popular form of direct financial support – although governments increasingly use other tools as well, such as indirect financial support (e.g. tax incentives, debt guarantees), innovation vouchers to work with academic researchers, and public procurement programmes for R&D.

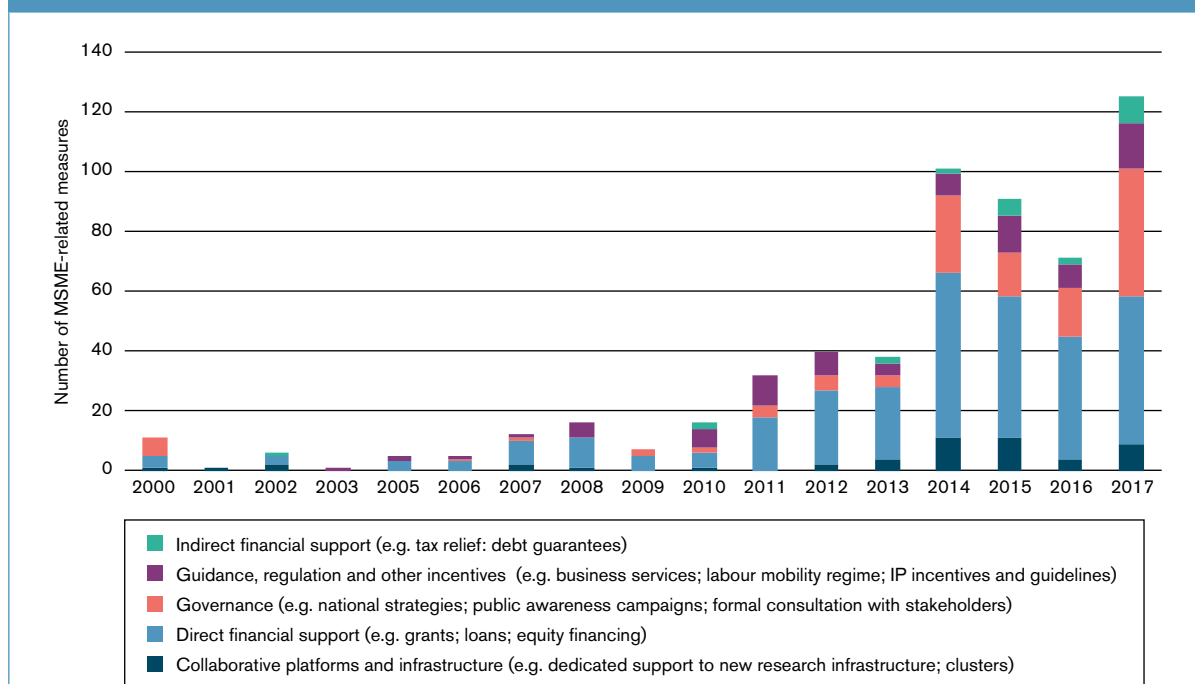
In addition to direct funding, governments can support R&D through tax incentives. R&D tax incentives have become a major tool for promoting business R&D in high-income economies. The choice of R&D tax incentives depends on country-level variables such as overall innovation performance, market failures in R&D, industrial structure, size of firms and the nature of the corporate tax system. R&D tax credits

are neutral with respect to the type of R&D being conducted by a firm, and therefore operate more in accordance with market rationale than direct support.

According to OECD (2020), many countries have increased the availability, simplicity of use and generosity of R&D tax incentives. In 2019, 30 out of 36 OECD countries, 21 out of 28 EU member states, and several other economies (Argentina, Brazil, Colombia, China, the Russian Federation and South Africa) gave preferential tax treatment to R&D expenditures. Over the period from 2009 to 2015, nearly half of 107 developing economies (20 low-income, 39 lower-middle income, and 48 upper-middle-income countries) also granted tax exemptions or tax reductions to firms on the condition that they spend on R&D (see Table B.7).

The design of R&D tax incentives varies across countries, with some governments providing higher tax subsidy rates on R&D expenditures to small firms. This is the case of Australia, Canada, the Republic of Korea, the Netherlands and the United Kingdom (Figure B.21). One notable exception is China, whose implied subsidy tax rate is much higher for large firms compared to small ones. Some examples of R&D tax incentive programmes targeting MSMEs are provided in Box B.4.

Figure B.20: Direct financial support is the main policy instrument to support R&D in MSMEs
Number of MSME-related measures aimed at fostering innovation and R&D in 51 economies (2000-17)



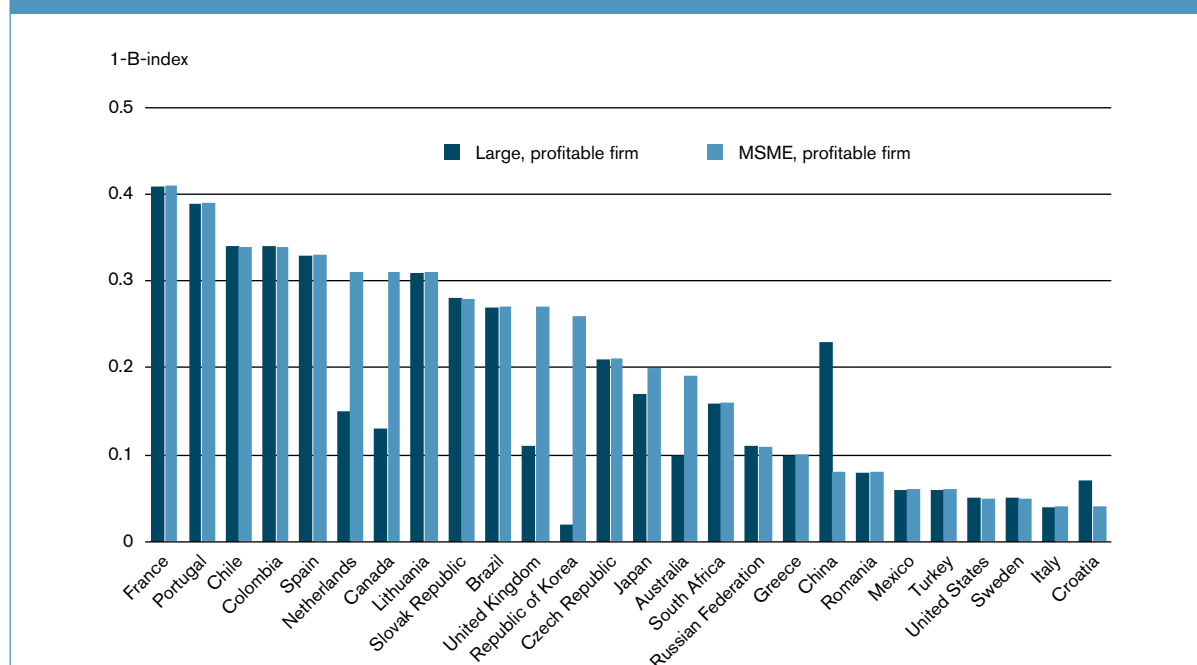
Source: European Commission and OECD (2019).

Table B.7: Nearly half of surveyed developing economies granted tax holidays or tax allowances to firms on condition that they spend on R&D

Based on 107 developing economies (2009–15)

	East Asia and Pacific	Europe and Central Asia	Latin America and the Caribbean	North Africa and Middle East	South Asia	Sub-Saharan Africa	Low-income	Lower middle-income	Upper middle-income	Total
Number of economies covered in database	15	18	23	8	6	37	20	39	48	107
% of economies providing tax exemptions subject to spending on R&D	65	24	32	48	34	38	24	40	23	40
% of economies providing tax reductions subject to spending on R&D	46	10	23	14	67	81	67	47	35	46

Source: Author's calculation based on the Developing Country Tax Incentives Database (Andersen, Kett and von Uexkull, 2017). This database provides information on 107 developing economies for the period 2009–15.

Figure B.21: In some countries, MSMEs enjoy preferential tax subsidy rates on R&D expenditures
Implied tax subsidy rates on R&D expenditures (2019)

Source: OECD R&D Tax Incentives Database (OECD, 2020).

Note: Figure B.21 reflects the tax treatment of R&D expenditure for MSMEs and large enterprises in OECD economies, the European Union and other major economies. The implied tax subsidy rate is defined as 1 minus the B-index, i.e. a measure of the income before taxes of a representative firm on one additional unit of R&D outlay (Warda, 2001). Measures of tax subsidy rates such as those based on the B-index provide a convenient proxy for examining the implications of tax relief provisions. They provide a synthetic representation of the generosity of a tax system. To provide a more accurate representation of different scenarios, B-indices are calculated for "representative" firms according to whether they can claim tax benefits against their tax liability in the reporting period (OECD, 2013).

Box B.4: Examples of R&D tax incentive programmes targeting MSMEs

In Canada, the National Research Council of Canada Industrial Research Assistance Program (NRC IRAP) has been Canada’s leading innovation assistance programme for small and medium-sized businesses for over 70 years. The programme offers financial assistance, advisory services and connections to the best business and R&D expertise in Canada. For instance, the NRC IRAP provides small or medium-sized Canadian businesses pursuing technology driven innovation with funding to support R&D projects (National Research Council Canada, 2020).

In the Republic of Korea, the Ministry of SMEs and Startups of Korea is carrying out a programme to develop technologically innovative MSMEs as part of its representative R&D programme of promoting first-mover and creative investment in promising technologies to enhance the key capacity of MSMEs that are playing a key role in the Korean economy. The 2020 budget for R&D to support technological innovation and commercialization for MSMEs reflects new R&D projects for the next generation such as AI and smart sensors to provide a stepping stone for the creation of new growth industries in the future (Ministry of SMEs and Startups of the Republic of Korea, 2020).

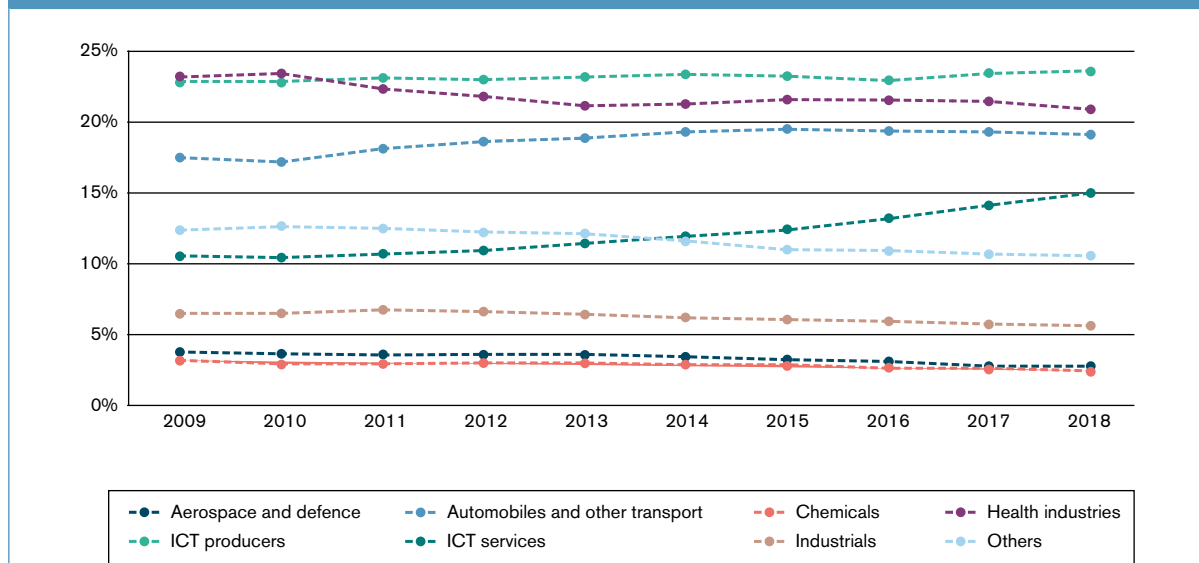
Over the past 10 years, R&D growth has mainly been driven by the automobile and ICT sectors, with ICT services rising the most.

Between 2009 and 2018, companies worldwide increased their R&D spending by 67 per cent, reaching a total of € 823.4 billion in 2018 according to the 2019 EU Industrial R&D Investment Scoreboard, which comprises the 2,500 companies

that invest the largest sums in R&D in the world and represents approximately 90 per cent of the world’s business-funded R&D (European Commission, 2019b). In 2018, global business-funded R&D were concentrated in three broad sectors: 38.7 per cent in ICT industries (ICT producers and services), 20.7 per cent in health industries and 17.2 per cent in automotive industries (see Figure B.22).

Figure B.22: The R&D share of ICT industries, in particular ICT services, has increased significantly since 2009

Evolution of global R&D shares for industrial sectors



Source: The 2019 EU Industrial R&D Investment Scoreboard (European Commission, 2019b).

Note: The figure refers only to the 1,650 companies for which data on R&D, net sales and operating profits were available for the entire period between 2009 and 2018. These companies represented 84.6 per cent of R&D, 84.1 per cent of net sales and 79.8 per cent of operating profits for the whole sample in 2018.

Figure B.22 illustrates the evolution of global R&D shares in main industries over the past decades. Globally, an important sector shift occurred in ICT industries, mainly in ICT services whose R&D share increased from 10.8 per cent to 14.2 per cent. The share of ICT producers also rose, although to a lesser extent, from 23.0 per cent to 23.7 per cent. Sectors that underwent a decrease in R&D shares included aerospace and defence, and chemicals, as well as other sectors covering low-tech activities, such as textiles.

(ii) *Public efforts to support digitalization and the ICT sector*

Governments have used a mix of policy interventions to support digital transformation and foster innovation in the digital sector over the last decade, from traditional tools such as direct and indirect funding of R&D and innovation-oriented public procurement, to more innovative tools like data-related regulations and regulatory sandboxes.

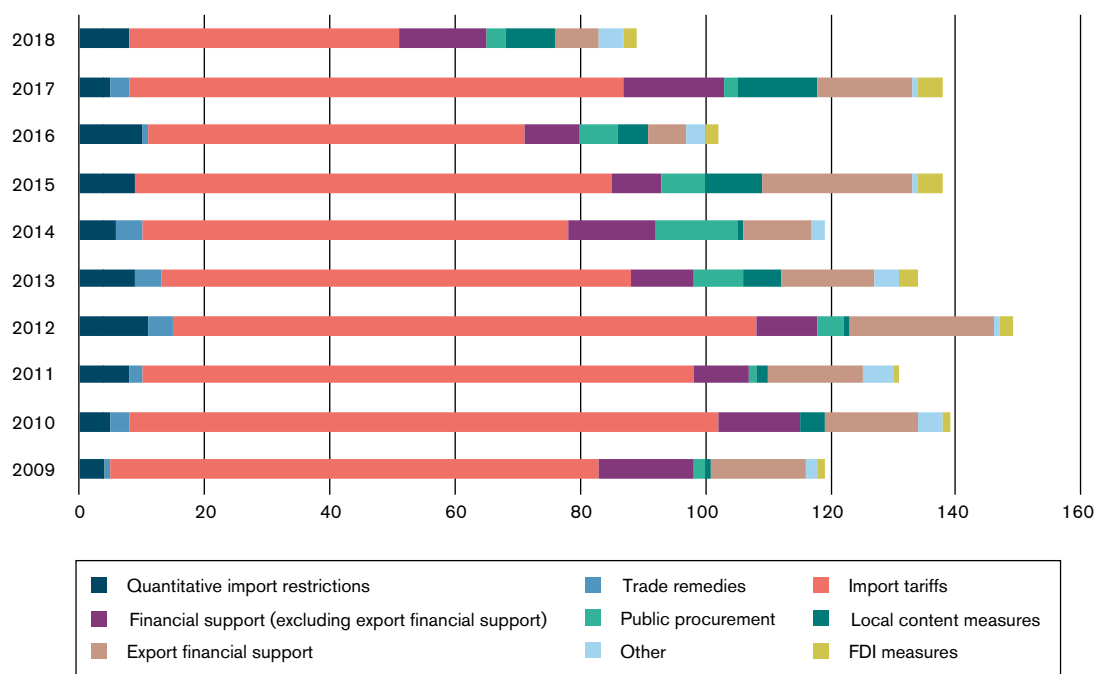
How traditional instruments are used to support the digital transformation

The various tools used to support traditional sectors examined in Section B.3(a) form part of the collection of instruments to which governments also commonly resort to support digitalization and the ICT sector.

Although the data from the Global Trade Alert are incomplete, they do give some idea of the extent to which such tools have been used in relation to ICT goods and ICT services over the last decade (see Figures B.23 and B.24).

Among the 184 economies tracked by the Global Trade Alert database (<https://www.globaltradealert.org>), 132 economies (of which the European Union counted as 27) took a total of 1,264 measures – both trade-facilitating and trade-restrictive – targeted ICT goods between 2009 and 2018. These 132 economies cover 71 per cent of the world’s developed economies, 75 per cent of its developing

Figure B.23: Various measures target ICT goods
Evolution of the type of measures targeting ICT goods between 2009 and 2018 (number of policy interventions)

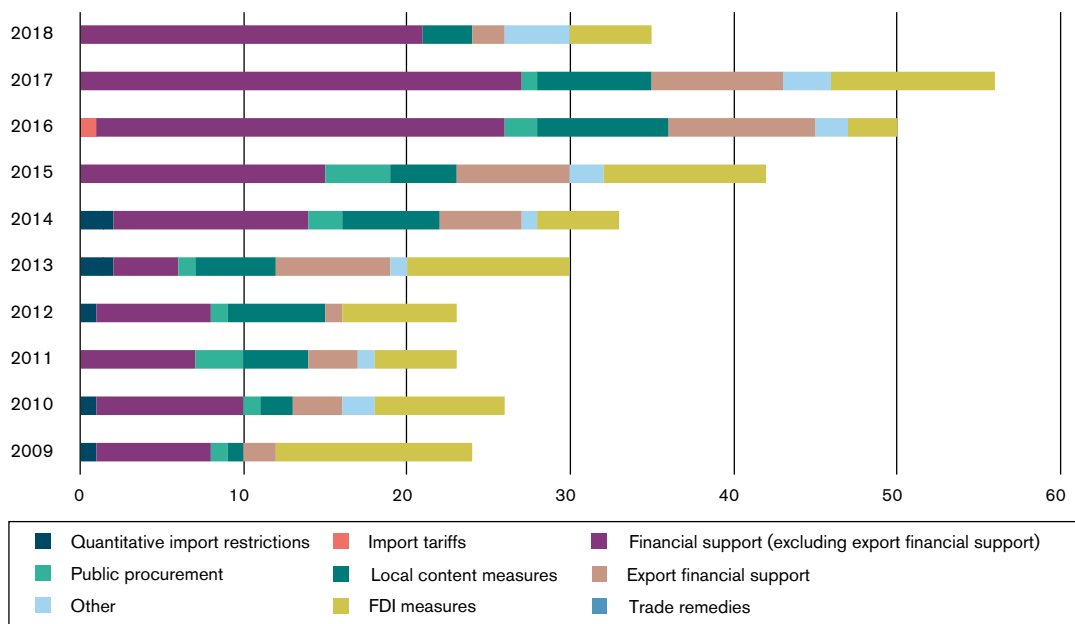


Source: Global Trade Alert (<https://www.globaltradealert.org>).

Note: ICT goods include: computing machinery and parts; television and radio transmitters, cameras, telephone sets; broadcast recording apparatus, microphones, loudspeakers, etc.; disks, tapes, storage devices and other media, not recorded; disks, tapes and other physical media, recorded; packaged software; and cards with magnetic strips or chip. The category “Other” includes: controls on commercial transactions and investment instruments; controls on credit operations; internal taxes and charges levied on imports; competitive devaluation; finance measures; undefined policy instruments; labour market access; licensing or permit requirements to export; export taxes and charges; and other export measures. Measures covered include both trade-facilitating and trade-restrictive measures.

Figure B.24: Only a few measures target ICT services

Evolution of the type of measures targeting ICT services sectors between 2009 and 2018 (number of policy interventions)



Source: Global Trade Alert (<https://www.globaltradealert.org>).

Note: Measures covered include both trade-facilitating and trade-restricting measures. ICT services include telephony and other telecommunications services, internet telecommunications services, and online content. Measures covered include both trade-facilitating and trade-restrictive measures.

economies and 31 per cent of LDCs. By contrast, only 342 measures targeted ICT services over the review period, and these were taken by 57 economies representing 57 per cent of developed economies, 30 per cent of developing economies and 8 per cent of LDCs (see Figure B.24).

In the case of goods, import tariffs appear to be the most widely used tool. About two-thirds of import tariff measures taken between 2009 and 2018 were trade-liberalizing. Financial support and export financial support are also popular instruments. In terms of measures targeting ICT services, FDI measures, financial support, export financial support and local content measures were the most widely used.

While, in the case of measures targeting ICT goods, trade-facilitating and trade-restrictive measures were used to more or less the same extent – 613 trade-restrictive versus 590 trade-facilitating measures, and 61 with unclear effects on trade. Measures targeting ICT services were mainly trade-restrictive, suggesting a preferred approach for endogenous innovation – 204 trade-restrictive versus 67 trade-facilitating, and 70 with unclear effects on trade (see <https://www.globaltradealert.org>).

As already noted, these numbers only provide a glimpse of the types of measures used to support digitalization. They do not provide a comprehensive picture of policy interventions and need to be handled with care.

Elimination of import tariffs as a trade-liberalizing tool to improve access to ICT products

Over the last decade, the elimination of import tariffs has been the primary tool used by most countries to improve their access to ICT products. The WTO ITA is the most significant tariff liberalization arrangement concerning trade in ITA products. Through the ITA, participants agreed to eliminate tariffs on a range of ICT products,²³ including computers, telecommunication equipment, semiconductors, software, as well as most of the parts and accessories of these products. Since 1996, the number of ITA participants has grown to 82, representing approximately 97 per cent of world trade in ICT products. In 2015, over 50 WTO members concluded the expansion of the ITA, which now covers an additional 201 products, accounting for 99 per cent of the value of global ICT goods, and some 80 per

cent of all product lines in this category. Trade in ITA products has expanded 3.7 times since the ITA came into force (see Figure B.25).

Direct and indirect government financial support to ICT innovation and the digital economy

The ICT sector plays an increasingly important role in the global economy. According to a study by the European Commission, the ICT sector of 40 economies²⁴ tripled in value-added in the last two decades (European Commission, 2019a). The COVID-19 pandemic will likely strengthen this trend. Government direct funding and indirect financial support foster ICT innovation and the digital economy in at least three ways: by stimulating R&D, by strengthening the supply of ICT innovative products, and by boosting the demand for these ICT innovative products.

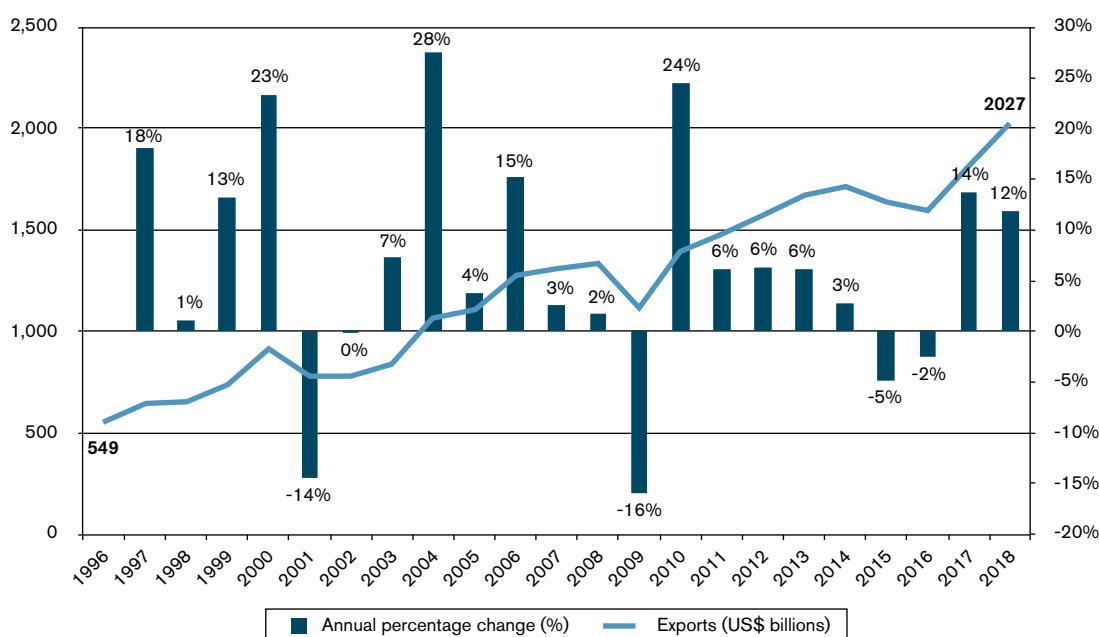
First, direct public funding of R&D in the ICT sector plays a critical role in the digital transformation. Although data are limited with regard to the amount of public spending on ICT innovation, available evidence in advanced economies shows that public funding of R&D (measured as total government budget allocations for R&D, or GBARD) devoted

to funding ICT-related expenditure has increased in value in the United States and European Union (European Commission, 2019a). By 2017, ICT-related government expenditure had reached € 6.7 billion in the European Union (representing 7 per cent of total EU government budget allocations for R&D), and € 10.9 billion in the United States (8 per cent of its total R&D budget). As for Japan, its share of ICT-related expenditures in total government budget allocations for R&D slightly decreased over the period with some ups and downs (see Figure B.26).

Governments also use direct funding and indirect financial support to foster R&D in advanced technologies, including AI, 5G mobile telephone networks, additive manufacturing (i.e. 3D printing), IoT and Blockchain. For instance, India, the Republic of Korea, Singapore and the United Kingdom finance 5G trials to enable businesses to test their 5G products and hence to develop new 5G use cases. The Republic of Korea offers tax exemptions to businesses undertaking 3D printing R&D, and Germany finances a blockchain R&D laboratory to assess blockchain applications. Brazil has set up a new AI institute (the Advanced Institute for Artificial Intelligence) promoting partnerships between universities and companies on joint AI R&D projects. In light of the growing importance of IP in today's

Figure B.25: World exports of ITA products almost quadrupled between 1996 and 2018

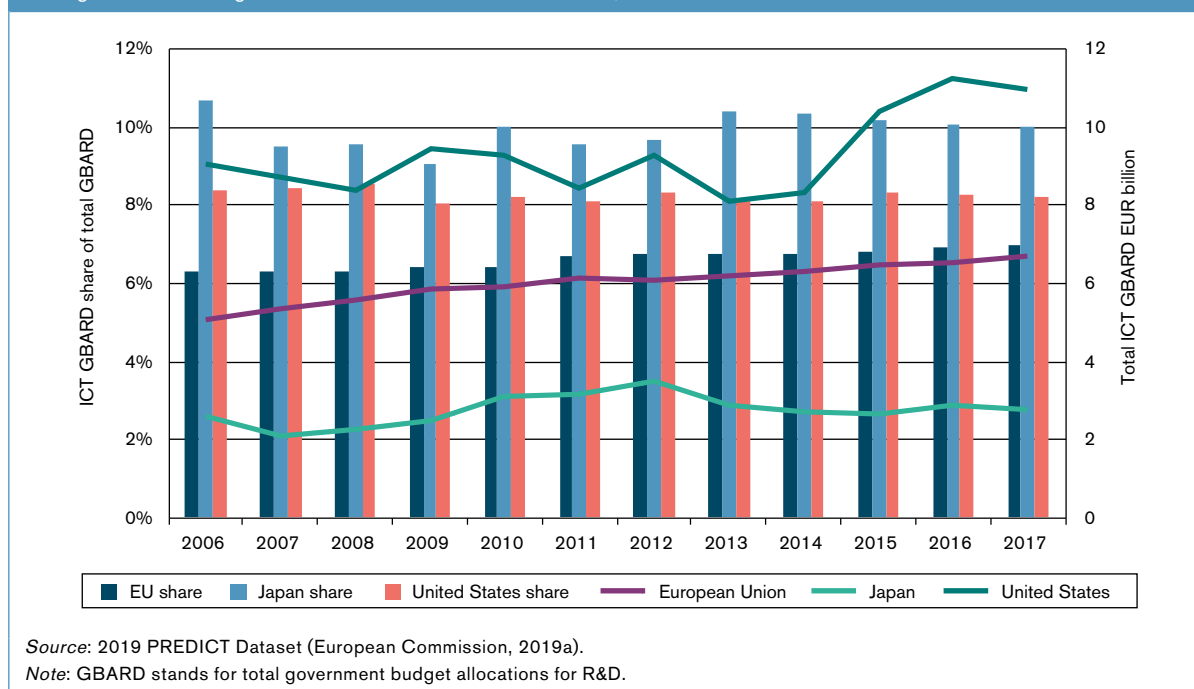
World exports of ITA products in US\$ billion and percentage change



Source: WTO Secretariat based on UN Comtrade (<https://comtrade.un.org>) (reported data, complemented by mirror estimates).

Figure B.26: Public funding of R&D devoted to the ICT sector has increased in value in the United States and European Union

Total government budget allocations for R&D devoted for ICT, 2006-17



economy, some governments also apply special corporate tax regimes to incentivise R&D by taxing patent revenues at a lower rate than other commercial revenues. Such regimes are often referred to as patent boxes (see also Table B.3 and Section C). Currently, about half of the EU member states have such regimes in place, as well as China, India, Israel, Singapore, Turkey and the United Kingdom.

Second, direct government funding and indirect financial support are used to stimulate the supply of innovative ICT products. Germany has established an investment fund to provide MSMEs with venture capital, enabling them to adopt AI or to start new AI-based companies. Similarly, Argentina offers grants to support blockchain-based MSMEs. The Republic of Korea provides tax benefits to incentivize mobile network operators to cooperate through network-sharing agreements in order to reduce the cost of 5G infrastructure deployment and maintenance.

In order to improve the supply of broadband services, many economies have developed national broadband plans and related policies to channel stimulus funding. Almost all developed economies (95 per cent), more than half of developing economies (65 per cent) and around one-third of LDCs (36 per cent) have a national broadband plan. Measures used to implement these national broadband plans vary across

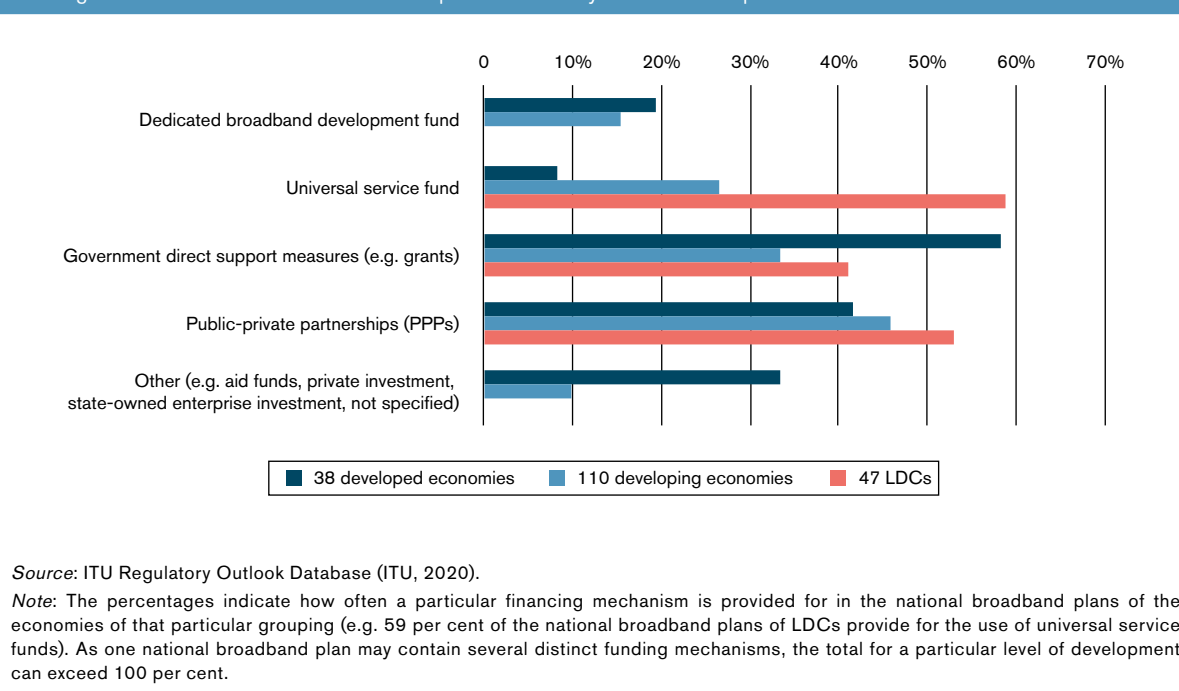
levels of development. LDCs heavily rely on a funding mechanism financed by licensed telecommunications operators (referred to as universal service funds) and on public-private partnerships. Developing economies use a balanced combination of funding mechanisms, and developed economies favour direct support measures (see Figure B.27).

Third, governments provide direct funding and indirect financial support to stimulate demand for and use of ICT innovative products. To surmount affordability and coverage barriers, some governments provide tax incentives on ICT equipment and services, subsidies for low-income households, and tax cuts and subsidies for MSMEs. For instance, between 2014 and 2016, eight LDCs reduced taxes on ICT services (e.g. specific VAT on SMS, data or calls, connection tax, or SIM card tax) to improve affordability, namely Angola, Bangladesh, the Democratic Republic of the Congo, Mauritania, Nepal, Niger, Senegal and Uganda (Alliance for Affordable Internet, 2017, 2019). In the European Union, the WIFI4EU programme (<https://ec.europa.eu/digital-single-market/en/wifi4eu-free-wi-fi-europeans>) has awarded € 15,000 in subsidies to 6,000 municipalities to cover the capital expenditures of providing free public Wi-Fi (Broadband Commission, 2019).

An analysis of WTO trade policy reviews (TPRs) conducted since 2011 shows that 58 of the 156

Figure B.27: LDCs favour universal service funds and public-private partnerships, and developed countries direct support measures

Funding mechanisms of national broadband plans in 2018 by level of development



members covered over the review period provided financial support to ICT-related services, that is almost 40 per cent of WTO membership representing all levels of development. Slightly more than four-fifths of the developed countries covered by the analysis, a quarter of the developing economies, and about a tenth of the LDCs have adopted similar support measures. LDCs essentially resort to tax incentives and developed economies to direct grants, while developing economies tend to use both instruments, although tax incentives appear to be more popular (see Figure B.28).

The use by developed economies of direct grants, which are a potent catalyst for growth and innovation, could further accelerate disparities between LDCs – which essentially resort to tax incentives – and more advanced economies. These numbers need to be considered with caution, as WTO TPRs do not systematically cover all services and may not provide the same level of detail across TPRs. However, they provide an interesting glimpse into the type of instruments being used to support ICT-related services.

Government procurement: a tool frequently used to foster innovation and digitalization

When used strategically, government procurement – also called public procurement – can boost

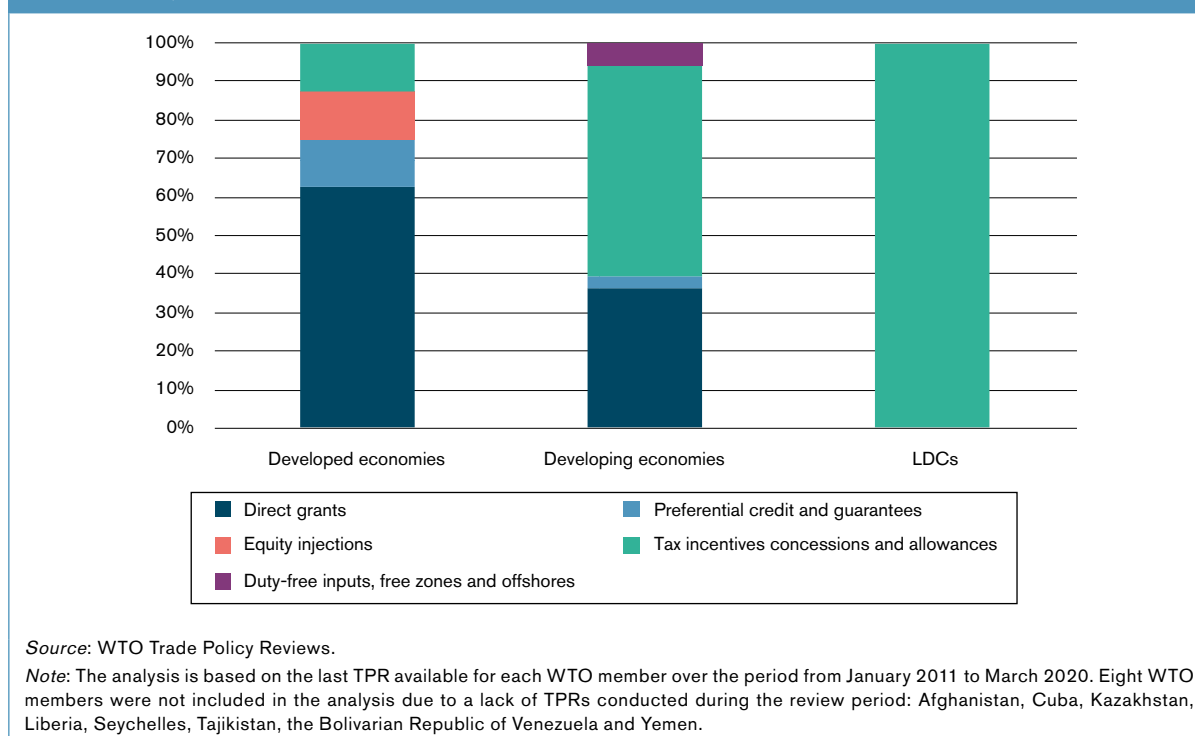
innovation at both the national and local levels, and can ultimately improve productivity and inclusiveness. Through procurement, governments can shape innovation directly or indirectly by helping firms to recuperate the sunk costs of large and sometimes risky investments.

A number of governments increasingly resort to procurement to foster innovation. According to the OECD (2017), 81 per cent of OECD countries have developed strategies or policies to support innovation through public procurement, and 50 per cent have developed an action plan for innovation procurement. Increasing attention is also being paid to the role that public procurement can play in supporting MSMEs to grow and innovate. Out of 180 economies covered by World Bank (2016), 85 economies (47 per cent) had introduced incentives for MSMEs to participate in public procurement. In 2012, participants in the WTO Government Procurement Agreement (GPA) launched a MSME work programme to assist, promote, encourage or facilitate MSME participation in government procurement (WTO, 2012).

Government procurement is often used to support the digital sector. Data from the European Centre for International Political Economy (ECIPE) show that 89 per cent of the economies represented in their dataset²⁵ have used public procurement in this way (ECIPE, 2020). While these data do not pretend to

Figure B.28: Tax incentives are a popular tool for supporting ICT-related services in developing economies and LDCs

Types of financial measures to support ICT-related services by level of development (based on TPRs published between 2011 and 2020)



be exhaustive, they provide interesting insights into the extent to which government procurement is used to bolster the digital sector. The tools used remain largely traditional ones, i.e. the purchase of goods and services at preferential rates. Table B.8 shows that “Preferential purchase schemes covering digital products and services” is the most popular type of tool.

In the digital sector, public procurement for digital goods and services is more popular in developing economies than in developed ones: 100 per cent of developing economies covered in the database have adopted public procurement measures targeting the digital sector, compared to 81 per cent in the case of developed economies, and the number of public procurement measures adopted by developing economies is almost double that of developed countries (see Table B.8).

Local content requirements

There has been a significant increase in the use of local content measures in the ICT sector. The Global Trade Alert database identified a total 29 local content measures related to the ICT sector between 2009 and 2018, with 20 such measures targeting ICT goods

and nine targeting ICT services. Examples of such policies include requirements that telecommunications companies use only locally manufactured SIM cards in providing their services or that they use a minimum value of local components, or that foreign enterprises trading ICT equipment include a certain share of domestically produced inputs.

Standards as a tool to facilitate innovation and digitalization

Standards define product and process characteristics essentially to set levels of product quality, safety, health and environmental protection and to improve process management, and they are not intrinsically an industrial policy tool. However, by codifying technical information on products and services and facilitating communication between economic agents, they foster innovation and competition, promote trust among stakeholders, and nurture international trade. Standards play a critical role in highly technical areas, including those that contribute to the digital transformation, and they can facilitate and accelerate the ongoing digitalization of our economies by promoting compatibility and interoperability between products and processes and the uptake of new digital technologies.

Table B.8: Public procurement for digital products is more popular in developing economies

Type of public procurement measure	Number of measures targeting the digital sector applied by developed economies	Number of measures targeting the digital sector applied by developing economies	Total
Preferential purchase schemes covering digital products and services	57	96	153
Requirement to surrender patents, source codes, trade secrets	0	5	5
Technology mandate	5	9	14
Total	62	110	172

Source: ECIPE (2020).

The accelerated pace of change is leading an increasing number of governments to actively support the development of standards to facilitate the adoption and steer the development of new digital technologies (see Section C for a discussion on the economic rationale of these measures).

In the area of 5G mobile networks, for example, the European Commission launched a Framework Programme for Research and Innovation (2014-20) and a public-private partnership to finance costs associated with the development of standards for higher-speed wireless communication. China, on its side, finances the development of global 5G standards in collaboration with research institutes and industry associations around the world.

Given the concerns about the potential ethical implications of the development of AI, several governments, such as Canada, Estonia, France and the United Kingdom, have developed an ethical and legal framework to guide the adoption of AI and facilitate market adoption.

Various governments also support standards development to facilitate the deployment of 3D printing in manufacturing sectors. In 2015, for instance, the Government of the Netherlands established a “Smart Industry” action agenda, through which it funds several field laboratory networks of companies and knowledge institutes to develop and test ICT applications. Similarly, the Federal Government of the United States finances the Standardization Roadmap for Additive Manufacturing (i.e. 3D printing), which is a programme meant to coordinate multiple organizations engaged in standards-setting for various aspects of additive manufacturing.²⁶

Government support to standards development extends to other advanced technologies, such as cloud computing or Blockchain. The European Union,

for instance, finances initiatives to develop common open standards for cloud computing, and Australia finances the development of blockchain-related standards.

Clusters and tech hubs as a tool to promote innovation and digitalization

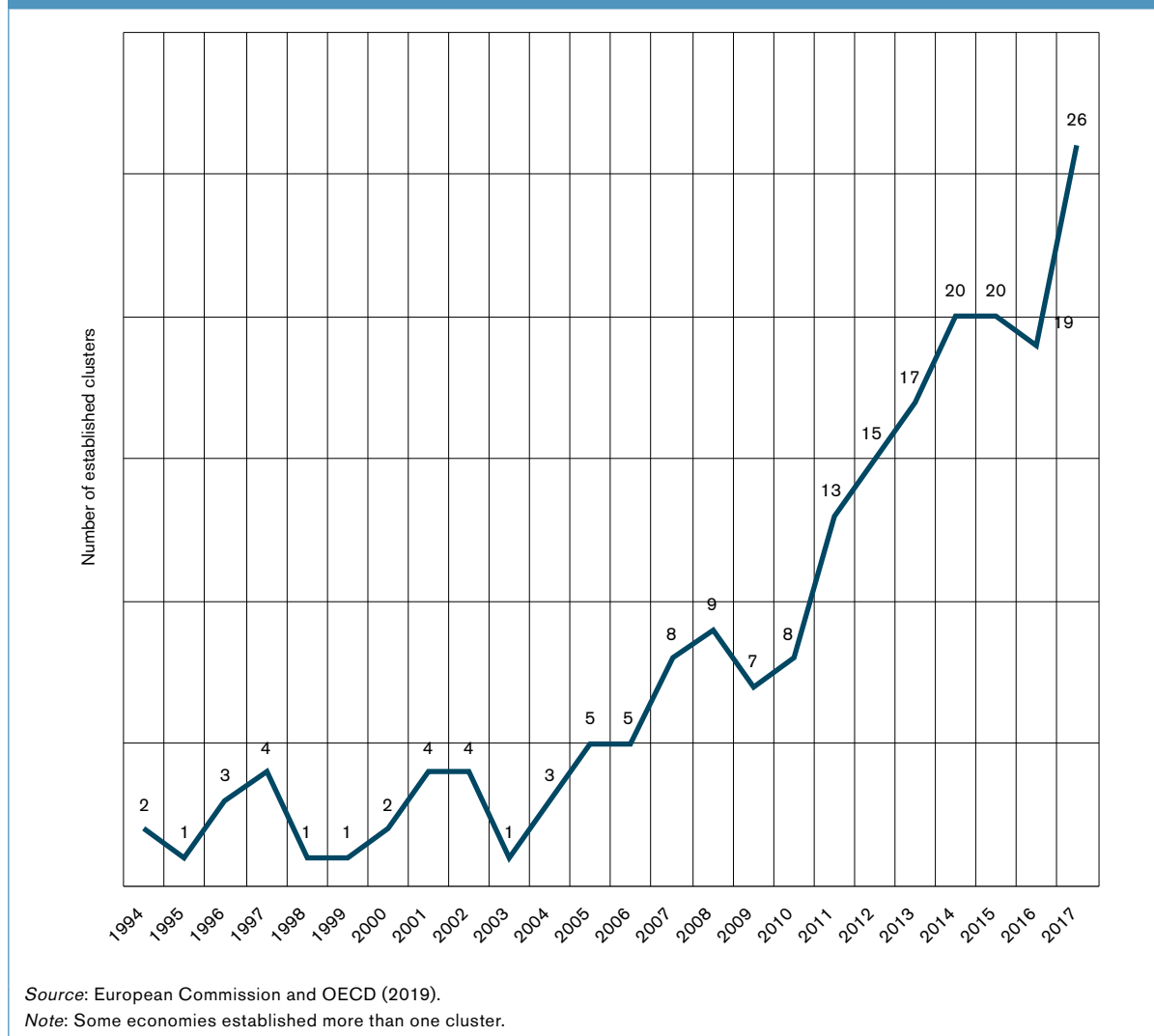
Governments frequently use clusters of firms and research centres as a tool to foster innovation. Clusters aim to capture the economic advantages that accrue through the agglomeration of firms, and sometimes of research centres. In this eco-system, firms can be more innovative and create more jobs than alone.

While interest in clusters is not new, data from the OECD and the European Commission's database on innovation policies, which covers 51 economies, shows that the number of cluster programmes in innovation policies has increased sharply over the last two decades, pointing to the growing importance attached to clusters as a tool to promote innovation (see Figure B.29). In 2017, 27 economies, of which 17 developed and 10 developing economies, reported having established clusters as part of their innovation policy (European Commission and OECD, 2019).

Some clusters are highly technology-oriented. These clusters, which usually have as a core renowned universities and research centres with which technology start-ups interact, are usually referred to as high-tech clusters. Other terms used are “science parks”, “technology parks”, “technopoles” or “research parks”. These high-tech clusters provide a vehicle to bring together business, public research, investors and university partners, offering a new mechanism for innovation and collaboration. Prominent examples of these high-tech clusters include Silicon Valley in the United States, the East London Tech City in the United Kingdom, Bangalore in India and Shenzhen in China. According to the

Figure B.29: Clusters are increasingly used as an innovation policy tool

Number of clusters reported as having been established under a country's innovation policy (27 reporting economies)



United Nations Educational Scientific and Cultural Organization (UNESCO), 81 governments have supported the establishment of at least one high-tech cluster (UNESCO, 2020a – see Figure B.30).

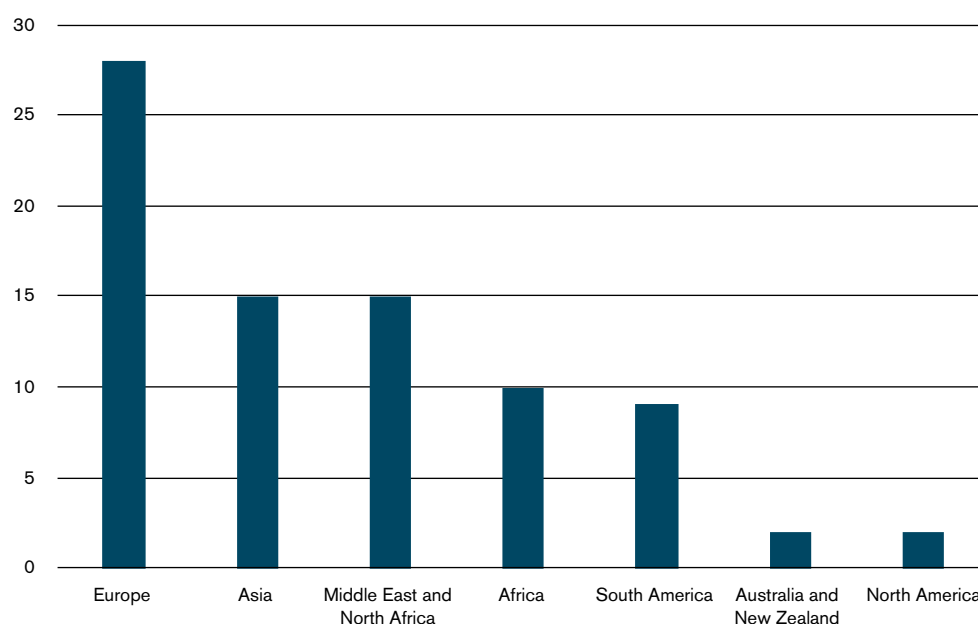
Another common form of agglomeration is tech hubs. A “tech hub” is a physical space – a city, a suburb or a suite of offices under a single roof – designed to support start-ups and help them thrive, and is viewed as a place where members of the technology and entrepreneurship community can get together (ITC, 2019). Tech hubs can be part of high-tech clusters, thereby tapping into the R&D facilities that characterize high-tech clusters (KPMG, 2019). Most tech hubs are either “accelerators” or “incubators”. Accelerators primarily target start-ups with a product that is ready to be used and/or traded and help them to achieve external funding. Incubators intervene at

an earlier stage. They assist start-ups in designing and building business models. These forms of agglomeration boost collaboration between start-ups and investors and provide a wide range of services to support innovation take-ups, such as mentorship services, legal services or access to investors.

Tech hubs have flourished around the world and their number keeps increasing. A 2017 study financed by the UK Department for Business, Energy and Industrial Strategy found that there were 205 incubators and 163 accelerators active in the United Kingdom in 2016-17 (Bone, Allen and Haley, 2017), and the International Business Innovation Association, based in the United States, estimates that there are about 7,000 incubators worldwide (InBIA, 2020). In Latin America, the LAVCA Accelerator Directory identified 112 accelerators as

Figure B.30: Eighty-one governments have supported the establishment of at least one high-tech cluster

Number of high-tech clusters established by governments



Source: UNESCO (2020a).

of 2016 (LAVCA Venture Investors, 2016), and in the Asia-Pacific region, the Global System for Mobile Communications Association (GSMA) estimated that there were 565 active tech hubs in 2018, versus 287 in 2016 (Bayen, 2018). In 2015, the World Bank counted 117 tech hubs in Africa (Kelly *et al.*, 2016). The GSMA, which uses a slightly broader definition of tech hubs than the World Bank by adding coworking spaces, estimated the number of tech hubs spread across at least 26 economies at 314 in 2016, 442 in 2018 and 618 in 2019 (Giuliani and Ajadi, 2019).

(iii) *New approaches to foster digital innovation and address digital challenges*

While well-established government policy tools are commonly used to promote innovation and the digital transformation, as shown in the previous section, the specific features of the digital economy have led numerous governments to broaden their toolboxes. With data becoming a central element of today's economy, and with transformation in the digital economy happening at a much faster pace than innovation in the traditional economy (see Section B.2(e)), traditional instruments no longer suffice. New approaches have

emerged to give companies the space to innovate outside of traditional regulatory frameworks. The growing importance of data in economic activities is also leading an increasing number of governments to put in place data-related regulations to address policy issues raised by the digital economy.

New regulatory approaches to promote digital innovation

The speed of digital innovation is pushing regulatory boundaries. In order to give high-tech companies the breathing space they need to innovate and to improve the regulator's understanding of digital developments, a growing number of jurisdictions are developing new regulatory tools.

These can take the form of a dedicated point of contact for firms to raise enquiries with public authorities on regulatory requirements and to seek non-binding guidance on the conformity of innovative products or business models with regulatory requirements. Such points are sometimes referred to as innovation hubs or innovation offices (WTO, 2019a). They help to educate innovators on the regulatory environment in which they operate but

also to improve the regulator's understanding of the sector. Innovation offices are often the first approach to improve regulator-innovator dialogue and are a good first option for resource-constrained regulators in emerging and developing economies, since they are easier to implement and operate than other regulatory initiatives.

Regulatory sandboxes are another new regulatory tool used by policy makers to stimulate business innovation. First tested in the financial technology (fintech) industry,²⁷ regulatory sandboxes create an environment whereby businesses can draw on the expertise and advice of a regulator and test their products under less stringent regulatory requirements resulting in lower compliance costs, thereby promoting the inclusion of new and small firms which often have limited resources. Regulators generally put in place safeguards to ensure consumer protection, such as disclosure requirements, limitations on the number of clients, and compliance handling mechanisms.

Regulatory sandboxes are now used to promote innovation beyond the fintech sector. The United Kingdom Information Commissioner, for example, established in 2019 a regulatory sandbox for businesses relying on personal data, such as businesses that use biometrics to speed up airport passenger journey (ICO, 2019). Governments also use regulatory sandboxes to foster the deployment of products based on advanced technologies. Brazil, the Isle of Man, Lithuania, Mauritius and Turkey, for example, recently set up regulatory sandboxes for blockchain innovation.

Cross-border regulatory sandboxes have also emerged to allow foreign investors to interact with domestic regulators and to test their products across more than one jurisdiction. Most of these cross-border regulatory sandboxes have thus far been concentrated in the fintech industry. Since the establishment of the UK-Singapore FinTech Bridge in 2016, 63 bilateral cooperation fintech agreements have been established (KAE, 2020).

Other regulatory approaches aim to foster innovation through data-sharing (Coyle, 2020; European Commission, 2020). In the case of data in the custody or under the control of a public body, several governments have already opened access to government data to promote innovation and government transparency. These open government data initiatives are also included in newly adopted national strategies for advanced technologies. In the context of its Artificial Intelligence Strategy, Mexico, for instance, has created a data sandbox whereby

government data from public administrations are made publicly available.

In the case of data in the custody or under the control of a private company, data-sharing regulatory frameworks are scarce, but exist. In some cases, governments act as facilitators, enabling data-sharing between firms. For instance, in the context of its data strategy, the European Commission intends to fund the establishment of EU-wide interoperable data spaces in strategic sectors such as manufacturing, agriculture, health and mobility, with a view to encouraging data-sharing between companies (European Commission, 2020). In other cases, governments act as regulators, requiring data-sharing between firms. For instance, several governments, such as Brazil, Sri Lanka and the United Kingdom, have already introduced or plan to introduce an open banking framework for the standardized and secure exchange of data between banks and reliable third-party providers, including new entrants such as fintechs (Banco Central do Brasil, 2019; Central Bank of Sri Lanka, 2020). Some governments, like France and Germany, are also discussing sharing corporate data on public interest grounds in the context of their national AI development strategy (Struett, 2020).

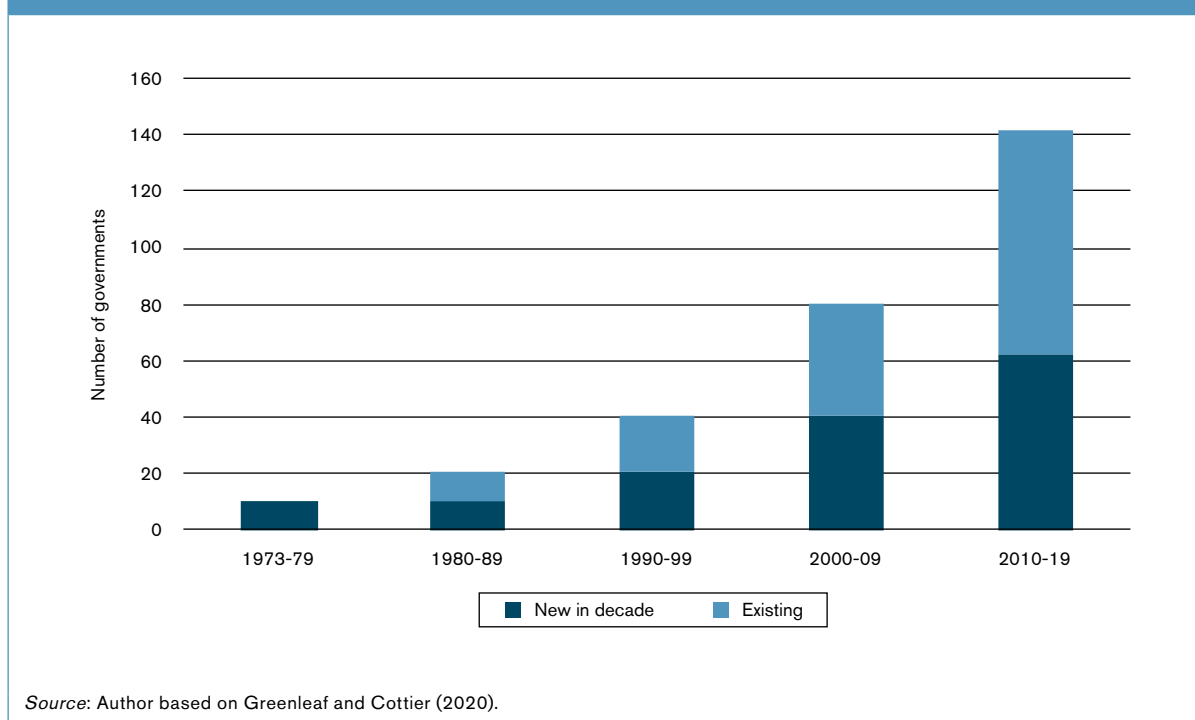
Regulatory approaches used to address digital challenges

As data have increasingly become an integral part of innovation, data-related policy issues are turning out to be even more prevalent. While some data-related policies are motivated by concerns about privacy and security, others seem to be more closely linked to industrial policy objectives. Data generation, collection, storage, capture and analysis by private firms have triggered concerns both for individuals and governments and led a growing number of jurisdictions to pass new regulations to address data-related policy issues such as data privacy, consumer protection and national security. Privacy considerations, for instance, have led an increasing number of governments to pass personal data protection laws and regulations, particularly in the 2000s (see Figure B.31).

Some of these data regulations govern cross-border data flows. Restrictions to data flow across borders have been a major policy tool used by governments.

Casalini and López-González (2019) categorize regulations governing cross-border data flows into four illustrative categories. The first type of approach relates to the absence of any regulation on data flows. The second type of approach – free flows of data – identifies regulations that do not prohibit the

Figure B.31: A growing number of governments have introduced privacy laws and regulations



cross-border transfer of data or require any specific conditions to be fulfilled in order to move data across borders, but it provides for accountability after the fact if data sent abroad are misused. The third features a flow of data conditional on safeguards. These safeguards often rely on the notion of adequacy or equivalence as a condition, whereby the data exporter or a public body evaluates whether the recipient entity provides an equivalent or adequate level of data protection. Another type of safeguard allows firms to include standard contractual clauses or binding corporate rules in their individual data-sharing contracts, thereby providing firms with accountability. A fourth approach makes data flows conditional on authorizations received as necessary from a relevant authority. That is, for data to be transferred to a country that has not been granted adequacy, the sender must fulfil the standard conditions and ensure that data, when it is processed, is treated in the same way as it would be in the sending country. Different approaches may be applied to different kinds of data, even within the same jurisdiction. Their impact also depends on the level of transparency, efficiency and non-discriminatory treatment in their application and related decision-making processes.

Based on this categorization, the OECD finds that there are more than 200 data regulations affecting cross-border data flows (see Figure B.32).

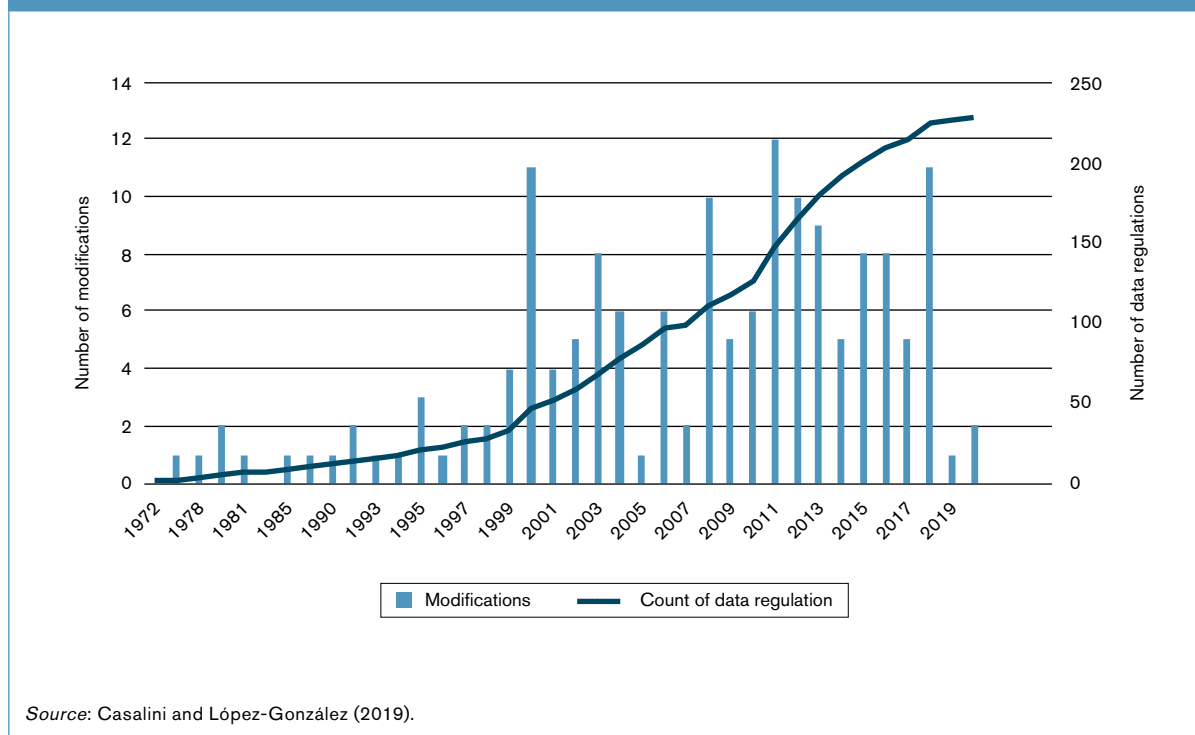
According to Ferracane (2017), 87 cross-border data flow restrictions, among which 50 data localization requirements, were in force across 64 economies in 2017. These data policies were introduced mainly as of the 2000s. Governments more frequently impose conditions on cross-border data flows rather than full prohibition, and data localization requirements are often mandatory (Ferracane, 2017).

Overall, out of the 64 countries studied, data localization requirements account for 58 per cent of data flow policies, and regulations imposing conditions on cross-border data flows for 42 per cent (see Figure B.33). Cross-border data flow restrictions often target personal data used in different sectors, and therefore are more likely to be applied horizontally across sectors. Data localization requirements are more often sector-specific, and often target the financial sector, the public sector, telecoms services, gambling services, healthcare services or maps services (Ferracane, 2017).

Lastly, the digital economy raises new challenges for fiscal policies. One of the most significant challenges is whether and how governments can tax cross-border supplies of digital products that are increasingly delivered remotely so that domestic companies can be on an equal footing with foreign digital product suppliers. Another challenge is the growing number of global businesses without

Figure B.32: Data regulations have become more popular since the 2000s

Evolution of data laws and regulations affecting cross-border data flows, 1972- 2018



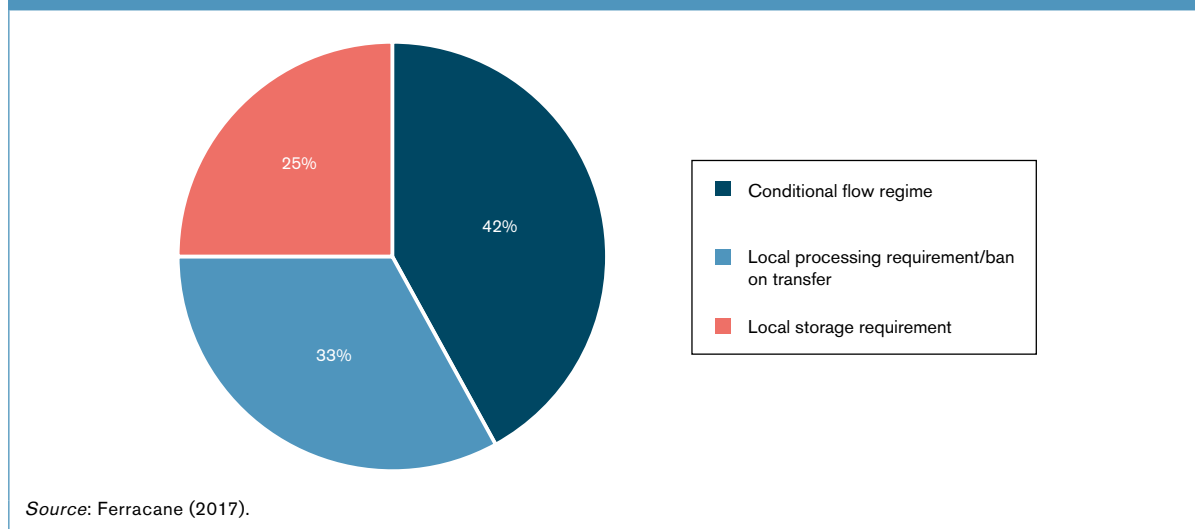
physical representation, which raises questions about which jurisdictions would subject them to taxes. A third challenge is the substitution of digital products for previously physical products (e.g. CDs and music streaming platforms). As discussed in section D, the concerns about a loss of customs revenue has triggered a debate about whether to

extend the WTO moratorium not to impose customs duties on electronic transmissions.

In response to these challenges, governments have modernized their fiscal policies. Regarding the first challenge about taxation of foreign-supplied digital products, governments across the world are rapidly

Figure B.33: Most restrictions take the form of data localization requirements

Type of restrictions to data flows across borders in 64 countries (1960-2017)



extending their existing domestic value-added taxes/general sales taxes (VAT/GST). According to Musgrove (2020), 27 developing economies and nine developed economies (counting the European Union as one) and three LDCs now tax remote sales of digital products based on where the customer resides. In some cases, this means that non-resident businesses have to collect and register for VAT with a local tax agent for making sales to end-consumers. In other cases, tax registration is required above a particular value threshold. Likewise, in order to level the playing field, a few governments have determined that foreign video-on-demand operators should be subject to an audiovisual tax in the same way as local operators. According to the tariff policies of the International Telecommunication Union (ITU), three developed economies (counting the European Union as one), six developing economies and four LDCs have extended their domestic audiovisual taxes to foreign video-on-demand operators (ITU, 2019).

4. Conclusions

This section analysed the broad trends of government policies aimed at boosting innovation, technological upgrading and long-term growth. They have, over time, included a mix of “vertical” policies, meant to support production in a particular sector, and “horizontal” measures, which aim to improve the business, cost, legal and infrastructural environment in which economic actors operate, and to support cross-sectoral economic development across all sectors.

Several features of the digital economy underline the evolution of these policies in the digital age. As data become an essential input in the digital value chain, firms in the digital economy rely less on physical assets and more on intangible assets. This also makes firms much more scalable, allowing them to reach global markets; this scalability is also a factor in the dominance

of certain market players in the digital sector. As a result of the special features of the digital economy (see Section B.2(e)), government policy also needs to evolve. Data policies are an integral part of innovation and industrial policy, and support in building and upgrading telecommunication infrastructure has become a key priority for many economies. Government policies are also aiming to foster innovation through R&D support and by developing innovation hubs and promoting digital literacy. Government policies need to be broad and agile to keep up with the pace of change, and policies to address market concentration and encourage competition are also an integral part of today's policies.

A close examination based on the WTO Trade Monitoring database complemented by the Global Trade Alert database shows that government policies are widely used to support traditional sectors and to attract investments. A relatively high density of policy tools is applied in the minerals, metals and chemical industries, textiles and clothing, electrical machinery and, to some extent, to the automotive sector. Many support measures are horizontal in nature, not attributed to a specific sector, for example tax holidays for corporate investment; while vertical support measures tend to focus on transport equipment, minerals and metals.

At the same time, an increasing focus has been placed on fostering innovation in the digital sector. Government innovation policies include public funding for R&D, innovation-oriented public procurement, promoting clusters and tech hubs, and new regulatory approaches, such as regulatory sandboxes and data-sharing schemes. While traditional policy instruments such as tariffs are becoming liberalized in the digital sector, there has been an increase in new types of government interventions such as data flow restrictions, data localization requirements and reforms of taxation policy, many of which stem from non-economic considerations.

Endnotes

- 1 <https://www.globaltradealert.org>
- 2 Cherif and Hasanov (2019) made the point that industrial and innovation policies have been intertwined for decades in the emerging economies of Southeast Asia.
- 3 Examples of the narrow definition of industrial policy can be found in Tyson and Zysman (1983): “Industrial policy... means government policy aimed at or motivated by problems within specific sectors” and in Kim and Dobbin (2012): “an industrial policy is a government-sponsored economic growth programme that encourages development of, or investment in, a particular industry. Industrial policies may target local, regional or national development of an industry by any number of means”.
- 4 Such wide definitions are used by Krugman and Obstfeld (1991): “Industrial policy is an attempt by a government to encourage resources to move into particular sectors that the government views as important to future economic growth” and Chang (1994): “Industrial policy is aimed at particular industries, and firms as their components, to achieve the outcomes that are perceived by the state to be efficient for the economy as a whole”.
- 5 For example, the “Making Indonesia 4.0” programme, launched in April 2018, plans to reduce Indonesia’s reliance on the extractive industries and to increase high-value exports. The programme sets forth the following ten national priorities: (1) reforming material flows and enhancing domestic upstream production, such as petrochemicals; (2) redesigning industrial zones; (3) embracing energy sustainability; (4) empowering MSMEs; (5) building a nationwide digital infrastructure; (6) attracting foreign investment; (7) upgrading human capital, notably by redesigning the education curriculum and creating professional talent mobility programmes; (8) establishing innovation ecosystems, notably for R&D; (9) incentivizing technology investment, notably through tax exemption for technology adoption; and (10) optimizing market regulations and policies, in particular through better cross-ministry collaboration.
- 6 Industrial policy instruments are defined broadly as: “tools that governments have at their disposal to implement industrial policies” (UNCTAD, 2016). Given the wide variety of industrial policy objectives, instruments can be fiscal, trade, investment, competition, intellectual property and other related policy tools (Riess and Väililä, 2006). Such instruments can be used either to open or to restrict (import) competition in a sector (e.g. by reducing or increasing tariffs, or by reducing or increasing the list of sectors for foreign direct investment), depending on the industrial policy objective being pursued.
- 7 See <https://dnh.com.my/budget2020-key-highlights-impacting-the-start-up-ecosystem-in-malaysia/#:~:text=The%20Modified%20Nexus%20Approach%20will,2020%20to%2031%20December%202022>.
- 8 According to the OECD (Ubaldi, 2013), open government data is a philosophy – and increasingly a set of policies – that promotes transparency, accountability and value creation by making government data available to all. By making their datasets available, public institutions become more transparent and accountable to citizens.
- 9 ICT goods include electronic components, loaded printed circuits boards, computers, telecommunications equipment, consumer electronics, and magnetic and optical media. ICT services include the development, wholesaling and repair of computers, computer equipment and software, telecommunications, data processing, web portals, hosting and related activities.
- 10 See <https://www.wipo.int/treaties/en/registration/pct/> for more information.
- 11 For example, in data centres and search engines, the initial investments in server farms, cooling systems and secure sites, as well as the cost of developing new software and applications, are high, but the costs rapidly decrease with scale.
- 12 The term “born globals” was first coined in a report by McKinsey (Rennie, 1993) to describe enterprises that are able to quickly and successfully engage in foreign exports. Born globals are characterized by an ability to overcome the initial barriers that are associated with entry into foreign markets without first establishing a strong home market presence. For example, in 2015, the Swedish government published an export strategy that specifically emphasized the importance of encouraging born global firms (Ferguson, Henrekson and Johannesson, 2019).
- 13 It is noteworthy that these shorter cycles of innovation do not necessarily imply progress at greater speed, as these innovations are also more incremental than before. For example, software updates can occur almost daily, with technical glitches quickly being resolved.
- 14 Trade remedies are counted based on the number of partners (e.g. a trade remedy that applies to two partners is counted twice).
- 15 Information on support measures is not available after 2016.
- 16 As highlighted in members’ discussions about the WTO trade monitoring reports, some trade remedy measures are taken to address what is perceived by some as a market distortion resulting from trade practices of entities in another trading partner. The WTO Antidumping Agreement and Subsidies and Countervailing Measures Agreement permit WTO members to impose antidumping or countervailing duties to offset what a member must prove to be injurious dumping or subsidization of products exported from another member to it. The trade monitoring reports cannot establish if, where or when such perceived distortive practices have taken place. Neither trade monitoring reports nor this report categorize the use of trade remedies as protectionist or WTO-inconsistent, nor do they criticize governments for using them. The main objective of monitoring these measures is to provide added transparency and to identify emerging trends in the application of trade policy measures.
- 17 Of the 153 quantitative restriction measures analysed, only five were implemented by LDCs.
- 18 Of the 43 different economies with quantitative restrictions, four (less than 10 per cent) were developed economies. In addition, very few measures were applied by LDCs (17 out of 354 measures analysed).

- 19 The Global Trade Alert classifies as “local content measures” all government interventions implying local sourcing, local operations, local labour and localization incentives.
- 20 The most recent Global Trade Alert data (as of July 2020) indicate that developing economies are using more financial support measures. This increase is due to the integration into the Global Trade Alert database of a substantial number of measures attributed to one big economy, as part of a specific research project for this country. No equivalent update was provided for other countries.
- 21 Economies are more and more concerned that citizens’ personal information could be targeted by malicious entities with detrimental personal and economic impacts. To try to ensure that this type of information remains secure, some economies are implementing measures to require that personal data remain physically within an economy or within the hands of nationals. One example includes the US Foreign Investment Risk Review Modernization Act of 2018, which requires foreign direct investment screening if the sensitive personal information of US citizens is involved (UNCTAD, 2019a).
- 22 Of these 51 economies, 28 are members of the European Union, 22 are non-EU members, and the remaining economy is the European Union itself.
- 23 ITA products cover a subset of ICT products.
- 24 Australia, Austria, Belgium, Brazil, Bulgaria, Canada, China, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, India, Ireland, Italy, Japan, Republic of Korea, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Russian Federation, Slovakia, Slovenia, Spain, Sweden, Switzerland, Chinese Taipei, United Kingdom and United States.
- 25 The dataset encompasses 37 developed economies – including individual EU member states, plus the European Union as a separate entity, as some measures are specific to the European Union – and 28 developing economies.
- 26 See, for example American National Standards Institute (2018).
- 27 The first regulatory sandbox, the UK Financial Conduct Authority (FCA), was established for the financial services market in the United Kingdom in 2016. Since 2016, around 40 fintech regulatory sandboxes have been established worldwide (Shearman & Sterling, 2019).

C

Innovation policy, trade and the digital challenge

This section focuses on innovation policy and discusses its economic rationales and impact on innovation. For innovation to take place, new knowledge has to be created through investment in research and it then diffuses through the education system or publications, patents and interchange of ideas. When firms or governments instigate technological progress by using this knowledge, or its embodiments via inventions, to change processes, behaviours or technologies, economic growth may be affected, depending on a number of variables. Within any country, the diffusion of new technology depends on institutions, the level of economic openness and investment in education and research.



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Some key facts and findings

- Several market failures in innovative activity, such as coordination failures across industries, provide economic rationales for government intervention.
- Some of the characteristics of digital innovations, such as the fact that they can be applied in a wide range of sectors or that they become more valuable the more they are used, make a strong case for orienting government policy toward digital innovation.
- Innovation policies have the potential to enlarge market size, increase the degree of competition in the product market, increase the productivity of research and development and improve the capability of firms to benefit from it.
- Trade, foreign investment, migration and data policies shape incentives for companies to innovate by affecting market size and competition. They also allow domestic firms to access foreign technology and know-how.
- Innovation policies have cross-border effects that will increasingly intensify in the digital age. Government policies should be designed to minimize the negative effects without limiting potentially positive spill-overs.

1. Introduction

This section focuses on innovation policy, its economic rationales and how it affects innovation. Section B of this report has argued that, in many countries, a major feature of the rethinking of government policies since the global financial crisis has been the emphasis on innovation, to accelerate the transition into the digital age. As Curtis (2016) puts it,

“the current debate and proposals on updated forms of industrial policy are less about market interventionism and more on technological innovation, productivity gaps, R&D, entrepreneurship, vertical specialization and agglomeration economies”.

The broad definition of “innovation policy” from Section B is also used in this section. It combines the views of innovation policy of Edler *et al.* (2016) as “public intervention to support the generation and diffusion of innovation”, and of the World Bank (2010) as “a set of policy actions in several policy areas [...] constituting a framework for innovation to occur, but also for the innovation to be marketed, and diffusion of the underlying knowledge”. To the extent possible, the focus will be on digital innovation, which, following on from Section B, implies in a narrow sense the implementation of a new or significantly improved digital product, and in a broader sense the use of digital technologies to create a new product, process, marketing method or organizational method, or to improve existing ones (Nepelski, 2019).

For innovation to take place, new knowledge has to be created through investment in research. Once new knowledge is created, it diffuses through the education system or publications, patents and interchange of ideas. New knowledge has the characteristics of a public good: it is non-excludable and non-rival in consumption. Thus, new knowledge can, in principle, be available to anyone.

However, this is not necessarily the case for all new knowledge. Patents, for instance, make new knowledge excludable (although still non-rival in consumption). Furthermore, not all knowledge can be codified. There is an important tacit component of knowledge that is not easy to acquire but is often crucial for transforming the knowledge into new production technology or for follow-up innovation.

Only when firms or governments can use existing ideas (or the inventions into which they are embodied) to change the production process or consumers’ habits, and to improve technologies, can any impact on a country’s economic growth be expected as a result of technological progress. This impact depends

on the speed and extent of the acquisition, learning, adaptation and diffusion of new technology. Firms may not be aware of all the possible technological alternatives available in the market, they may not be able to identify the technology that best suits their need, or they may find it too costly to adapt foreign technologies to their production process. The lack of skills or incompatible managerial practices are also obstacles for technology diffusion and upgrading. At the country level, the diffusion of technology is facilitated by an adequate institutional environment, openness, and investment in education and research.

To develop these ideas in a structured way, this section proposes a taxonomy of the economic rationales (discussed in Section C.2) and of the effects (discussed in sections C.3 and C.4) of innovation policy, with a focus on digital innovation. Table C.1 presents this taxonomy.

(a) Types of market failures in innovative activity which rationalize government intervention

The starting point of the analysis is the discussion of why innovation policy is needed in the first place. Despite the key role of public bodies, like research institutes and universities, innovation largely takes place at the level of the firms, which invest in research and development (R&D) and create new ideas or adopt technologies developed abroad. There are, however, several reasons why governments may need to intervene to foster innovation. Economists explain the need for innovation policies on the basis of market failures that characterize innovative activity. As displayed in the top panel of Table C.1, five types of market failures in innovative activity rationalize government intervention.

First, the outcomes of innovation have the characteristics of public goods (non-excludable and non-rival in consumption). Public goods are supplied in inefficiently low quantities by the market because private returns are lower than social returns. The section discusses various applications of this basic insight, including the issue of the appropriability of returns from innovation, the public good nature of data, and the public good nature of digital innovation in the current COVID-19-related health crisis.

Second, some technologies find important applications and instigate further technical change in a wide range of sectors, if not all. The introduction and adoption of these general-purpose technologies (GPTs) is subject to a series of market failures: positive externalities (whereby the production and

Table C.1: Taxonomy of the economic rationales and effects of innovation policy	
1. Types of market failures in innovative activity which rationalize government intervention	Examples in the digital age
Public good aspects of technology	Imperfect appropriability of returns from digital innovation. Public good nature of data.
Economy-wide spill-overs of general-purpose technology (GPT)	Externalities created by new digital technologies in industries connected by upstream-downstream relationships.
Financial frictions	Start-ups tend to face excessively costly external finance, although financial frictions may be less relevant in the digital economy than in the traditional economy.
Coordination failures	Digital products and services are complex sectors, and the innovation process is more collaborative than in the past, calling for increasing partnership between traditional industry, digital technology or other service providers and research institutions.
Network externalities, technology lock-in and "winner-takes-all" dynamics	Some digital products generate value when consumed together with other users, and the market fails to deliver the efficient network size. The combination of Big Data and machine-learning creates large rents, strengthens leaders' dominance and deters further market entry.
2. Types of policies affecting innovation based on the factors they target	
Policies affecting market size	Increased access to foreign markets can induce firms to increase spending on computers and software.
Policies affecting the incentives to invest in R&D	A larger supply of highly skilled immigrants increases innovation outcomes (i.e. patents) in ICT sectors.
Policies affecting the appropriability of research results	Intellectual property protection aimed at keeping open source software non-excludable allows high quality open source contributions to be widely adopted in a short time span.
Policies affecting product market structure	Wireline speeds are often higher in markets with two or more wireline internet service providers (ISPs) than with a single wireline ISP.
3. Cross-border spill-overs of innovation policy	
Knowledge spill-overs and technology diffusion	Digital innovations in one country can benefit the innovation activity of all other countries since they increase the global stock of knowledge.
Strategic government policy	In imperfectly competitive digital markets, policies can shift rents or profit from a producer in one country to a producer in another.
Competition for scarce resources	Tax incentives to attract headquarters of digital companies have "beggar-thy-neighbour" effects.
Supply and demand effects	Local content requirements for smartphones apps reduce the demand for foreign apps and can harm foreign producers.
Inter-industry linkages	Downstream digitally enabled industries across the world can benefit from productivity gains in upstream supplying industries like IT or electronic equipment due to innovation policy in one country.

Source: Authors.

consumption of these technologies benefits a third party not directly involved in the market transaction) leading to their under-provision; coordination failures across industries connected by an upstream-downstream relationship; and some public good aspects of infrastructural GPTs. This section shows that digital technologies are indeed GPTs, and that the above-mentioned market failures provide economic rationales for government intervention.

Third, innovative activity is characterized by asymmetric information (i.e. an information gap) between the potential innovator and the potential financier. Consequently, an innovative entrepreneur may not have access to the required sources of finance (funding gap). Because of these financial frictions, R&D investment will be underfunded, and government financing of innovation may be justified on these grounds. This section argues that although the

problem may be less relevant than in the traditional economy, it still exists in the digital economy.

Fourth, complex activities like innovation are subject to coordination failures among stakeholders. It may not be possible to attain a more desirable economic equilibrium if stakeholders do not coordinate their decision-making. Government action in this regard may be justified by the need to coordinate the different parties involved in the innovation process, ensuring that all the required complementary advances have been developed and are available in the market. For instance, to support the economic development of digital economy, the government may need to intervene to coordinate the co-financing of communication infrastructures.

Fifth, in situations where the value of a network increases with additional users (which are defined as network effects or, equivalently, network externalities – see Katz and Shapiro, 1985), governments may want to intervene because there is a gap between the private and the social value of joining the network, which leads to inefficiently small networks. Government intervention may further be warranted to address the risk of anti-competitive behaviour by “winners” that take the whole market and dynamic inefficiencies in networks where, because of government-mandated or *de facto* standardization, a single technology dominates the whole market.

These rationales for government intervention are even more relevant in digital markets, where the combination of Big Data and machine-learning magnifies “winner-takes-all” dynamics creating large rents, i.e. revenues exceeding total costs including the opportunity cost (or normal profit) (McConnell and Brue, 2005). These rents strengthen leaders’ dominance and deter further market entry, thus hindering innovation.

(b) Types of policies affecting innovation based on the factors they target

The existence of a market failure justifies government intervention. However, there is no guarantee that such intervention will succeed in delivering better outcomes, because designing appropriate innovation policies is difficult (Bloom, Van Reenen and Williams, 2019). The effectiveness of innovation policies is therefore an empirical question, which is tackled in Section C.3. As shown in Section B, the toolkit of policies to promote innovation is vast, because there are many factors that affect the innovation activity in the economy. The central panel of Table C.1 categorizes policies affecting innovation based on the factors they target.

First, a firm's decision to invest in R&D is affected by market size. When the market is large, firms have a greater incentive to innovate as their potential profits are larger. Increased access to foreign markets and government procurement in innovative sectors or activities, by enlarging the size of the market, can provide additional incentives for firms to invest in R&D and innovate.

Second, higher productivity of R&D also increases the incentives to invest in R&D. Several of the policies discussed in this section are likely to spur innovation through their impact on R&D productivity. These include: government tax incentives and R&D grants; policies favouring the supply of the type of human capital, both native and foreign-born, that is, those most involved in innovative activities, such as science, technology, engineering and mathematics (STEM) graduates; policies that favour the agglomeration of innovative activity, and more broadly all policies that allow inventors to benefit from research produced by others via knowledge spill-overs, such as interactions with foreign buyers and suppliers, global R&D networks, business travel and open data flows; and horizontal policies that create an innovation-friendly environment, such as the creation and maintenance of high-speed broadband.

Third, appropriability of research results is important. The extent to which firms can benefit from the reward of the results of their research determines their willingness to invest in R&D. This dimension is determined by two aspects: the nature of innovation (if it can be easily imitated/upgraded by competitors or not) and the degree of legal protection granted to the innovation through the intellectual property (IP) system. This latter aspect is clearly determined by policy choices.

Fourth, product market structure matters. The degree of competition in the product market affects the potential benefits of R&D investment because it determines the level of profits and the likelihood of displacing competitors. Trade policy and how it affects foreign firms’ access to domestic markets is one of the factors that shapes the competitive environment. Another factor is the regulation of competition.

The five rationales for innovation policy in the top panel of Table C.1 are related to the four types of policies in the central panel of Table C.1. The public good nature of knowledge, the GPT nature of some technologies, financial frictions, coordination failures and network externalities lead to under-provision of innovation relative to socially optimal levels. Innovation policies that enlarge market size, increase the productivity of R&D, and ensure the appropriability of

research investments, by filling, or reducing, the gap between the social and private returns to innovation, increase innovation investment above the inefficiently low levels delivered by the market.

In the presence of network externalities, there are incentives for firms that have managed to capture large shares of the market (the “winners”) to engage in anti-competitive behaviour in order to keep their dominant position.¹ This also entails the risk of technology lock-ins (see Section C.2(e)), a dynamic inefficiency because technologies that have become obsolete over time might still be in place. Policies that ensure that markets are contestable, and policies that regulate the abuse of dominant position, address these issues.

(c) Cross-border spill-overs of innovation policy

Innovation policies can, and do, have an impact on other countries. These spill-over effects, which can be positive or negative, are partly based on the same factors that provide an economic rationale for innovation policy, ranging from knowledge spill-overs to inter-industry linkages, but there are also additional externalities such as competition for scarce resources. The bottom panel of Table C.1 displays the cross-border spill-overs of innovation policy that are discussed in Section C.4.

First, knowledge spill-overs and technology diffusion across borders imply that innovation in one country can benefit the innovation activity of all other countries, since it increases the global stock of knowledge.

Second, in imperfectly competitive markets different policy tools, while affecting innovation, can shift rents from a producer in one country to a producer in another. That is, innovation policy can act as strategic trade policy.

Third, innovation policy (in the form of tax competition) that attracts scarce factors of production such as “superstar” investors, or that imposes localization requirements on data, or that offers tax incentives to attract company headquarters, is likely to harm other economies by reducing their capacity to invest in R&D.

Fourth, supply and demand effects can also lead to cross-border spill-overs. If innovation policy in a large country increases the competitiveness of domestic producers on world markets, world prices may decrease. This benefits foreign consumers while harming foreign producers. If innovation policy raises aggregate productivity in a large country, its import demand increases, and so do world prices. This

benefits foreign producers while harming foreign consumers.

Fifth, cross-border inter-industry linkages (i.e. global value chains (GVCs)) can magnify the cross-border effects of innovation policies. Innovation in upstream (downstream) industries can benefit or harm foreign downstream (upstream) industries, depending on their effects on the price and availability of inputs.

It should be noted that different innovation policies may imply different cross-border spill-overs. When spill-overs are both positive and negative, for instance when a policy creates knowledge spill-overs but attracts scarce resources to the innovation production function, what matters is the net effect of such spill-overs.

This is especially the case in the digital age, in which, as argued in Section C.4, both positive and negative cross-border spill-overs are likely to intensify. An a priori determination of whether innovation policy in one country benefits or harms other countries' welfare is therefore inherently difficult.

2. The rationale for innovation policy in the digital era

Section B has shown that government policies have shifted to support the digital economy. These policies take various forms, including direct R&D incentives, infrastructural investments to support digital connectivity and data-sharing regulations to balance the need for data and the protection of privacy.

Section C.2 focuses on the rationale for innovation policies, pointing to what is new in the digital era. In so doing, it refers to a broad concept of innovation that includes not only policies that may help with invention, but also policies that may foster the diffusion of innovation.

While recognizing the key role that firms play in innovation, economists identify a number of reasons why governments may need to intervene to foster innovation. Firms invest in R&D and create new ideas or adopt technologies developed abroad. Firms operating in the digital technology field were among those with higher R&D investments in 2017 (Hernández *et al.*, 2019), confirming that research is a factor in being and remaining innovative. Yet, investments in innovation in some circumstances may be suboptimal if left only to market forces.

Economists explain the need for innovation policies on the ground of market failures. These can be due to

externalities, asymmetric information or coordination failures.

Markets can fail and generate too little innovation because new ideas, new products or new technologies in a particular sector can be used by firms in that sector to create other ideas or can be used by firms in other sectors (that is, there are externalities of innovation), but with the innovator not basing decisions to invest in research on economy-wide benefits. Without government intervention, the innovator might therefore invest too little compared to the socially optimal level of investment (i.e. the level of investment that would be made if its economy-wide benefits were taken into account).

Innovators may also invest too little because they do not manage to raise adequate funding from financial institutions (financial frictions and asymmetries of information between the innovator and the financial institution can be the root cause of this problem) or because they need other technologies or infrastructure in place for their investment to generate adequate returns (coordination failure).

Finally, governments may need to intervene to prevent innovators from gaining excessive power and creating obstacles to the entry of new firms into the market (this is the case of network externalities and winner-takes-all dynamics). Section C.2 discusses each of the rationales for government intervention in the light of the characteristics of digital technologies.

A key message of Section C.2 is that some of the rationales for innovation policies are particularly relevant in the case of digital innovations. This is because:

- Big Data, a key input in digital technology innovation, present public good characteristics;
- digital technologies are GPTs and generate large benefits across the whole economy;
- digital products are complex and suffer from coordination failures;
- network effects may induce anti-competitive behaviour and deter innovation;
- network effects may require standards to be set for the market to have the sufficient size to deploy the innovation;
- large rents (revenues) may represent an incentive for strategic competition between countries; and
- the adoption of digital technologies may deliver public policy objectives.

In light of the above, digital innovation policies are likely to take several forms, such as R&D subsidies, competition policy, IP regulation, data policies and standards-setting.

(a) The public good nature of creating and using digital technologies

(i) *The issue of appropriation of returns from digital innovation*

One argument often used to justify government's subsidies for firms' R&D or the strengthening of the intellectual property rights (IPR) regime to protect profits stemming from innovation is that innovation creates knowledge. Knowledge has an important public good component: it is non-rival and non-excludable. When a scientific discovery is published, everyone can access the information and eventually use it to create new knowledge. This creates a wedge between private returns and social returns to innovation. The latter are larger because better knowledge increases long-run economic growth.

Thus, there is too little investment in R&D relative to the socially optimal level. Some economists estimate social rates of return to R&D between 30 and 50 per cent compared to private returns of between 7 and 15 per cent (Hall *et al.* 2010). If left to the market alone, public goods are underprovided by private actors, therefore public intervention is economically justified.

Knowledge created by digital innovation is no different from knowledge created in the traditional economy, with the creation of a new product or process. When the patent relevant to a new artificial intelligence (AI) device is filed, its knowledge is codified, public and can be used as an input for other innovations. Knowledge diffusion is key to fostering growth, but it reduces private returns for R&D investments. This problem for innovators is similar to that of pioneer entrepreneurs in developing countries who adapt a foreign digital innovation to the local market (see Box C.1).

However, as for the traditional economy, not all knowledge generated in the digital economy is codified. There is an important tacit component of knowledge (i.e. knowledge that cannot be codified in a patent, say) that is not easy to acquire. After the first innovation there is a process of improvement of the original idea developed through the interaction between the innovating firms, consumers and suppliers. This is essential in order to move from the new idea to the know-how of how to develop a new product or implement a new process innovation. This requires capabilities that are not easy to appropriate (Dodgson, 2017). Intergenerational differences in the ability to use new technologies show

Box C.1: Self-discovery and the pioneer entrepreneur in developing countries

Although the diffusion of knowledge created by an innovation is key to fostering economic growth, it reduces the returns for the original innovators. A similar problem is faced by pioneer entrepreneurs in developing countries who discover that an existing foreign technology can be utilized profitably at home. There are large social benefits associated with “self-discovery”, i.e. the process through which a less-developed economy initially specialized in traditional activities discovers, as a result of adapting foreign technology to local production, the set of modern activities in which it has comparative advantage (Hausmann and Rodrik, 2003). This is because the knowledge acquired by the pioneer entrepreneur can orient the investments of other entrepreneurs – in other words, other entrepreneurs can quickly emulate the discovery.

The initial entrepreneur who makes the discovery, however, can capture only a small part of the social value that this knowledge generates. Adapting new technologies to local conditions, especially in developing countries, is costly. As with any new invention, the first entrepreneur who adapts a new technology to local conditions may not be able to capture all the benefits because the technology may diffuse to his/her competitors. In the economy, there will thus be too little self-discovery, and consequently too little diversification into modern activities. However, policies that reduce the wedge between private and social benefits of self-discovery will increase this type of diversification and increase national welfare.

In their review of technology transfer, Evenson and Westphal (1995, p. 2261) describe the case of rice-threshing technology:

“... the key activity enabling Philippine rice producers to benefit from rice threshing technology developed in Japan was the adaptive invention of a prototype thresher at IRRI [the International Rice Research Institute]. Using this prototype, local inventors made the specific adaptations required to enable the economic use of threshers in the many different circumstances in which they are now used in the Philippines”.

Hausmann and Rodrik (2003) argue that the key to this success was the fact that IRRI is a non-profit, public entity. As a private producer, it would have been unable to appropriate much of the social returns due to the rapid entry of imitators.

It is hard to say to what extent this argument applies to digital technologies. When a foreign digital technology (an application used for car-sharing, for example) is adapted to local conditions by the local pioneer entrepreneur who discovers that the idea has a market in the domestic economy, the idea can easily be imitated. The fact that the returns on the innovation cannot be fully appropriated by the pioneer can prevent firms from investing in innovation, thus slowing the process of modernization. As argued by Hausmann and Rodrik (2003), the policy issue here is that, while in general, governments may have legal frameworks to protect the rights of innovators, they do not have in place similar regimes for self-discoverers. Yet, as discussed for open sources and music streaming, there are solutions that digital markets have devised.

that capabilities are not necessarily simple to acquire in the context of digital technologies. Tacit knowledge is a way in which an innovator retains some of the returns to innovation. However, typically, it is not a solution to the problem of under-provision of innovation.

In some cases, markets appear to have found some solutions to the issue of the appropriation of returns from digital innovation. For example, music streaming, like a typical public good, is non-rival (since one person listening to the music does not prevent another person from listening to the same music) and non-excludable (since, once a certain piece of

music is put online, it is difficult to stop someone from listening to that piece). Innovators' inability to appropriate the profits generated by the new musical creation would typically imply that the service is under-provided (too few new songs go on streaming) and call for public intervention. However, the industry has found solutions: it collects revenue by selling advertising (which is an indirect way of charging listeners by taking up some of their time) or by charging a subscription for streaming music without commercials (in this case technology, through digital rights management tools, has helped to make the product excludable).

The development of open-source economics, of which software is the principal example, is another case of digital innovation that, although being a public good, has evolved without public intervention. The network environment, within which developers of open source software operate, makes it possible to organize production in a decentralized manner among individuals who cooperate with each other and share resources and outputs, without working for the same organization. At the level of the individual, the incentives to develop open-source software may stem from altruistic reasons or be related to leisure activity (some contribute to open-source projects simply because they enjoy it). But there can be also economic factors, such as improving a person's reputation with a view to obtaining access to a better job or capital. A company can also have an incentive to develop open source software in order to attract talented human resources.

(ii) The public good nature of data

In the case of digital technologies, inefficiencies generated by the public good nature of data (a key input in digital innovation) can take the form of insufficient data collection, processing and sharing. Consider the case of a private company developing an algorithm to help diagnose COVID-19. The algorithm can be trained using information from patients with COVID-19 symptoms and comparing it with the pathology reports and outcomes of diagnosed patients. The company can buy and exclusively use information collected by hospitals from all patients in its network to train the algorithm. The hospital will collect data, pay the software company and provide a better service to its patients. But the service provided to patients would be clearly inferior to one generated by a situation where many companies around the world compete to develop algorithms to analyse freely available information from all patients in the country or in the world. The software based on larger samples could help doctors everywhere better treat patients and save lives.

The current COVID-19 crisis has highlighted the importance of rapidity and openness in data and research results. One key lesson from the crisis is that data-sharing helps the advancement of science. The problem is that when data are public, gains for a single company to develop an algorithm may not be sufficient to generate the broad use that is beneficial to society, because other companies may provide the same software at a cheaper price. This reduces the incentives to collect and process data. The issue of data ownership is key. In a recent paper, Jones and Tonetti (2019) argue that consumers' ownership of data can address this problem. Many governments

have outlined data strategies to create an enabling legislative framework for data governance, make available public sector data for all market players, and provide incentives for data collection, processing and sharing across sectors.

These policies need however to also take into account the risks associated with data-sharing. These risks can be intrusion into private lives or the use of technologies for criminal purposes. A number of governments recently associated with a lack of transparency in decision-making, gender-based or other kinds of discrimination, issued regulations to address privacy and security concerns. The European Union, for example, issued the General Data Protection Regulations (GDPR) in 2018 to address data protection and privacy. The US State of California recently passed the California Consumer Privacy Act (CCPA) intended to enhance privacy and consumer protection.

(iii) The social benefits of using digital innovations for innovation policies in the context of COVID-19

There are also non-economic reasons for innovation policies. Governments can invest in new technologies for societal missions, such as to reduce poverty and inequality, improve health, reduce environmental damage or address security considerations. In this case, private actors underinvest in digital innovation, not because the innovation itself has a public good dimension (as discussed in Section C.2(a)), but because digital innovation is instrumental to the provision of a public good or the pursue of a non-economic objective by the government. The use of digital innovation in the health sector during the COVID-19 pandemic is a good example.

The COVID-19 crisis has highlighted the important role that digital technologies can play both in building resilience and in helping to control the spread of the virus. A range of digital innovations have been developed to meet the challenge raised by the pandemic, from drones used for public health messaging to symptom checkers and tracing-and-tracking applications. Digital technologies have been increasingly used by firms and schools to cope with social distancing measures adopted by governments to limit the spread of the virus. Workers and students adapted to telework and online schooling in order to continue production and teaching activities under the lockdown. Telework helped firms to keep producing and to sustain supply chains with significantly positive economic results – the economic downturn is likely to be larger in sectors which did not offer the possibility to work remotely.

Governments have provided incentives for investment in new technologies to allow for teleworking and online schooling, with the twin goals of minimizing the negative effects of social distancing and of reducing the spread of COVID-19 (WTO, 2020c). These policies have responded to the need to address an unexpected and unprecedented shock for which the global economy was not ready.

The pandemic highlights both the great potential of digital innovations and the existing barriers to access and adopt new technologies. As countries adopted lockdown measures to limit the spread of COVID-19, individuals' computer access and digital skills, and the reliability of their internet and electricity services, determined their ability to work remotely, access online education services, and even purchase online medical supplies and home goods (see Box C.2). In some countries, tariffs as high as 35 per cent on computers and 40 per cent on telecommunications devices added to the difficulties for some of easily accessing digital technologies (WTO, 2020c).

The current pandemic has fostered the adoption of new practices. The technology for long-distance interactions and collaborations existed before, but its use was not sufficiently widespread. People continued physically to fly to attend conferences, board meetings and audit committees. The current crisis has offered the opportunity to observe the beneficial effects of teleworking and online schooling on the levels of pollution in the cities and on traffic congestion.

Will these habits be retained in the future? Will there be an increased use of these new technologies, given that their massive use in the current crisis has highlighted their potential in helping to deliver public goods, such as improved public health due to lower levels of urban pollution? Economic theory suggests that, in all these regards, private agents will continue to underinvest in digital technologies, as the investment decisions of private agents do not take into account the impact of their decisions on public goods. In other words, private agents are likely to underinvest in digital technologies for teleworking (even if they now realize that these technologies may help them to build resilience in the case of a shock, such as the COVID-19 crisis) because their investment decisions do not take into account the beneficial effects of teleworking on their firms and on urban traffic, nor the implications on the spread of disease.

(b) Economy-wide spill-overs of general-purpose technology

Economists traditionally justify government intervention to support some industries as "special". This has to do

with the fact that they generate economy-wide, inter-industry benefits, i.e. positive externalities. Technical innovations originating in particular industries find important applications and instigate further technical change in other economic sectors.

In these circumstances, economists show that forcing the economy toward the sector(s) generating positive externalities in the economy might improve welfare. This is because the losses from going against comparative advantage are dominated by the gains associated with the economy-wide externalities generated (Harrison and Rodríguez-Clare, 2010). This is one of the motivations for traditional support for industries such as steel or chemical, grounded in the fact that these industries provide critical inputs for several other industries.²

(i) *Are digital technologies "special"?*

The development of the digital economy is transforming the world economy. Increasing innovation in products and processes linked to digital technologies is making it possible to collect, process, store and diffuse data automatically.

The digital economy is essential for global economic growth not because of its size – it only accounts for 6 to 8 per cent of value-added and at most 4 per cent of employment (IMF, 2018; Warwick and Nolan, 2014) – but because the global economy increasingly depends on digital goods, services and data to make it more productive.

Digital technologies are a form of GPT (Basu and Fernald, 2008). Important examples of GPTs from the past are the steam engine and electricity. GPTs are characterized by a wide range of applicability and substantial spill-overs to the rest of the economy (Jovanovic and Rousseau, 2005).

Like other GPTs, new digital technologies are used by most sectors, i.e. in agriculture, manufacturing and services. In agriculture, for example, machinery producers have started to offer digital agriculture services such as rural data and analytical services to better predict and manage agriculture investment; in the automotive industry, companies are offering digital after-sales services and new digitally managed ownership models (car-sharing). Retailers are investing in data collection and augmented reality to allow the consumer to get a better sense, simply through their mobile phone, of whether a piece of furniture, for example, might fit in their house; transportation services in urban areas increasingly rely on platforms and digital technology providers. All technologies can be applied to sectors from medical to infrastructure services (see figures B.2 and B.5).

Box C.2: Inclusiveness issues in the context of the COVID-19 pandemic

The economic impact of the pandemic is expected to fall especially heavily on least-developed countries (LDCs), micro, small and medium-sized enterprises (MSMEs) and women. This is due to factors such as sectoral specialization, occupational characteristics and financial resources, as well as to inadequate access to digital infrastructure and insufficient IT skills.

The COVID-19 pandemic will severely impact LDCs. The fall in tourism revenues and in remittances from migrant workers from LDCs returning from host countries affected by the pandemic have significantly dried up critical sources of income for many countries (WTO, 2020a).

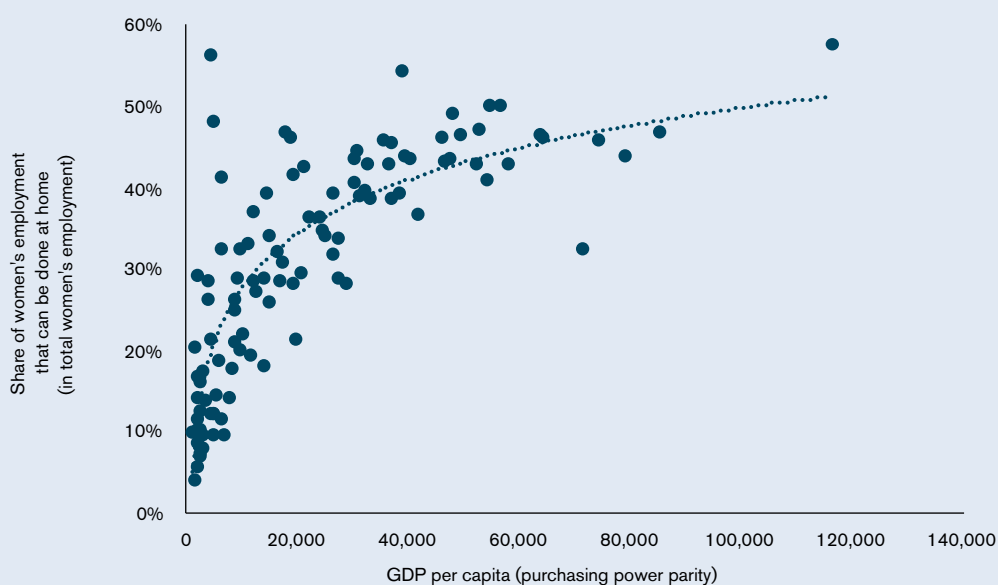
Preliminary evidence also suggests that the impact of the crisis is likely to be harsh for MSMEs. In the United States, firms with less than 50 workers laid off more than 25 per cent of their staff during the lockdown, compared to 15 to 20 per cent of staff being laid off in firms with more than 100 staff (Cajner *et al.*, 2020). In general, MSMEs are overrepresented in the hardest-hit sectors, such as accommodation, food services, and wholesale and retail services (OECD, 2020b) and, due to their financial constraints, they are more vulnerable to lockdown measures (WTO, 2020b).

The COVID-19 recession is also likely to have a harsher impact on women workers and entrepreneurs because the sectors in which they are economically active are among those which have been the worst affected by lockdown and distancing measures (e.g. textiles, apparel, footwear, tourism and business travel services) and because female entrepreneurs tend to own or manage small businesses. In addition, women tend disproportionately to bear household chores and childcare responsibilities that, in many countries, have been exacerbated by school closures (Alon *et al.*, 2020).

Digital tools allow certain jobs to be performed remotely, thus minimizing health risks. However, the jobs that can be performed remotely tend to be better-paying services jobs and tend to exist in a higher share in developed countries, rather than in developing or LDC economies (Dingel and Neiman, 2020). In other words, social distancing places a higher toll on developing countries because they have a higher share of occupations that cannot be done remotely.

Similarly, a large number of women tend to be more occupied in activities that require face-to-face interactions, such as health and retail activities, which prevent them from telecommuting, especially in lower-income countries (see Figure C.1). This is one of the reasons why the COVID-19 pandemic is likely to hit women particularly harshly (WTO, 2020a) – an issue to which regulators should pay attention (Bahri, 2020).

Figure C.1: Women's jobs that can be done remotely increase with the level of income



Source: WTO (2020a).

Box C.2: Inclusiveness issues in the context of the COVID-19 pandemic (continued)

Thus, the digital divide crosses economies, genders and firm sizes. Limited access to digital technologies and lower IT skills rates further reduce teleworking and e-commerce opportunities in LDCs and MSMEs and for women, making them particularly vulnerable in the current crisis. In fact, the adoption of digital technologies is largely concentrated among highly productive firms that can complement digital technologies with good management and digital skills. The difference in adoption rates between more and less efficient firms is particularly pronounced in manufacturing (Andrews, Criscuolo and Gal, 2016; Bajgar *et al.*, 2019).

The main feature of GPTs is that they change the production process of the sectors using the new invention. For example, railroads transformed retailing by allowing nationwide catalogue sales (Chandler, 1977). Similarly, the availability of cheap computers and internet connections has generated complementary innovation in industries using information and communications technology (ICT), if only because they allow resources to be redeployed in a different way.

These complementary inventions in turn further increase demand for ICT. When industries are connected by an upstream-downstream relationship, some coordination is required. When a GPT is an infrastructure, as in the case of the road or the internet, congestion problems may arise. Externalities, coordination failures and the public good nature of the infrastructure of some digital technologies provide economic rationales for government intervention.

(c) Financial frictions in a digital world

Financial frictions, such as those generated by information asymmetry about market conditions, may also inhibit firms from investing in innovation. Not all the actors in an economy have the same information about market conditions. Potential financiers may have less information than inventors, making it more difficult for the financiers to predict the returns from a potential investment in innovative ventures. As a consequence, an innovative entrepreneur may not have access to the required sources of finance, resulting in a funding gap. Because of these financial frictions, R&D investment may be underfunded.

Finance is not neutral. First, private finance tends to be directed toward applied research (i.e. research conducted to solve a specific problem, with, as a commercial objective, a new product or process) rather than basic research (i.e. research conducted with the aim of advancing a particular theory or knowledge). This is because basic scientific research is highly risky, requires large investments, and returns are unlikely to be seen in the short term. Private R&D, which aims to maximize profits in the short term,

tends to be more concentrated on applied areas, neglecting general-purpose research. Yet innovation opportunities are driven by a strong interaction between basic and applied research. To fill this gap, governments invest in research with a broader scope and higher commercialization uncertainty. In the areas of biotech and renewable energy technologies, for example, it has been shown that venture capitalists enter markets many years after governments finance the earlier, higher-risk stages (Mazzucato and Semieniuk, 2016).

Second, finance is biased against MSMEs, especially start-ups, which tend to face excessively costly external finance. Frictions, including information asymmetry, asset intangibility and incomplete contracting, can lead to costly finance and thwart privately profitable investment opportunities (Holmström, 1989; Howell, 2017). Banks do not have enough historical information about the likelihood of a firm to reimburse loans when it is a new firm. The risks associated with an innovative product in the market are hard to identify and foresee in the conditions of a contract. All of this generates higher costs for start-up firms and is likely to reduce their investment in R&D. Yet there is evidence that start-ups play an important role in economic growth.³ To address financial frictions and private finance's bias against new firms, government interventions often reduce the regulatory burden for start-ups, as well as facilitate access to finance for new and young firms (see Section B.3).

In a digital world, MSMEs which sell goods and services have less costly access to global markets. Digital MSMEs need skills, but investment in physical assets is less important in a digital world. Financial friction problems may be less relevant than the traditional economy, but they still exist.

(d) Coordination failures of complex industries

The environment in which firms operate can act either as a resource or as an obstacle for innovation creation and diffusion. A successful innovation cycle and its

impact on the economic performance of a country depends on a number of factors, such as demand for innovation, access to complementary knowledge and financial resources, and on the way these factors interact. Government actions in this regard consist of coordinating the different parties involved in the innovation process, ensuring that all the required complementary advances have been developed and are available in the market.

Complex industries – i.e. those that require more coordination among economic agents, according to Harrison and Rodriguez-Clare (2010) – are more subject to coordination failures. Such failures occur when a group of firms could achieve a more desirable economic equilibrium but fails to do so because the firms do not coordinate their decision-making. For example, private agents that want to develop hotels and restaurants in a particular location need each other in order to flourish, as well as a good transportation system to bring in tourists and supplies from different locations. Without coordination among all relevant actors, an attractive tourist site might not be properly developed, and the necessary infrastructure may not be provided. In order to launch the economic development of such an area and foster related tourism industries, the government may need to intervene to coordinate the co-financing of jointly required infrastructure by both groups of investors and offer its own contribution, given the public goods nature of roads and other transport-related investments.

Digital products and services are complex sectors, and the innovation process is more collaborative than in the past (Paunov and Planes-Satorra, 2019). Given the fast development of digital technologies, collaboration allows firms to gain access to a larger pool of expertise and skills, and to solve the skill gap. Beyond the traditional engagements, new forms of collaboration have been born to answer to the new needs of the digital age. Incubators or accelerators (see Section B for an explanation of these terms), generally used by firms to engage with start-ups, have come to be more oriented toward more innovative and technological activity. Walmart's Store N°8 is an example of a start-up incubator which aims to identify digital innovation in the retail sectors, offering virtual and augmented reality or drone product delivery.

The growing importance of services value-added and the role of digital technologies call for increasing partnerships between traditional industry, digital technology or other service providers and research institutions. In the automotive sector, for example, car manufacturers are collaborating with technology companies to improve their design processes and to develop autonomous cars (e.g. Toyota and Ford

collaborate with Microsoft). In the retail industry, partnerships aim to create digitally connected stores or to develop voice-enabled shopping (e.g. Walmart and Google). There are also new forms of collaboration, such as crowdsourcing platforms, which are used by firms to search for ideas from outside those firms' cultures, to gain access to many skills and to reduce the time needed to find solutions. Generally, firms present their challenges online and different innovators present their proposals in response; the selected solution is then adopted by the firm. An intermediary platform which organizes the online competition is often used by these firms.

In order to support the economic development of digital economy, the government may need to intervene to coordinate the co-financing of communication infrastructures, given their public good character.

(e) Network externalities, technology lock-in and "winner-takes-all" dynamics

Evolutionary economics stress the key role in the development process not only of creation, but also of the selection process that leads from a new idea to the elimination of the least promising solutions (Metcalfe, 1998). The selection process, especially in a world where network externalities prevail (that is, when the value of a new idea increases with additional users, see Katz and Shapiro, 1985), allows only one solution to emerge. This makes it difficult to implement changes when a certain evolutionary path has been selected. In an example offered by Edler and Fagerberg (2017), electrical and petrol cars were both viable options a century ago, and at the time, the selection process favoured cars which ran on petrol, and with this the development of an infrastructure that supported petrol cars. Nowadays, innovation toward more environmentally friendly (i.e. social welfare-enhancing) solutions is only viable thanks to government intervention, including through appropriate regulations. Path dependency (the fact that history matters, that is what happened in the past persists) makes government intervention needed in these circumstances. The problem is typical of sectors and technologies with network externalities.

Digital technologies are characterized by significant network externalities. The utility a user derives from joining a social network such as Facebook, for example, clearly depends on the number of other users in the same network. Some digital products have little value when consumed in isolation but generate value when consumed together with other users. There may also be indirect effects that give rise to network externalities.

Digital products are largely complementary goods or services – that is, they have value when consumed together. For example, a user purchasing a mobile phone with a pre-installed operation system will be affected by the number of other consumers purchasing similar mobile phones because the amount and variety of applications that will be supplied for use with that particular operating system will be influenced by the number of similar mobile phones that have been sold. The peculiarity of these systems is that consumers do not derive their utility only from the quantity and the quality of what they consume, but also on the availability and variety of complementary goods or on the number of people using the same product or compatible ones. So in fact, it is only once the number of subscriptions to a network reaches a certain critical mass point, and as the value of the network increases, that additional users will find it valuable to subscribe to that network.

The market in this case fails to deliver an efficient outcome, because the private benefit of joining a network differs from the social benefit. The social benefit of joining a network includes not only the private benefit of the new consumer, but also the benefit that old consumers derive from the enlargement of the network. It is in the interests of the consumer to join the most popular network (or the most popular good if there are complementarities). But lack of information, different preferences and firms' marketing actions may generate non-optimal pricing. Therefore, the equilibrium network size may be smaller than the social optimum because of the coordination problem generated by lack of information.

A government can intervene and set standards, thus solving the coordination problem. EU and US experiences in the wireless telecommunication industry show that a government-mandated standard can partially solve the coordination problem among consumers, as the critical mass of the network is reached very quickly, and consumers benefit from the network externalities associated with a larger market. When the Advanced Mobile Phone System (AMPS) was deployed as the American standard for the first generation of mobile phones, it quickly became a *de facto* world standard. The adoption of the Global System for Mobile Communications (GSM) as the pan-European standard for second-generation mobile phones in 1989 also fostered the diffusion of GSM outside Europe. As a result, GSM is the *de facto* global standard today.

If the government does not intervene, in network industries the market tends to determine a standard. A single technology tends to dominate the whole

market once it has reached a certain size. Therefore, firms owning different technologies will engage in forceful competition to benefit from "winner-takes-all" gains, or will collaborate to invent a technology. In these cases, there is the risk of anticompetitive behaviour and dynamic inefficiencies.

Setting a standard, while essential to allow for technology diffusion, presents the risk of slowing down innovation if the standard turns out to be inefficient. However, the problem of inertia exists independently of whether the standard is government-mandated or set by the market's dominant firm (Katz and Shapiro, 1985). Switching costs, which affect consumers (such as the cost of replacing a cellular phone or breaking an existing contract), and carrier costs (such as the costs of replacing base stations, retraining employees and redesigning contracts) may lock in obsolete technologies even when the standard has been set by the government. The argument in support of a government-mandated standard should rest on good governance, i.e. such a standard is good when it is set with public interest in mind and is free from lobbying, or is set with the objective of avoiding anti-competitive behaviour.

As argued in Section B, in the case of digital technology, the combination of Big Data and machine-learning magnifies "winner-takes-all" dynamics. These dynamics create large incomes, strengthen leaders' dominance and deter further market entry, thus hindering innovation. Since digital technologies are global, and in the absence of adapters (an interface between technologies with different specifications), the question is whether there is need for international cooperation to set an international standard and/or to guarantee competition, a topic further elaborated in Section D.

Governments themselves have an incentive to intervene in markets and capture incomes (rents).⁴ Supporting the development of digital technologies can be welfare-enhancing if the market exhibits rents. This is potentially one rationale behind the support of 5G technology that is observed in several economies. The competition between firms to become dominant becomes competition between countries when network externalities are global.

The issue of dominance in digital technologies is particularly relevant for developing countries (Foster and Azmeh, 2019). The global spread of the internet has not been matched by a big number of digital providers, firms and platforms. These still predominantly originate from a few countries, in which excellence is concentrated. Dominance generated by "winner-takes-all" dynamics also reinforces

geographical inequality and makes such dynamics more persistent.

Data availability is another important issue for the geographical diffusion of technology. Data availability is key for innovation in business models and to process optimization in the supply chain. Data are collected from consumers, internal business processes or other sources, such as suppliers or market prices. This large amount of information allows large-scale experiments or virtual simulations to be conducted, favouring the customization or creation of products according to the preferences and needs of the market. Data flows allow the development of new business models; this was the case, for example, for Airbnb (an online peer-to-peer holiday rental marketplace company) and Uber (a platform that connects drivers with customers seeking services such as transport and food delivery). Real-time business information is used to make decisions and to optimize supply-chain activities.

Increasingly, data are essential to determine firms' competitiveness and a country's comparative advantage. Data are therefore often kept internal to the firm. This raises an important challenge of structural inequality within and across countries.

One way to foster innovation in a digital world is to favour knowledge-sharing by improving access to data and addressing the challenges arising from the need to respect privacy as well as security concerns. Digital technologies allow for the very rapid transfer and sharing of data and information across a large number of actors, and distance is not an issue. Open-source software and data flows promote spill-overs, fostering the diffusion of new technologies. From this perspective, the potential for knowledge spill-overs is likely to be greater than with traditional technologies. However, the non-rivalry of data can pose problems. Firms may choose to keep data in-house if they fear to lose the returns from their creative efforts.

3. The determinants of innovation in the digital era

This subsection considers the determinants of innovation in the digital era. As discussed in Section B, innovation can take various forms, such as the development and commercialization of new products, the improvement of existing products or of the production process for existing products. There are various factors that affect innovation activity in the economy and policies that aim to enhance innovation typically target one of them. In the taxonomy shown in Table C.1, the four main factors are market size,

productivity of R&D, appropriability of research results, and product market structure.

This subsection provides an in-depth analysis of policies that can affect innovation and that fall under these four categories. In particular, policies that affect market size discussed in this subsection include increased access to foreign markets and government procurement. Policies that affect the productivity of R&D include: government tax incentives and R&D grants; policies favouring the supply of the type of human capital that is most involved in innovative activities; policies that favour the agglomeration of innovative activity, and more generally all policies that allow inventors to benefit from research produced by others via knowledge spill-overs; and horizontal policies that create an innovation-friendly environment, such as the creation and maintenance of high-speed broadband.

This subsection also discusses IP policies, which affect the appropriability of research results, and policies that affect product market structure – in particular trade policy and its effects on foreign firms' access to domestic markets, and policies that regulate competition.

It is worth noting at the onset that there is no one-size-fits-all approach of innovation policy, neither across countries nor within countries. Acemoglu, Aghion and Zilibotti (2006) show that R&D intensity is positively correlated with proximity to the world technology frontier (i.e. the extent to which a country lags behind the best-performing country in the adoption of the most recent innovations), consistent with the view that R&D is more important in industries or countries closer to the world technology frontier. They also show that, among countries that are in the process of development, market entry barriers are more harmful to the growth of those countries that are closer to the world technology frontier than to that of those countries that are far from the frontier. This is because, in the initial stages of economic development, countries tend to adopt an investment-based strategy to maximize investment. In this strategy, innovation is largely associated with adoption of existing technologies, which does not require a tough selection of high-quality entrepreneurs. As an economy approaches the world technology frontier, there is typically a switch to an innovation-based strategy, wherein innovation becomes more important than adaptation, and the selection of successful entrepreneurs becomes relatively more important.⁵

The set of policies that are relatively more appropriate for countries at different level of economic development does not only include policies that

regulate competition, as in Acemoglu, Aghion and Zilibotti (2006), but also education policies: investment in higher education is relatively more effective (compared to investment in basic education) in rich economies than in poor ones. Furthermore, in economies, industries and firms far from the technology frontier, productivity is more likely to be spurred by improvements in management practices than by the set of innovation policies discussed in this subsection (Bloom, Van Reenen and Williams, 2019).

With these caveats in mind, the rest of this subsection discusses the empirical evidence on the impact of innovation policies that, via the market size, productivity of R&D, appropriability of research results and product market structure mechanisms outlined above, affect innovation. This subsection concludes with some insights on the wider economic implications of innovation policy, in particular its general equilibrium welfare impacts and its effects on inequality within economies.

(a) Openness and competition

Trade, foreign investment, migration and data policies determine the openness of an economy. They affect the size of the markets that firms can access, shape the degree of competition in the domestic economy and determine the access of domestic firms to foreign technology, knowledge and know-how. A study of 27 emerging economies shows that both competition from foreign firms and linkages with foreign firms, through importing, exporting or supplying multinationals, increase product innovation, the adoption of new technologies and quality upgrading (Gorodnichenko, Svejnar and Terrell, 2010). This subsection provides detailed empirical evidence on the different channels that lie behind this positive effect of openness on innovation.

(i) *Improved access to foreign markets*

Larger markets increase the scale of production and revenues from innovation. This motivates firms to incur the (often sunk, i.e. already incurred and irrecoverable) costs of implementing new technology or investing in R&D. Bustos (2011) shows that an easier access to the Brazilian market after the establishment of MERCOSUR (i.e. the Southern Common Market) led Argentinian exporters to increase their spending on computers and software, technology transfers and patents, and on inputs into innovation activities. Similar reactions to increased export demand have been documented for Canadian and French firms by Lileeva and Trefler (2010) and by Aghion *et al.* (2019b), respectively. Based on data on exporting and R&D expenditure of electronics

producers from Chinese Taipei, Aw, Roberts and Xu (2011) estimate that a reduction in the average tariff faced by exporters from approximately 10 to 5 per cent would increase the proportion of firms that invest in R&D by 2.5 percentage points after two years and 4.7 percentage points after 15 years. This is a sizeable effect given that only 18.2 per cent of plants in the sample conduct R&D.⁶

Furthermore, the effect of market expansion can ripple through the economy along the supply chain. When an exporter increases its production, its suppliers can benefit from the larger scale as well. Linarello (2018) provides some evidence that increased export opportunities for Chilean companies also positively affected the productivity of their suppliers.

Finally, interactions with foreign buyers can help knowledge diffusion. Atkin, Amit and Osman (2017) find that Egyptian artisanal rug producers that started exporting through an intermediary improved their production techniques and the quality of their rugs. The study shows that trade intermediaries do not only facilitate matching suppliers with foreign customers, but can also help transfer knowledge about techniques of production. The potential for large orders from a market that values high quality provided the motivation, and the information exchange via the intermediary provided the know-how for technology upgrading.

In conclusion, trade policies that result in a reduction of export costs increase firm profits. This in turn increases the expected profits from innovation and stimulates technology adoption and innovation activities in firms that benefit from the better market access. The expansion of export activities also increases the demand for inputs and can therefore motivate firms in their supply chain to upgrade their technology. Importantly for small and developing-country firms, interaction with foreign buyers facilitates technology transfer. Export promotion policies thus can improve firm performance, especially for small firms (Munch and Schaur, 2018).

(ii) *Imports of capital goods and intermediate inputs*

Trade enhances knowledge spill-overs through the diffusion of knowledge embodied in intermediate inputs. Cheaper imports raise productivity via learning, variety and quality effects. Several studies show that total factor productivity in an industry increases with imports of intermediate inputs with high technology content.

The pioneering work of Keller (2002) finds that foreign R&D, embodied in intermediate input imports, accounted for around 20 per cent of the total effect of R&D investment on productivity in eight Organisation for Economic Co-operation and Development (OECD) countries. Using international input-output data for 32 developed and emerging economies, Nishioka and Ripoll (2012) find positive spillovers from R&D-intensive imports. Evidence from Indonesian firms suggests that a fall of 10 percentage point in input tariffs leads to a productivity gain of 12 per cent for firms that import their inputs (Amiti and Konings, 2007). A firm-level analysis from India suggests that India's tariff liberalization in the early 1990s accounted on average for 31 per cent of the new products introduced by domestic firms because it allowed them to access a larger variety of inputs (Goldberg *et al.*, 2010). Fielor, Eslava and Xu (2018) complement this evidence with the analysis of unilateral tariff liberalization in Colombia.

Liberalization of input trade stimulates both imports and innovation by lowering production costs. Firms can cut production costs and raise profits by sourcing inputs internationally. As discussed above, higher expected profits increase the incentives to invest in R&D and thus cheaper access to intermediate inputs spurs innovation (Bøler, Moxnes and Ulltveit-Moe, 2015). Firm-level studies for Argentina, Chile, Hungary and India confirm that better access to foreign intermediate inputs increases plant productivity (Gopinath and Neiman, 2014; Halpern, Koren and Szeidl, 2015; Kasahara and Rodrigue, 2008; Topalova and Khandelwal, 2011). Lane (2019) highlights the role of subsidized intermediate imports in the positive impact of the Republic of Korea's policy to promote its heavy chemical industry. He also shows that the impact of the government policy was transmitted along the supply chain, with a positive impact on downstream firms, which saw a decline in their input prices and increased capital investment.

(iii) *Import competition*

Conceptually, there are forces pulling in two directions when it comes to the impact of increased competition on innovation. On one hand, competition erodes the profits of domestic firms, and hence their motivation and the availability of their internal funds to invest in innovation. It is the flipside of the argument concerning why export expansion increases innovation. On the other hand, domestic firms can escape competitive pressure by increasing productivity or differentiating their products from those of new competitors. Innovation and adoption of new technologies should thus increase among domestic firms.

The impact of increased competition may also depend on the initial conditions in the market. Escaping competition through innovation may be particularly relevant in industries where firms are similar in their technological levels. However, in industries where there is a technology leader with a tail of less competitive firms, increased competition may, in theory, lead to lower innovation activity (Aghion *et al.*, 2005).

The empirical evidence shows that, on balance, import competition increases innovation (Shu and Steinweider, 2019). Based on data from 27 emerging market economies, Gorodnichenko, Svejnar and Terrell (2010) find positive effects of foreign competition on innovation by domestic firms. These effects do not depend on the underlying degree of competition in the industry and they hold both for manufacturing and service sectors.⁷ Evidence from Colombia shows that tariff liberalization has a strong positive impact on plant productivity. The impact is stronger for larger plants and plants in less competitive industries (Fernandes, 2007). Furthermore, import competition forced the least productive plants to exit the market, which had a large positive impact on aggregate productivity (Eslava *et al.*, 2013).

Comparing the different channels through which tariff liberalization affects firm performance, Amiti and Konings (2007) also find that a decline in tariff protection leads to an increase in the productivity of Indonesian producers, but the positive effects of lower input tariffs on the productivity of importing firms is at least twice as high. In other words, the imported inputs channel is stronger than the import competition channel. Topalova and Khandelwal (2011) come to similar conclusions in their study of Indian firms.

Turning to the impact of import competition on firms in high-income economies, Bloom, Draca and Van Reenen (2016) study the reaction of firms in 12 EU countries to competition from Chinese imports. They find that the firms most affected increased their innovation, measured by the number of patents. The intensified competition also forced the least productive firms out of the market and thus led to a reallocation of employment to technologically advanced firms. In combination, these two effects accounted for 14 per cent of European technology upgrading between 2000 and 2007.

In contrast, Chinese import competition had a negative impact on innovation activity in US firms (Autor *et al.*, forthcoming). The reduction in sales and profitability of import-competing firms led to their decline in R&D spending and hence patenting. The authors show that

smaller and less capital-intensive firms were affected the most, which, as the authors argue, could eventually lead to a positive reallocation of resources to stronger firms. They also suggest that the difference in the reaction of EU and US firms can be due to different initial conditions of competition in the markets and the larger size of the import shock in the United States.

Innovation incentives, such as R&D subsidies, may help to ensure the positive impact of foreign competition on innovation in large high-income economies. Akcigit, Ates and Impullitti (2018) study the interaction between globalization and innovation in the United States in the 1970s and 1980s, when US firms faced intensified international competition due to the technological catch-up in Japan and in Western European countries. The study shows that R&D subsidies help domestic firms to escape competition through innovation, thus maximizing the welfare gains from globalization. Raising trade barriers, on the other hand, harms the economy in the longer run because it weakens the competitive pressure and hence decreases innovation incentives.

In conclusion, most empirical studies support the positive impact of trade liberalization on firm-level innovation. Some studies also hint at the importance of the ensuing resource reallocation towards more innovative firms. That is, trade liberalization can increase innovation in the economy not only by increasing innovative activity within firms but also by inducing a shift in resources to more innovative firms. Similarly, trade policy can affect the allocation of resources between more and less innovative industries. This is the focus of the infant industry argument that is discussed in Box C.3.

(iv) Global value chain participation

As discussed in previous paragraphs, the interaction between domestic and foreign firms favours technological diffusion in two ways: (1) foreign buyers may provide incentives to local suppliers to adopt new technologies, and (2) inputs from foreign suppliers may embody advanced technologies.

Participation in international supply chains can be an even more powerful channel for technology transfer. International production sharing involves a high degree of interdependency between producers from different countries, as the production of a good in one country depends on the timely delivery of inputs from a factory abroad, and these inputs need to be perfectly compatible with the domestic production line. Therefore, foreign outsourcing firms are more willing to transfer the know-how, managerial practices and technology required for an efficient production

of the outsourced input. The same argument applies also for firms that become part of a supply chain of foreign affiliates in the host country.

Using industry-level data for 25 countries, Piermartini and Rubínová (forthcoming) show that participation in international supply chains helps industries to benefit from R&D performed by their foreign partners. These international knowledge spill-overs boost domestic innovation, especially in emerging economies. Javorcik (2004) shows that supplying affiliates of foreign companies can increase the productivity of firms in a transition economy. She argues that it is the result of more stringent requirements on quality and timely delivery, combined with training for personnel and transfer of know-how. More recently, Alfaro-Urena, Manelici and Vasquez (2019) show that Costa Rican firms that started to supply foreign multinationals experienced strong and persistent improvement in their performance. Based on their survey of managers in both multinational corporations (MNCs) and local Costa Rican firms, they conclude that this positive impact is driven by a variety of inter-related transformations in the production process that lead to expansions in product scope with higher-quality products, better managerial and organizational practices, and improved reputations.

(v) Face-to-face interaction within global value chains and research networks

Another reason why GVCs facilitate technology transfer is that they intensify face-to-face contacts between foreign firms and their suppliers. Firms in a production chain need to interact and coordinate to guarantee a smooth functioning of the chain. Consequently, high-skilled personnel often move within multinational firms across borders to assure technological as well as managerial cohesion across production units in different countries. This face-to-face communication facilitates the transfer of know-how and tacit knowledge.

A study by Hovhannisyan and Keller (2014) finds that a 10 per cent increase in business travel from the most innovative regions of the United States increased patenting in the destination country by about 0.2 per cent. Focusing on knowledge flows between US regions, Agrawal, Galasso and Oettl (2017) find that better connectedness facilitates the circulation of knowledge and, consequently, a 10 per cent increase in the number of interstate highways leads to a roughly 1.7 per cent increase in innovation as measured by patenting activity in the region. Box C.5 also provides further evidence of the positive effect of knowledge flows associated with business travel by migrant diasporas to their countries of origin.

Box C.3: Trade policy as a tool to change the industry composition of an economy

A long-standing debate in economics centres around the idea that temporary protection from foreign competition may help a domestic high-tech industry to become internationally competitive and expand production, thus increasing innovative activity and economic growth in the country. This so-called infant-industry argument is conditional on the supported sectors having potential economy-wide positive knowledge externalities but high initial production costs that decrease only progressively over time as a result of learning by doing (Aghion *et al.*, 2015).⁸ Local content requirements often complement import protection.

An empirical assessment of the infant industry argument has been inherently difficult. As with any similar government policy intervention, the motivation to target a specific industry is usually unobservable to the researcher and creates endogeneity issues that complicate causal assessment of the policy. Moreover, even if the policy intervention is successful in boosting the targeted industry, such a result is not sufficient to claim that the policy was welfare-enhancing.

Recent literature has started to tackle the first issue and sheds some light on whether import protection boosted the protected industry's performance. As an example, Juhász (2018) focuses on the adoption of a technology that drove productivity and innovation in the 19th century – mechanized cotton spinning. She finds that French regions that were affected by the Napoleonic blockade, and thus could not import textiles from England, adopted mechanized cotton spindles faster than other regions. The author suggests that this first-mover advantage lasted for a century. The results can be interpreted in the light of external economies of scale⁹ which imply that even temporary interventions may have a long-lasting impact on the location of an industry. Recent work by Hanlon (forthcoming) and Mitrunen (2019) comes to a similar conclusion in the context of other historical interventions.

Nunn and Trefler (2010) explore the hypothesis that due to path dependency, an initial protection of R&D-intensive industry (characterized by knowledge spill-overs) can lead to a higher per capita GDP growth. They find that productivity growth in a country is positively correlated with the tariff protection of sectors that are skill-intensive (a proxy for R&D-intensive sectors) and argue that at least 25 per cent of the correlation corresponds to a causal effect.

Overall, there is still very little evidence about the operation and mechanisms of infant industry policies. One emerging framework to study the impact of these policies builds on historical cases that clearly spell out the policy context and isolate specific mechanisms (Lane, 2020). While this approach can offer a clear assessment of past policies, more research is also needed into how the assumptions that underpin the infant industry argument – path dependency and positive economy-wide impact of certain industries – translate into the world in which economic growth is driven by fast-paced digital innovation.

In general, since tacit knowledge and know-how travel with people, business travel plays an important role in fostering productivity and economic growth. The importance of meeting and networking with other business or researchers is often reflected in government programmes targeted at promoting innovation (Edler and Fagerberg, 2017).

Knowledge spill-overs from universities and research centres increase with the mobility of scientists. However, knowledge diffusion is geographically limited if measured by citations to patents and scientific publications. A seminal study by Jaffe, Trajtenberg and Henderson (1993) shows a clear home bias in patent citations in the United States. This bias is not only at the country level but also at

the state and even the county level. Belenzon and Schankerman (2013) confirm that knowledge spill-overs among US universities are strongly constrained by state borders, and show that these localization effects are the strongest in states with low interstate scientific labour mobility. However, Head, Li and Minondo (2019) argue that personal and professional ties foster knowledge flows, and that therefore the spatial concentration of knowledge spill-overs is driven by the fact that these ties are predominantly local. They show that if two mathematicians have a tie, such as past co-authorship or a common thesis advisor, current distance between them has little impact on the likelihood of one citing the other. Mobility of students and scientist fosters global ties and thus facilitates global knowledge spill-overs.

Consistent with the fall of travel and communication costs in the 1980s and 1990s, the localization of knowledge spill-overs has declined (Griffith, Lee and Van Reenen, 2011). The home bias nevertheless remains in sectors with strong external economies of scale, such as ICT technology.

Knowledge transfer can be a consequence of labour mobility, especially of researchers, engineers and other skilled workers, between employers. During the innovation process, workers develop and acquire new knowledge and competences, as well as an understanding of the implemented technologies. When they move from one firm to another, the new employer can benefit from this human capital (Breschi and Lissoni, 2001). This is another example of how knowledge generated in one country can foster economic growth in another country.

Global research networks promote the sharing of key scientific inputs, such as knowledge, equipment or data, and thus are essential for scientific and technological progress. Iaria, Schwarz and Waldinger (2018) use historical data to show that an interruption in scientific cooperation leads to a decline in the production of basic science and its technological application. For example, the First World War created a scientific schism between the Allies and the Central Powers that lasted until well after the war ended. During that time, the delivery of international journals was delayed and scientists from the Central Powers (i.e. Austria-Hungary, Bulgaria, Germany and the Ottoman Empire) were officially boycotted by their Allied peers (e.g. Great Britain, France, Italy, Japan, Russia and the United States) until 1926, which excluded them from international research associations and conferences. Iaria, Schwarz and Waldinger (2018) show that this led to a reduction in knowledge flows that were crucial for top-tier research. Consequently, scientists who relied on frontier research from abroad published fewer papers in top scientific journals, produced less Nobel Prize-nominated research, introduced fewer novel scientific words, and introduced fewer novel words that appeared in the text of subsequent patent grants.

Recent studies show that global R&D networks, often driven by R&D offshoring, enhance the innovative output of researchers in emerging and developing economies. For instance, they can explain the rapid increase in the number of Chinese and Indian patents granted in the United States (Branstetter, Li and Veloso, 2014; Miguélez, 2018). This illustrates the importance of international research networks in enhancing learning from the global pool of knowledge and the consequent economic growth.

(vi) *Successful technology transfer and knowledge spill-overs*

While every economy can benefit from imports of high-quality inputs, more competitive domestic markets and access to large foreign markets, knowledge spill-overs that enhance innovation and the implementation of foreign technologies in domestic production are often conditional on the receiving party's capabilities to maximize their benefits. The major barriers to technology transfer are related to the specific characteristics of firms or to systemic problems that derive from the environment in which firms operate. Firms may not be aware of all the possible technological alternatives available in the market or may not be able to identify the technology that best suits their needs. A lack of skills or incompatible managerial practices are also obstacles for technology upgrading. At the country level, technology transfer is facilitated by the presence of an adequate institutional environment, openness, and investment into education and research.

To exploit a new foreign technology, firms need to have an adequate absorptive capacity. Absorptive capacity refers to the capacity to learn how to use a new technology, to learn about the principles of how it works, and to adapt a technology developed abroad to the local conditions of a country. The quality of education, the number of skilled workers and the resources spent on public research are some of the important factors that improve absorptive capacity in a country (Augier, Cadot and DAVIS, 2013; Piermartini and Rubínová, forthcoming). Collaboration between industry and research institutions is also crucial for the adaptation of foreign technologies to domestic conditions.

Many technologies are developed in high-income economies by multinational companies and may fit best with the organizational and institutional environment of those economies. The successful implementation of new technologies in other economies or types of firms thus often requires a change in managerial practices. Giorcelli (2019) studies the effects of a Marshall Plan¹⁰ project in the 1950s which provided some Italian firms with advanced American capital goods as well as management training. She shows that the new managerial expertise was instrumental to the persistent positive effect of new machines on firm performance.

Another study shows that even organizational differences, such as the type of labour contracts, can hamper the adoption of a new technology. Atkin *et al.* (2017) experimented with producers of footballs in Pakistan by teaching them a new technique that would reduce their material waste. To their surprise, only a very small number of firms implemented the

technique. The reason was an incentive misalignment between workers and managers. Workers in most firms were paid by the piece, and implementing the new technique would have slowed them down, at least initially, leading to lower wages. Therefore, despite the potential of the technique to improve overall efficiency of production, workers resisted its adoption.

Digital technologies are no different. Even in high-income countries, the uptake of digital technologies lags behind policy goals. Making the most of digital technologies and successfully competing in digital innovation requires not only investment into equipment and skills, but also changes in the organizational structure and processes.

(vii) Open and transparent data policies

In the digital age, what matters is not only openness to the flow of goods, services or people, but also to the associated data. As discussed extensively in WTO (2018a), data policy is a key to comparative advantage in the digital age because it drives the innovativeness and performance of digital firms. Its value and untapped potential for companies and governments has increased dramatically as new data extraction and analysis methods based on AI coincide with the exponential growth of data availability in the digital age. This has made data an important input for innovation across all sectors in the economy (Guellec and Paunov, 2018), as also highlighted in Section B.1. The market for data analytics has been estimated to grow on average by 40 per cent per year, and the immense value of data for innovation has been highlighted in a series of studies which show that firms that use Big Data for innovation exhibit productivity growth 5-10 per cent faster than other firms (OECD, 2015).

As a consequence, data policy, from data localization to web content or privacy regulation, can serve as an important tool in the innovation policy toolbox, even if data policy, especially concerning privacy protection, is often enacted for other legitimate policy objectives. In theory, restrictive data privacy policies can reduce the use of technologies that depend on data, and limit innovation that benefits from large and connectable datasets. However, they can also increase the supply of available data if they lead consumers to trust firms that collect data or if they cause foreign firms to transfer data to the intervening economy. In practice, however, the first effect seems to dominate, and less restrictive data privacy protection policies seem to benefit firms that use digital technologies (Goldfarb and Tucker, 2012). In the context of the online advertising industry, for example, Goldfarb and Tucker (2010) show that strict European privacy laws

reduce the effectiveness of online marketing by 65 per cent compared to the United States.

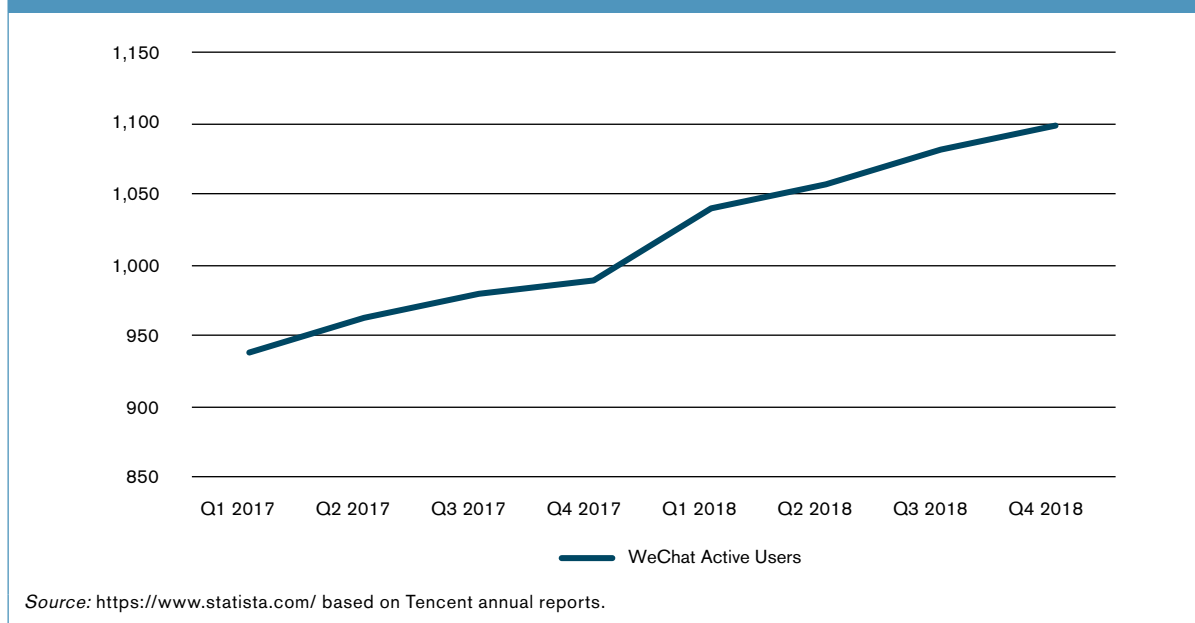
Web content and access restrictions can reduce incentives for innovation by limiting firms' understanding of consumer preferences and by limiting market size for providers of blocked content.¹¹ However, access restrictions to foreign websites or platforms can also serve to protect infant digital industries in a way equivalent to import bans (Erixon, Hindley and Lee-Makiyama, 2009). This can increase innovation and the performance of domestic firms offering the same service if the domestic market is sufficiently large. There is correlational evidence that suggests, for instance, that the Chinese firms WeChat and Baidu benefitted from the departure of foreign service providers like WhatsApp and Google (Chu, 2017; Vale, 2019). This is supported by Figure C.2, which shows that WeChat's active users in China increased above trend in the quarter in which WhatsApp left the Chinese market at the end of 2017. Restrictive data policies could also lead to retaliatory measures and may contribute to the fracturing of the internet, increasing the cost of conducting business globally (Swanson, Mozur and Zhong, 2020).

Data localization can have the effect of imposing costs primarily on foreign firms. Policies which require domestically acquired data to be stored locally can limit the data available to foreign firms, necessitate investment in domestic server capacity, and prevent data centralization. This can effectively protect domestic data-intensive industries and stimulate domestic innovation and performance. However, the limited evidence available to date suggests 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 negative effect is particularly strong for downstream firms which interact directly with consumers (Ferracane, Kren and van der Marel, 2020).

Based on case studies from Brazil, China, the European Union (28), India, Indonesia, the Republic of Korea and Viet Nam, data localization policies have also been shown to lead to substantial GDP losses, decreases in domestic investments and lower salaries (Bauer *et al.*, 2014). This supports the hypothesis that the free flow of information is conducive to firms innovating. When there are severe restrictions on the flow of information, individuals are prevented from collaborating and developing new ideas, in a manner similar to the effects of limits on goods, services or researcher mobility discussed above (Pepper, Garrity and LaSalle, 2016). Thus, data localization policies hinder the development of new information technologies which can benefit the ability of firms to innovate (Chander and Le, 2015).

Figure C.2: WeChat's active user numbers increased with the departure of WhatsApp

Quarterly active WeChat users in China (millions) (2017-18)



Government data access policies are also central to innovation in the digital age. The public sector is one of the most important users and suppliers of data in the economy (OECD, 2015). "Open data" initiatives, which provide public data for non-commercial use for free, and for commercial use at prices below marginal costs, have strongly promoted the utilization of such data (see examples in section B2(c)). They are estimated to benefit product and sales growth significantly, with one study estimating that firms benefitting from access to open data experienced sales growth 15 per cent faster than other firms (Capgemini Consulting, 2013; Koski, 2011, 2015).

Privacy, security or other similar concerns, especially in sensitive areas such as the health or defence industries, can moreover lead to competitive advantages for domestic data-intensive firms if public data are made available based on nationality criteria or otherwise restricted such that only a subset of domestic firms can access it. This has an effect comparable to a production or innovation subsidy in the digital age, where firms rely on data (Goldfarb and Trefler, 2018). Of course, if access is too limited, this can generate market power and stymie domestic innovation and productivity rather than stimulate it. Evidence from US state medical privacy laws suggests, for instance, that variations in access to health records by hospitals contribute to explaining variations in neo-natal mortality (Miller and Tucker, 2011). More direct evidence for the importance and effects of public data access policies for innovation is

not available, however, so a more precise assessment of these policies is currently not possible.

Overall, the available evidence generally promotes open and transparent data policies as important contributors to innovation in the digital age. While this evidence is limited so far, it broadly supports the idea that, for data to flourish as an input to innovation, it benefits from flowing freely. In light of the relative novelty of this field and the corresponding scarcity of studies, it is important to conduct more research on the relationship between data policies and innovation or firm performance to understand what the long term effects of such policies are, and to further substantiate the evidence that has been collected thus far.

(b) Innovation funded by the government

It has been shown in Section B that governments worldwide employ various policies to support R&D. These policies find economic justification in the presence of market failures that prevent markets from supplying socially desirable levels of R&D (see Section C.2). Here, the focus is on the impact of tax incentives given to private firms performing R&D, on the impact of government research grants, on the role of government procurement, and on the role of government in "mission-oriented" innovation.

(i) Tax incentives for private R&D

There is consensus in the economic literature that R&D tax credits increase R&D spending. In a recent survey,

Becker (2015) concludes that the negative demand elasticity of R&D with respect to its own tax price is estimated to be broadly around unity. This implies that a 10 per cent fall in the tax price of R&D increases R&D by roughly 10 per cent. Subsequent studies (Dechezleprêtre *et al.*, 2016; Pless, 2019) find an even higher impact, with an estimated elasticity around 2.5.

Obviously, R&D tax incentives are meant to stimulate innovation. Firms, however, can respond to such incentives by relabelling other expenses as R&D to take advantage of favourable tax treatment (Chen *et al.*, 2018). To circumvent the issue of relabelling of non-R&D expenses as R&D expenses, some studies consider the direct impact of R&D tax credit schemes on non-R&D outcomes. Czarnitzki, Hanel and Rosa (2011) examine the effect of R&D tax credits on the innovation activities of Canadian manufacturing firms. Over the 1997-99 period, the Federal and Provincial R&D tax credit programmes were used by more than one-third of all manufacturing firms and by close to two-thirds of firms in high-technology sectors. Czarnitzki, Hanel and Rosa (2011) find that R&D tax credits increased the innovation output of the recipient firms. Tax credit recipients realized a higher number of product innovations and increased sales shares of new and improved products. The tax credit recipients were also more likely to introduce market novelties for both the Canadian (home) market and the world market.¹²

Using a rich database for Norwegian firms, Cappelen, Raknerud and Rybalka (2012) find that projects receiving tax credits result in the development of new production processes and to some extent the development of new products for the firm. However, the authors find no impact on innovations in the form of new products for the market or patenting. Bøler, Moxnes and Ulltveit-Moe (2015) find that the introduction of an R&D tax credit in Norway in 2002 stimulated not only R&D investments but also imports of intermediate goods. Finally, Dechezleprêtre *et al.* (2016) find that an R&D Tax Scheme in the United Kingdom induced a 60 per cent increase in patenting by "treated" MSMEs.¹³ Taken together, the results of these studies provide some evidence that R&D tax credits can have an impact on innovation.¹⁴

Another concern with R&D tax credits is that they may not raise aggregate R&D, but rather may simply cause a relocation toward geographical areas with more generous fiscal incentives and away from geographical areas with less generous incentives (Akcigit and Stantcheva, forthcoming; Bloom, Van Reenen and Williams, 2019). There is evidence of such relocation both between sub-federal states in federal countries, such as the United States

(see Moretti and Wilson, 2017), and internationally (see Akcigit, Baslandze and Stantcheva, 2016).¹⁵ However, even in the presence of relocation effects, Bloom, Van Reenen and Williams (2019), conclude that "the aggregate effect of R&D tax credits at the national level both on the volume of R&D and on productivity is substantial".

Section B highlighted patent boxes as yet another fiscal instrument used by governments to spur innovation. Patent boxes are special tax regimes that apply a lower tax rate to revenues linked to patents relative to other commercial revenues (Bloom, Van Reenen and Williams, 2019). While, in theory, patent boxes may incentivize R&D, in practice they induce tax competition by encouraging firms to shift their intellectual property royalties into different tax jurisdictions (Bloom, Van Reenen and Williams, 2019; Neubig and Wunsch-Vincent, 2018). Using comprehensive data on patents filed at the European Patent Office, including information on ownership transfers pre- and post-grant, Gaessler, Hall and Haroff (2019) investigate the impact of the introduction of a patent box on international patent transfers, on the choice of ownership location, and on invention in the relevant country. They find some impact on patent ownership transfer, and no impact on innovation. This result, they conclude, "calls into question whether the patent box is an effective instrument for encouraging innovation in a country, rather than simply facilitating the shifting of corporate income to low tax jurisdictions".

(ii) Research grants

With the amount they spend on R&D, countries can affect both the quantity and the quality of innovation. Shambaugh, Nunn and Portman (2017) report that countries with relatively low R&D spending tend to produce few high-quality patents (defined as those filed in at least two offices).

Several commentators have highlighted the active role of governments in shaping and fostering technological breakthroughs. Mazzucato (2013), for instance, argues that the US government is the economy's indispensable entrepreneur, innovating at the frontiers of science and technology, and able and willing to take risks in environments characterized by uncertainty about the end result of the innovation effort. Mazzucato (2013) uses the example of the technologies that currently make phones smart, such as the internet, wireless systems, global positioning, voice activation and touchscreen displays. All of these technologies, and others such as the search algorithm used by Google, were funded by the government through competitive research grants.

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MISSION-ORIENTED INNOVATION AND INDUSTRIAL POLICY

The world faces enormous challenges around health and climate, and the underlying structure of our economies has prioritized short-term targets over long-term ones for too long. What is required is a radical change, consisting of putting challenges at the heart of the economy, rather than seeing economic growth on one side and the solutions to social problems on the other. With this aim, it is useful to think about the role of challenge-led policies – that is, policies that use investment and innovation to solve difficult problems (Mazzucato, Kattel and Ryan-Collins, 2019).¹⁶

Industrial strategies are seeing a revival around the world and should be harnessed to direct economies towards solving the biggest challenges through innovation and investment (Mazzucato, Kattel and Ryan-Collins, 2019; Mazzucato, 2018a). By creating well-defined missions to solve significant challenges, policymakers can influence the direction of growth by making strategic investments and using suitable policy instruments in many different sectors.

In order to apply innovation to challenges, the latter have to be broken down into ambitious but pragmatic and achievable tasks (Mazzucato, 2018b) or missions – concrete targets within a challenge, that act as frames and stimuli

for innovation. Using missions to drive national industrial strategy or innovation policy means focusing less on sectors – such as the car industry, aerospace or telecommunications, as has been seen in past “vertical” policies – and more on the societal challenges that affect all.

One example of such a mission-oriented framework is the European Union’s Horizon Europe research and development programme, in which a proportion of approximately € 100 billion will be deployed to five mission areas, as set out in my report for the European Commission, *Mission-Oriented Innovation Policy: Challenges and Opportunities* (Mazzucato, 2018b). In July 2019, I launched a second report titled *Governing Missions in the European Union*, which focused on three main areas: how citizens can be engaged in co-designing and co-implementing missions; what are the tools that the public sector needs in order to foster a dynamic innovation eco-system; and how can mission-oriented finance and funding leverage other forms of finance (Mazzucato, 2019).

The United Nations Sustainable Development Goals (SDGs) also present tremendous opportunities to direct innovation aimed at multiple social and technological challenges, thereby addressing the urgent need to create societies that are more just, inclusive and sustainable.

Today, in the midst of the COVID-19 crisis, the world must address the twin challenges of recovery from the economic shock due to COVID-19 and the transition to a low-carbon economy. These are not separate challenges. COVID-19 has prompted a bold state response, and if the green industrial strategy is to be successful, it will require a rethink on a similar scale of how governments negotiate with business. Strategies in which risks and rewards are shared fairly among all actors are vital for fostering the dynamic and sustainable investments that are needed across the long and uncertain process of innovation, and in order to produce a symbiotic, collaborative relationship between the public and private sectors.¹⁷ The existing paradigm of socialized risks and privatized returns needs to be replaced by one where public investment leads to public returns.

If governments are fully to take this purposeful approach to innovation and industrial policy, they will need to learn how to build new types of public-private collaboration for the public good, and how this can be achieved through industrial policy. This must involve using tools such as procurement and patient strategic finance, but also truly confronting the “ways of doing things” that currently exist in government.

Governments can also have large impact on innovation through their procurement policies. Cozzi and Impullitti (2010) show that the technological content of government purchases is a *de facto* innovation policy instrument. Likewise, Moretti, Steinwender and Van Reenen (2019) argue that government defence spending is often the most important policy used by governments to affect the speed and direction of innovation in the economy.

This subsection evaluates the empirical evidence on the effectiveness of government research spending and procurement on innovation. It further considers the potential merits of "mission-based" innovation policy.

Governments may want to target specific types of R&D, for instance basic R&D rather than more applied R&D, if it is believed that they create more knowledge spill-overs than more applied R&D. Government research grants are a better instrument than R&D tax credits in these circumstances.

University research and innovation

Research grants awarded to academics significantly affect academic output, but also have the potential to affect private R&D, if the knowledge they help to generate spills over outside of the "ivory tower" of academia. High-technology firms often locate close to strong science-based universities. Such location choices are at least partly determined by geographically localized knowledge spill-overs from university research. Such spill-overs include personal interactions, university spin-off firms, consultancies and pools of highly trained graduates supplied by universities for employment in industry (Becker, 2015). Literature on the United States and a variety of other countries surveyed by Becker (2015) predominantly suggests that private R&D benefits from geographically localized knowledge spill-overs from university research.

More recently, Toivanen and Väänänen (2016) consider how universities affect innovation via their role as human capital producers. Using distance to a technical university in Finland as an instrument for engineering education, they find a large and significant impact of engineering education on patents: according to their estimations, establishing three new technical universities resulted in a 20 per cent increase in the number of United States Patent and Trademark Office (USPTO) patents by Finnish inventors.

A similar research question is studied by Andrews (2019), who estimates the causal impact on patenting of the (quasi random) allocation of universities to US

counties over the period 1839-1954. He finds that establishing a new university resulted in 45 per cent more patents per year in that location than in runner-up locations (i.e. locations that were strongly considered to become the sites of new universities but were ultimately not chosen for exogenous reasons).

In a multi-country setting, Valero and Van Reenen (2019) show that a 10 per cent increase in a region's number of universities per capita is associated with 0.4 per cent higher future (five years ahead or more) GDP per capita in that region. They argue that the association of per capita GDP and the presence of a university works partly through the increase of the supply of human capital and partly by raising innovation.

Finally, Azoulay *et al.* (2019b), exploiting quasi-experimental variations in funding from the US National Institutes of Health (NIH) across research areas, show that a US\$ 10 million increase in NIH funding to academics leads to 2.7 additional patents filed by private firms.

The literature discussed above clearly suggests that universities will continue to have an important role in fostering innovation in the digital economy.

Publicly funded R&D conducted by private firms

Government research grants are not only destined for academic researchers (or researchers in public labs or research centres), but also to private entities. The success of public R&D support of this form in stimulating private R&D depends on the design of the measure. Measures supporting firms' R&D that are transparent (e.g. research grants awarded through an open competitive process), non-discriminatory (equally available to domestic and foreign-established firms), and targeted towards young firms that face financing constraints in raising upfront capital, are more desirable than support measures for R&D that take the form of blanket subsidies benefiting large incumbents or domestic firms (OECD, 2019).

Evidence that direct R&D subsidy programmes can have positive impacts on innovation by small high-tech firms is provided by Howell (2017). She considers applications by such firms to the US Department of Energy's Small Business Innovation Research (SBIR) programme between 1983 and 2013 and finds that awards received in Phase 1 of the programme (which also had a Phase 2, for which successful Phase 1 applicants could apply nine months after receiving Phase 1 awards) have powerful effects. Phase 1 grants increase a firm's chance of receiving venture

capital investment from 10 to 19 per cent. In addition, Phase 1 grants almost double the probability of positive revenue and increase the probability of the survival and successful market exit (initial public offering or acquisition) of small businesses. Most importantly for the purposes of this report, Phase 1 grants increase a firm's subsequent cite-weighted patents by at least 30 per cent.¹⁸

Although limited, there is also some evidence of a positive effect of public R&D subsidies on private R&D in some developing countries. For manufacturing firms in Turkey, Özçelik and Taymaz (2008) corroborate the evidence of additionality effects (i.e. public subsidies on average increase private R&D) found for several developing countries. More recently, Wu *et al.* (2020) show that R&D subsidies provided to 1,166 non-finance sector Chinese firms between 2008 and 2013 increased firms' innovation input (R&D investments), although they failed to foster innovation output (patent applications). Fernández-Sastre and Montalvo-Quizhpi (2019), using data on Ecuadorian firms for the period 2009-11, find that innovation support programmes which are intended to increase firms' technological capabilities induce firms to invest in R&D activities.

What is the combined effect of various policy instruments? This issue has received surprisingly little attention. Bérubé and Mohnen (2009), using data from the 2005 Survey of Innovation from Statistics Canada, consider the impact of R&D grants for Canadian plants that already benefit from R&D tax credits. They find that firms that benefited from both policy measures introduced more new products than their counterparts that had only benefited from R&D tax incentives. These firms also made more product innovations and were more successful in commercializing their innovations.

More recently, Pless (2019) tests whether direct grants and tax credits for R&D are complements or substitutes in their effects on UK firms' R&D investment behaviour. She finds that these schemes are complements for small firms but substitutes for larger firms on the intensive margin (i.e. increases in R&D expenditures by firms that already invest in R&D). She also shows that such complementarity between R&D policies enhances small firms' efforts towards developing new goods and services (i.e., horizontal innovations), as opposed to improving existing goods and services (i.e., vertical innovations), and that complementarity between R&D policies increases the probability that small firms will produce new or significantly improved goods, as opposed to processes.

(iii) *The role of government as a customer of innovative products*

By enlarging the size of the market, public procurement in a given sector can spur private R&D and innovation. Examples abound – for instance, in the United States, the new technologies developed include semiconductors, large civil aircrafts, the internet and GPS technology, while digital phone switching technologies have been developed in Sweden and Finland, and high-speed trains have been developed in several countries.¹⁹ Innovation in high-tech sectors, and in particular digital innovation, can therefore be increased by raising shares of government procurement in high-tech and digital sectors.

The innovation effects of public demand in the United States for the period 1999-2009 are investigated by Slavtchev and Wiederhold (2016). They relate state-level private R&D expenditures to the technological content of federal procurement in US states. Slavtchev and Wiederhold (2016) find that an increase in the technological content of government procurement induces additional private R&D in the economy.²⁰ The value of the elasticity of private R&D with respect to the high-tech procurement they estimate implies that each procurement dollar that the government shifts from non-high-tech industries to high-tech industries induces an additional US\$ 0.21 of private R&D.²¹

Evidence that obtaining government contracts can spur dynamic learning effects is provided by Jaworski and Smyth (2018). Using data on all planes introduced in the commercial market between 1926 and 1965, they find that commercial airframe manufacturers with bomber contracts during the Second World War were more likely to have post-war market presence than firms without such contracts. They attribute the effect of bomber contracts to advantages in R&D learning capacity acquired by firms with military airframe contracts.

Cross-country evidence of the positive effects of government-funded R&D on private R&D is presented by Moretti, Steinwender and Van Reenen (2019). In a dataset comprising 26 industries in all OECD countries over 23 years, they find strong evidence that increases in government-funded R&D generated by variations in defence R&D translate into significant increases in privately funded R&D expenditures, with an estimated elasticity equal to 0.43.²² This impact is economically sizeable. The authors consider the example of the US "aerospace products and parts" industry, where defence-related R&D amounted to US\$ 3,026 million in 2002. Their estimates suggest that this public investment resulted in US\$ 1,632

million of additional private investment in R&D. Moretti, Steinwender and Van Reenen (2019) further consider the impact of investment in R&D on productivity, finding a positive effect. An increase in defence R&D to the value-added ratio of one percentage point is estimated to cause a 5 per cent increase in the yearly growth rate of total factor productivity – i.e., from 2 per cent per annum to 2.1 per cent.

Overall, Moretti, Steinwender and Van Reenen (2019) show that cross-country differences in defence R&D play a role in explaining cross-country differences in private R&D investment, speed of innovation, and ultimately in the productivity of private-sector firms.

(iv) *The role of government in developing radical innovation*

Breakthrough technological developments are often achieved in the framework of mission-oriented innovation policies, which Bloom, Van Reenen and Williams (2019) call "moonshots" with reference to President J. F. Kennedy's Apollo programme.

Moonshots are characterized by a high level of centralization and intentionality (i.e. there is a specific and well-defined technology target) and heavy government intervention: the state is both the funder and the customer, and public agencies perform the R&D operations (École Polytechnique Fédérale de Lausanne (EPFL), 2020).

Moonshots are inherently hard to evaluate. This is due to the absence of clear counterfactuals (what would otherwise have happened had they not taken place) (Bloom, Van Reenen and Williams, 2019), but also to the fact that for a programme that makes long-term and high-risk investments, many failures can be justified by a single success. Furthermore, measurable short-term outcomes such as publishing or patenting do not capture the success embodied in rare transformational outcomes (Azoulay *et al.*, 2019a).

Against this background, Bloom, Van Reenen and Williams (2019) discuss two main arguments that might justify moonshots.

First, the mission may be justifiable in and of itself. Bloom, Van Reenen and Williams (2019) give the example of using technology to address climate change. In this context, research subsidies have been shown to be prevalent in the optimal policy mix to mitigate climate change by transitioning from dirty to clean technology (Acemoglu *et al.*, 2012; 2016). A moonshot approach could speed up the pace of such a transition. Other desirable social

goals, such as disease reduction, could also be the objective of a moonshot. In the context of the current COVID-19 pandemic, some have argued in favour of adopting "a mission-oriented approach that focuses both public and private investments on achieving a clearly defined common goal: developing an effective COVID-19 vaccine(s) that can be produced at global scale rapidly and made universally available for free" (Mazzucato and Torreele, 2020). This is discussed in Box C.4.

The second argument put forward by Bloom, Van Reenen and Williams (2019) that might justify moonshots is considerations related to geographical inequality. If moonshots are developed in cities or regions that lag behind in terms of economic development, the local spill-overs generated by them could spur the development of these locations.

(c) Intellectual property protection

As discussed in WTO (2018a), the importance of IPR regulation is 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 IPRs are central and can increase the attractiveness of a country for digital firms. WTO (2018) concluded, however, that whether IPR regulations increase or reduce competitiveness in digital sectors is ultimately an empirical question. On the one hand, weak copyright enforcement can lead to lower revenues in industries where copyrights matter, such as the music, film and publishing industries. On the other hand, tight IPR policies (such as, in the case of patents, longer patent terms, broader subject matter coverage or available scope, and improved enforcement) could constrain the creation and quality of digital products by limiting access or raising royalty costs.

In this subsection, the interest lies in the relationship between IPRs and innovation. In principle, stronger IPR protection should stimulate technology transfers to a country, while it has an ambiguous impact on domestic innovation (Hall, 2020). Empirical studies reviewed by Hall (2014) find a positive correlation between IPR enforcement and technology transfer through the channel of foreign direct investment (FDI), especially in host countries with enough absorptive capacity and ability to engage in imitation.

In terms of domestic innovation, empirical evidence is mixed. The direct effect of IPRs on growth is mediated by a number of factors, including a country's R&D capacity, its per capita wealth, the

Box C.4: Is there a case for a mission-oriented approach in finding a vaccine for COVID-19?

Finding a vaccine against COVID-19 is an "innovation imperative" (École Polytechnique Fédérale de Lausanne (EPFL), 2020), which seems to represent a strong case for a mission-oriented approach in which governments intervene in funding, developing and purchasing the new technology (i.e. the successful vaccine). Is this really the case?

In normal times, vaccines are subject to systematic underinvestment in R&D by private pharmaceutical companies for two fundamental reasons: first, there is not enough demand for vaccines; and second, R&D investment is subject to various market failures.

Too little demand for vaccines in normal times is due to the fact that there is a positive externality of being vaccinated (individuals who take vaccines not only become immune to the disease but also contribute to slowing down its transmission), to the fact that consumers seem to be more willing to pay for treatment than for prevention, and to the fact that some individuals are opposed to vaccination.²³

On the supply side, R&D investment in vaccine development is discouraged by the gap between the social and the private returns to innovation, by the high risk in financing such activities, and by a time-inconsistency problem (once a vaccine is available, governments have incentives to obtain vaccines at prices that only cover manufacturing costs, but not R&D costs). Moreover, in the case of cross-border diseases, such as pandemic diseases, each country has an incentive to free ride on R&D financed by foreign governments (Kremer, 2000).

During the current pandemic, there has been a significant dissipation of most market failures for vaccine consumption (for instance, a significant fraction of consumers are willing to pay a higher price than the manufacturing cost) and market failures related to R&D (for instance, due to the research-encouragement effects of public-private partnerships). As a result, companies have worked with unprecedented speed to develop a vaccine. At the time of writing (early August 2020, a mere seven months after the first genome sequence of the SARS-CoV-2 virus was released), the landscape of COVID-19 candidate vaccines included six candidate vaccines in Phase 3 clinical stage (World Health Organization (WHO), 2020).

The current vaccine race is best described as the outcome of intellectual freedom, scientific openness and decentralized competition, rather than the outcome of a mission-oriented command-and-control approach.²⁴ This is not very different from past life science innovations. As argued by Cockburn, Stern and Zausner (2011), a single R&D surge seems never to have paid off in the pharma industry and has been actually counterproductive. Past and current experience therefore suggests that the current decentralized, competitive approach is preferable to a mission-oriented approach in the quest for a vaccine against COVID-19.

Once the vaccines are available, the important question of how to guarantee rapid, fair and equitable access to them. Advance market commitments – through which private or public donors pledge that, if a firm develops a specified new vaccine and sets the price close to the manufacturing cost, they will top up the price by a certain amount per dose – could play a role.²⁵ The manufacturer of one promising vaccine, AstraZeneca, has signed up to the Gavi Advance Market Commitment for COVID-19 Vaccines (Gavi COVAX AMC), launched in June 2020, guaranteeing 300 million doses of the COVID-19 vaccine it is developing in collaboration with the University of Oxford. These doses will be supplied upon licensure or WHO prequalification.

It should be noted that advance market commitments help with financing opportunities and alleviate the risks associated with vaccine production, but do not necessarily take into account an equitable allocation of vaccines. Together with guaranteeing a fixed amount of orders for the vaccine as an incentive for pharmaceutical firms, the Gavi COVAX Facility has further implemented an equitable distribution clause to ensure that no country is left behind in the pandemic, and that distribution of the vaccine is by necessity rather than demand.

nature and efficacy of its institutions, its development stage and its economic volatility (Gold, Morin and Shadeed, 2019). Cross-country studies that look at the correlation between IPR protection and innovation generally consider country-level measures of patents, without distinguishing between sectors/technologies. Exploiting the availability of patent data disaggregated by sectors, Figure C.3 displays a weakly positive (unconditional) correlation between IPR protection and the share of ICT patents in total patents in a cross-section of 91 developing and developed economies.²⁶

The question of whether IPRs have a causal impact on innovation can hardly be answered satisfactorily in cross-country studies, in the absence of exogenous variation in IPRs. A couple of recent careful studies show that patent protection increases the availability of new drugs.

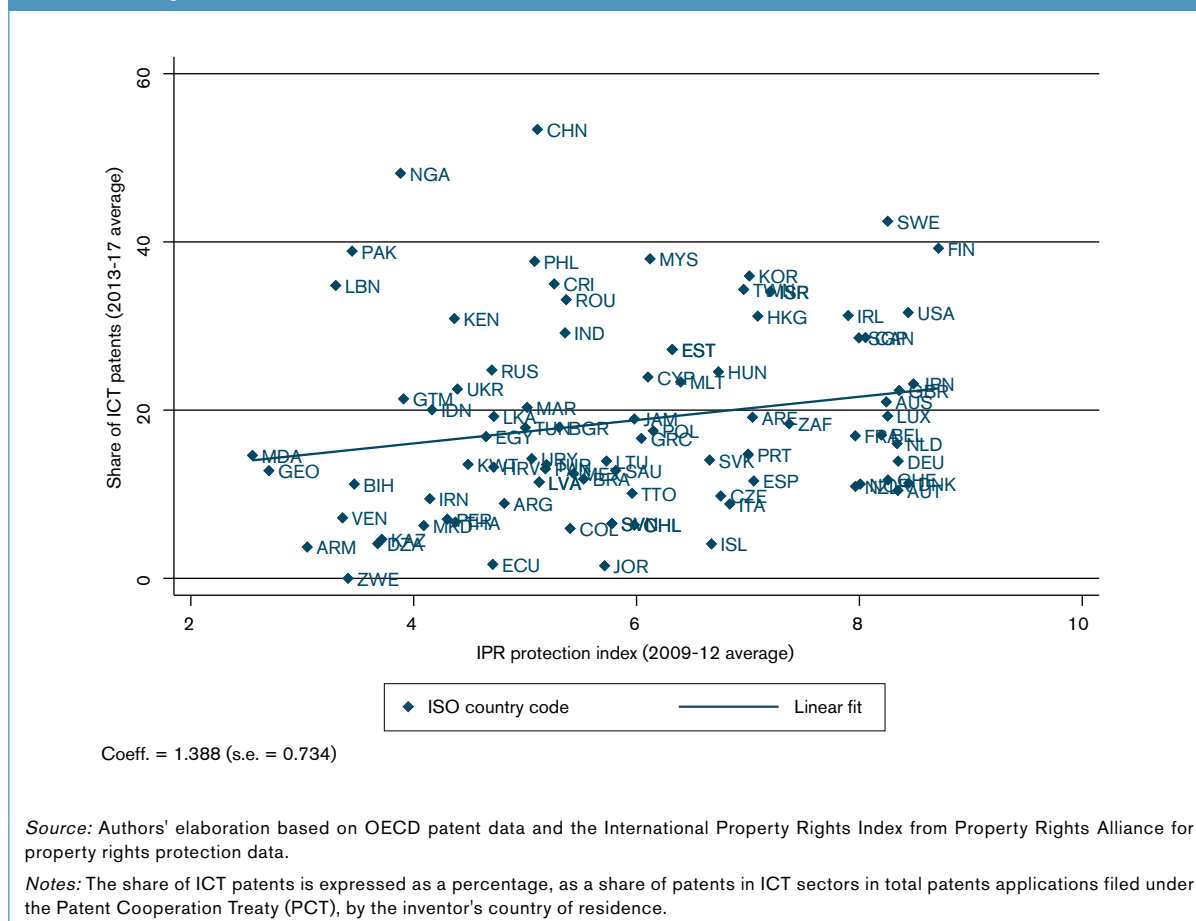
Kyle and Qian (2014) consider the effect of pharmaceutical patent protection on (among others) the speed of drug launch in 60 countries from 2000 to

2013. They use variations in the compliance deadlines of the WTO Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS Agreement) at the product level to obtain exogenous variation in the "treatment" (i.e. the implementation of a minimum level of patent protection as mandated by the TRIPS Agreement). They find that patents have important consequences for access to new drugs: in the absence of a patent, launch is unlikely.²⁷ Cockburn, Lanjouw and Schankerman (2016) analyse the timing of the launches of 642 new drugs in 76 countries between 1983 and 2002. They show that longer and more extensive patent rights shorten the time span before new drugs become commercially available in different countries.

In a survey on the impact of patents on research investments, Williams (2017) identifies three key questions to be addressed. First, how does patent disclosure – i.e. the requirement to disclose the invention in exchange for the patent right – affect research investments? Second, is stronger patent protection – i.e. longer patent terms or broader patent scope – effective in inducing additional research

Figure C.3: The share of ICT patents positively correlates with IPR protection

Correlation between the share of ICT patents in total patents (2013-17 average, vertical axis) and the IPR protection index (2009-12 average, horizontal axis)



investments? And third, do patents on existing technologies affect subsequent research investments?

For all these questions, the empirical evidence is not conclusive. There is limited evidence showing an increase in research investments due to patent disclosure.²⁸ There is also not much evidence that stronger patent rights encourage research investments.²⁹ And different studies come to different conclusions on the impact of IPRs on follow-on innovation.³⁰

Compulsory licensing – under which a government allows the production of a patented product or process without the consent of the patent owner or plans to use the patent-protected invention itself – can be used to get access to essential foreign technology (a typical example being a life-saving drug).³¹ Such policy can impact innovation both in the licensing country and in the foreign country. The impact of compulsory licensing on invention in the licensing country is theoretically ambiguous (Moser, 2013). On the one hand, access to foreign-owned inventions may discourage domestic invention in the licensing country if it displaces domestic R&D. On the other hand, licensing may encourage domestic R&D that is complementary to foreign-owned inventions, increase the stock of knowledge and allow learning-by-doing. Empirically, Moser and Voena (2012) exploit an episode of extensive compulsory licensing under the US Trading with the Enemy Act (TWEA) of 1917 to identify its effects on patenting activity of US inventors in organic chemistry.³² They show a 20 per cent increase in domestic patenting in response to compulsory licensing.

The effects of compulsory licensing in the country of the inventors whose patents were licensed are also theoretically ambiguous. Compulsory licensing may discourage long-run innovation by reducing the expected effectiveness of patents, but it may also foster innovation by increasing the threat of competition. The US TWEA made all German-owned patents available for licensing to US firms as of 1919. Baten, Bianchi and Moser (2017) study the impact of this episode of compulsory licensing on patenting activity by German firms. They show that German firms whose patents were licensed increased their R&D efforts in fields with licensing. On average, firms whose patents were licensed patented 89 per cent more after 1919 in fields with licensing.

Taken together, the case study results of Moser and Voena (2012) and Baten, Bianchi and Moser (2017) indicate a net positive cross-border impact of compulsory licensing on invention, both in the licensing country and in the country of the inventors

whose patents are licensed. It is worth emphasizing, however, that these results refer to the exceptional case where an entire nation's patent portfolio is licensed within a wartime economy. Very little is known about the innovation impact of more limited forms of compulsory licensing that are more in line with current practice.

In the digital economy, IP protection takes the form of patents, trademarks and copyright, legal protection against the circumvention of technological protection measures or the removal of digital rights management information (see the discussion in Section D of WTO, 2018a) and, increasingly, trade secrets (Baker McKenzie, 2017). The complexity of products that use digital technology has led to the emergence of patent thickets, defined by Shapiro (2000) as a "dense web of overlapping IPR that a company must hack its way through in order to actually commercialize new technology". For instance, it is estimated that a smartphone is covered by 250,000 patents (Wagner, 2015). In theory, patent thickets may have the perverse effect of stifling innovation. However, in a sample of 121 publicly traded software firms during the period 1980-99, Noel and Schankerman (2013) find that greater fragmentation of patent rights is associated with lower market value, but higher levels of patenting and R&D.

Copyright law is more important in digital markets because digital products can be copied at zero cost (Goldfarb and Tucker, 2019). Several studies have addressed the issue of how copyrights affect the creation of new cultural products. The economic history literature suggests that copyrights increase the quality of creative output (Giorcelli and Moser, forthcoming). Evidence from the digital age, however, points in the opposite direction. Waldfogel (2012) shows that, while the quality of music began to decline in the early 1990s, it stopped declining, and may well have improved, in the decade following the 1999 arrival of free online copying. He explains this result by noting that digital technologies greatly reduced the costs of creating, promoting and distributing music. As a consequence, independent labels (whose releases represent a high share among albums most highly rated by critics) are playing a growing role in the music industry.³³ Similar results pointing to an increase in quality of cultural products in the digital era have also been found for books (Waldfogel and Reimers, 2015) and movies (Waldfogel, 2016).

Open source software (see Section C.2) is a digital public good for which IP protection serves the purpose of keeping the project non-excludable (Tirole, 2017). Consider the general public licence under which Linux operates. Users may freely copy,

change and distribute it, but may not impose any restrictions on further distribution, and must make the source code available. That is, they are obliged to ensure that the community benefits from any modified version (Tirole, 2017).³⁴ Due to the non-rival and non-excludable nature of open source software, and to the immediate online availability of new code, high quality open source contributions can be widely adopted in a short time span.

There are many important contributions of open source software to digital innovation. As argued above in this subsection, data are a key input of digital innovation. With Big Data accumulating over time, data extraction and analysis methods based on AI require supercomputers, servers and cloud infrastructure. In 2019, all of the fastest 500 supercomputers in the world, 96.3 per cent of the world's top 1 million servers, and 90 per cent of all Cloud infrastructure were using the open source Linux operating system.³⁵

(d) Developing and attracting human capital

Human capital fosters economic growth through two mechanisms (Cinnirella and Streb, 2017). First, human capital can be viewed as a factor of production which increases productivity for a given level of technology – see for instance the contribution by Mankiw, Romer and Weil (1992), who present a production function where output is determined by physical capital, human capital and effective (i.e. technology-adjusted) labour. Second, human capital is an input in the innovation process – see for instance Romer's (1990) model of endogenous technological change. In this second mechanism, higher levels of human capital lead to the generation or diffusion of new technologies or to a more efficient adoption of a given technology, thereby shifting the production possibility frontier outwards.

Innovation is almost exclusively accomplished by formally educated individuals. Shambaugh, Nunn and Portman (2017) report that patent-holders are substantially more educated than the rest of the population: in the United States, 27 per cent of the population hold a Bachelor's degree, while more than 90 per cent of US patent-holders have at least a Bachelor's degree. The authors also show that high-quality patent activity (filing of the patent in at least two offices) is almost exclusively accomplished by people with advanced degrees. The percentage of triadic patent-holders (i.e. holder of a patent filed with all three of the United States, Japan and European Patent Offices) with a PhD, MD or equivalent degree is equal to 45 per cent, and 70 per cent of triadic patent-holders have at least a Master's

degree. Only 23 per cent of them completed only a Bachelor's degree and – contrary to the stereotype of the college-dropout inventor/entrepreneur – only 7 per cent did not complete a four-year degree. Furthermore, the educational attainment of innovators has increased over time.

The type of human capital that seems to matter most for innovative activity (as measured by patenting) is STEM graduates (Romer, 2001). Shambaugh, Nunn and Portman (2017) report that industries that employ more STEM workers, such as communications equipment industries, produce more patents, even if some of the variation across industries is associated with differences in the tendencies of industries to use patents as the preferred mechanism to protect their IP. Autor *et al.* (forthcoming) show that this phenomenon is growing over time: the computer and electronics industries, which employ a large share of STEM workers, increased their patent production between 1975 and 2007. In contrast, the chemicals and pharmaceuticals industries, which have a much lower share of STEM employment, saw little or no growth in patenting.

In several countries there is a fear that the school systems do not produce an adequate number of STEM graduates to support innovation (Bianchi and Giorcelli, 2019).³⁶ In 2012, the US President's Council of the Advisors on Science and Technology (PCAST) highlighted the "need for approximately 1 million more STEM professionals than the United States will produce at the current rate over the next decade". This would be achieved by increasing "the number of students who receive undergraduate STEM degrees by about 34% annually over current rates".

Previous subsections discussed the role of universities as producers of the type of human capital that spurs innovation. Further insights can be gained from Bianchi and Giorcelli (2019). They exploit a 1961 reform that relaxed the enrolment requirements in Italian STEM majors, more than doubling the number of STEM first-year students, to document an increase in innovation activity, particularly in chemistry, medicine and information technology. The authors, however, also find that access to scientific educations increased employment opportunities in high-paid occupations not focusing on the production of patents.

This latter result is in line with Carnevale, Smith and Melton (2011), who argue (for the United States) that the increase in the relative demand for STEM workers (which was larger than the increase in their relative supply, leading to an increase in STEM workers relative wages) occurred across many sectors,

including outside of STEM. In particular, Carnevale, Smith and Melton (2011) report that in all but two occupational clusters, the rate of growth in demand for core STEM competencies increased at far greater rates than the growth in employment. They conclude that "the growing demand for STEM talent allows and encourages the diversion of students and workers with STEM competencies".³⁷

(i) The role of international migration

High-quality human capital can not only be produced domestically (through the education system), but also be imported (via permanent or semi-permanent immigration). The United States has traditionally constituted a magnet for talented immigrants. Shambaugh, Nunn and Portman (2017) report that while immigrants make up only 18 per cent of the US labour force aged 25 and older, they account for 26 per cent of the STEM workforce, for 28 per cent of high-quality patent-holders, and for 31 per cent of PhD holders. In other English-speaking countries such as Canada, Ireland and the United Kingdom, the share of immigrants with tertiary education is higher than the share of natives with tertiary education (see Figure C.4).

As shown in Figure C.5, in a cross-section of 63 developing and developed countries, there is an unconditional positive correlation between the country-level stock of highly-skilled migrants and the share of ICT patents in total patents. This suggests that highly skilled migrants positively contribute to

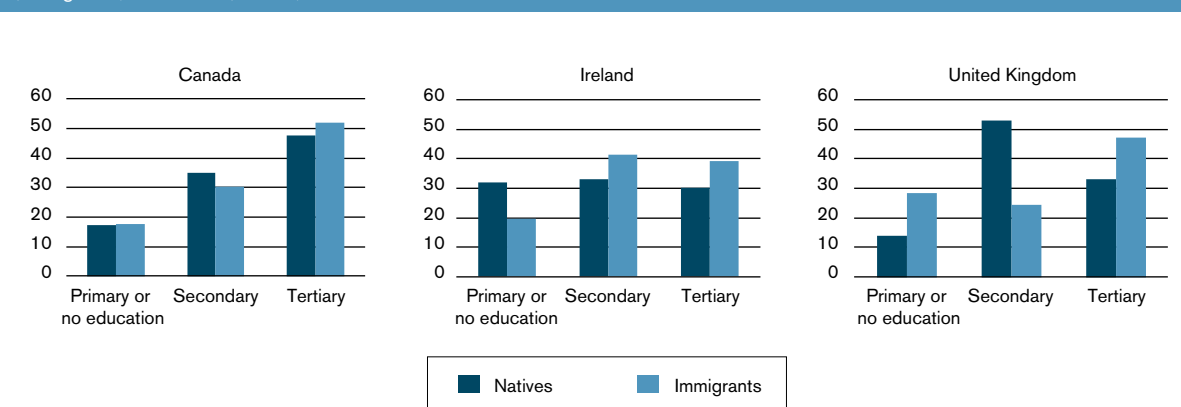
innovation in the knowledge economy. The rest of this subsection discusses the empirical evidence available on the link between migration and innovation.

There is abundant research focusing on the extent of net innovation stemming from immigration of highly skilled migrants. Much like the evidence on the labour market effects of immigration, the evidence of the innovation effects of immigration is debated, at least for the United States. As reported by Kerr *et al.* (2016), studies exploiting long-horizon and spatial variation in high-skilled immigration often find results consistent with immigrants boosting innovation and productivity outcomes.³⁸ However, other studies suggest that immigrants mostly displace natives to yield a zero net benefit.³⁹ In the case of European countries, there is clearer evidence that national diversity has had a net positive impact on innovation.⁴⁰ The overall conclusions reached by Kerr *et al.* (2016) and by Bloom, Van Reenen and Williams (2019) is that highly skilled immigrants boost innovation and productivity.

Attracting highly skilled migrants to developed countries is generally implemented through one of two approaches. The first is a points-based system, which ranks individuals based on observable characteristics that comprise their skill set (education, language skills, work experience, existing employment). Australia and Canada implement such "supply-driven" systems. The second approach is an employer-driven system, in which firms select skilled workers for admission in the country. The US H1-B and L1 visas are primary examples of this "demand-driven" system.

Figure C.4: In some countries, immigrants have higher educational attainments than natives

Proportion of natives or immigrants with primary or no education, with secondary and with tertiary education, 2010 (immigrants) and 2011 (natives)

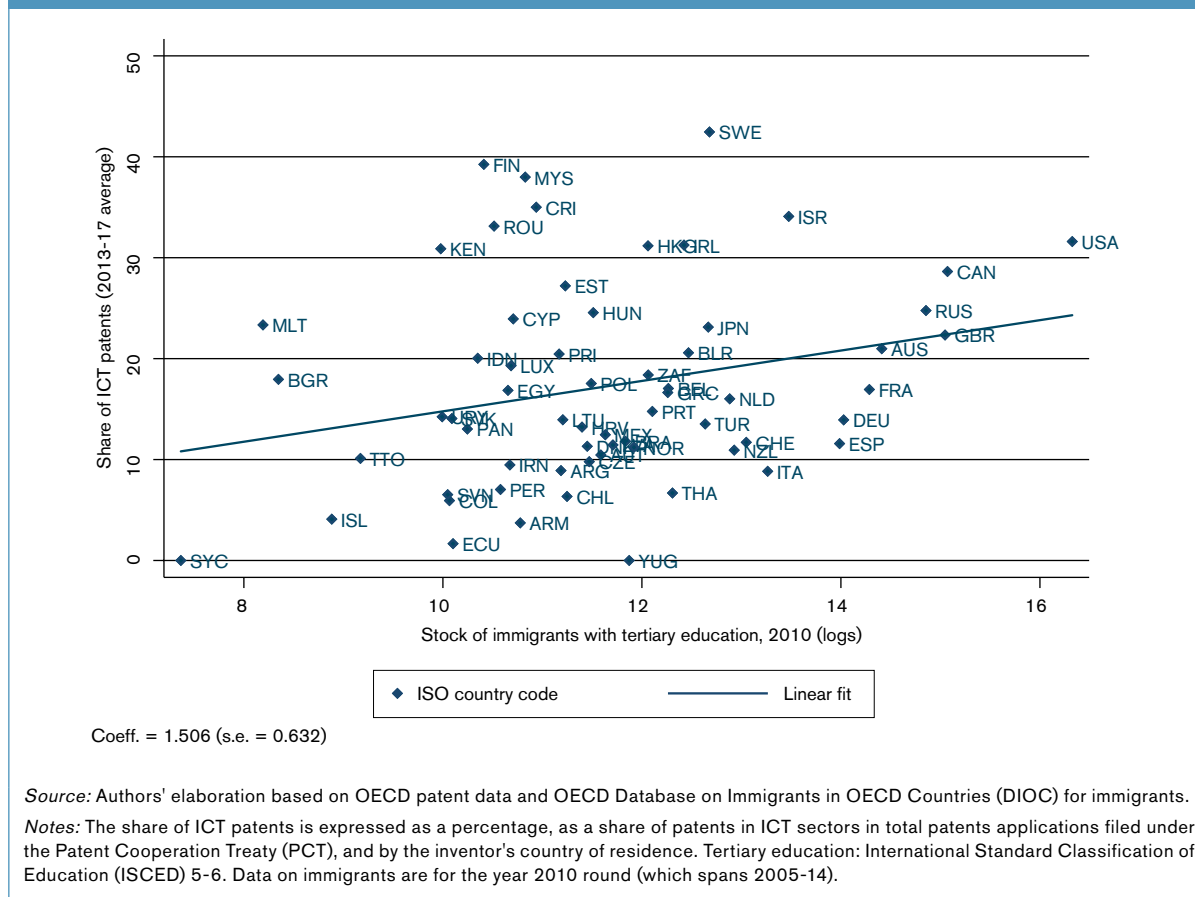


Source: Authors' elaboration based on data from OECD Database on Immigrants in OECD Countries (DIOC) for immigrants, and the United Nations Educational, Scientific and Cultural Organization (UNESCO) Institute for Statistics (UIS) for natives.

Notes: Primary or no education: International Standard Classification of Education (ISCED) 0-2. Secondary education: ISCED 3-4. Tertiary education: ISCED 5-6. Data are for the year 2010 round (which spans 2005-14) for immigrants, and for 2011 for natives. Data for immigrants are for individuals aged 15 or above. Data for natives are for individuals aged 25 or above.

Figure C.5: The share of ICT patents positively correlates with the stock of highly skilled migrants

Correlation between the share of ICT patents in total patents (2013-17 average, vertical axis) and the stock of immigrants with tertiary education (2010, in logs, horizontal axis)



Source: Authors' elaboration based on OECD patent data and OECD Database on Immigrants in OECD Countries (DIOC) for immigrants.
 Notes: The share of ICT patents is expressed as a percentage, as a share of patents in ICT sectors in total patents applications filed under the Patent Cooperation Treaty (PCT), and by the inventor's country of residence. Tertiary education: International Standard Classification of Education (ISCED) 5-6. Data on immigrants are for the year 2010 round (which spans 2005-14).

As discussed by Kerr *et al.* (2016), both systems have advantages and disadvantages, and in practice most immigration policies set by developed countries contain elements of both systems. Czaika and Parsons (2017) offer an empirical gravity-based evaluation, using annual bilateral (i.e. origin-destination) data on labour flows of highly skilled workers for ten OECD destinations between 2000 and 2012. They conclude that points-based systems are much more effective in attracting and selecting highly skilled migrants than systems which require a job offer, labour market tests and shortage lists. They also show that some provisions of bilateral agreements, such as the recognition of diplomas and social security agreements, also increase the skill composition of migrant flows.⁴¹

Using the 2003 National Survey of College Graduates, Hunt (2011) shows that immigrants who entered the United States on a student/trainee visa (e.g. F-1, J-1, H-3) or a temporary work visa (e.g. H-1B, L-1, J-1) have a large advantage over natives in patenting, commercializing or licensing patents, and writing books or papers for publication and presentation at conferences. Her results suggest a

ranking of the gross contribution of immigrant groups according to their status on arrival in the United States: postdoctoral fellows and medical residents, graduate students, temporary work visa-holders, college students, other students/trainees, legal permanent residents, dependents of temporary visa-holders, and other temporary visa-holders.

Attracting highly skilled migrants is an important policy objective in several developing countries, too. The evidence on the impact of policies is, however, scant. In South-East Asia, for instance, there is some evidence showing a positive impact of skilled migrants on productivity in the Malaysian manufacturing sector, but no evidence that employing more skilled foreign workers has any effect on innovation or R&D spending in Thailand (see the studies discussed in Testaverde *et al.*, 2017). In Latin America, the Start-Up Chile programme pays foreign entrepreneurs to spend six months in the country in an effort to build global skill connections. The programme has been successful, as it supports between 200 and 250 new ventures per year, and Chile has launched other similar programmes (Kerr *et al.*, 2016). In an evaluation

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EDUCATION AND HEALTH AS INDUSTRIAL POLICY

Human capital is among the most important drivers of long-run economic growth and industrial development (Hanushek, 2013; Hanushek and Woessmann, 2011; Jones, 2014), yet it is frequently overlooked in discussions of industrial policy. As governments and business groups search for ways to boost economic growth, targeted measures often take precedence over basic investments in education and health. This is a mistake.

Economic growth is fuelled by people. An economy's capacity to produce is driven by the vitality, skills and innovation of its population. Without education, individuals have limited opportunities to imagine, create and build the products of today and the industries of the future. Without health, societies have neither the capacity to produce nor the appetite to consume the goods and services that form the backbone of industry. The COVID-19 crisis has demonstrated with unflinching severity the critical role of public health in the modern global economy. At the same time, the pandemic has highlighted the necessity for broad-based education, especially scientific literacy, as an essential determinant in countries' success in beating back the virus. No industry can thrive for long without the twin foundations of public education and health.

Education and health are not simply necessary preconditions for economic success. They are also critical drivers of frontier growth, particularly in high value-added, high-innovation sectors of the economy that depend on the cognitive skills and creativity of the working population (Ciccone and Papaioannou, 2009). In many such sectors, virtuous cycles can emerge: investments in human capital can increase a country's ability to compete globally in high-value industries. Growth in these industries expands the job opportunities and incentives for future educational and skill attainment by younger workers, who subsequently invest more in human capital, further deepening a country's competitive position in the future (Atkin, 2016; Bajona and Kehoe, 2010; Blanchard and Olney, 2017). Even small initial investments in human capital can yield significant economic returns over time.

Another important advantage of human capital investment is that it does not require governments to make risky gambles on future conditions in particular industries. It is notoriously difficult to "pick winners," and far too often, well-intentioned industrial policies end up betting on the wrong horse, wasting precious fiscal resources that, in hindsight, would have

been better directed elsewhere. In contrast, investments in human capital strengthen a country's most important and flexible resource – its workers – who will naturally gravitate toward the most dynamic sectors, provided that labour markets are flexible and transparent, and that educational opportunity is broadly shared. Workforce flexibility also plays a critical role during hard times: healthier and more educated workers are more able to adapt to negative shocks and unexpected changes in the global economy. Economic resilience depends critically on workers' versatility, which depends in turn on individual health, public health, high-quality universal education and access to lifelong learning.

Finally, but most importantly, human capital investments are two-fers – "two for one" investments. Not only do investments in education and health boost economic growth, but they also contribute directly to individual and societal prosperity. The ultimate goal of economic development is to serve humanity. As key drivers not only of economic dynamism and resiliency, but also of the fundamental determinants of human progress, education and healthcare rank among the most vital and highest-return investments countries can make.

of special economic zones (SEZs) in Panama, Hausmann, Obach and Santos (2016) report that immigrants in Panama are more educated, more likely to be entrepreneurs, work in industries that are more complex and earn higher wages than nationals. They show large immigrant-to-national spill-overs in the form of a positive relationship between the share of immigrant employees and the productivity of Panamanian workers in a particular industry-province space. The authors conclude that Panamanian SEZs are functioning as channels that are not only moving people across borders, but are also transmitting know-how.

In developing countries, innovation and its diffusion are more likely to be impacted by the emigration than by the immigration of highly skilled individuals. Diasporas can generate net positive gains for the migrants' home countries (see Docquier and Rapoport, 2012; Parsons and Winters, 2014 for extensive reviews). Box C.5 discusses, in particular, how diasporas can impact innovation in the emigrants' countries of origin.

(e) Regulation of competition

Some economists have posited an inverse U-shaped relationship between competition and innovation (Aghion *et al.*, 2005). In their framework, at low initial levels of competition, more competition would foster innovation, while at high initial levels of competition, more competition would hinder innovation.

Recent empirical research shows, however, that if there is an effect of competition on innovation, it is a positive one.⁴² Federico, Morton and Shapiro (2020) contend that the notion of an inverse U-shaped relationship between competition and innovation is not only empirically, but also theoretically invalid. They argue that greater rivalry, in the sense of greater contestability of future sales, unambiguously leads to more innovation. This is because in contestable markets, future sales will be won by the most innovative firm – be that the incumbent or a disruptive challenger. Therefore, both current market leaders (including a dominant incumbent) and disruptive rivals have an incentive to innovate and capture future sales in contestable markets. It follows that innovation-friendly competition policy prevents "current market leaders from using their market power to disable disruptive threats, either by acquiring would-be disruptive rivals or by using anti-competitive tactics to exclude them" (Federico, Morton and Shapiro, 2020).

The evidence of the impact on regulation of competition on innovation is quite sparse, although generally supportive of a positive effect.

First, some studies have shown, both for developing and developed countries, that product or service market regulation reduces the intensity or the efficiency of R&D in the same sector or in downstream sectors.⁴³

Second, there is some evidence that competition law enforcement may enhance innovation. Koch, Rafiquzzaman and Rao (2004) find positive impacts of antitrust regulation on the R&D intensity in former G7 countries. Bütthe and Cheng (2017) find that the effect of a country having a substantively meaningful competition law on innovation (measured by the number of patent applications) is positive in cross-sectional and panel analyses for OECD and developing countries. More convincingly, Watzinger *et al.* (forthcoming) consider the potential impact of compulsory licensing as an antitrust remedy to increase innovation.⁴⁴ They exploit a 1956 consent decree which settled an antitrust lawsuit against Bell (a US telecommunications equipment firm), forcing Bell to license all its existing patents royalty-free, including those not related to telecommunications. Watzinger *et al.* (forthcoming) show that this led to a long-lasting increase in innovation, but only in markets outside the telecommunications industry. Conversely, no effect is found within telecommunications, where Bell continued to exclude competitors. This is evidence that compulsory licensing can act an effective antitrust remedy if markets are contestable.

Third, several studies show that the removal of market entry barriers fosters innovation. In the pharmaceutical sector, Grossmann (2013) finds that entry deregulation increases firms' R&D intensity. In the digital technology field, Gruber and Koutroumpis (2013) consider the effect of regulatory policy changes that introduced retail local loop unbundling (LLU) – a form of technology that allows multiple providers to use a single telecom network. In a sample of 167 developing and developed countries during the period between 2000 and 2010, they provide evidence that full LLU and, to an even larger extent, retail LLU positively affect the adoption of broadband telecommunications.

Similarly, Nardotto, Valletti and Verboven (2015) consider the impact of regulation on broadband infrastructure on broadband penetration in the United Kingdom. They document a strong – although heterogeneous across locations – increase in LLU entry in the United Kingdom over the period between 2005 and 2009. During the same period, broadband penetration more than doubled. LLU entry only contributed to higher penetration levels in the early years of the sample, while inter-platform competition (from cable) positively contributed in all years of the

Box C.5: Diasporas, brain circulation and innovation in migrant origin countries

The emigration of scientists and engineers has long been regarded as a threat to the innovation potential of their countries of origin through the loss of home-educated human capital or "brain drain". Several strands of research discuss various compensatory mechanisms through which innovation may take place in or diffuse to migrant countries of origin due to the "circular flow of talents" (also known as "brain circulation").

First, networks of inventors from the same country may have a role in spurring innovation diffusion in their country of origin. Kerr (2008) finds that non-US based researchers tend to cite US-based researchers from their own countries 30–50 per cent more frequently than US-based researchers from other countries. This is consistent with a positive role of "frontier expatriates" in the adaptation of foreign frontier technology to local production.

Agrawal *et al.* (2011), however, reach different conclusions. They show that the likelihood that a patent is cited by Indian inventors is more likely influenced by co-location effects (i.e. the fact that at least one of the inventors of the cited patent is in India) than by diaspora effects (i.e. the fact that at least one of the inventors of the cited patent is an Indian located abroad). They conclude that – except in the case of high-value inventions – technology absorption might be higher if highly skilled workers stayed at home than if they migrated.

In a similar vein, Breschi, Lissoni and Miguélez (2017) show that "brain gain" effects (US-resident foreign-origin inventors being disproportionately cited by inventors in their home countries) exist for China and Russia, but not for India.

Second, migrant inventors may facilitate the conduct of innovative activity (R&D and patenting) in their countries of origin. As shown by Kerr and Kerr (2018), between 1982 and 2004, the share of R&D for US companies conducted by their foreign operations rose from 6 per cent to 14 per cent (see also Branstetter, Li and Veloso, 2014). During the same period, patents with global inventor teams (i.e. patents where at least one inventor is located outside of the United States and at least one inventor is located within the United States) rose from 1 per cent of US public firm patents in 1982 to 6 per cent in 2004.

Miguélez (2018) documents the role of highly skilled diaspora communities for the development of global inventor teams. He finds that international collaboration in patenting activities within pairs of developing-developed countries is positively correlated with the stock of migrant inventors from one country into the other. Foley and Kerr (2013) study the impact that non-US born innovators have on the operations of the foreign affiliates of US MNCs. They find that increases in the share of a firm's innovation performed by inventors from a particular country are associated with increases in investment and innovation in those inventors' countries, and with decreases in joint venturing with local companies.

Third, returned migrants may have an important role to play in innovation back home. Liu *et al.* (2010) exploit a four-year panel dataset of around 1,300 enterprises located in the Zhongguancun Science Park (Beijing, China). Both ownership by a returnee and the density of returnees in the company's sector positively affect patenting activity, measured by the number of patents filed by each firm at SINO (the Chinese patent office). Similarly, in a sample of more than 800 Chinese photovoltaic firms between 1998 and 2008, Luo, Lovely and Popp (2017) show that corporate leaders who have studied or trained in an advanced country positively influence patenting activity. Research also shows that Chinese returnee entrepreneurs play a positive role in promoting innovation by firms that are geographically close to the firm where they are employed (Filatotchev *et al.*, 2011; Luo, Lovely and Popp, 2017).

In the case of India, Nanda and Khanna (2010) find that entrepreneurs who were members of the National Association of Software and Services Companies trade association and who had previously lived outside of India were more likely to activate overseas connections when living outside of the prominent software hubs. Choudhury (2016) studies whether return migrants facilitate knowledge production by local employees working for them at geographically distant locations. Using data for 1,315 employees at the Indian R&D centre of a technology firm, he finds that local employees with returnee managers file more US patents than local employees with local managers.

Box C.5: Diasporas, brain circulation and innovation in migrant origin countries (continued)

In countries with very high "brain drain" rates, however, the impact of return migrants on innovation creation or diffusion is modest at best. Using survey data for Tonga, the Federated States of Micronesia, Papua New Guinea, Ghana and New Zealand (countries with high "brain drain" rates in their respective geographical or income group), Gibson and McKenzie (2012) find that returned migrants are only marginally more likely to engage in knowledge transfer than non-migrants, especially to business.

Overall, there is evidence that migration is an important factor in innovation creation and diffusion in most migrants' countries of origin. However, as emphasized by Carlino and Kerr (2015) and Kerr *et al.* (2017), more research is needed to understand the relative impact of different forms of migration, including permanent migration to the new economy, regular business travel across places (which, looking at U.S. business travel to foreign countries, Hovhannisyan and Keller, 2014 show to have a positive impact on innovation in these countries) or return migration.

sample. However, local markets that experienced LLU entry had a considerably higher average broadband (a measure of quality of service) speed than those that did not experience LLU entry.

Finally, Molnar and Savage (2017) show that, in the United States, internet wireline speeds are often higher in markets with two or more wireline internet service providers (ISPs) than with a single wireline ISP.

For countries in the process of development, market entry barriers are relatively less harmful the further away the country is from the world technology frontier (Acemoglu, Aghion and Zilibotti, 2006). This is because the adoption and adaptation of existing technologies does not require as tough a selection of high-quality entrepreneurs as that required for frontier innovation. Moreover, a would-be pioneer entrepreneur in a developing country interested in adapting an existing foreign technology to the local market, i.e. self-discovery, may have more incentives to innovate in the presence of market entry barriers than in their absence.

These arguments come with an important caveat. Government intervention in the form of policies limiting product market competition, among others, may only be useful to improve the short-run allocation of resources, but may have adverse long-run consequences, including making the economy stick in a non-convergence trap, from where it fails ever to achieve the world technology frontier (Acemoglu, Aghion and Zilibotti, 2006).

(f) Creating an innovation-friendly environment

This subsection considers a set of policies that contribute to creating an innovation-friendly environment. First is an examination of policy aimed at building

and maintaining telecommunication infrastructure. Such policy is crucially important for innovation, and in particular digital innovation, because access to broadband is an essential input in the innovation production function. Second, the impact of policies favouring agglomeration of economic activity is reviewed. Third, policies that favour the exposure to innovation during childhood are discussed, as well as why such policies are likely to have a large impact on innovation, by allowing talented individuals to become inventors, even if they are born into disadvantaged socio-economic groups.

(i) Telecommunication infrastructure policy

ICTs contribute significantly to economic and productivity growth and efficiency (Sharafat and Lehr, 2017). Access to a reliable, comprehensive and affordable high-speed broadband network is essential for such contributions to materialize, and it is likely to become a central factor of competitiveness in the digital age, as discussed in WTO (2018a). Yi (2013) finds for 21 OECD countries that better broadband access provides for a comparative advantage in less routine task-intensive sectors. The production of innovation, and in particular digital innovation, is by its very nature intensive in non-routine tasks. Indeed, high-speed broadband is an essential input in the digital innovation production process. Consequently, only countries (or locations within countries) endowed with a reliable, comprehensive and affordable high-speed broadband network will be able to contribute to innovation, especially in the digital realm.

(ii) Policies to favour agglomeration

Innovative activity, including R&D, venture capital investments and patents, is spatially concentrated (Carlino and Kerr, 2015). The spatial concentration of innovative activity is largely driven by the same forces

that determine the spatial concentration of economic activity (see Box B.2): sharing of common inputs, matching in local labour markets and knowledge spill-overs.⁴⁵ According to Madaleno *et al.* (2018), sharing effects arise from pooled equipment, facilities, etc.; matching effects from networking or peer-to-peer linkages, which help to identify partners; and knowledge spill-overs arise from peer-to-peer interactions, mentoring or networking. On the negative side, there can also be diseconomies of agglomeration, for instance if knowledge spill-overs give rise to group thinking and the poaching of ideas in environments where secrecy may be hard to maintain (Madaleno *et al.*, 2018). The net effect on innovation is positive, however, as shown by the fact that innovative activity is significantly more concentrated than general economic activity.

In knowledge-based economies, "tech clusters" (Kerr and Robert-Nicoud, 2019) or "science parks" (Liang *et al.*, 2019) play a growing role in accommodating high-tech firms. In the absence of targeted policy interventions, such clusters emerge as an equilibrium outcome when there are strong localized knowledge spill-overs, high start-up costs, skilled labour abundance, or low commuting costs (Liang *et al.*, 2019). Furthermore, location-specific endowments of fixed factors in the production of innovation, such as strong universities and government-sponsored laboratories, are important attractors of clusters of innovation. Historical accidents (including where breakthrough inventions were made, or where anchor firms initially locate) and self-fulfilling expectations (Krugman, 1991) also matter.⁴⁶

Co-location policies aimed at encouraging high-tech firms to locate in high density accelerators, incubators or science parks are increasingly popular.⁴⁷ There is, however, little empirical evidence that justifies such policies. Chatterji, Glaeser and Kerr (2014) note that, among the three most well-known clusters in the United States (Silicon Valley, Boston's Route 128, and Research Triangle Park), only the latter was clearly a product of dedicated state-level planning. Hochberg (2016) documents a few empirical attempts to assess whether US accelerators do indeed have a positive effect on the outcomes of the companies that participate in the programmes, with mixed results. Gonzalez-Urbe and Leatherbee (2017) consider the impact of Start-Up Chile, an accelerator aimed at stimulating start-up activity by offering equity-free cash infusion, shared co-working office space and the possibility of being selected into an exclusive sub-programme, akin to an "entrepreneurial school". They find no evidence that basic accelerator services of cash and co-working space have an effect on the fundraising, scale or survival of treated start-ups.

Conversely, the combination of basic accelerator services and entrepreneurship schooling leads to significantly higher venture fundraising and scale (number of employees). For the United States, there is evidence that accelerator programmes have a positive impact on the region (regardless of their effects on the small number of companies that attend them): US metropolitan statistical areas that receive an accelerator programme exhibit significant differences in initial (seed and early stage) venture capital attraction compared to areas that do not receive an accelerator programme (Fehder and Hochberg, 2014).

In the case of science parks, there is some evidence of a direct impact on innovation. In particular, two studies reviewed by Madaleno *et al.* (2018) find that co-location in science parks increases patenting both within and across industries for firms in the park. United Nations Conference on Trade and Development (UNCTAD) (2019) further reports that, in the 156 high-tech development zones established in China by the end of 2017, the ratio of R&D expenditures to total production value was 6.5 per cent, three times the average in the national economy. Patents granted to enterprises within such high-tech development zones account for 46 per cent of all business patents granted nationwide.

The experience of Chinese high-tech development zones suggests that SEZs might play a role in supporting innovation in the digital economy. At present, however, there is no systematic evidence of the impact of SEZs on innovation, let alone in digital sectors.

(iii) *Policies to favour individual exposure to innovation*

Most talented people never become inventors in the first place, for reasons that have to do with the environments in which they grow up. Bell *et al.* (2019) show that, in the United States, children born into low-income families, women and minorities are much less likely to become successful inventors. They provide evidence that gaps in innovation across individuals with different characteristics at birth are not due to inherited differences in talents or preferences to pursue innovation as a career. Rather, they are driven by differences in exposure to innovation during childhood through one's family or neighbourhood. According to Bell *et al.* (2019), increasing exposure to innovation among children who excel in mathematics and science at early ages, but come from unrepresented groups, can have large effects on aggregate innovation. They estimate that if women, minorities and children from lower-income families were to invent at the same rate as white

men from high-income (i.e. top-quintile) families, the total number of inventors in the US economy would quadruple.

The results of Bell *et al.* (2019) suggest a potentially large innovation impact of policies to increase exposure to innovation. Such policies, they argue, could range from mentoring by current inventors to internship programmes at local companies. Since it is talented children born in low-income families, women, and minorities that are relatively more likely to be "lost Einsteins", Bell *et al.* (2019) further suggest that aiming exposure programmes at women, minorities and children from low-income families who excel in maths and science at early ages is likely to maximize their impacts on innovation.

(g) Aggregate impact of innovation policy

Most empirical literature on the determinants of innovation does not deal with the aggregate effects of innovation policy. As argued above, in estimating the impact of some innovation policies, like R&D tax credits, it should be considered that these policies may simply cause a relocation toward geographical areas with more generous fiscal incentives and away from geographical areas with less generous incentives. Such relocation might both occur within borders and across borders – a point further elaborated in Section C.4.

There are relatively few studies that address the impact of innovation policy on aggregate welfare. Sollaci (2020) investigates the impact of the spatial dispersion of R&D tax credits in the United States. Increasing the geographical concentration of innovation in highly productive locations on the one hand increases the rate of growth of the economy, and on the other hand reduces individual firms' investments in R&D due to a higher rate of creative destruction (i.e. faster product and process innovation by which new products and processes replace outdated ones). Empirically, Sollaci (2020) finds that removing the spatial variation of R&D tax credits in the United States would generate a reduction in welfare, implying that the US states that offer the largest credits are indeed those that are comparatively better at producing innovation. However, he also finds that welfare could be further improved through an optimal distribution of R&D tax credits.

Knowledge spill-overs are critical in shaping the aggregate welfare impact of innovation policy. Atkeson and Burstein (2019) consider that changes in the innovation intensity of the economy entail relatively modest annual fiscal costs in the long run, equal to 1.1 per cent of GDP. Depending on the calibration,

the corresponding changes in welfare range from 1.7 to 20 per cent of aggregate consumption. The lower bound (1.7 per cent) is obtained in a scenario with business-stealing (i.e. the entry of a lower-cost alternative makes incumbent firms cease production of a product) and with low intertemporal knowledge spill-overs (i.e. knowledge spill-overs that occur over time); the upper bound (20 per cent) is obtained in a scenario without business-stealing and with high intertemporal knowledge spill-overs. Note that, even assuming that business-stealing occurs, innovation policy entailing annual fiscal costs in the long run of 1.1 per cent of GDP would increase welfare by 7.3 per cent, with high intertemporal knowledge spill-overs. These results show, once again, the importance of knowledge spill-overs stemming from innovation (for similar conclusions, see also Atkeson, Burstein and Chatzikonstantinou, 2019).

Beyond aggregate welfare impacts, another important question to be addressed in evaluating the aggregate effects of innovation policy is how and whether it affects inequality within a country.⁴⁸

As extensively discussed in WTO (2017a), technological progress can be biased in favour of certain groups of workers depending on their skills or on the tasks they perform. Digital innovation is a typical example of skill-biased technical change, because digital technologies tend to be used more intensively by skilled workers than by unskilled workers. Moreover, digital innovation tends to be routine-biased since it decreases the relative demand for routine tasks.

In general, workers performing non-routine cognitive tasks tend to see both their employment opportunities and their earnings go up; workers performing routine tasks (both manual and cognitive) tend to see both their employment opportunities and their earnings go down; and workers performing non-routine manual tasks tend to see their employment opportunities go up, but their earnings go down as middle-skilled workers in routine occupations are displaced and start competing for the available jobs in non-routine manual occupations (WTO, 2017a). The resulting employment and wage polarization in labour markets is a source of inequality that can be (at least partly) driven by digital innovation.

Furthermore, it has been argued in several parts of this report that when there are network externalities and technology lock-ins, "winner-takes-all" dynamics are likely to emerge. Innovation-based rents, while needed to incentivize innovation and compensate for its cost, tend to accrue mainly to investors and top managers and less to the average workers,

thereby increasing income inequality (Guellec and Paunov, 2017). Consistently with this, Aghion *et al.* (2019a) find that, across US states and local labour markets, there is a positive impact of innovation on top income inequality. Innovation does not, however, increase broad inequality. This is because innovation, particularly by new entrants, is positively associated with social mobility.⁴⁹

In contrast, lobbying to prevent entry by an outside innovator dampens both the impact of entrant innovation on top income inequality and the impact of innovation on social mobility. Based on these results, Aghion *et al.* (2019a) conjecture that, unlike innovation, lobbying should be positively correlated with broad measures of inequality, and negatively correlated with social mobility. This points once more to the importance, not only for innovation, but also for preventing further rises in inequality, of the above-discussed regulations of competition that ensure that current market leaders do not prevent entry of disruptive rivals via preventive takeovers or other anti-competitive tactics.

4. Cross-border effects of innovation policies

One important aspect of innovation policies in the context of trade is that they often have an impact on other countries. These spill-over effects are partly based on the same factors that provide an economic rationale for innovation policy, ranging from knowledge spill-overs to inter-industry linkages, but there are also additional externalities such as competition for scarce resources.

This subsection reviews the main cross-border effects of innovation (sections C.4(a) to C.4(e)) before analysing potential changes to these externalities arising in the digital age (Section C.4(f)). It concludes with a discussion of the potential aggregate cross-border effects of innovation policy and how policy can be designed to minimize negative spill-overs to other countries (Section C.4(g)).

A key message of this chapter is that cross-border externalities can be both positive and negative. For instance, knowledge created in one country tends to benefit other countries as it diffuses across space over time. On the other hand, innovation incentives can attract human and physical capital from one country to another, and this can hurt innovation in the former.

It is also important to highlight that cross-border externalities can be caused to varying degrees by almost all policy tools discussed in this report, from

trade policy to tax policy or even education policy. Understanding which policy tools maximize positive spill-overs and minimize negative spill-overs is crucial to designing innovation policy well. This brings us to the final key message, which is that the absence of high-quality literature in this area makes policy advice difficult and emphasizes the need for future research.

(a) Knowledge spill-overs and technology diffusion

Two of the most analysed cross-border externalities are knowledge spill-overs and technology diffusion. Endogenous growth theory argues that innovation is not just based on private inputs to the innovation process but also on the stock of publicly accessible knowledge which has been generated through previous R&D investments across the world (Grossman and Helpman, 1991; Romer, 1990). It is the formalization of the well-known concept of "standing on the shoulders of giants".

The idea is that once an innovation has been made, it can inspire and accelerate follow-up innovations. As a result, innovation policy pursued by one country can benefit the innovation activity of all other countries, since it increases the global stock of knowledge. In addition, innovation policy has spill-over effects, by creating technology that diffuses globally and facilitates the technological catch up and innovation of countries that are not at the technology frontier. There is a large literature confirming this theory, and the presence of international knowledge spill-overs that goes back to Coe and Helpman (1995). This literature has been further discussed in Section C.3(a).

A related strand of literature discusses other types of regional spill-overs and agglomeration effects of industrial and innovation policy. Such effects comprise, for example, labour-pooling when policy attracts skilled workers to a region, or local demand and supply linkages when policy causes suppliers and customers of targeted industries to locate in the targeted region. There is, for instance, evidence that capital subsidies, such as investment grants, benefit regional investment and employment but not productivity (Cerqua and Pellegrini, 2017). For SEZs, positive regional spill-overs, including increases in productivity and human capital investments, have also been found for neighbouring regions and cities further away (Alder, Shao and Zilibotti, 2016).

While this literature looks mostly at domestic regional spill-overs, the findings are also relevant for cross-border externalities, as many economic regions extend beyond national borders such as the Great

Lakes Regions in Africa (Burundi, the Democratic Republic of the Congo, Kenya, Malawi, Rwanda, Tanzania and Uganda) and North America (United States and Canada). More generally, regional spill-overs are always likely to affect neighbouring countries if they are targeted at regions close to the border in the intervening country.

(b) Strategic government policy

A second well-studied cross-border externality arises in the context of imperfectly competitive markets, such as oligopolies. If markets are not perfectly competitive, firms can extract rents or profits. That is, they can set prices above marginal costs. If only a few firms from different countries operate in a market, these firms share these rents. In such a situation, different policy tools, such as subsidies or tariffs, can shift rents from a producer in one country to a producer in another, or allow for increased entry in the intervening country. This is typically referred to as strategic trade policy and provides another theoretical underpinning for infant industry protection.

The idea behind strategic trade policy is that firms set their output or prices strategically, taking into account the output or prices of their foreign competitors. Countries can limit foreign firms' sales or boost the domestic firm's sales through different tools from export or R&D subsidies to import tariffs. The mechanism is that the policy intervention allows the domestic firm to enter the market or to lower its price and increase output. This, in turn, causes the foreign firms to strategically limit their output to protect their profit margin. Effectively, the policy intervention shifts the profits from these new or additional domestic sales from foreign to domestic producers and thereby raises domestic welfare at the expense of foreign welfare (Brander and Spencer, 1985; Spencer and Brander, 1983).

Applications of strategic trade policy have been observed in various contexts. Prominent examples include the market for large civil aircraft (Baldwin and Flam, 1989; Baldwin and Krugman, 1988), the automobile market in connection with voluntary export constraints (Krishna, Hogan and Swagel, 1994; Venables, 1994) or the semiconductor market (Baldwin and Krugman, 1986). Results of such simulation exercises often vary widely depending on parameter choices, but they typically differ from the majority of trade models in that they advocate some form of trade policy intervention over free trade. However, in many of these analyses, alternative policy tools, such as production subsidies, are preferable since they imply less costs for consumers (Brander, 1995).

(c) Competition for scarce resources

A related cross-border externality arises through competition for scarce resources or factors of production. If innovation policy attracts those factors of production, be they human capital, investment or any other resource, this can severely limit the supply of these factors in other countries. Similarly, if a policy prevents these resources from being exported, it limits availability abroad. This effect is particularly strong for very rare production factors. There is, for instance, evidence that tax policies are important to attract inventors with the most highly cited patents. Estimates suggest an elasticity of 1 for such foreign "superstar" investors with respect to the top marginal income tax rates (Akcigit, Baslandze and Stantcheva, 2016).

The same is likely to apply to data where data localization policies in different countries can act as a barrier to innovation for firms operating in these countries as they cannot connect data across borders. This, in turn, reduces innovation in the firms' headquarter countries (Pepper, Garrity and LaSalle, 2016).

Tax incentives that attract company headquarters or research facilities are likely to have the same effect and can, in addition, impose harm on the domestic economy if such incentives are too generous (Bartik, 2018; OECD, 1998). While focusing on domestic cross-state tax competition, one study has found, for example, that state-level R&D tax credits in the United States spurred local innovations, but largely by shifting R&D expenditure away from other US states, leading to "beggar-thy-neighbour" effects (Wilson, 2009). This type of cross-border externality has recently also been in the spotlight due to the discussion surrounding the incentives offered by various US states to Amazon for its second headquarters (Parilla, 2017).

(d) Supply-and-demand effects

Another mechanism leading to cross-border spill-overs is based on supply-and-demand effects. Innovation policy can increase the competitiveness of domestic producers on world markets. This can decrease world prices and lead to an oversupply of products at the expense of foreign competitors but for the benefit of foreign consumers.

For instance, if a country supports innovation policy in any given sector, countries that have a comparative advantage in this sector might see their terms of trade deteriorate as the innovation policy depresses prices in the sector (Samuelson, 2004). However, the multilateral nature of trade can provide a natural insurance mechanism against this effect, as what

matters in a globalized world is comparative advantage vis-à-vis the world rather than any single country. To that effect, a study on technological progress of China in comparative advantage sectors of the United States has shown that such technological progress supported by Chinese innovation policy increases US welfare (di Giovanni, Levchenko and Zhang, 2014).

The counterpart of supply effects is demand effects. Successful innovation policies increase domestic income, which typically leads to higher import demand. This, in turn, raises world prices for the benefit of foreign producers but to the detriment of foreign consumers. Other innovation-targeted policies, like local content requirements or import tariffs, reduce demand for foreign products and, thus, hurt foreign producers.

While cross-border supply effects of industrial and innovation policy in industries such as steel or solar cells dominate the public discourse, empirical evidence as to the size and impact of such externalities is rare. This might not come as a surprise, given the difficulty in establishing clear causal evidence on the effects of innovation policies at the domestic level. In addition, tracking the cross-border effects of such policies adds another layer of complexity to the exercise and renders estimates highly imprecise.

One exception is two recent studies on supply effects in the context of subsidies to the ship-building industry and export subsidies. The study looking at ship-building finds that subsidies to the sector in the mid-2000s led to a highly inefficient global reallocation of production, from low-cost to high-cost producers, with only marginal gains for consumers (Kalouptsi, 2018). In contrast, evidence based on the reduction of estimated subsidies with export share requirements across industries from 2000 to 2013 suggests that such subsidies led to positive welfare effects abroad while hurting domestic welfare. The effects were driven primarily by changes in consumer prices, with foreign consumers having access to cheaper products at the expense of domestic consumers that did not benefit from export subsidies (Defever and Riaño, 2015). In the context of policy responses to COVID-19, supply and demand spill-overs will probably play a large role as well (see Box C.6).

(e) Inter-industry linkages

Finally, the cross-border externalities discussed here can be multiplied and magnified by inter-industry linkages. Some industries provide crucial inputs to other industries. Innovation policy targeted at these

sectors can benefit or harm downstream industries across the world through its effect on the price and availability of inputs.

For example, import quotas should reduce the competitiveness of downstream sectors by increasing input prices, while domestic production subsidies or grants should boost the competitiveness of downstream sectors by decreasing input prices. Similarly, innovation policy targeted at downstream industries can affect upstream industries across the world by changing demand for their products.

In the age of GVCs, the importance of cross-border inter-industry linkages has increased sharply. In line with this, a growing number of studies has estimated how the effects of trade and trade policy differ with a proper accounting of such linkages (Bacchetta and Stolzenburg, 2019; Caliendo and Parro, 2015; Lee and Yi, 2018). They typically suggest that such cross-border linkages are economically meaningful as international transmitters of domestic policy. Explicit evidence for this is provided in a study on policies targeted at the steel sectors of 22 countries over the period 1975 to 2000. It finds that such policies hurt the export performance of domestic downstream industries, especially in the case of developing countries, since they lead to higher input prices and higher market concentration (Blonigen, 2016). It is reasonable to assume that such negative effects also hurt international customers of these steel industries. The COVID-19 pandemic has intensified calls for supply chain reshoring to ensure the provision of essential goods (see Box C.7).

(f) Cross-border externalities in the digital age

Cross-border externalities are likely to intensify in the digital age for several reasons.

First, as shown in Section B, digital industries such as IT are knowledge-intensive and account for a growing share of R&D expenditures and patents. This implies that knowledge spill-overs are likely to increase as economies undergo a structural change towards a knowledge-based structure.

Second, the "winner-takes-all" characteristics of many digital industries lead to heavily concentrated markets. Such a market structure and the corresponding monopoly profits in these industries lend themselves to applications of strategic trade policy.

Third and relatedly, network externalities inherent in digital industries can cause sharper supply-and-demand effects and profit-shifting effects because

Box C.6: Cross-border effects of policy responses to COVID-19 in the field of innovation

Policy responses to COVID-19 are likely to have large cross-border externalities along the dimensions discussed in this section. Most importantly, research support given to the pharmaceutical industry and other entities engaged in the development of vaccines or antibody tests creates both positive knowledge spill-overs and, by eventually spurring a faster recovery of the economy, will lead to large positive global demand effects.

For example, the COVID-19 Genomics UK consortium, funded by the United Kingdom, has started to collaborate with the COVID Genomics Network, funded by Canada, in order to facilitate knowledge spill-overs (Genome Canada, 2020). Similarly, during the recent #EUvsVirus Hackathon, organized by the European Innovation Council to spur innovation related to COVID-19, three of the six challenge category winner teams consisted of members from four or more countries (European Commission, 2020).

Broad fiscal policies that benefit innovation and research among other industries also boost domestic supply and demand and, therefore, support foreign supply and demand. Evidence from the great recession of 2008 and 2009 and other contractionary periods shows that expansionary fiscal policies help to contain recessions, not just domestically, but also abroad (Auerbach and Gorodnichenko, 2013). An important aspect in this area during the present crisis is investments in digital infrastructure, which help to sustain supply and demand in the present and will facilitate trade and international cooperation in the future.

On the other hand, export restrictions on medical supplies can slow down medical innovation abroad by limiting access and raising prices for the necessary supplies and inputs to research. According to a recent report, 72 WTO members and eight non-WTO member countries have put restrictions on the exportation of medical supplies (WTO, 2020d).

Countries also compete for scarce resources such as firms at the technology frontier in vaccine development. These types of zero-sum games by design generate negative cross-border externalities. Policy responses to the Great Recession are also helpful with regards to avoiding negative spill-overs, as many of these responses contained local content requirements or conditioned eligibility on nationality which limited positive demand spill-overs, and thus the usefulness of the responses (Larch and Lechthaler, 2011). Such approaches should be avoided when responding to the current crisis.

International inter-industry linkages will multiply the effects of any policy response to COVID-19. Recent studies highlight how the effects of shutdown policies propagate through GVCs to trade partners (Gerschel, Martinez and Mejean, 2020; Sforza and Steininger, 2020). While these linkages led to a faster diffusion of the initial supply-and-demand contraction, they will also generate faster and larger positive demand and supply spill-overs from the policy responses that counter the contraction.

they allow for only very few firms in the market to maximize the network-related benefits to customers. This can lead to the sudden disappearance of formerly dominant firms, as was for instance observed in the case of Altavista, or local competitors of Facebook.

Finally, as the uptake of digital technologies across industries increases, supplying industries like IT or electronic equipment become more and more pivotal by producing general purpose technologies. If their performance improves due to innovation policies enacted in one country, this can have significant positive effects for downstream digitally enabled industries across the world and offset the potential negative supply-side effects of such policies, such as overcapacity or price depression.

(g) Aggregate assessment of cross-border externalities

It is difficult, and highly context-specific, to assess whether cross-border externalities from innovation policies imply net benefits or net losses for foreign countries. Different externalities pull in different directions, and different country characteristics, such as market share in targeted products or the position in GVCs, have a large impact. Hence, aggregate assessments are complex and there is little established literature on the subject.

A calibration study in the context of Eastern and Western Europe suggests, for instance, that positive knowledge spill-over effects of R&D subsidies

Box C.7: Is reshoring the best option to ensure the supply of essential goods?

The COVID-19 pandemic has spotlighted the need to ensure a supply of essential goods such as medical supplies and personal protective equipment (PPE). Discussions have intensified among business and policymakers about reorganizing global supply chains to ensure self-sufficiency with regard to essential goods.

The calls to reorganize supply chains had started even before the COVID-19 pandemic, and a number of factors were behind this growing trend. First, rising wages in emerging countries mean that wage differentials between developed and emerging economies are shrinking, leading firms to respond by shifting production to more cost-effective locations. Second, technological progress and automation are enabling firms to locate certain types of production closer to consumer markets. Thirdly, changes in the policy environment that are raising trade costs and causing uncertainty about future policy are triggering a reorganization of supply chains. The calls for self-sufficiency in the wake of the COVID-19 pandemic could accelerate the trend of reshoring and nearshoring of supply chains.

To ensure the supply of essential goods in a pandemic, a range of policy options may be considered. One option is to establish domestic production of essential goods, in other words, to reshore the supply chain. While reshoring can guarantee supply during times of crisis, it is likely to have several drawbacks. First, only the largest and most advanced countries are likely to have the manufacturing capacity, specialized machinery and access to inputs to be capable of self-sufficiency. Second, whereas trade allows production to relocate to where it is most efficient and helps to increase access to more goods at affordable prices, reshoring policies could involve high costs in the form of government subsidies, import barriers and higher consumer prices. Furthermore, self-sufficiency is not, in itself, a guarantee of greater security. Eliminating reliance on foreign production and inputs means increased reliance on domestic production, which can also be subject to adverse shocks (Bonadio *et al.*, 2020).

Alternative policies could include increased stockpiles, diversification of sources of supply in order to avoid dependency on only a small number of countries, and flexible production capacities, enabling economies to switch production quickly to essential goods when needs arise. Economists argue that these alternative options are more cost-effective (Freund, 2020; Miroudot, 2020). In the case of medical products, international trade and cross-border supply chains not only lead to higher efficiency and lower costs, but also enable large-scale R&D to develop new medicines and medical technology (Stelling, Berglund and Isakson, 2020).

International cooperation can play an important role in helping governments secure the supply of essential goods during crises. Governments can cooperate to collect and share information on potential concentration and bottlenecks upstream and/or to develop stress tests for essential supply chains (Fiorini, Hoekman and Yildirim, 2020; OECD, 2020). Identifying bottlenecks in supply chains and measures to address them requires cooperation between industry and government, as well as among governments. Governments could also cooperate to facilitate trade to guarantee supply chain continuity in PPE and other essential products. International cooperation is also very important with regard to the stockpiling of essential goods. The European Commission recommends that stockpiling be coordinated at the EU level and that any stockpiling by member states should be undertaken at the national level and in moderate quantities based on epidemiological indications (European Commission, 2020g).

In addition, advancements in information and communication technologies (ICTs) could significantly facilitate information management and coordination along supply chains, thus reducing the cost of business continuity. New technologies such as artificial intelligence (AI) and the Internet of Things (IoT) could be used to optimize cargo and shipment logistics and to improve autonomous driving and real-time itinerary mapping, thus increasing supply chain visibility. Blockchains and AI could further decrease transaction and compliance costs and increase the transparency of supply chains (Francisco and Swanson, 2018). Additive manufacturing, or 3D printing, could allow companies to swiftly convert manufacturing capacity to new products (WTO, 2018) – for example, during the COVID-19 pandemic, 3D printing was used to manufacture face shields and ventilators (Statt, 2020). These technologies are likely to enable firms to improve visibility across supply chain and increase supply chain resilience without the traditional costs associated with risk management (Deloitte, 2020).

are larger than negative profit-shifting effects, in particular when there are strong FDI linkages between the countries involved (Borota, Defever and Impullitti, 2019). Similar conclusions can be drawn from simulation studies, which show that cooperative subsidies tend to be higher in certain settings than non-cooperative subsidies, as this suggests that the positive externalities of R&D subsidies outweigh negative externalities (see, for example, Haaland and Kind, 2008).

Thus, it bears repeating that many cross-border externalities improve innovation, welfare and productivity abroad. A complete assessment of innovation policies and their consequences for international cooperation needs to take these positive effects into account in order to reach a balanced and efficient outcome.

For an assessment of the net effects, it is also necessary to observe that governments enact policies that are aimed at promoting or limiting both positive and negative cross-border externalities. For instance, local content requirements prevent positive demand effects to benefit foreign upstream industries. IP protection chapters in international trade agreements can limit knowledge spill-overs, as can nationality-based merger and acquisition screenings or nationality-based eligibility criteria for subsidies or government procurement.

What is also important in understanding cross-border externalities is that the different mechanisms through which cross-border externalities arise are usually not policy-specific. That is, the same type of externality can be created through a variety of policy interventions even if to a varying degree and nature. Policies as different as import tariffs and antitrust laws can both cause all the mentioned externalities – from knowledge spill-overs to supply and demand effects – and it depends on the details of these measures which effects dominate.

For instance, R&D subsidies in one country tend to create knowledge that spills over to other countries and facilitates technological leapfrogging and original innovation there (Moretti, Steinwender and Van Reenen, 2019). But R&D subsidies also can be used for profit-shifting since they facilitate entry into R&D-intensive industries (Spencer and Brander, 1983). In addition, they have supply-and-demand effects as they both raise supply in the subsidized activity and demand in supplying industries. These effects are then magnified by cross-border input output linkages, as GVCs have been shown to be particularly effective in promoting knowledge diffusion (Piermartini and Rubínová, forthcoming).

Similarly, import tariffs, by protecting domestic industries, can boost domestic innovation that eventually spills over to other countries as discussed in Section C.3. But they can also be used for profit-shifting since they reduce the output produced by foreign firms and increase entry of domestic firms. They also lead to cross-border externalities by reducing domestic demand of domestic downstream industries that now face higher input prices, and they have supply effects by boosting domestic production for world markets.

Less obvious policies, like education policies, can also create cross-border externalities, even if this occurs in the long-term. Shifting government funds to technical universities can, for instance, increase over time the output of domestic industries dependent on workers with a technical background, leading to important supply effects; and, obviously, education policy can increase knowledge spill-overs. Competition policy can be used to promote national champions and shift monopoly profits across borders, but it can also be used to stimulate international innovation by preventing competition-stifling takeovers. Tax policy, especially in the digital age with heavily concentrated markets, can also be used to shift profits across borders, but such tax policy can also be used to incentivize innovation and promote knowledge spill-overs.

These examples show that, while very different policies can create the same type of externality, it is nevertheless likely that some policies have a stronger impact on certain externalities than others. Similarly, some policies, such as export subsidies, are obviously more trade-distortive than others. In particular, non-specific measures such as education policy or basic research grants are likely to be less harmful than more direct and targeted measures, at least in the short- to medium-term.

Negative spill-overs from direct and targeted measures are likely to be smaller if they are transparent, time-limited and non-discriminatory, but the literature quantifying such differences is meagre. This emphasizes that the spill-over effects of industrial and innovation policy should be targeted for future research in order to guide policymakers who will need to attempt to regulate innovation policies and negotiate international cooperation in this area. This is of particular importance since externalities like profit-shifting and resource competition sometimes involve a "prisoner's dilemma", in which a cooperative outcome leads to higher welfare than unilateral policy-setting (Rodrik, 2020). This will be discussed more extensively in Section D.

5. Conclusions

This section has considered the rationales and the impact of innovation policy. The rationales for government intervention to support innovation include the public good nature of knowledge, the economy-wide spill-overs of general-purpose technologies, the market failures in financing innovation, the coordination failures in complex industries, and network externalities.

Some of these rationales are particularly important in the case of digital innovations, for a number of reasons: Big Data present public good characteristics; digital technologies are general-purpose technologies generating large benefits across the whole economy; digital products are complex and suffer from coordination failures; there are large network effects that may require various types of government action, from addressing anti-competitive behaviour to setting standards; and the adoption of digital technologies may deliver public policy objectives.

The toolkit of policies to promote innovation is vast. Innovation and innovation-related policies affect firms' decisions to engage in R&D and innovate by impacting market size, the productivity of R&D, the appropriability of research results, and product market structure.

This section has discussed the effectiveness of policies that can enhance innovation and that fall under these four categories. Although the empirical evidence currently available does not allow to fully answer the question of which policies matter most, let

alone the question of which policies are most cost-effective to advance digital innovation, the findings of various extant literature streams provide useful guidance. An important take-home message from the wider literature on industrial and innovation policy is that government interventions should be grounded in sound expectations, and should be aligned with countries' static or dynamic comparative advantages. Understanding the determinants of comparative advantage in the digital age is therefore a necessary precondition for the success of innovation policy.

Like several other government policies, innovation policy can have an impact on other countries. The impact on third countries can be positive, for instance if knowledge created in one country benefits other countries as it diffuses across space over time. But it can also be negative, for instance if innovation policy in imperfectly competitive markets shifts profits across jurisdictions.

Cross-border externalities are likely to intensify in the digital age because knowledge spill-overs matter more in knowledge-based economies, because of the "winner-takes-all" characteristics of many digital industries, which lead to heavily concentrated markets, and because of the general purpose technology nature of IT and electronic equipment industries, which enable the digital sectors.

Due to both the positive and negative third-country effects of innovation policies, there might be scope for international cooperation to improve upon unilateral policy-setting. This will be discussed more extensively in Section D.

Endnotes

- 1 Network externalities may give rise, in the first place, to business-stealing overinvestment in R&D. This is socially wasteful because innovator firms may acquire market shares at the expense of rivals (or capture nearly the entire market) without necessarily generating any social benefit, for instance if the innovative technology/product is only marginally better than the existing technology/product (Bloom, Van Reenen and Williams, 2019). See also Nobel Committee (2018) and Atkeson, Burstein and Chatzikonstantinou (2019) for further discussion.
- 2 See Succar (1987), Greenwald and Stiglitz (2006), Stokey (1991) and Young (1991) for theoretical arguments. See Wade (1990) and Pack (2000) for evidence on Chinese Taipei. Blonigen (2016) studies government policies related to steel in 22 countries. Lane (2019) studies the effects of the heavy chemical and industry drive in the Republic of Korea between 1973 and 1979.
- 3 See Audretsch, Keilbach and Lehmann (2006), Akcigit *et al.* (2018) and Haltiwanger, Jarmin and Miranda (2013).
- 4 See Brander and Krugman (1983), Helpman and Krugman (1989), Harrison and Rodríguez-Clare (2010) and Katz and Summers (1989).
- 5 Acemoglu, Aghion and Zilibotti (2006) emphasize the importance of the timing of the switch from an investment-based to an innovation-based growth strategy. Government intervention in the form of policies limiting product market competition or providing subsidies for investment may be useful to improve the short-run allocation of resources and to avoid the switch to an innovation-based strategy occurring too soon, but may have adverse long-run consequences, delaying or impeding altogether the switch. In the latter case, the economy is stuck in a middle-income trap, and fails to ever achieve the world technology frontier. For further discussion on the importance of switching to an innovation-based strategy along the development trajectory, see Cherif and Hasanov (2019). They emphasize the role of homegrown innovation in avoiding middle-income traps.
- 6 In a model by Aw, Roberts and Xu (2011), exporting and investment in R&D are two interconnected activities. More export opportunities increase the expected returns to R&D and more R&D investment that boosts productivity increases the expected returns to exporting. Both also involve an investment to overcome initial entry barriers, even though the cost of exporting is lower than the cost of conducting R&D.
- 7 Another study based on data for thousands of products exported by 56 economies to the United States lends some support for the non-linear relationship between innovation and competition proposed by Aghion *et al.* (2005). It finds that a decrease in tariff protection is associated with quality upgrading for products close to the world quality frontier (the best available quality), whereas the opposite holds for products far from the frontier (Amiti and Khandelwal, 2013). This relationship holds only in countries that have business environments that are sufficiently good that the competition channel is relevant.
- 8 Harrison and Rodríguez-Clare (2009) provide an overview of the infant industry argument's theoretical underpinnings.
- 9 External economies of scale refer to the benefits of industry co-location. Firms in the same industry may benefit from being located geographically close to each other because it allows them to draw upon larger pools of workers with specific skills, specialized suppliers and customers, and because proximity favours knowledge diffusion.
- 10 The Marshal Plan was a US programme which provided aid to Western Europe following the devastation of the Second World War.
- 11 There is, for instance, evidence that access restrictions to the Chinese-language version of Wikipedia in mainland China reduced contributions from contributors in economies that were not blocked, such as Chinese Taipei, Hong Kong (China), Singapore and other regions of the world, since the reach of such contributions was reduced (Zhang and Zhu, 2011).
- 12 Czarnitzki, Hanel and Rosa (2011), however, do not find significant differences between the recipient firms and the selected control group representing the recipients in the counterfactual situation of the absence of R&D tax credits. This implies that the firms may indeed conduct more R&D, but some are likely to invest in short-term projects that have a lower marginal rate of return than projects that would have been conducted even in the absence of R&D tax credits. As a consequence, the authors find no effect of R&D tax credits on more general firm performance indicators such as profits or domestic market share.
- 13 In research using US data and considering corporate and personal income taxation rather than innovation-focused policies such as R&D tax credits, Akcigit *et al.* (2018) show that taxes matter for innovation: higher personal and corporate income taxes negatively affect the quantity and quality of inventive activity.
- 14 Manelici and Pantea (2019) study the impact of a personal income tax break to programmers working on software development in IT sectors, implemented by Romania in 2001. They show that, as a result of this policy change, the IT sector grew faster in Romania than in otherwise similar countries. Downstream sectors relying more on IT services also grew faster in Romania after 2001. These results suggest that this policy has been effective in promoting the development of the IT sector, a sector typically seen as key to the transition to a knowledge economy.
- 15 Moretti and Wilson (2017) show that within-US migration by star scientists is very responsive to changes in personal and business tax differentials across US states. Akcigit, Baslandze and Stantcheva (2016) study the effect of top tax rates on "superstar" inventors' international mobility since 1977. They find that superstar inventors' location choices are significantly affected by top tax rates. See also sections C.3(g) and C.4 for further discussion of the general equilibrium effects of innovation policies.

- 16 We have pioneered this approach at the UCL Institute for Innovation and Public Purpose (IIPP), where we hosted a commission on mission-oriented industrial strategy concentrating on the United Kingdom but applicable in a global context.
- 17 IIPP has explored this topic in depth in a study of innovation in the pharmaceutical industry (UCL Institute for Innovation and Public Purpose (IIPP), 2018).
- 18 Using propensity score matching to tackle selection issues (i.e. R&D grants are not randomly assigned, but depend in part on unobservable firm characteristics), Le and Jaffe (2017) examine the impact of R&D grant receipt on innovation outcomes for firms in New Zealand. They show that the innovation performances of grant-receiving firms exceed that of "similar" (propensity-matched) firms that do not receive grants. In particular, they find a positive effect on the probability that a firm applied for a patent during 2005–09. They also find that R&D grants have a stronger effect on more novel innovation than on incremental innovation: receiving an R&D grant almost doubles the probability that a firm introduces new goods and services to the world, while its effects on process innovation and any product innovation are relatively much weaker. Finally, they show that R&D project grants have much larger effects on innovation outcomes than R&D capability-building grants. Le and Jaffe (2017) interpret the latter result as evidence for the public policy value of R&D project grants.
- 19 See Slavtchev and Wiederhold (2016, footnote 2 on page 46). They also provide for references to studies showing a positive impact of government purchases on firm-level innovation. For a very detailed overview of the literature studying the nexus between public procurement and innovation, see Lenderink, Johannes and Voordijk (2019).
- 20 The measure the technological intensity of public procurement employed by Slavtchev and Wiederhold (2016) is the share of federal procurement in high-tech industries performed in a state in total federal procurement in that state, considering only non-R&D procurement contracts awarded to private-sector firms.
- 21 In the case of Ecuador, a developing country, the above-mentioned paper by Fernández-Sastre and Montalvo-Quizhpi (2019) finds that, in contrast to innovation support programmes, public procurement does not induce firms to invest in R&D activities, even for the largest contracts.
- 22 The increases in private R&D expenditures as a result of raising defence expenditures, as estimated by Moretti, Steinwender and Van Reenen (2019), do not just reflect higher wages and input prices caused by increased demand. The authors show, in fact, significant positive effects on the employment of R&D personnel. The fact that higher demand for the labour of specialized R&D workers raises their employment, and not only their wages, is consistent with a fairly elastic labour supply of specialized R&D workers.
- 23 In an online survey among representative samples of the population in seven EU countries (Denmark, France, Germany, Italy, the Netherlands, Portugal and the United Kingdom), 73.9 per cent of the 7,664 participants stated that they would be willing to be vaccinated against COVID-19 if a vaccine were available. A further 18.9 per cent of respondents stated that they were not sure, and 7.2 per cent stated that they do not want to be vaccinated (Neumann-Bohme *et al.*, 2020). In a survey conducted in the United States between April 29 and May 5 (Pew Research Center, 2020), 72 per cent of adults said they would definitely (42 per cent) or probably (30 per cent) be vaccinated against COVID-19 if a vaccine were available, while about a quarter (27 per cent) said they would not.
- 24 See Whitley (2003) for a discussion of the merits of decentralized competition in developing highly novel and disruptive technologies.
- 25 See Kremer, Levin and Snyder (2020) on the economics of advance market commitments for vaccine development.
- 26 A positive correlation is obtained both in a sub-sample of developing economies and in a sub-sample of developing economies. The interaction between a "developed" dummy variable and IPR protection is not significantly correlated with the share of ICT patents in total patents in the full sample of 91 economies.
- 27 Qualitatively similar conclusions are reached by Watal and Dai (2019). Using launch data from 1980 to 2017 covering 70 markets, they find that the introduction of product patent for pharmaceuticals in the patent law has a positive effect on launch likelihood, especially for innovative pharmaceuticals. This effect is, however, quite limited in low-income markets.
- 28 Focusing on the biomedical industry, Hegde and Luo (2018) show that the impact of a policy change in US regulations (according to which patent applications have to be published 18 months after filing) made US patent applications less likely to be licensed after the patent was granted, and more likely to be licensed between publication and grant. This suggests that disclosure facilitates sales and transactions in the market for ideas.
- 29 Survey evidence reported by Williams (2017) suggests that, from the perspective of firms, patents are not essential for spurring R&D investments, except in chemicals, and in particular pharmaceuticals. Empirical studies based on patent law changes (Lerner, 2009; Sakakibara and Branstetter, 2001) also find little evidence that stronger patent rights encourage research investments. Finally, Budish, Roin and Williams (2015), who exploit variation in clinical trial lengths in the context of cancer research, find evidence of a positive impact of shortening clinical trial lengths on R&D investment, but they cannot isolate the importance of patents as opposed to other factors.
- 30 Survey evidence suggests that neither university nor industrial researchers tend to abandon worthwhile projects because of issues of access to intellectual property. Econometric evidence by Williams (2013) and Murray *et al.* (2016) suggests that non-patent forms of IP protection can reduce follow-up innovation in the field of biomedical sciences. Conversely, Galasso and Schankerman (2015) find that removing patent rights by court invalidation increases subsequent research related to the focal patent, as measured by later citations, in sectors such

- as computers, electronics and medical instruments, but not in others, such as drugs, chemicals, or mechanical technologies. Finally, Azoulay *et al.* (2019b), who consider patents on human genes, find no evidence that they have any impact on follow-on innovation.
- 31 The WTO TRIPS Agreement allows compulsory licensing (defined in Article 31 as "other use without authorization of the right-holder"), provided that the person or company applying for a licence has first attempted unsuccessfully to obtain a voluntary licence from the right-holder on reasonable commercial terms, and that if a compulsory licence is issued, adequate remuneration is paid to the patent-holder. To save time, the former requirement does not need to be met in case of national emergencies or other circumstances of extreme urgency. The original TRIPS Agreement (Article 31) restricted the use of compulsory licensing mainly to supply the domestic market. The Annex to the Amendment of the TRIPS Agreement, which came into force on 23 January 2017, allows compulsory licensing for production and subsequent exporting of pharmaceutical products, including medicines, vaccines and diagnostics, needed to fight an epidemic. This is relevant in the current COVID-19-related health crisis, as discussed in Section D. For detailed information on the use of compulsory licensing in the pharmaceutical sector, see WTO, WIPO and WHO (2020).
- 32 The TEWA permitted US firms to violate enemy-owned patents if they contributed to the war effort. As the war dragged on, the TWEA became more and more punitive. In November 1918, US Congress amended the TWEA to confiscate all enemy-owned patents. By February 1919, German-owned patents were systematically licensed to US firms.
- 33 See also Aguiar and Waldfoegel (2018). While not focusing on innovation (quality of music), Oberholzer-Gee and Strumpf (2007) present evidence that file-sharing does not reduce the legal sales of music.
- 34 Open-source projects more typically use permissive licences, whereby the user retains the possibility of using the code as he or she wishes, including for developing marketable proprietary software (Tirole, 2017). This is the case, for instance, of BDS (Berkeley Software Distribution) and Apache (a free web-server software that powers nearly half of all websites in the world).
- 35 See <https://hostingtribunal.com/blog/linux-statistics/#gref>.
- 36 Consider the extreme case of fixed supply of scientists and engineers. Higher demand for scientists and engineers would simply increase their wages, without increasing innovation. Obviously, supply may be fixed at any given point in time, but elastic (i.e. upward-sloping) in the long run. Also, in the presence of substitutability between scientists/engineers and other factors of innovation production, an increase in their relative price would induce a decrease in their relative utilization (Bloom, Van Reenen and Williams, 2019).
- 37 Although he does not focus on STEM graduates, Mitrunen (2019) offers interesting evidence that human capital development can be an endogenous response to high-skill industry-biased government policy, such as the one implemented by Finland in the aftermath of the Second World War to be able to pay war reparations to the Soviet Union.
- 38 See footnote 10 in Kerr *et al.* (2016) for a list of these studies. Hunt and Gauthier-Loiselle (2010) is among the seminal papers in this literature. They document that a 1 percentage point increase in immigrant college graduates' population share increases patents per capita by 9 to 18 per cent. They also argue for a spill-over effect into the rest of the population. Several other studies document how exogenous shocks to immigration affected innovation. Moser, Voena and Waldinger (2014), for instance, show that American innovation in chemistry was boosted by the arrival of Jewish scientists who were expelled by the Nazi regime in Germany in the 1930s. Doran and Yoon (2020) and Moser and San (2020) show that quotas introduced in the 1920s in the United States that more strongly affected migrants from Southern and Eastern European countries than migrants from Northern European countries discouraged Eastern and Southern European countries from migrating to the United States and reduced aggregate invention.
- 39 See footnote 11 in Kerr *et al.* (2016) for a list of these studies. The most relevant study is Borjas and Doran (2012). They consider the post-1992 influx of Soviet mathematicians, finding a negative productivity impact on their US counterparts, in particular on those mathematicians whose research overlapped with that of the Soviets.
- 40 See footnote 12 in Kerr *et al.* (2016) for a list of these studies. In a recent contribution, Fassio, Montobbio and Venturini (2019) study the effects of skilled migration on innovation (proxied by patent citations) in France, Germany and the United Kingdom. They show that highly educated migrants have a positive effect on innovation, although this effect is about one-third the effect of highly educated natives: a 1 per cent increase in the number of educated natives (immigrants) leads to a 0.3 (0.1) per cent increase in the citation-weighted number of patents. The effects are stronger in industries with low levels of over-education, high levels of foreign direct investment (FDI) and openness to trade, and in industries with higher ethnic diversity.
- 41 Offers of permanent residency prove more attractive to non-high-skilled workers than to high-skilled workers, thereby reducing the human capital content of labour flows according to Czaika and Parsons (2017). Family reunification, not captured in their dataset, also tends to be biased towards low-skilled groups, at least in the United States (Kerr *et al.*, 2016).
- 42 See for instance Correa (2012) who, using the same dataset as Aghion *et al.* (2005), finds a structural break in the early 1980s. This coincides with establishment of the US Court of Appeals for the Federal Circuit (CAFC) in 1982. Correa (2012) shows that, in the United States, there is a positive innovation-competition relationship in the pre-CAFC period (1973-82) and no relationship at all in the post-CAFC period (1983-94). See World Bank (2017, p. 49), for more details and explanation of these results.
- 43 For instance, Bassanini and Ernst (2002) find a negative correlation between product market regulations and the intensity of R&D expenditure in OECD countries. Similar results are obtained by other studies cited by Blind (2016, p. 454). In the case of a developing country (India), using a sample of 291 manufacturing firms, Kumar and Saqib (1996) show that in cases where the entry of new firms in

a market is restricted by government policy, the absence of competitive pressure reduces the likelihood of firms undertaking R&D. However, the competitive pressure does not influence the intensity of R&D expenditures of firms once they have decided to invest in R&D. Franco, Pieri and Venturini (2016) show that upstream restrictive service regulation reduces R&D efficiency of downstream manufacturing in OECD countries. Using firm-level data for 100 developing countries, Hoekman and Shepherd (2017) show that services trade restrictiveness indices negatively impact manufactured exports performance. Similar evidence for sub-Saharan African countries is presented by Arnold, Mattoo and Narciso (2008).

- 44 The use of compulsory licensing (defined as "other use without authorization of the right-holder") to remedy anti-competitive practices is foreseen and disciplined in Article 31 of the WTO TRIPS Agreement.
- 45 A larger-scale presence of complementary specialized inputs and professional service providers is also relevant (Kerr *et al.* 2017).
- 46 See Kerr and Robert-Nicoud (2019), pages 15-16, for a discussion of the importance of the location of anchor firms and for a review of some recent studies providing historical accounts of the shakeout process of emerging frontier technologies.
- 47 Accelerators use competitive entry and intensive support. They usually provide an on-site workplace, as well as business skills training, intensive mentoring and networking activity. Incubators also provide workplace and training relevant to business, but entry is less competitive, and the level of support is limited to minimal mentorship. Science parks are agglomeration of high-tech firms at walking distance from each other.
- 48 Between-country inequality related to innovation policy is discussed in Section D.
- 49 Acigit, Grigsby and Nicholas (2017) also find a positive correlation between patenting intensity and social mobility across the United States over the past 150 years.

D

International cooperation on innovation policies in the digital age

National innovation policies, like other government policies, serve domestic policy objectives. As discussed in Section C, they can generate both positive and negative international spill-over effects, and some of the mechanisms through which they generate spill-overs involve trade. This section focuses on cooperation aimed at addressing the trade-related international spill-overs from innovation policies. Such cooperation could help to ensure that governments have the policy space to pursue innovation policies, and could help to maximize the positive international spill-overs of such policies, while minimizing their negative effects on trading partners.



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Some key facts and findings

- The multilateral trading system contributes to innovation and the diffusion of technologies by promoting trade and stimulating international competition.
- Many provisions in regional trade agreements on industrial and innovation policy in the digital age do not only replicate or build on existing WTO agreements but establish new obligations for participants covering issues including data protection, localization of certain processes, competition and intellectual property.
- The WTO agreements have proved forward-looking in helping to foster the development of economies that can benefit from information and communications technology. The WTO's agreements and other trade agreements can help to prevent the introduction and spread of barriers to cross-border digital trade and to make it an engine for development.
- The rising importance of data as an input in production and the potential use of such data by multiple parties is leading to demand for new international rules on data transfer, data localization and privacy protection.
- The increasing positive "network effects" that innovation policies in digital equipment industries generate for digitally enabled industries across the world strengthen the case for international cooperation to encourage national governments to support innovation.
- The "winner-takes-all" characteristics of many digital industries can lead to calls for international cooperation to limit negative cross-border effects resulting from strategic government policies.

1. Introduction

Over the years, in both regional and multilateral fora, governments have negotiated agreements which, to one degree or another, discipline the use of industrial and innovation policy instruments. With the current revival of industrial policies in the digital age, the relevance of these disciplines tends to increase.

Three trends in the global economy challenge the way in which current multilateral rules regulate innovation policies.

First, the rapid growth of the digital and data-driven economy is leading to changes in national innovation policies. These changes call for more international cooperation to explore the need for and possibly agree upon new international disciplines.

Second, some least-developed and developing countries have not been able to benefit sufficiently from the current wave of globalization and technological progress, and some developing countries seem to be stuck in a so-called middle-income trap, unable to further converge towards the high-income range. The challenge is to ensure that all will benefit from the rapid growth of the digital economy.

Third, big emerging countries have rapidly expanded their economic size and role in the global economy, which has led to bigger cross-border spill-over effects from some of their policies. The growing size of the spill-overs generates more innovation and provides more market opportunities for trading partners, on the one hand, but, on the other hand, tips the balance of rights and obligations in the multilateral trading system, and could lead to growing trade tensions.

Against this background, this section considers the international disciplines and cooperation that may be relevant to digital innovation policies.

Section D.2 provides an overview of multilateral and regional disciplines on digital innovation policies and of innovation-related activities in other international organizations. The overview of multilateral disciplines addresses how the WTO agreements regulate the use of trade or trade-related policy instruments for innovation policy purposes. The discussion covers the relevant provisions in the Subsidies and Countervailing Measures (SCM) Agreement, the Agreement on Trade-Related Investment Measures (TRIMs), the General Agreement on Tariffs and Trade (GATT), the Technical Barriers to Trade (TBT) Agreement, the General Agreement on Trade

in Services (GATS) and the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS).¹

This is followed by a mapping of the main provisions addressing digital innovation policies in regional trade agreements (RTAs) notified to the WTO. The mapping indicates, amongst other things, where and how disciplines in RTAs go beyond multilateral disciplines.

The first part of Section D.2 ends with a brief sketch of the role played by some international organizations in promoting innovation.

Section D.3 discusses where and why digitalization and digital innovation policies are creating new needs for international cooperation and possibly for new and updated international disciplines on innovation policy instruments.

This discussion starts with a description of how digitalization, in the form of changes in technology and the organization of production, is inducing changes in the structure of the economy which, in turn, are generating changes in national policies which may require a change in international disciplines. A particular focus for the discussion is the new international spill-overs that innovation policies are generating in the digital age and the scope for more international cooperation to either encourage or mitigate these new spill-overs. The arguments for and against more policy space (i.e. the margin of manoeuvre available to governments under international disciplines to adopt the most appropriate mix of economic policies to achieve their development goals) for developing countries are also described.

This discussion serves as a framework for the subsequent discussion of international cooperation in specific areas such as support measures, standards and regulation, intellectual property (IP) protection, competition policy and data policies.

2. The existing framework of international cooperation

(a) Cooperation in the multilateral trading system

Trade is an important engine and vector for innovation. International cooperation in the multilateral trading system favours innovation-related policies in the digital world. By enhancing the flow of goods and services, the multilateral trading system makes a

major contribution to innovation worldwide and to the transfer of technologies.

Since its inception, the basic principles of the GATT (and today the WTO), such as non-discrimination, transparency, reciprocity and the prohibition of unnecessarily trade-restrictive measures, combined with the preservation of policy space for addressing important societal concerns, have promoted trade liberalization and innovation. These principles, although they pre-date the emergence of digitalization, continue to promote innovation in the digital world through the sophisticated, detailed disciplines contained in the WTO agreements examined in this section.

For instance, the SCM Agreement and the TRIMs Agreement require that financial support for innovation be accorded with respect for the principles of the multilateral trading system. The Information Technology Agreement (ITA) promotes innovation in the digital age through the non-discriminatory reduction and progressive elimination of tariffs on information and communications technology (ICT) goods. The TBT Agreement ensures that regulatory measures are transparent, non discriminatory and not unnecessarily trade-restrictive. The Government Procurement Agreement (GPA) requires that domestic public procurement procedures be conducted based on principles of transparency, non-discrimination and procedural fairness. The GATS requires that WTO members design and implement innovation policies with regard to services in a transparent and most-favoured-nation-consistent manner, and in accordance with their specific commitments on market access and national treatment.² The TRIPS Agreement requires a common minimum level of IP protection and enforcement, flanked by non-discrimination provisions, transparency requirements and binding dispute settlement, and ensures that incentives for innovation and the creation of intangible assets are comparable across WTO members' economies.

These agreements transcribe the fundamental principles of the multilateral trading system into detailed rules that affect innovation-related policies and, through those, decisions by public and private economic actors on how and where to invest in innovation. These rules are flexible enough to enable and promote innovation, while ensuring that all WTO members enjoy the benefits of trade liberalization. Moreover, the multilateral trading system provides predictability, while also promoting cooperation and enabling flexible responses to new problems. The WTO agreements thus ensure certainty and flexibility, which are crucial for deploying both innovation-

related policies and quick and adjustable responses to global crises.

(i) *Subsidies*

This subsection provides a brief overview of WTO subsidy disciplines, with a focus on how these relate to innovation-oriented government policy in the multilateral context.

Government financial support, in diverse forms, has long been integral to the development and implementation of innovative technologies, including procurement policies (see Section D.2(vi)). Programmes supporting research and development (R&D) have led to fundamental advances in innovation, creating technological platforms for many of today's dynamic industries. Satellite communications, genomic sequencing³ and the internet are areas of extensive commercial activity today, and came into existence through significant government support. For example, the internet owes its existence to a project funded by the US Defense Advanced Research Projects Agency (DARPA).

WTO subsidy disciplines come into play when government funds are directed more specifically at commercial activities, and these disciplines exist at present only for trade in goods.⁴ Article III:8(b) of the GATT 1994 explicitly affords space to national industrial policy in the form of subsidies. This provision allows subsidy programmes to promote exclusively domestic production, such as of ICT equipment, without falling afoul of the national treatment obligation, but attention to programme design is critical for such programmes to qualify for this carve-out. For example, such subsidies are also subject to the disciplines of the SCM Agreement, including the prohibition against subsidies contingent upon the use of domestic over-imported goods (for example, Article 3.1(b) prohibits subsidies that obliges a recipient of a subsidy to use in-puts or other domestic goods over imported goods). Conditions for eligibility for the payment of subsidies, which define the class of eligible "domestic producers" by reference to their activities in the subsidized product market, are also critical considerations (see, for example, WTO (2018b)).

Under the SCM Agreement, the definition of a subsidy requires a financial contribution by a government or any public body. The different forms of financial transfers are listed explicitly, namely:

- (i) direct transfers of funds such as grants, loans, or equity infusions as well as potential transfers, such as loan guarantees,

- (ii) foregone revenues that are otherwise due, and
- (iii) goods and services provided by the government other than general infrastructure, and purchases of goods by the government.

Article 1.1(a)(1)(iv) of the SCM Agreement specifies that subsidies are also deemed to exist if a government makes payments to a funding mechanism, or entrusts or directs a private body to carry out one or more of the type of functions illustrated under (i), (ii) and (iii) above. In addition to financial contributions by a government within the meaning of Article 1.1(a)(1), SCM Article 1.1(a)(2) also mentions any form of income or price support, as described by Article XVI of the GATT 1994, i.e. support which operates directly or indirectly to increase exports of any product from, or reduce imports into, a member's territory. SCM Article 1.1(b) stipulates that any such financial contribution or income or price support pursuant to SCM Article 1.1(a) must confer a benefit to the recipient if it is to be considered a subsidy in the sense of the SCM Agreement.

A subsidy is not subject to the SCM Agreement unless it is specific. The concept of specificity is also crucial in definitional terms, since particular forms of specificity (i.e. export contingency and contingency on use of domestic goods) attract the strictest discipline (i.e. prohibition), while non-specific subsidies fall outside the scope of the WTO subsidy rules. Specificity in the general sense is deemed to exist where access to the subsidy is explicitly limited to a particular set of beneficiaries. Subsidies in respect of which access is based on objective criteria and neutral conditions, which are strictly respected, are defined as non-specific. Government support for general infrastructure, for example, is excluded from the WTO definition of subsidies.

Concerns with trade effects and impacts on the level field of competition have been a continuing focus of multilateral subsidy disciplines. Certain subsidies (i.e. export subsidies and local content subsidies) are prohibited. Certain other subsidies are treated as actionable, or subject to challenge, either through multilateral dispute settlement or through countervailing action, if they cause adverse effects to the interests of another WTO member. Finally, certain subsidies were provisionally designated as non-actionable (e.g. non-specific subsidies, certain research assistance, certain assistance for adapting to environmental requirements, certain regional assistance), although this designation has since expired.⁵

Non-actionable subsidies included specific subsidies for assistance to promote adaptation of existing

facilities to new environmental requirements, assistance to disadvantaged regions, and research assistance. Research assistance was limited to cover not more than 75 per cent of the cost of industrial research and 50 per cent of the cost of pre-competitive development activity.⁶ Footnote 28 of the SCM Agreement defines the term "industrial research" as:

"[P]lanned search or critical investigation aimed at discovery of new knowledge, with the objective that such knowledge may be useful in developing new products, processes or services, or in bringing about a significant improvement to existing products, processes or services",

and footnote 29 defines the term "pre-competitive development activity" as:

"[T]he translation of industrial research findings into a plan, blueprint or design for new, modified or improved products, processes or services whether intended for sale or use, including the creation of first prototype which would not be capable of commercial use. It may further include the conceptual formulation and design of products, processes or services alternatives and initial demonstration or pilot projects, provided that these same projects cannot be converted or used for industrial application or commercial exploitation. It does not include routine or periodic alterations to existing products, production lines, manufacturing processes, services, and other on-going operations even though those alterations may represent improvements".

Thus, while research directed at upgrading the features of the latest model of a mobile telephone might be understood as competitive innovation, and not as being potentially entitled to non-actionable status, research directed at demonstrating the viability of mobile telephony technology prior to the development of commercial products utilizing such technology might be understood as pre-competitive development activity that could potentially have been eligible for non-actionable status.

Members could not agree to extend the operation of Articles 6.1, 8 and 9 of the SCM Agreement, and these provisions expired on 31 December 1999. At the time, certain developing members opposed provisional extension and wanted these provisions revised to address development concerns as part of a package that would also have revised the transition periods contained in the TRIPS and TRIMs agreements.

The SCM Agreement recognizes three categories of developing-country members: least-developed countries (LDCs),⁷ members with a gross national product (GNP) per capita of less than US\$ 1,000 per year (which are listed in Annex VII to the SCM Agreement),⁸ and other developing members.⁹ The lower a member's level of development, the less stringent is the treatment it receives with respect to subsidies disciplines. Serious prejudice presumptions contained in Article 6.1 are not applicable to developing countries. Actionable subsidies maintained by a developing country are generally not subject to claims of serious prejudice. With respect to countervailing measures, developing-country members' exporters are entitled to more favourable treatment with respect to the termination of investigations where the level of subsidization or volume of imports is small.

Government assistance to R&D for large commercial aircraft became a focus of the most extensive dispute settlement proceedings arising to date under the SCM Agreement. Despite earlier notions that R&D subsidies might be granted without causing trade effects, both complainants (the United States and the European Union) challenged R&D subsidies through the WTO's dispute settlement system. Extensive legal analysis and reference to voluminous factual evidence led dispute panels and the Appellate Body to conclude that much of the government R&D assistance constituted financial contributions that provided a benefit to the recipients, were specific, and caused adverse effects or serious prejudice to the trade interests of the complainants. One factor in the findings was the conditions of competition in the global market for large civil aircraft, as described for example by one panel report:

“[T]echnological innovation is a key feature of the competition that takes place between Airbus and Boeing for new and existing customers. Airbus and Boeing will introduce new LCA products that are technologically advanced precisely to win the competition against each other's existing aircraft” (WTO, 2010c).

Because of this competitive dynamic, R&D assistance was found to cause adverse effects or serious prejudice when the producer would be unable, but for the subsidy, to bring to market a product at a specific time and/or with specific technological attributes.

The findings in the large civil aircraft disputes are grounded in specific circumstances, but one may query the extent to which technological innovation constitutes a field of commercial competition is an important, or increasingly important, feature

in relation to other high-tech and digital economy products and industries. While the SCM Agreement provision of non-actionable status for precompetitive development activity has lapsed, the concept may continue to be relevant to governments in their support policies for innovation in industries where technological innovation is part of the competitive dynamic.

(ii) *Trade-related investment measures*

This subsection provides a brief overview of the TRIMs Agreement, with a focus on how it may relate to innovation policy in the multilateral context. Foreign investment can present an opportunity for governments to integrate new and innovative commercial sectors, such as the digital economy, into their local economies. Investment measures are, therefore, a potential means of implementing policy goals relating to economic development in these fields.

The TRIMs Agreement recognizes that certain investment measures can restrict and distort trade, and when such measures discriminate against foreign products or lead to quantitative restrictions, these are measures inconsistent with basic WTO obligations.

In the Uruguay Round (1986-94), negotiators were directed to undertake “an examination of the operation of GATT Articles related to the trade-restrictive and trade-distorting effects of investment measures”. The TRIMs Agreement applies to investment measures related to trade in goods only. The disciplines of the TRIMs Agreement focus on investment measures that infringe GATT Articles III and XI, in other words, that discriminate between imported and exported products and/or create import or export restrictions. Article 4 of the TRIMs Agreement clarifies that, to the extent that Article XVIII of the GATT 1994 permits developing-country members to deviate temporarily from Articles III and XI of the GATT 1994, Article 2 of the TRIMs Agreement does not preclude such deviations with respect to trade-related investment measures. An annex to the TRIMs Agreement provides an illustrative list of inconsistent measures.¹⁰

In *Brazil – Taxation* (WTO, 2018b), programmes related to the ICT industry, among others, were challenged by the European Union and Japan as being inconsistent with the TRIMs Agreement, as well as with the GATT and the SCM Agreement. With respect to the ICT programmes, imported ICT products were found to be taxed more than similar domestic finished ICT products in a manner inconsistent with GATT Article III. Accreditation requirements under the ICT programmes were found to result in less favourable

treatment for imported ICT products, in the form of the differential tax burden to which imported ICT products are subjected by virtue of the fact that foreign producers cannot be accredited under the ICT programmes, and because imported intermediate ICT products face an administrative burden that is not faced, or is faced to a lesser extent, by purchasers of domestic intermediate ICT products that receive favourable tax treatment.

Those aspects of the ICT programmes found to be inconsistent with Article III of the GATT 1994 were also found to be inconsistent with Article 2.1 of the TRIMs Agreement. A defence claimed by Brazil on the basis of Article III:8(b) of the GATT 1994 (which permits subsidies to be paid exclusively to domestic producers) was rejected, among other reasons due to the product discrimination elements of the measures. A requirement to use domestic rather than imported goods in the production of ICT products, in order to have access to the assistance programme, was not permitted. Nevertheless, it was clarified that a subsidy programme to promote domestic production of certain products (such as ICT products critical for digital commerce), if properly designed in light of Article III:8(b), could be limited to domestic producers, however the latter were designated by the government programme, without contravening the national treatment obligation of GATT Article III, even though this might result in some competitive effects in the market for ICT products.

(iii) Tariff elimination and reduction in some sectoral agreements

The reduction and progressive elimination of tariffs on ICT goods has a key role in promoting innovation in the digital age. It not only enables and promotes the international flow of ICT goods, thus stimulating innovation, but also has a multiplier effect on the international trade of goods and services that use ICT-based components, infrastructure and hardware, as discussed in Section C.

The 1996 Information Technology Agreement (ITA) eliminated tariffs on computers, peripherals, semiconductors, semiconductor manufacturing equipment, ICT parts and components, productivity software, mobile telephones, and several other "enabling" instruments and equipment for the internet for all participants in the ITA.¹¹

The 14 initial participants in the ITA (counting the European Union as one participant) had grown by 2015 to 53, as most WTO accessions included agreement to the ITA, and several large members' free trade agreements (FTAs) required the parties to

agree to the ITA. Today, the 1996 ITA covers 85 WTO members, which account for approximately 97 per cent of world trade in ITA products.

The elimination of tariffs across the supply chain helped to enable the expansion of multi-country value chains. It also increased trade and related economies of scale, thereby contributing to the reduction of import prices and the increased affordability of ICT goods, freeing the associated potential of technology innovation (WTO, 2017). The lower cost and widespread availability of computers and mobile phones has had a positive impact on access to the internet and the growth of the digital economy, and has created new opportunities for trade. By binding and eliminating duties and other charges on ITA products in their WTO schedules of commitments, ITA participants extend duty-free treatment to all WTO members on a most-favoured-nation (MFN) basis, thereby bringing the benefits of the ITA to the entire WTO membership (WTO, 2017). The ITA has also enabled intensified global competition in mobile phones and smartphones which contributed to the development of mobile internet.

By reducing barriers to trade in ICT products, the ITA can play an enabling role in technology diffusion and innovation. Under the right circumstances, it can ultimately allow broader penetration of developing economies into global production networks and spur innovation in other sectors, thereby benefitting the economy as a whole (WTO, 2017). The ITA has contributed to reducing the costs of acquiring hardware infrastructure for the digital economy, hence expanding access to and usage of the internet in many countries, including LDCs, where access to telecommunications and the internet occurs mainly through mobile devices such as laptop computers and telephones. Removing tariffs on ICT products has made these products, and the potential of the technology innovation associated with them, affordable for a growing number of people around the world (WTO, 2017).

The 2015 ITA expansion added 201 additional tariff lines to the existing ITA, including new-generation semiconductors, semiconductor manufacturing equipment, optical lenses, GPS navigation equipment, and medical equipment, such as magnetic resonance imaging products and ultrasonic scanning apparatus. The ITA expansion allows the benefits of tariff elimination to be connected to innovation by extending these benefits to new ICT products, parts or components that did not exist in 1996. It currently has 26 participants covering 55 WTO members, and represents approximately 90 per cent of the world trade in ITA expansion products. In 2016, world

Box D.1: Tariff elimination in the pharmaceutical sector

At the end of the Uruguay Round, several WTO members agreed to reciprocal tariff elimination for pharmaceutical products and for chemical intermediates used in the production of pharmaceuticals.¹² Currently there are seven signatories of the WTO Pharmaceutical Agreement (Canada; the European Union; Japan; Macao, China; Norway; Switzerland; and the United States). The elimination of tariffs among these WTO members promotes innovation in the pharmaceutical sector, particularly as this plurilateral sectoral agreement eliminates import duties on the entire supply chain.

The Pharmaceutical Agreement has certainly contributed to the emergence of more interconnected and global production chains. Given the dynamism of global trade in this sector (trade of pharmaceutical products has experienced an annual compound growth rate of close to 15 per cent since 1995), the Agreement could also open opportunities for developing countries building production capacity in the pharmaceutical sector.¹³

In the context of the global COVID-19 pandemic in 2020, several WTO members have suggested an approach similar to that pioneered by the ITA. In April 2020, Australia, Brunei Darussalam, Canada, Chile, Lao People's Democratic Republic, Myanmar, New Zealand, Singapore and Uruguay issued a joint ministerial statement affirming their commitment to ensuring supply chain connectivity amidst the COVID-19 situation.¹⁴

Following this joint statement, New Zealand and Singapore launched the “Declaration on Trade in Essential Goods for Combating the COVID-19 Pandemic” on 15 April 2020,¹⁵ whereby signatories commit to eliminating all customs duties (it is unclear whether this commitment is for permanent and binding tariff elimination or for temporary tariff relief) and commit not to apply export prohibitions or restrictions on essential goods, including medical products, hygiene products, pharmaceutical products and agricultural products.¹⁶ Other WTO members have expressed interest in joining the initiative.

In addition, the European Union has recently called for comprehensive negotiation of a plurilateral agreement that would lead to a level playing field, including the possible permanent liberalization of tariffs on medical equipment.¹⁷

exports of both ITA and ITA expansion products reached a share of more than 20 per cent of total manufactures exports (see also Box D.1).

(iv) Technical standards

Technical standards¹⁸ provide an essential framework for the development of innovative and interoperable digital technologies. Technical standards facilitate innovation because they codify and disseminate best practices in technology in a way that can be built upon by others and make it easier to bring inventions to the market (Blind, 2009) (see section C). Technical standards regulating safety, quality and other characteristics of products – including technological goods – often affect international trade (see also Box D.2).

The main WTO agreement disciplining these measures is the TBT Agreement.¹⁹ The TBT Agreement also recognizes the pivotal role of technical standards, in particular of “international standards”, in technology development and dissemination. For instance, it enshrines in its preamble the recognition by WTO members of the “contribution which international standardization can make to the transfer of technology

from developed to developing countries”. The seamless interoperability that consumers expect in digital technologies, enabling and driving forward innovative digital technologies (e.g. autonomous vehicles; additive manufacturing such as 3D printing; the Internet of Things (IoT); Blockchain; artificial intelligence (AI)),²⁰ is built upon a rich patchwork of technical standards (e.g. those for enabling IoT, the 5G mobile network, etc.). Together, these elements allow “the whole to be greater than the sum of its parts” (Lim, 2019).

However, technical standards do not only ensure interoperability; they are also designed to ensure other important societal values such as safety, quality and environmental protection. This is why regulators draw upon technical standards when they intervene in the market to address market failures.

WTO disciplines on international standards and mutual recognition are two important tools by which the multilateral trading system fosters cooperation on digital technologies. The TBT Agreement promotes the harmonization of national technical requirements and standards with international standards, enabling the

Box D.2: International regulatory cooperation and COVID-19

The COVID-19 pandemic illustrates the value of international regulatory cooperation to build trust in the regulatory approvals of other members that can be relied upon in an emergency.²¹

For instance, if a crucial vaccine has already been approved by a regulator in a trusted member, this approval can be relied upon directly by regulatory agencies in other members. This will allow them to fast-track their own domestic approval process, ultimately ensuring that the vaccine is put to use more quickly.²²

There are a range of fora that bring together regulatory authorities of members to align procedures and standards in specific medical sectors, such as the International Medical Devices Regulators Forum and its Medical Device Single Audit Program, by which a single on-site audit of a medical device manufacturer is accepted by five countries.²³ This could minimize burden on industry and help promote more efficient and effective use of regulator resources for faster approval of innovative devices.

Mutual recognition of conformity assessment for medical devices and pharmaceuticals in RTAs, or in other bilateral or regional arrangements, can also help to avoid duplication and reduce unnecessary delays in approvals. To date, members have notified 22 such agreements (mutual recognition agreements, cooperation agreements etc.) to the TBT Committee.²⁴ Nine of these notifications concern both pharmaceutical products and medical devices, while another seven concern solely pharmaceutical products and six solely medical devices.

global diffusion of interoperable digital technologies. The Agreement recognizes that (voluntary) standards development may sometimes be a joint private and public endeavour. Its various disciplines (reinforced by the guidance developed by the TBT Committee over the years)²⁵ apply equally to technical standards prevalent in the digital economy. The ultimate goal of the TBT Agreement is to ensure that regulatory measures adopted by economies around the globe are transparent, non discriminatory, and not unnecessarily trade-restrictive, while preserving the wide policy space that countries have for addressing important societal concerns, such as health and the environment.

As already mentioned, one key element in the TBT Agreement for furthering its ultimate goal is the promotion of the harmonization of technical standards. To this end, the Agreement favours, in particular, regulatory harmonization on the basis of “international standards”. The TBT Agreement strongly encourages governments to use international standards as a basis for their own regulations and standards. For instance, technical regulations that are “in accordance with” international standards are in principle “presumed” to be TBT-consistent (at least in the sense that they do not create “unnecessary obstacles” to international trade).

The TBT Agreement also promotes other forms of global regulatory harmonization or convergence. One such tool is “mutual recognition”. Under the Agreement, members shall ensure, wherever possible, that the results of conformity assessment (e.g. testing

and certification) carried out in other members are accepted, even when such procedures differ from their own. Members are also encouraged to be willing to enter into negotiations for the conclusion of mutual recognition agreements.

Another tool is “equivalence”. The TBT Agreement provides that members must at least give “positive consideration” to accepting as “equivalent” the technical regulations of other members, even if these regulations contain specifications that differ from their own (provided that they are “satisfied” that these regulations “adequately” address the legitimate objective of their own regulations).

Karachalios and McCabe (2013) argue that the success of the internet has benefitted from the bottom-up, globally open, market-driven system of standardization as supported by the TBT Committee’s *Decision on Principles for the Development of International Standards, Guides and Recommendations with Relation to Articles 2, 5 and Annex 3 of the TBT Agreement*²⁶ in 2000. For instance, on “Effectiveness and Relevance”, the Decision states that:

“international standards need to be relevant and to effectively respond to regulatory and market needs, as well as scientific and technological developments in various countries. They should not distort the global market, have adverse effects on fair competition, or stifle innovation and technological development”.²⁷

The TBT Agreement is also relevant with respect to regulations implementing the results of research when applied to products traded internationally. For example, clinical trials, product testing, or marketing approval of medicines, biotechnology or other novel products²⁸ are governed by the disciplines of the TBT Agreement to the extent that the said regulatory measure is, for instance, a “conformity assessment procedure” within the meaning of the TBT Agreement.

Cooperation on technical standards is also especially important when confronting novel regulatory challenges and risks, such as those related to “dual use technologies” (i.e. both for civil and defence purposes) or to the area of AI.²⁹ Technical standards applying to dual-use technologies, for instance with respect to radio, telecommunication and network security, or autonomous vehicles and aircraft, are notified by WTO members under the TBT Agreement.³⁰

AI offers many potential benefits – including addressing health challenges³¹ – but may also lead to potentially significant risks (including for health, safety and privacy), the contours of which are not yet fully understood. Nevertheless, governments are already developing new regulatory frameworks to grapple with such risks. It is possible, therefore, that countries may end up adopting divergent AI regulations addressing similar types of risks. These divergences may deter or substantively delay the deployment of AI, IoT and robotic solutions, including those that could be relevant for addressing urgent and serious situations. Early global regulatory cooperation on AI,³² including through agreement on common international standards for AI safety and performance, is important for avoiding unnecessary barriers to trade in products involving AI. Members can draw upon the practices and disciplines of the TBT Agreement to promote better regulations that will allow AI to deliver while posing as few unintended risks as possible (Lim, 2019).

(v) *Government procurement*

Public procurement on average accounts for 10 to 15 per cent of GDP in most countries, and is thus a key economic activity. In addition to governments’ primary need to purchase goods and services for public purposes to fulfil their functions, governments increasingly use public procurement as a strategic tool to attain broader policy objectives, as discussed in Section C. These objectives notably include supporting and facilitating innovation (OECD, 2019).

“Innovation procurement” consists in using the government’s purchasing power to buy the process

of innovation (R&D) or the outcomes of innovation (innovative goods or services). What this means is that governments, by virtue of their purchasing power, have the ability to create markets for or to shift markets towards innovative products. This is of some interest notably in the context of sustainability-oriented public procurement (United Nations Environment Programme, 2018). Policy instruments used to support procurement for innovation vary from concrete overarching strategies to financial instruments.

The plurilateral WTO GPA, which currently has 20 parties covering 48 WTO members, enables and facilitates innovation procurement in three key respects.

First, innovative solutions may not be available for purchase at home or may be available at home only at a substantially higher cost, offering less value for money, or at lower quality than abroad. On this basis, several parties to the GPA have opened relevant procurement to international competition in the framework of the GPA, i.e. covered such procurements in their Appendix I Annexes to the GPA (or “schedules”) as follows:³³

- Several GPA parties cover specialized research bodies as procuring entities.
- GPA parties cover most goods, including innovative goods.
- GPA parties provide significant services coverage. While R&D services are not typically covered, many other services sectors, including those with particular relevance to digital innovation (e.g. computer and related services) are covered. Furthermore, some parties cover commercial market research services, and market research and public opinion polling services.

Second, the GPA procedural and transparency rules facilitate innovation procurement. Generally, GPA rules reflect and incorporate international best public procurement practices. Adherence to these rules supports successful innovation procurement, at least indirectly. GPA rules notably require that domestic public procurement procedures be conducted based on principles of transparency, non-discrimination and procedural fairness. The GPA also contains more directly innovation-related rules that are useful to highlight.

To begin with, GPA rules bar procuring entities from excluding suppliers from public procurement procedures on the basis that they have not previously

been awarded contracts by those entities and clarify that relevant prior experience may be used as a condition for supplier participation only where such experience is essential (Article VIII:2). These rules clearly support newly entering (start-up) or disruptive suppliers that wish to provide innovative technological or other solutions. Moreover, the GPA explicitly permits qualitative contract award criteria (as opposed to solely price- or cost-based criteria) (Article XV:5 and X:6). This is highly relevant in the context of innovative products. Owing to their important R&D component or still limited market penetration, innovative products may be associated with higher purchase prices. In addition, the GPA allows procuring entities to design technical specifications to promote the conservation of natural resources or protect the environment (Article X:6) and thus potentially use such environmental standards to drive and foster technological innovation.

Similarly, GPA rules stipulate that procuring entities must, where appropriate, set out technical specifications in terms of performance and functional requirements (rather than design or descriptive requirements) and may not normally prescribe technical specifications that require or refer to particular trademark, patent, etc., or else they are to indicate that “equivalent” solutions may also meet their requirements (Article X:2 and 4). These rules promote innovative solutions and keep public procurement markets contestable for innovative new market entrants.

Furthermore, to safeguard policy space for GPA parties, normal GPA rules do not need to be followed in their entirety where a procuring entity in the context of a government contract with a supplier for research or development procures a prototype from that supplier (Article XIII:1(f)).

Finally, the GPA also permits procuring entities to leverage suppliers’ innovation capabilities in times of extreme urgency. The COVID-19 pandemic demonstrated the critical importance of governments’ access to innovative solutions and products in a context of urgency and scarcity of medical supplies and related services. GPA rules provide procuring entities with the necessary procedural flexibility to fast-track innovation in urgent situations (Article XIII:1(d)).

Third, the GPA encourages (but does not require) the use of e-procurement as an alternative to paper-based procurement. The GPA-sanctioned trend towards e-procurement in itself stimulates demand for innovative digital technology solutions and can lower the costs associated with and lead to greater

participation in public procurement procedures of micro, small and medium-sized enterprises (MSMEs) (Anderson and Sporysheva, 2019). MSMEs, owing to their agility, can often be innovation leaders.

To date, most GPA parties have been developed-country WTO members, but most WTO members that are currently negotiating accession to the revised GPA are developing-country members. The revised GPA provides policy space for least-developed and developing members to pursue domestic socio-economic policies. In its preamble, the revised GPA recognizes “the need to take into account the development, financial and trade needs of developing countries, in particular the least developed countries”. The GPA incorporates provisions on special and differential treatment for developing and least-developed countries through tailor-made transitional measures, subject to negotiations during the GPA accession. In particular, developing countries may be allowed to maintain or adopt offsets and/or price preferences and to implement coverage commitments (entities and lower thresholds) gradually over time, subject to these measures being set out in their negotiated coverage schedules. Overall, the GPA transitional measures are designed to respond to the development, financial and trade needs, and circumstances of least-developed and developing countries.

(vi) Trade in services

There are mutually beneficial synergies between innovation and multilateral cooperation on trade in services. The existing multilateral framework for cooperation in services trade has enabled and promoted enhanced innovation around the world. The GATS contains detailed disciplines that contribute to competitive frameworks and good regulatory practices that support innovation. The GATS regular bodies also serve as forums for WTO members to share experiences and compare regulatory regimes governing services regulation that are often intimately linked to innovation policies. As discussed in Section C, innovation and digitalization have also transformed trade in services, bringing about new and different business models and allowing for the cross-border supply of services by the use of digital technologies (Franc, 2019).

The existing multilateral framework – GATS

The GATS does not mention “innovation” specifically; nevertheless, it contains relevant obligations and commitments, including provisions on the domestic regulation of trade in services. It allows WTO

members to design and implement innovation policies provided that they do so in conformity with their specific commitments, GATS general obligations and in the recognition of each member's right to regulate.

The link between the GATS and innovation is premised on two assumptions. The first is that trade in services, through four modes of supply (i.e. the cross-border supply of services from the territory of one member into the territory of another member (mode 1); the consumption of services abroad (mode 2); the establishment by a service supplier of a commercial presence abroad (mode 3); and the movement of individuals to another country in order to supply a service there (mode 4)), may promote innovation (and technology transfer) in host countries. The second is that members are free to design and implement innovation policies provided that they do so in accordance with their obligations under the GATS, in particular their specific commitments on market access and national treatment, as well as the principles of transparency and MFN treatment.

Indeed, trade in services may influence technological innovation in host countries through several mechanisms:

- the development of R&D in host countries, through the establishment of tech labs, design centres, or R&D hubs (mode 3);
- the creation of backward linkages, i.e. domestic services suppliers becoming suppliers of services for multinational corporations (MNCs), through outsourcing contracts (modes 1 and 3);
- the development of forward linkages in the host country through mode 3 subsidiaries of or joint ventures with services MNCs, requiring therefore some form of knowledge transfer from headquarters;
- the effects on local capital formation, e.g. staff of foreign services subsidiaries, via mode 3;
- the dissemination of knowledge through staff mobility as intra-corporate transferees or contractual service suppliers (mode 4).

GATS commitments on mode 3, in particular, provide a predictable environment for foreign service suppliers to establish a commercial presence abroad. To the extent that these suppliers are at the forefront of innovative processes or products (such as the outsourcing of software development or of network

management), they provide a conduit to transfer knowledge to the local workforce they employ and, potentially, to local suppliers, thereby promoting innovation diffusion. It should be noted, however, that any requirements that foreign suppliers establish locally as joint ventures need to be scheduled under the GATS as a market access limitation in committed sectors.

Similarly, any mandatory requirements that foreign suppliers train employees or transfer technology, or any policy that would reserve for domestic services firms only any subsidies related to R&D or to the development of technology by other means would need to be scheduled as national treatment limitations in committed sectors (this can also be done in the horizontal section of a member's schedule of commitments, thus covering sectors that are specifically scheduled, as well as those that are not).

Apart from the MFN and transparency obligations (and to some extent domestic regulation), most GATS disciplines, including most provisions on domestic regulation, apply only to committed services. The most advantageous conditions for the digital supply of information-intensive services are achieved when relevant commitments exist and when those are as open as possible (Tuthill, Carzaniga and Roy, 2020).

So far, WTO members have made uneven use of the possibility of undertaking GATS commitments. The proportion of schedules that contain commitments on cross-border supply and commercial presence for electronically transmitted 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. However, more than one-third of schedules provide no guarantees of treatment even in these sectors. Retailing services, which include online retailing platforms, are uncommitted in the majority of members' schedules. Commitments on R&D services fall between these two poles, with a moderate but not extremely high number of commitments.

In addition, the number of schedules containing commitments on mode 1 is limited with regard to services, where the ongoing improvement of digital networks provides opportunities for cross-border electronic supply of services such as accounting, engineering, R&D, and advertising, audiovisual and educational services. Currently, 64 per cent of members' schedules that includes additional commitments in relation to the Reference Paper on Basic Telecommunications, drafted during the WTO negotiations on basic telecommunications.³⁴

Indeed, innovation and digitalization in the telecommunication and computer services sectors wherein generous GATS commitments supported open borders and regulatory reforms, have brought about further innovation not only in technology, but also in business models, for a wide array of information and knowledge-intensive services in other sectors.

The GATS and its obligations and commitments are considered to apply to the online services that result from digital innovations. As a result, innovation policies have had to take into account the cross-border contributions to innovation afforded by GATS modes 1 and 3, providing a stable framework for the flow of ideas regardless of origin. Software development and other forms of R&D, for example, are often conducted abroad both through foreign direct investment (FDI) and outsourcing by foreign subsidiaries taking advantage of GATS commitments. Moreover, the GATS serves as an overarching framework that can impact all services sectors; the following sectors are the most relevant examples.

Telecommunications

The GATS Annex on Telecommunications³⁵ and Reference Paper on regulatory principles for basic telecommunications³⁶ promote innovation policy insofar as they support competitive regulatory frameworks for the supply of telecommunications services. The Reference Paper helps to foster innovation, generally, as well as digital trade, by means of the extension of an affordable and efficient infrastructure for the wide array of electronic supply and purchasing activities that constitute e-commerce (WTO, 2018).

The Annex on Telecommunications applies to all WTO members. It requires that WTO members ensure that foreign service 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.

The Reference Paper, unlike the Annex, becomes legally binding only on members that incorporated it into their schedules of commitments. Thus far, 103 WTO members have done so. It requires adherent governments to prevent anti-competitive practices by dominant suppliers of telecommunications that serve basic transport functions in regulatory areas ranging from interconnection to universal service provision.

Telecommunications services, including internet, mobile and data transmission services, play a key role in supporting continued innovation in the digital

age. Information telecommunications hardware and services infrastructure enable the electronic supply of innovative services and trade through digital networks. Telecommunications services, for which GATS contributed to opening markets, are today at the forefront of innovation and digitalization. For example, GATS commitments on market access for mobile telecommunications are by and large made on a technology-neutral basis in line with the scheduling guidelines contained in the Chairman's Note on Scheduling Basic Telecommunications).³⁷

Therefore, as innovation in mobile telephony has transformed the networks to adopt increasingly sophisticated technologies (i.e. second-generation mobile networks (2G) to 3G, with 5G and 6G currently on the horizon), the services could be smoothly introduced and continue to benefit from the predictability guarantees offered by the commitments and the Annex and Reference Paper obligations. By extension, development of the 5G mobile network is expected to support R&D and the deployment of enhanced audiovisual and other media services requiring high speeds and bandwidth, and also to serve as a launchpad for new and emerging technology services to become more widely available. These will include services such as AI, the IoT and high-capacity data analytics (Big Data).

Financial services in the digital age

The GATS coverage of financial services can play a key role in supporting their transformation in the digital age. The GATS Annex on Financial Services defines a financial service as "any service of a financial nature offered by a financial service supplier of a member", and defines a financial service supplier as "any natural or juridical person of a member wishing to supply or supplying financial services". The Annex on Financial Services allows WTO members to take measures for prudential reasons and to recognize other countries' prudential measures, through harmonization or otherwise.

The financial services industry has become one of the most ICT-intensive industries. Innovation in financial services has led to the introduction of innovative financial products and services, has altered the production process of financial institutions (e.g. non-core functions now tend to be outsourced/offshored), has allowed for the multiplication of delivery channels (e.g. ATMs, internet banking, mobile banking), and has led to new organizational forms (e.g. virtual banks) (WTO, 2010).

A concrete example of innovation in the area of payments is the accelerated use of electronic

payments (e-payments), which allow the whole transaction to be carried out through electronic means. Due to innovation and digitalization, the area of payments, once dominated by banks, is witnessing both increasing competition from new entrants and the emergence of e-payment methods that involve partnerships among different players, from telecommunications operators to express delivery companies and retail agents (WEF, 2018).

The development of e-payments allows for the expansion of e-commerce and drives the sale and purchases of new digitalized products and services. Nevertheless, together with these new opportunities, e-payments often arise as a challenge facing businesses trying to expand their global e-commerce, particularly small businesses. The main concerns often mentioned by small businesses with regard to making and accepting cross-border payments are transaction fees, the risk of fraud, foreign exchange fees and the speed of processing and settling payments (Saxo Payments Banking Circle, 2017) (see Box D.3).

(vii) Trade-related aspects of IP and innovation

The TRIPS Agreement sets in a trade policy context the traditional objectives of IP policy – namely, to balance incentives for innovators and creators with the interests of business and the public at large in promoting the benefits of disseminating the fruits of innovation and creativity.

Through common minimum levels of IP protection and enforcement, and provisions on non-discrimination and transparency, the TRIPS Agreement provides the necessary legal foundation for investment in innovative activities and the creation of intangible assets. It articulates general principles to be adapted according to domestic circumstances, allowing scope for diverse policy choices, so as to achieve a “balance of national IP systems and essential interoperability between national systems, rather than providing a specific model or prescription for innovation capacity.” (Taubman, 2019). The TRIPS Agreement also forms the basis for trading IP protected products, such as e-books and apps, as well as IP licences, securely and predictably within and across borders, thus facilitating a burgeoning trade in creative content.

Article 7 of the TRIPS Agreement sets out the policy context for the IP system, situating the objective of incentivizing innovative activity alongside the dissemination of, and access to, inventions and creations, so as to ensure a functioning, sustainable

innovation ecosystem, and to contribute to overall public welfare gains. TRIPS negotiators incorporated this provision against a longstanding background of international debate about the role of IP as a tool of public policy, marked particularly by the concerns of developing countries that the IP system should not simply respond to the interests of innovative firms – at the time, largely located in the developed world – but should serve broader social interests through the effective dissemination and diffusion of new technologies. The debate continues today, even as the landscape for innovation diversifies across the globe, with particular emphasis on health innovation, the green economy and overcoming the digital divide, with a continuing emphasis on balancing spurs for the development of new technology with mechanisms to accelerate its diffusion: in short, innovation and access (WTO, WHO, WIPO, 2020).

To achieve these ends, the TRIPS Agreement formulates a balanced set of standards across the entire spectrum of IP, also covering administration and enforcement, and providing scope for competition safeguards and public policy exceptions and limitations. The principles expressed in the TRIPS Agreement have proven sufficiently flexible to accommodate both new digital technologies and ways of creating and using protected materials in the digital environment (World Trade Report, 2018), and it extends traditional copyright principles to computer programmes and data compilations.

The implementation of TRIPS Agreement copyright standards by members forms part of the essential framework for e-commerce and international digital trade, as many digital products are defined in terms of use of specific intellectual property rights (IPRs), often in the form of a licence to use a copyrighted work. For instance, purchasing a video game, an application or a music file from an online retailer, or renting a film from a streaming platform, usually means obtaining a limited licence from the right-holder to use copyright-protected material, which can include the authorization to make a copy, and to obtain and use future updates of the game or software.

Patent laws implementing TRIPS standards mobilize private sector investment in R&D for new technologies, and facilitate technology transactions and the integration of complex technologies from diverse sources, both public and private, in a decentralized fashion. Recent patent filings have grown sharply, with computer technology and digital communication remaining among the top three categories in China, Japan, the Republic of Korea and the United States for several years, illustrating how firms seek to bring new applications of scientific

Box D.3: COVID-19-related measures and notifications in the WTO and in other contexts

WTO members have adopted a number of regulatory and legislative measures in the context of the COVID-19 pandemic, which have direct or indirect connections with WTO agreements. Since the beginning of the pandemic, the WTO has received a number of notifications under the transparency obligations of specific agreements or on a voluntary basis, as many members were willing to share such information.

The availability of online information is especially important in situations of global crisis, where physical access to national legislation is impeded or delayed. Online access to national legislation greatly improved opportunities for foreign operators to become acquainted with the different measures put into place by WTO members in response to the pandemic. The WTO also dedicated a webpage to compiling and reporting on COVID-19-related trade measures.³⁸

Border clearance for COVID-19-critical medical goods has been expedited by cutting back red tape. Since the beginning of the pandemic, the WTO has received a number of notifications regarding trade facilitation measures related to COVID-19. The measures have included, for example, guidelines on facilitating air cargo operations, relief from import duties and VAT exemption, streamlined procedures for applications to import, and export licences, among others. Thanks to digitalization, interested parties have detailed information about notifications, ratifications and implementation statistics and other relevant content at their fingertips.

Efforts to secure supplies of medical supplies and personal protective equipment (such as facemasks) in the early phase of the pandemic led some countries to protect national stocks of such equipment with temporary export restrictions, with measures being relaxed and imports being facilitated to improve sourcing from producing nations. Notifications of measures taken and relaxed were important to provide transparency during this difficult period.

About two-thirds of the 150 formal notifications and communications on the COVID-19 trade-related measures received to date from WTO members and observers, including from G20 economies, were related to sanitary and phytosanitary (SPS) measures and measures relating to technical barriers to trade (TBT). Many of these measures aimed to streamline certification procedures and tended toward increased use of electronic/digital procedures, including electronic certification, to facilitate access to medical and protective equipment.

Under the SPS Agreement, members have the right to adopt emergency and/or provisional measures based on available information. As more scientific evidence emerges and risk assessments begin to be carried out, the measures imposed must be reviewed within a reasonable period of time. A glance at the measures notified to the WTO under the SPS Agreement seems to indicate that, initially, members adopted measures imposing import restrictions on live animals from affected areas. Subsequently, most notifications and communications from members concerned measures aimed at facilitating trade by temporarily easing product certification requirements and moving towards more electronic/digital procedures, for example, regarding the acceptance of scanned copies instead of original documents, while ensuring product safety.

While some members explicitly indicated the temporary character of their measures during the pandemic, others have completed their ongoing transitions to paperless certification in their trade of plants and plant products and, to a lesser extent, animal products. Several members also included temporary flexibilities for foodstuffs, for example with respect to packaging and labelling. While food safety and animal and plant health remain a priority, the procedures set up by countries during the pandemic can contribute to reducing time and costs in the performance of SPS-related control, inspection and certification procedures, and could set the basis for more permanent solutions. TBT notifications concerned both pharmaceutical products and medical devices.

The work undertaken by the Committee on Government Procurement also provided opportunities for exchanges of views on digital innovation related topics. The COVID-19 pandemic has led to reflection on how best to procure innovative goods and services needed to respond to a crisis or on using government procurement to stimulate rapid innovation, as well as on how government procurement can best support post-crisis economic recovery. During the COVID-19 pandemic, several governments worldwide responded to their need for up-to-date information on the spread of COVID-19 by procuring innovative COVID-19-tracing applications. In that regard, considerations such as the need for the rapid development of new technology and concerns regarding how information will be used and stored should be taken into account when government procurement procedures are being designed.

Box D.3: COVID-19-related measures and notifications in the WTO and in other contexts (continued)

Many other actions and measures have been notified during the pandemic, in the contexts of existing agreements, committees, working groups and other informal mechanisms and on matters such as information-sharing on IP (including free access to relevant patents databases, technology transfer incentives, facilitating the exchange of clinical trial data and sharing IP to develop treatments), regulatory cooperation and competition policies. Several competition authorities issued additional guidance on the application of competition policy in times of urgency and of limited supplies, and clarified whether and when coordination between firms in order to respond to crisis needs could be permitted at least temporarily. Experience-sharing between competition authorities was important during the pandemic.

Beyond the crisis-response phase, competition authorities are expected to focus on how competition policy can support economic recovery and facilitate a return to optimal levels of competition. In that regard, the application of competitive neutrality rules and other competition policy principles to government support measures could help to avoid unnecessary market distortions.

and technological advances to the market. Patent applications on blockchain technologies have risen at least 140 per cent annually since 2013, forming over 3,000 patent families (IP Australia, 2018). Innovation in AI techniques grew by at least 28 per cent annually between 2012 and 2017 (WIPO, 2019), in over 55,000 patent families, the predominant applications being in the fields of computer vision and natural language processing. Recent trademark activity has been pronounced in the distinct clusters of research and technology, leisure and education, and business services, illustrating innovation in organizational and business models.

Much technology is disseminated when business right-holders license their IP or sell IP protected products or services, resulting in rapid commercialization of innovative products, notably digital technologies such as applications, smartphones, operating systems and video games, as private sector players respond to market incentives for the dissemination of new technology, which – in turn – allows and enables downstream technological and organizational innovation by users. The TRIPS Agreement framework has enabled a flexible range of innovation structures, defined by a diverse array of business models and technology licensing practices which defend IP assets – and thus investment – against free-riding by competitors and yet ensure avenues for private and public actors to formulate diverse arrangements for cooperation and pooling of technology licences. Public research institutions and other players therefore leverage IP to facilitate the take-up and dissemination of new technologies while advancing a social responsibility agenda (see Box D.4).

Pooling technology can remove obstacles to implementing common technology standards that create benefits and foster downstream markets.

For instance, over 30 companies contributed their patented technologies to a patent pool that enabled numerous commercial actors to implement the MPEG 4 visual standard, a widely used technology for compressing video and audio content. Through this pool, standard-essential patents have been licensed collectively to video, television and gaming applications – such as QuickTime or Xvid – for use on computers and mobile devices. Companies have also licensed and pooled relevant IPRs to cooperate in other complex technological areas.

The main IP mechanisms for the development and dissemination of innovations are commercial initiative and public-private cooperation through licensing. But the TRIPS Agreement also promotes access to and use of innovations by requiring patent applicants to disclose their inventions in a manner sufficiently clear and complete for them to be carried out by a person “skilled in the art” in return for the granting of patent rights, thus enabling early publication and understanding of emerging technologies, which can, in turn, spur technology transfer and further innovation. New digital research tools have significantly facilitated the use of patent information as a rich source of technological know-how, much of it in the public domain in most developing countries. For example, the World Intellectual Property Organization (WIPO) PATENTSCOPE enables detailed searches of over 80 million patent-related documents.³⁹

The TRIPS framework includes exceptions and limitations to IP rights that serve as regulatory tools to reconcile competing interests in IP policymaking, notably in the digital economy and in the public health space. Many innovative online business models (e.g. search engines, news aggregator services and platforms for user-generated content) rely on

Box D.4: Initiatives to accelerate innovations to fight COVID-19

Since creating a new drug is risky, lengthy, and expensive, while producing the drug is very cheap, the pharmaceutical industry offers a compelling case for patent protection (EPFL, 2020). Against this background, there is a lively ongoing discussion about the role of IP protection in the current fight against COVID-19.

There have been free licensing initiatives by private firms. The most well-known cases involve the antiretroviral drug Kaletra, produced by AbbVie (the company announced it will not enforce its patent in the current pandemic), and Remdesivir, an experimental drug for COVID-19 for which Gilead Sciences issued a voluntary licence to generic drug-makers. There are also ongoing initiatives of voluntarily sharing knowledge, IP and data, such as the Tech Access Partnership (TAP), hosted by the United Nations Technology Bank, or the Open COVID Pledge. Initiatives like these can foster innovation by providing information on patents, by offering legal certainty to follow-on innovators, and by reducing contracting costs between the patent-holder and potential users of the technology (EPFL, 2020).

Since 2010, a number of firms have concluded voluntary licences for health technologies with the Medicines Patent Pool (MPP). The MPP facilitates affordable access to medicines for those in most need and promotes transparency concerning patent coverage and licensing structures through its MedsPaL database (<https://www.medspal.org/>). Its mandate was recently extended to cover medicines under investigation for possible treatment of COVID-19.

In April 2020, the World Health Organization (WHO) joined with governments, global health actors and private sector partners to establish the Access to COVID-19 Tools (ACT) Accelerator, with the goal of accelerating the development and production of and equitable global access to new COVID-19-related essential health technologies. In May 2020, the WHO launched the Solidarity Call to Action and the COVID-19 Technology Access Pool (C-TAP) “to promote global public health goods, based on equity, strong science, open collaboration and global solidarity”. C-TAP will centralize commitments to share COVID-19 health technology-related knowledge, IP and data voluntarily.

Other significant initiatives both by the public and private sectors have aimed to accelerate innovations to protect against and treat COVID-19 and to secure equal access to relevant technologies through the voluntary sharing of IP rights. Sanofi and GSK entered into a Material Transfer Agreement to jointly develop a COVID-19 vaccine. Some publishers have made copyright-protected content on COVID-19 freely available to support research efforts. Under the Open COVID Pledge, multinational technology companies such as Microsoft, Amazon, IBM, Intel, Hewlett Packard and Facebook offered free worldwide licences to anyone to exploit essentially all their IP portfolios to end the pandemic and minimize its impact. Medtronic grants permissive time-limited licences to allow open access to design files and software for its ventilator for the purpose of treating COVID-19.⁴⁰ Its Ventilator Training Alliance transfers know-how required for the use of ventilator technology. The European Union and Singapore are making copyright-protected standards freely available to facilitate the manufacturing of medical devices and personal protection equipment (Enterprise Singapore, 2020; European Commission, 2020b). Singapore has made its contact tracing app open-source (Choudhury, 2020).

exceptions to constraints on the use of copyright-protected content (e.g. displayed by search engines or aggregators). Patent exceptions and limitations define where proprietary technologies can be used for research without the right holder’s authorization, thus helping to spur further innovation, and TRIPS dispute settlement practice has clarified the scope for generic producers to seek timely regulatory approval of follow-on medicines. Members may authorize more extensive use of patented technologies without the right-holders’ consent, including government use or public non-commercial use, with TRIPS leaving open the grounds for such authorization while stipulating procedural conditions so that the scope, time span

and territorial extent of such permitted use remains commensurate with its rationale (Box D.5).

(viii) Aid for Trade and innovation

The Aid for Trade initiative seeks to help developing countries, and in particular LDCs, to address supply-side and trade-related infrastructure obstacles that constrain their ability to engage in international trade. The initiative works by seeking to leverage development finance to resolve these obstacles. Total support disbursed through official development assistance since 2006, following the launch of the Aid for Trade initiative, amounts to some US\$ 450 billion.

Box D.5: TRIPS policy options to address COVID-19

The 2001 Doha Declaration on the TRIPS Agreement and Public Health affirmed that the Agreement “can and should be interpreted and implemented in a manner supportive of Members’ right to protect public health and, in particular, to promote access to medicines for all”, and clarified key public health flexibilities. It thus underpins general recognition that the TRIPS Agreement provides significant latitude for members to deploy policy options for public health.

In the absence of voluntary collaboration, patent exceptions and limitations in the TRIPS Agreement, as implemented into regional and national law, determine to what extent proprietary technologies can be used to develop new technologies and to secure access to existing technologies relevant to the pandemic. For example, when treatments and vaccines to treat COVID-19 come to market, the regulatory review exception permitted under Article 30 of the TRIPS, and clarified in dispute settlement, will enable a patented invention to be used to obtain early regulatory approval of a generic follow-on product.

Where appropriate, and subject to the conditions established in Article 31 of the TRIPS, compulsory or government use licences may also be granted to allow the manufacture or import of technologies protected by patents. All WTO members may grant such licences for healthcare technologies, such as medicines, vaccines and diagnostics, as well as any other product or technology needed to address COVID-19. To date, one government-use licence has been granted to import generic versions of lopinavir/ritonavir (deemed effective in treating COVID-19) because the right-holder could not supply the medicine. Some WTO members have also eased procedures to prepare or facilitate the prospective use of compulsory and government use licences to respond to the pandemic.⁴¹

Since 2003, an additional flexibility, now enshrined in Article 31bis of the amended TRIPS Agreement, has allowed members to issue special compulsory licences for the export of pharmaceutical products to members with insufficient manufacturing capacity, an avenue for access to medicines that may become more important as patents on pharmaceuticals become more prevalent in traditional low-cost producer countries. According to paragraph 1 of the Annex to the amended TRIPS Agreement, special compulsory licences may cover pharmaceutical products, including medicines, vaccines and diagnostics, needed to address epidemics.

The mechanism may thus be used by developing countries with insufficient or no manufacturing capacities and by LDCs to import healthcare technologies relevant to COVID-19. How a potential exporting country responds to the demand of an importing country would depend on a range of factors, including their own domestic needs, as special compulsory licences provide for the entire production to be exported. For instance, if a producing country grants a standard compulsory licence for its domestic needs, a non-predominant part may be exported to meet the import needs of such a country.

Limited digital infrastructure and poor internet connectivity constrain the participation of many developing country firms to be able to engage in e-commerce and to use the internet to spur innovation. International Telecommunication Union (ITU) data estimate that 47 per cent of the world’s population is still not connected to the internet. It also reveals a diverse picture: whereas in advanced nations, nearly 90 per cent of inhabitants enjoy access to reliable and affordable internet services, the figure does not exceed 45 per cent in the case of the most connected LDC, and is under 20 per cent for most other LDCs.

In 2017, the WTO-led Aid for Trade Global Review focused on the topic of “Promoting Connectivity”. A monitoring and evaluation exercise invited

stakeholders to outline actions they were taking to improve digital connectivity. The results of the exercise provided further information on the digital divide within countries: between large and small firms and between urban and rural areas, as well as between women and men. It also highlighted the difficulties many developing-country governments have in approaching the issue of digital connectivity and e-commerce from a trade perspective (WTO and OECD, 2017).

Further findings from the OECD and WTO (2017) centred on the critical role that digital connectivity plays for trade facilitation (a top priority for developing countries), given how it intertwines with other modes of physical connectivity (air, maritime, road and rail) and unlocks participation in e-commerce.

Digital networks offer access to e-commerce, but this process is far from automatic, as other skills need to be acquired to participate successfully in e-commerce trade. In short, digital connectivity is not sufficient to engage in e-commerce.

OECD and WTO (2017) points to action by a range of countries at different levels of income to harness digital connectivity for their development – actions that are being actively supported by Aid for Trade financing and the private sector. Aid for Trade support for digital connectivity has reached US\$ 8.6 billion.⁴² Many developing countries suggest that expenditure on digital connectivity should be boosted in future.

OECD and WTO (2017) also underscores the role that trade policy plays in influencing digital trade connectivity costs, in terms of both the availability and the affordability of connections, and so the ability of developing countries to use digital connectivity for their trade integration and economic development.

(b) Cooperation at the bilateral, plurilateral and regional level

Regional trade agreements (RTAs) have often been dubbed laboratories in which new types of provisions are adopted in order to address existing and more recent trade-related issues and challenges. As of October 2020, 306 RTAs that are in force have been notified to the WTO.

A limited number of RTAs incorporates provisions referring explicitly to industrial and innovation policy. The inclusion of such explicit provisions in RTAs is, however, not a recent phenomenon. For instance, the 1959 Central American Multilateral Free Trade and Economic Integration Treaty committed the parties to adopt, by mutual agreement, measures designed to further the establishment or expansion of regional industries. Explicit provisions on industrial and innovation policy take different forms, from industrial policy coordination to cooperation activities in industrial development as well as in science and technology. Besides the main text of RTAs, relevant provisions on industrial and innovation policy can also be found in specific declarations, directives, resolutions or agreements on industrial and innovation policy adopted after the entry into force of some RTAs.

While most trade agreements do not explicitly address industrial and innovation policy, many different provisions can both support and constrain industrial and innovation policy in the digital era. Importantly, in some cases, some issues relevant to industrial and innovation policy are explicitly excluded from the scope of application of RTAs. In

other cases, the parties to the RTA agree to enter into future discussions concerning specific issues related to industrial development or innovation. As with the WTO agreements, and given their cross-cutting nature, there is no one single type of provision in RTAs that addresses industrial and innovation policy.

A broad range of provisions in RTAs can be relevant to industrial and innovation policy in the digital era, such as those on support measures, IP, competition, investment, movement of natural persons, government procurement, telecommunications, data management, standards, and cooperation activities on issues related to industrial development and innovation.⁴³ While some of these provisions replicate or build on existing WTO agreements, other provisions establish new commitments. These new provisions remain particularly heterogeneous, including in agreements negotiated by the same country. Overall, the most comprehensive and detailed provisions and commitments relevant to industrial and innovation policy are found in relatively recent RTAs in which one of the parties is a developed economy.

(i) Support measures

Subsidies are part of the traditional industrial and innovation policy toolbox. Similarly, subsidies and state aid have been included in most RTAs representing one of the standard chapters of trade regulation even though these provisions do not make an explicit reference to industrial or innovation policy. Most provisions on subsidies in RTAs build on the SCM Agreement. Most additional commitments are mainly of an ancillary or procedural nature (Rubini, 2020).

Prohibition of export subsidies and trade-distorting subsidies are some of the most common type of subsidy provisions found in RTAs.⁴⁴ Most RTAs with subsidies provisions regulate local content requirement through references to existing WTO disciplines. In parallel, some RTAs incorporate provisions exempting legitimate subsidies, mostly regional aid, agricultural subsidies, sectoral aid and public service support.

Subsidies and grants applied to trade in services are excluded from the scope of application of most RTAs (Gootiiz *et al.*, 2020). Only a limited number of RTAs have established explicit subsidy disciplines relating to services trade.⁴⁵ For instance, the Revised Treaty of Chaguaramas establishing the Caribbean Community (CARICOM), including the CARICOM Single Market and Economy, commits its members to harmonizing national incentives to investments in the industrial, agricultural and services sectors. The Agreement establishing the European Economic

Area (EEA), concluded between the European Union and Norway, Iceland and Liechtenstein, introduces substantive disciplines on state aid that may distort competition, including in services sectors.⁴⁶

(ii) Intellectual property

IP can play an important role in mitigating the risk faced by the different actors involved in the process of taking innovative technologies to the marketplace, including through the commercialization of new or improved goods and services. Although the inclusion of IP provisions in RTAs is not new, the incorporation of comprehensive and detailed IP is a relatively recent phenomenon (Wu, 2020).

IP provisions in RTAs cover a broad range of issues, including those related to MFN and national treatment, IP enforcement procedures and issues related to specific IP rights, such as copyrights, trademarks, industrial designs, patents and trade secrets. As with other types of provisions in RTAs, the language, scope and depth of IP provisions vary widely across RTAs (Valdés and McCann, 2014).

While some provisions build on the existing TRIPS provisions, other provisions go beyond the TRIPS Agreement (TRIPS-plus) and expand the scope of IP issues covered.⁴⁷ Some of the most contentious TRIPS-plus provisions relate to patents, such as the obligation to apply new use and/or new process patents for a known product, patent term extension in case of unreasonable (regulatory) delays, patent linkage and patent revocation (Wu, 2020).⁴⁸ Other TRIPS-plus provisions, considered controversial by some, include provisions providing for a minimum term of protection for undisclosed tests or other data for a new pharmaceutical product, agricultural chemicals and biologics. These provisions are often complemented by cooperation provisions, some of which promote the exchange of experience and information on technology and market intelligence.

An increasing number of RTAs also explicitly address a broad range of different specific digital regulatory issues related to IP (WTO, 2018). Several IP provisions related to digital technologies establish disciplines on the protection and enforcement of copyrights and related rights, including through the accession and ratification of the WIPO Copyright Treaty and the WIPO Performances and Phonograms Treaty (“WIPO Internet Treaties”),⁴⁹ implementation of technological protection measures, and rights management information protection.⁵⁰

The confidentiality protection of the list of programming commands necessary to understand

and modify how software works, commonly known as source code, has also been explicitly addressed in the e-commerce chapter of a couple of recent RTAs, such as the Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP) and the Economic Partnership Agreement between the European Union and Japan. In particular, these few agreements commit the parties 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 obligation is, however, limited to mass-market software or products containing such software, and explicitly excludes software used for critical infrastructure.

(iii) Competition

Competition laws can be an important instrument in industrial and innovation policy. The recognition of competition as a fundamental tool for trade is explicitly incorporated in many RTAs (Anderson *et al.*, 2020; Anderson *et al.*, 2019). Although some differences remain in countries' approach to and focus of competition-related provisions in RTAs, an increasing number of more recent RTAs include detailed provisions on competition policy (Laprévôte, 2019; Licetti, Miralles and Teh, 2020).

The obligation to establish or maintain competition laws and to create an institution to enforce them is one of the most significant competition-related commitments found in RTAs. In parallel, an increasing number of RTAs include substantive provisions regulating competition policies either by referring to existing treaties regulating competition, or by specifying provisions on antitrust obligations and merger control.

In addition to such substantive competition-related commitments, some RTAs incorporate provisions on procedural fairness, transparency and cooperation among authorities, with a view to guaranteeing an efficient competition policy framework. A limited number of RTAs, such as CARICOM, include provisions calling for the creation of supranational competition rules. However, competition provisions in a relatively large number of RTAs are not subject to dispute settlement under the RTA.

More recently, some RTAs established disciplines on state-owned enterprises (SOEs) and designated monopolies. For instance, the CPTPP commits its parties to avoiding discrimination and applying commercial considerations to SOEs. The parties are also committed to limiting the scope for designated

monopolies to engage in anticompetitive practices. Furthermore, the parties are required not to provide non-commercial assistance capable of causing adverse effects or injury to the interests of another party. The parties have also the obligation to offer an impartial regulatory and institutional framework for SOEs, and to make them accountable for their actions in the other parties' territory.

(iv) *Investment*

Foreign investment can promote industrial development and technological innovation in host countries through several mechanisms, including the dissemination of knowledge and human capital formation. While, initially, investment was addressed in bilateral investment treaties, the number of RTAs with investment provisions has increased significantly in the last 20 years (Crawford and Kotschwar, 2018).⁵¹

The investment chapter in RTAs often combines disciplines on the protection and promotion of investment with provisions on the liberalization of foreign investment. These provisions complement other provisions related to the establishment of commercial presence in the partner country (mode 3 of the GATS) found in the RTA chapter on cross-border services.⁵²

An increasing number of RTAs commits parties to removing restrictions on foreign investment in their respective economies and/or to providing protection for foreign investors seeking to enter their markets. Performance requirements on investment, defined as conditions or measures that host states impose on investors in order to operate a business or benefit from an incentive offered by the host state, are explicitly prohibited in many RTAs.⁵³ A limited number of RTAs extend this prohibition to the pre-establishment phase with respect to some sectors/industries. Some agreements further incorporate special provisions prohibiting nationality requirements for senior management but allowing nationality requirements for a majority of the investment's board of directors.

(v) *Rules of origin*

Rules of origin set out the criteria that determine the national source of a product to qualify for preferential tariff treatment. Although preferential rules of origin are designed to avoid trade deflection, they are often negotiated with the objective of helping to scale up regional industrialization and promote regional value chains by affecting the sourcing of inputs.⁵⁴

Rules of origin are not only incorporated in an increasing number of RTAs, but the method for determining the origin varies across agreements. While the requirement of substantial transformation is universally recognized, some agreements apply the criterion of change of tariff classification, others use the *ad valorem* percentage classification or the criterion of manufacturing or processing operation. An increasing number of RTAs set out a combination of these methods for determining origin (Donner Abreu, 2013).

In recent years, rules of origin in RTAs have received increased attention in the trade policy debate because strict rule of origins could be used to support the re-localization of certain parts of production processes to avoid facing additional tariffs (Francis, 2019). For instance, the rules of origin for automobiles and auto parts under the United States-Mexico-Canada Agreement (USMCA), formerly known as the North American Free Trade Agreement (NAFTA), have been renegotiated with a view to increasing the North American content in several key aspects of the production. In particular, the USMCA requires 40 per cent or more of parts for each passenger vehicle be manufactured by workers who are paid at least US\$ 16 per hour as a condition to be granted duty-free tariff treatment.

(vi) *Movement of natural persons*

The temporary movement of people to supply R&D services and other (skilled) professional services abroad (mode 4) can be an important means of supporting research networks and innovation. While governments resort primarily to bilateral, non-trade policy instruments, such as labour market arrangements EPS, to manage flows of workers, an increasing number of regional trade arrangements with specific provisions on temporary entry have been negotiated (WTO, 2019a).

Most of the regulatory disciplines on movement of natural persons in RTAs go beyond the obligations contained in the GATS (WTO, 2019a). The most common type of provisions on movement of natural persons relates to the setting of visa fees. These provisions are often complemented by the obligation to process visa and work permit applications in an expeditious manner or within a given time limit. Other relatively less common related provisions include the obligation to inform visa and/or work permit applicants of the outcome of their application and to publish material relevant to visa applications.

Many of the RTAs with provisions on the movement of natural persons limit the recourse to their dispute

settlement mechanisms to situations where there is a practice of rejecting applications and after local administrative remedies have been exhausted. Only a couple of RTAs, such as the European Union and the Southern Common Market (MERCOSUR), have established work visa exemptions or facilities allowing citizens from any of the parties to work in any other parties. Some RTAs also incorporate provisions for cooperation and mutual recognition of qualifications of specific professional services, including the validation or recognition of foreign studies and degrees.

(vii) Government procurement

Public procurement can be used as a strategic tool to stimulate innovation in the private sector by opening up procurement markets for specific goods and services and prescribing rules for the conduct of government procurement requiring innovative solutions. An increasing number of RTAs incorporate provisions on government procurement in a dedicated chapter.

Most government procurement chapters in RTAs are based on the GPA (Anderson, Müller and Pelletier, 2017; Anderson and Sporysheva, 2019), in terms of language, content and structure. While some RTAs provide market access commitments in specific sectors that are deeper than those of the GPA, overall market access opportunities created by RTAs are generally lower than those available under the revised GPA (Anderson, Müller and Pelletier, 2017). Furthermore, some government procurement chapters explicitly exclude research and development services from their respective scope.

An increasing number of RTAs include provisions encouraging e-procurement. While in most instances, these provisions replicate the relevant GPA provisions, increasingly RTAs incorporate other, more specific provisions related to digital technology, such as the dissemination of information on government procurement through a single electronic portal (Ganne, 2018). More recent RTAs, such as the new EU-Mexico agreement, establish provisions on sustainable public procurement, allowing procuring entities to take into account environmental and social considerations throughout the government procurement process, provided that the principle of non-discrimination is respected (European Commission, 2020a, 2020b).

(viii) Telecommunications

Telecommunications services, including internet, mobile telephony, and data transmission services, provide basic information telecommunication hardware and transmission capacity that can play a key role in industrial and innovation policies in the digital age.

Provisions establishing specific telecommunications regulatory principles, including with respect to anti-competitive behaviours of major suppliers in the telecommunications sector, are increasingly incorporated in RTAs.

While some provisions in RTAs replicate or add clarity to certain disciplines established in the WTO Annex on Telecommunication⁵⁵ and the Reference Paper on Regulatory Principles on Basic Telecommunications,⁵⁶ other provisions establish new obligations either by extending the type of telecommunications services covered by the regulatory provisions or by addressing new regulatory issues (WTO, 2018a; 2019a).

An increasing number of RTAs extend the scope of the Reference Paper obligations beyond basic telecommunications services by also covering value-added telecommunications services in certain respects. Unlike the Annex and the Reference Paper, some RTAs explicitly address the question of whether to employ *ex-ante* or *ex-post* regulatory approaches. This includes, for example, provisions on so-called forbearance, whereby governments are encouraged to exercise their enforcement powers after the fact only when it is found to be necessary to prevent unreasonable or discriminatory practices or to protect consumers.⁵⁷

A limited but increasing number of telecommunications chapters in RTAs include provisions calling on governments to extend to telecommunications services suppliers the right to use the technology of their choice in supplying services. Some recent RTAs, such as the CPTPP, specify, however, that the parties retain the right to condition the financing of broadband networks on the use of particular technologies. A few recent RTAs also contain explicit principles on access to and use of the internet, such as suppliers' right to negotiate with the other parties' suppliers international internet connection on a commercial basis and consumers' right to run the applications and services of their choice subject to law enforcement needs. Similarly, the principle of internet neutrality, according to which all internet traffic should be treated equally, has been explicitly addressed in a couple of recent agreements, such as the RTA between Argentina and Chile.

(ix) Data management

Besides connectivity, industrial and innovation policies in the digital age are dependent on access to and use of data. A limited but increasing number of RTAs incorporate specific provisions explicitly addressing data management, including personal data protection and cross-border data flows.⁵⁸

A very limited number of RTAs to which the European Union is a party includes a chapter dedicated to personal data protection. Many of these provisions establish specific principles, such as purpose limitation, data quality and proportionality, transparency, security, right of access, rectification and opposition, as well as restrictions on onward transfers. Other provisions address the protection of sensitive data and enforcement mechanisms.

Commitments to adopt measures to protect personal data have also been established in a limited but increasing number of e-commerce chapters negotiated by some high-income economies, such as Australia, Japan, Singapore and the United States (Monteiro and Teh, 2017). In parallel, a few recent RTAs, including the RTA between Australia and Hong Kong, China and the USCMA, incorporate specific provisions committing the parties to allow cross-border electronic transfer of information, including personal information, in the context of digital trade (see Box D.6).

Cross-border data flows and personal data protection are also explicitly addressed in the financial services chapter of several RTAs. In particular, the commitment not to adopt measures preventing the processing of

financial information, including electronic transfers of data, is complemented by 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.

Closely related to free flows of information across borders is the controversial issue of disciplining data localization requirements (Azmeah *et al.*, 2019). Only a couple of recent RTAs, including the RTA between Japan and Mongolia and the CPTPP, establish specific disciplines related to the use and location of computer servers and devices for the processing or storage of information for commercial purposes. These RTAs commit parties not to require that another party's service suppliers, investors and investments use or locate computer facilities in the [first] party's territory as a condition for the exercise of their business activity. However, some of these RTAs specify that 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.⁵⁹

Box D.6: Digital economy agreements

In addition to chapters on e-commerce negotiated in their respective RTAs, Australia, Chile, New Zealand and Singapore have negotiated standalone digital economy agreements. In June 2020, in an entirely online virtual signing ceremony, Chile, New Zealand and Singapore signed the Digital Economy Partnership Agreement (DEPA). Australia and Singapore also signed the Australia-Singapore Digital Economy Agreement (DEA) in August 2020.

This new type of trade agreement aims to create a framework for the digital economy and facilitate digital trade. These agreements specify that they co-exist with the parties' rights and obligations contained in other international agreements such as the WTO agreements and RTAs. While some of the provisions in these agreements build on existing provisions found in e-commerce chapters of RTAs, in particular the CPTPP, other provisions establish new obligations related to various digital issues.

These new agreements expand on existing obligations on the cross-border transfer of data, data localization and improved protection for source code. They also establish new commitments on compatible e-invoicing and e-payment frameworks, as well as new benchmarks for improving safety and consumer experiences online. Some obligations are specific to a single agreement. For instance, the Australia-Singapore DEA establishes obligations to facilitate submarine cable installation, maintenance and repair, and the prevention of cable disruptions.

These agreements put in place a comprehensive framework for bilateral cooperation covering different digital issues. For instance, these agreements foresee collaboration between financial technology (fintech) and regulatory technology (regtech) enterprises and industry bodies to explore business opportunities and to develop standards for open banking. Other cooperation topics include government procurement, competition policy, MSMEs, digital identity (e.g. national business numbers), digital inclusion and AI, including the promotion of ethical and governance frameworks.

(x) Standards

Standards and technical regulations can play an important role in fostering technological progress. Standard-related issues, and more generally technical barriers to trade (TBT) measures, are increasingly being addressed in RTAs.

While some provisions replicate those found in the TBT Agreement, an increasing number of RTAs establish TBT commitments that go beyond what is provided in the TBT Agreement (TBT-plus) (Espitia *et al.*, 2020). Provisions on equivalence and mutual recognition in RTAs typically cover technical regulations and conformity assessment procedures, while provisions on harmonization tend to apply more to voluntary standards.

In addition to general TBT provisions, some RTAs include TBT-related disciplines that apply to specific industries or products, such as telecommunications equipment and renewable energy generation. More recently, a couple of RTAs, including the USMCA, have established specific disciplines on technical regulations and conformity assessment procedures for ICT products using cryptography, and on the electromagnetic compatibility of IT equipment products. Under these agreements, the parties commit not to impose or maintain technical regulation or conformity assessment procedures that would require manufacturers or suppliers of ICT products using cryptography to transfer or provide access to their proprietary information for cryptographic technology or to use or integrate a particular cryptographic algorithm or cipher, as a condition of the manufacture, sale, distribution, import or use of those ICT products for non-governmental uses.⁶⁰

(xi) Cooperation activities

Beyond the rules and obligations established under RTAs, many agreements establish cooperation provisions to support the implementation of certain commitments. A limited but increasing number of RTAs include explicit cooperation provisions on industrial and innovation policy, whose scope and purpose are often specific to a single agreement.

The RTA between the European Union and Armenia includes a cooperation chapter dedicated to industrial and enterprise policy, in which the parties commit to enhance cooperation based on the SME and industrial policies of the European Union. In particular, the cooperation aims, among other things, to facilitate the modernization and restructuring of industry in certain sectors; to encourage the development of innovation policy, via the exchange of information and

good practices regarding the commercialization of R&D (including support instruments for technology-based business start-ups), cluster development and access to finance; and to promote a more business-friendly environment with a view to enhancing growth potential and investment opportunities.

More explicit provisions on innovation, including R&D and transfer of technologies, are incorporated in the cooperation chapter. For instance, the RTA between the Eurasian Economic Union (EAEU) and Singapore foresees the possibility of holding informational seminars, training courses or sessions, roundtables and other events dedicated to improving cooperation between the parties in the fields of transfer of technologies encompassing digital innovation, entrepreneurship and application of cutting-edge technologies. Similarly, the RTA between the European Union and Central America includes a detailed article on scientific and technological cooperation covering a broad range of issues, such as the development of centres of excellence and high-tech clusters.

Although they do not refer explicitly to industrial development and innovation, many other cooperation provisions found in RTAs can be particularly relevant to industrial and innovation policy.⁶¹ These cooperation provisions cover a wide range of issues, including education and training, environmental protection, digital trade and MSMEs.

(c) Other forms of international cooperation

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. There is scope for international cooperation in addressing the specific issues arising from digitalization that have cross-border ramifications. In particular, international organizations have an important role in international cooperation, to enhance positive cross-border spill-overs such as technology diffusion or to mitigate potential negative spill-overs.

Most international organizations are involved in some capacity in international cooperation on innovation and industrial policies in the digital economy. Initiatives of international organizations can be categorized by more specific policy objectives, such as harmonizing and mutually recognizing standards and regulatory frameworks, addressing IP-related issues, tackling challenges in ICT infrastructure, tax and competition issues, and supporting digital inclusion and MSME participation. This subsection discusses relevant work

and initiatives in international fora other than the WTO to foster international cooperation in the digital field.

Many of these efforts conducted by international organizations support and provide direction for countries' policies to achieve the United Nations Sustainable Development Goals (SDGs), in particular Goal 9 to build resilient infrastructure, promote sustainable industrialization and foster innovation, and Goal 17 on revitalizing the global partnership for sustainable development.

(i) Harmonizing and mutually recognizing standards and regulatory framework

Technical standards are an established norm and requirement in virtually every product. These standards safeguard the interests of consumers and are crucial in the adoption of new technologies. Technical standards for the safety and interoperability of new and existing digital products and services are important to bridge the gap between research and markets, and to ensure the speedy diffusion of new technologies. To date, governments, industry and user groups have engaged in both intergovernmental and multi-stakeholder fora to develop international norms, guidelines, principles and standards, primarily to build trust and enable openness (World Economic Forum, 2020).

International organizations like the International Organization for Standardization (ISO) and International Electrotechnical Commission (IEC) play an important role in the introduction and implementation of standards. The standards set by the IEC are especially important for innovation in ICT and digital sectors as the focus of the IEC is the standardization of electro-technologies. The IEC has specific committees on various digital technologies, such as IoT and related technologies, AI, cloud computing and distributed platforms, data management and interchange, the interconnection of IT equipment and software and systems engineering. The ISO has a technical committee on innovation management,⁶² which works on the standardization of terminology, tools and methods with a specific focus on innovation. This committee has so far published four standards under its direct responsibility and is currently working on four more.

The United Nations Economic Commission for Europe (UNECE) publishes standards related to public-private partnerships in various sectors.

The transboundary nature of the digital economy and the fragmentation of domestic regulatory frameworks may undermine the potential benefits of digital innovations. The lack of a robust legal and regulatory

framework for the governance of digital trade can hinder technological advances and pose serious challenges for consumers and businesses alike. Thus, international organizations can play an important role of establishing international regulatory frameworks, facilitating coherence between domestic frameworks, increasing dialogue or providing guidance and recommendations. The dynamic characteristics and the strong cross-border effects of digital economy regulations will require periodic adaptations and constant monitoring.

The United Nations Conference on Trade and Development (UNCTAD)'s eCommerce 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, IP and electronic signatures.

The Budapest Convention on Cybercrime under the Council of Europe has 67 signatories, including non-members of the Council of Europe from outside the European Union. Signatories have agreed to designate certain acts as criminal within their legal systems, and some participating signatories also provide each other with legal assistance for offences jointly defined as criminal. Regulatory cooperation is also under development within the Association of Southeast Asian Nations (ASEAN), where legal alignment on data governance definitions and privacy is being developed concurrently with internal data flow mechanisms.

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. In 2019, the ITU hosted the Global Symposium for Regulators that focused on inclusive digital connectivity and established the Best Practice Guidelines to encourage digital connectivity for inclusive participation in the digital economy to benefit from digital transformation (ITU, 2019).

(ii) IP-related issues

The protection of IPRs is crucial to incentivize innovation and the dissemination of technologies. The effect is particularly pronounced in digital markets, where the global and borderless nature of the internet has challenged the concept of trademark and copyright use. 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 licences and protected subject matter, the disruptive impact of digital technology did raise challenges for the existing rules: for instance, the trademark significance of a domain name, and the ease of copyright piracy on the internet (Meier-Ewert and Gutiérrez, 2020). Discussions in multilateral fora have sought to accelerate the development of international harmonized principles in this regard (Croze, 2000).

As discussed in Section D.2(a), WIPO administers the WIPO Copyright Treaty and the WIPO Performances and Phonogram Treaty (known together as the "Internet Treaties"), which set down international norms aimed at preventing unauthorized access to and use of creative works on the internet or on other digital networks. The WIPO General Assembly also adopted the "Joint Recommendation Concerning Provisions on the Protection of Marks, and Other Industrial Property Rights in Signs, on the Internet" in 2001. It was the first implementation of WIPO's policy to adapt to the pace of change in the field of industrial property by considering new options for accelerating the development of international harmonized common principles.

One example of international cooperation is in the registration of domain names. Domain names are not considered to be distinctive marks but are internet addresses that define a realm of administrative autonomy or control within the internet. The global nature of the domain registration system means that cross-border disputes may arise over the ownership of common domain names. The WIPO Domain Name Process and Article 6 of the WIPO "Joint Recommendation" addressed the issue by providing a standard legal framework for the redressal of grievances related to "cybersquatting", or the practice of registering domain names based on others' trademarks, with a view to leveraging financial gain (Croze, 2000; WIPO, 2020).

One of WIPO's responsibilities is to facilitate and support the transfer of technology and knowledge. In 2007, WIPO members agreed to adopt a multilateral agreement with 45 proposals under the WIPO Development Agenda. The objective of this instrument is to facilitate the transfer of technology to developing countries while maintaining incentives for innovative firms in developed countries. The proposals include a recommendation for conducting analytical studies and evaluations related to the impact and efficiency of IPR systems in countries, enabling better policymaking. The WIPO Development Agenda also aims to bridge the digital divide, promote best practices and works in

accordance with the outcomes of the World Summit on the Information Society (WSIS). A committee was also established to monitor the implementation of these proposals, and has since overseen various projects related to the development of IP infrastructure, training of personnel and sharing of knowledge.

(iii) Addressing challenges in ICT infrastructure

As a secure and reliable ICT infrastructure is crucial for capturing the benefits of digital innovation and can be a catalyst for economic growth, it has become central in domestic policy agendas (OECD, 2018). Yet a digital divide between countries can be a major obstacle to inclusive growth. Several international organizations are actively involved in initiatives that aim to support governments in developing ICT infrastructure and using digital technologies, through supportive measures such as financing, policy guidance and technical capacity assistance.

A recent report by the ITU and the United Nations Educational, Scientific and Cultural Organization (UNESCO) estimates the cost of bridging the connectivity gap in Africa by 2030 at around US\$ 100 billion, or close to US\$ 9 billion a year (Broadband Commission, 2019). The World Bank Group's regional initiative, the Digital Economy for Africa Initiative,⁶³ aims to ensure that every African individual, business and government will be digitally enabled in Africa by 2030. One of the foundational pillars in the framework set to accomplish this objective is digital infrastructure, with the increase in broadband and cashless payments as a priority. To attain this objective, the World Bank intends to invest US\$ 25 billion between now and 2030 to assist in enabling policy frameworks in digital economy policy measures (e.g. in development policy operations) and in financing measures (e.g. investment in broadband infrastructure).

Another example of international support for ICT infrastructure is the ITU's Telecommunication Development Sector programme. The ITU, through the ICT Development Fund, co-finances projects with partners from member governments and from the public and private sectors to enhance countries' capacity, cybersecurity, digital inclusion and digital innovation systems. In partnership with the United Nations Children's Fund (UNICEF), in 2019 the ITU launched a global school connectivity initiative to connect every school in the world to the internet and empower young people with digital skills.

A number of regional organizations, as well as various regional development banks, also have programmes

in place to facilitate the development of ICT infrastructure. The African Development Bank plays a key role in coordinating a Connect Africa Initiative to mobilize the human, financial and technical resources needed to bridge major gaps in ICT infrastructure across Africa. It has funded a number of connectivity projects including an eastern African submarine cable system deployed along the east and south coasts of Africa, and a central African “backbone” project to provide several central African countries with digital broadband access through terrestrial fibre connections. In the Asia Pacific region, the Asia-Pacific Economic Cooperation (APEC) Internet and Digital Economy Roadmap identifies the development of digital infrastructure, the promotion of interoperability and the achievement of universal broadband access as key focus areas (APEC, 2017).

(iv) Tax and competition issues

As also discussed in Sections B and D.3, technology can enable taxpayers to use sophisticated methods to avoid tax, and can also impact taxpayers' business models more generally, thereby raising systematic policy challenges for the international tax framework. Multinational firms have an incentive to shift their profits to jurisdictions with lower tax rates, and such jurisdictions have an incentive to keep their tax rates low to attract foreign investment, thus eroding the tax base of the higher-tax jurisdictions.

To combat this, countries have agreed to review key concepts of the international income tax system, responding to a mandate from the G20 Finance Ministers to work on the implications of digitalization for taxation. Under the Organisation for Economic Co-operation and Development (OECD)/G20 Inclusive Framework on tax base erosion and profit-shifting (BEPS), over 135 countries are collaborating to put an end to tax avoidance strategies that exploit gaps and mismatches in tax rules to avoid paying tax. In November 2016, over 100 jurisdictions concluded negotiations on the “Multilateral Convention to Implement Tax Treaty Related Measures to Prevent Base Erosion and Profit Shifting”,⁶⁴ which offers concrete solutions for governments to close loopholes in international tax treaties. This framework facilitates international collaboration to end tax avoidance and aims to mitigate the negative spill-overs that may arise by equipping policymakers with tools to combat tax avoidance and by creating a harmonized international taxation framework that ensures profits are taxed where economic activity and value creation occurred.

As discussed in Section 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 impacts on national markets. Hollman and Kovacic (2011) argue that negative international spill-overs may arise if an economically significant jurisdiction persists in using manifestly inferior analytical approaches, procedures or techniques for the administration of a competition agency. 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 active in the field of competition policy (Anderson *et al.*, 2018b). The ICN has been working to increase understanding of individual competition systems, identify and build consensus about best practices, and encourage individual jurisdictions to opt in to these practices. 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).

(v) Supporting digital innovation inclusion and MSME participation

Although digital innovation can create many opportunities for businesses, MSMEs are on average less innovative than their larger counterparts, mainly due to a lack of resources, finance, skilled labour, legal and regulatory counsel, etc. (OECD, 2018a). To harness the full potential of digital innovation, tailored innovation initiatives directed at MSMEs can assist not only in increasing innovation among these businesses, but also in helping to close productivity and wage gaps between MSMEs and larger firms. Initiatives can further focus on bridging the digital divide within countries, targeting marginalized groups and enabling such groups to use digitalization and innovative technologies as a catalyst for inclusion instead of experiencing them as a barrier, which furthers the divide.

Various international organizations are active in this area. The International Trade Centre (ITC) has actively focused on supporting the participation of MSMEs in digital trade. ITC's ecomConnect initiative,⁶⁵ for example, supports MSMEs in developing countries and LDCs through their digitalization transformation. It utilizes training programmes, research and the facilitation of innovative solutions, collaborative structures, partnerships and digital tools and technologies to support trade internationally via online channels. A recent ITC report presents recommendations to boost the participation of women in trade through FTAs, as a tool-kit for policymakers and trade negotiators to gauge how gender-

responsive their agreements and trade policies are (ITC, 2020).

The United Nations Industrial Development Organization (UNIDO) has a science, technology and innovation group that seeks to enhance MSMEs' productivity and international competitiveness by providing technical assistance while simultaneously acting as a global forum. UNIDO uses its Business Information Centres programme⁶⁶ as an access point for MSMEs, usually in conjunction with private and public institutions, to provide advisory services, access to information and reliable internet, ICT training and assistance in establishing connections to local, regional and international markets. In addition, UNIDO's e-learning platform offers high-quality courses in areas such as e-commerce and value chain development.

The World Bank has undertaken an "eTrade for Development" programme⁶⁷ to assist developing countries in expanding their 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 procedures and logistics conditions to reduce costs related to the movement of goods through e-commerce. The World Bank further provides finance as well as advisory services for MSMEs, and especially for underserved groups such as MSMEs owned by women. The programme has specifically introduced digital innovation finance to its MSME projects through e-lending platforms, the use of alternative data for credit decisions, e-invoicing and supply chain financing.

Other global and regional organizations also focus on digital inclusion and supporting MSMEs. For example, the G20 Financial Inclusion Action Plan encourages dialogue in financial inclusion through policy advocacy, knowledge-sharing, and international cooperation. Within the action plan, a main pillar is MSME finance with an overarching theme of digital innovation. APEC sponsors a "Startups Incubator Capacity Building Symposium towards Digital Society", focusing on how incubators can help MSMEs in digital transformation and how to improve capacity-building for female entrepreneurs and female executives in high-tech companies (see Box D.7).

Box D.7: University cooperation

International and regional organizations are not the only players key to international cooperation for digital innovation. Universities and academic institutions also have an important and unique role in knowledge curation and transfer, both necessary components for innovation. While the benefits of knowledge transfer and the associated spill-overs are most often seen regionally, for example in agglomerations such as Silicon Valley, such positive gains can be accrued on an international level as well.

Digital tools and increased access to international research are key not only for innovation curation but have increased international collaborative research. Globalization has led countries and the private sector to prioritize global issues (e.g. climate change, food security, matters of public health), and this has increased the need for international collaborative research for solutions to these issues.

Universities can act as a link between the international research frontier and regional stakeholders. In addition, international collaborative solutions and research initiatives can be an effective tool in addressing issues of inequality between developed and developing countries, such as the digital divide, where cooperation in scientific research and policies can be linked to developmental goals.

While initiatives to encourage international cooperation in academia are mostly carried out by national governments and academic institutions themselves, international organizations can facilitate cooperation and knowledge transfer with tools such as forums. For example, the OECD holds the Global Science Forum to provide policy consultations and recommendations for senior policy officials in the area of scientific research. The Global Science Forum addresses the scientific dimensions of social issues and explores opportunities for international cooperation in research. Regional policy initiatives are effective as well. For example, the European Commission implemented the Horizon 2020 research and innovation programme. The programme serves primarily a funding tool, which centralizes EU research initiatives, facilitating higher international cooperation within the European Union and globally.

3. Do we need more cooperation on innovation policies in the digital age?

The digital age leads to changes in technology and the organization of production, provoking changes in the structure of the economy, which, in turn generate changes in national policies. This may require a change in international disciplines. This subsection addresses the question of whether innovation policies generate new international spill-overs in the digital age and whether there is scope for more international cooperation to either encourage or mitigate these new spill-overs.

Section D.3(a) describes the changes in technology, the structure of the economy, and the national policies which may call for changes to international cooperation, as well as the arguments for and against more policy space for developing countries. This discussion serves as a theoretical framework for the discussion of international cooperation in different specific areas in Section D.3(b), such as support measures, IP protection, competition policy and data policies.

(a) Technological, economic and regulatory changes in the digital age

(i) *Technological changes*

As discussed in Sections B and C, several changes to the organization of production associated with the emergence of digital technologies are relevant for the international coordination of innovation policies. These changes are: the growth in importance of data as a key input in the digital economy; the prominent role of general-purpose technologies in the digital age; the increasing impact of network externalities (i.e. when the use of a network by others makes it more attractive to use the same network for an individual user); and the rise of scale economies.

First, data have become a key input in production in virtually all sectors of the economy. New possibilities for handling data have also made them core inputs for innovation in many sectors (Guellec and Paunov, 2018). An important feature of data is that they are non-rival, i.e. the use of data by one consumer will not be at the expense of consumption by others. Some scholars argue that, in practice, data are only partially excludable because private agent collectors of data have insufficient incentives to store data in an excludable way (Carrière-Swallow and Haksar, 2019). The non-rivalry and partial excludability of data make it resemble a public good. However, data are not a

pure public good, as a pure public good typically benefits all members of a society and individuals cannot be excluded from using it.

Second, digital technologies tend to be general-purpose technologies (Jovanovic and Rousseau, 2005). This means that they can be applied in a wide range of sectors. Examples are AI, Blockchain, and IoT, which are widely employed in many sectors. These digital technologies tend to employ large amounts of data as input and the applications of these technologies have drastically reduced the costs of searching, sharing and analysing data (Guellec and Paunov, 2018). Once available, digitalized data can be shared instantaneously among any number of actors, no matter what the geographic distance.

Third, the digital economy, like other more traditional networked industries such as energy, telecommunications and railroads, is characterized by network externalities. Network externalities can be both direct and indirect (Tirole, 2019). Direct network externalities emerge from the desire for users to be on the same network as the people they know (as with a social network). The digital economy also comes with indirect network externalities, because bigger platforms can develop better applications and better search algorithms, given that there are more users.

Fourth, as in some of the traditional networked industries, scale economies are large in the digital economy, because most digital services are characterized by high fixed costs and low marginal costs. This is the case for example for a search engine or for the development of a new application, where the initial cost of development can be high while the marginal cost of additional production is close to zero. It is also the case, for example, for the AI-based software used in self-driving cars. Once developed, the additional cost of deployment is rather small.

(ii) *Economic effects*

The changes in the technology and organization of production described in the previous subsection have the economic effects outlined below.

Regarding the role of data as an increasingly key input in production and innovation, it is difficult to organize a market for data with transparent transaction prices and clear ownership rights (Ciuriak, 2019b). Currently, consumers of digital services are typically involved in a direct exchange without monetary transactions. Consumers tend to hand over information to digital platforms and providers of digital services in exchange for digital services. Some examples are the streaming of music,

the use of search engines and social networks, or rebates in exchange for data. In these digital settings, two-sided markets emerge, with digital platforms delivering apparently free services to customers and raising revenues from advertisers and market parties interested in communicating with customers and in their data.

Another economic effect of the role of data as key input is related to its fluid nature. Fluidity renders data ubiquitous and allows it to transcend distance and national boundaries. Hence, digital innovation is global in reach and potential impact. There are important consumer/producer gains from serving global markets, with scale economies and network benefits from digital innovations that naturally extend beyond national boundaries, including the lower unit cost of serving a larger, international market.

The fact that more technologies are general-purpose implies that positive spill-over effects of innovation activity become bigger, both between sectors within a country and internationally between countries and sectors.⁶⁸

Network externalities and scale economies lead to winner-takes-all market outcomes and thus a greater concentration of market power (see also Section C.4). Hence, the digital economy leads to natural monopolies, as has been the case in the conventional economy for services and goods supplied through networks such as fixed line telephone providers and the supply of electricity. While these conventional networks are bound by physical capabilities, and their effectiveness often diminishes with distance, many digital economy networks have an international, either global or regional, reach. Network externalities cross borders: there is a strong advantage from joining a network because consumers in other countries are already employing the same network. This is the case for the services of companies such as the GAFAMs (i.e. web giants such as Google, Apple, Facebook, Amazon and Microsoft).

(iii) National policy implications

As explained in the previous paragraph, the non-rival nature of data leads to imperfect market outcomes. Jones and Tonetti (2019) argue that the way ownership of data is defined is important for economic growth, because of the non-rival nature of data. They claim that forbidding the use of data to guarantee privacy would lower economic growth, because the positive benefits of data would not be exploited. Jones and Tonetti (2019) argue that from a welfare perspective it would be best to give ownership rights of data to the consumers generating the data, so that consumers

can trade the privacy concerns of the wider use of their data off against the productive use of non-rival data.

The previous subsection also described how network externalities lead to market concentration and two-sided market settings. Although there is a lot of static market concentration, the digital economy is displaying a substantial amount of dynamic competition, because market leaders change frequently. Examples are Google replacing AltaVista and Facebook replacing MySpace. However, the phenomenon of buy-out of newcomers by incumbent firms is stifling this type of dynamic competition, with digital markets still characterized by a large degree of market concentration (Motta and Peitz, 2020).⁶⁹ Competition authorities around the world are attempting to adjust their policies to the new market settings in the digital economy.

The fact that digital technologies are general-purpose and generate cross-sectoral spill-over effects gives national governments strong incentives to promote these technologies in order to promote their positive spill-over effects. Innovation has become a more central policy objective. Governments in developing and developed countries increasingly see it as key to stimulating productivity, competitiveness, employment and growth.

As also described in Section C.4, a larger concentration of market power and winner-takes-all outcomes may lead to an increased desire by large countries to conduct strategic innovation policy, fostering the appropriation of monopoly profits in the global economy, i.e. profits of firms with a dominant market position in global markets.⁷⁰

The fact that digital technologies are general-purpose implies that these technologies could increasingly be classified as dual-use (i.e. both for civil and defence purposes). Dual-use technologies are subject to additional export controls for reasons of national security.⁷¹ For example, the technology for telecommunication networks such as 5G is employed across the entire economy and thus also by segments of the economy which are argued to be important for national security. Furthermore, since technologies are digital, they are potentially able to absorb sensitive information. Classifying more technologies as dual-use may lead to additional restrictions to the free flow of trade, technology and capital.

(iv) Implications for international cooperation in the digital age

The described changes to the organization of production and their economic and national policy effects have important implications for international

disciplines in the digital age. The rising importance of data as input in production and its fluidity has led to increasing demands for new international rules on data transfer, data localization and privacy. The increasingly blurred boundaries between goods and services imply that demands could emerge for a re-examination of the disciplines in areas where the provisions that apply to goods trade differ most significantly from those that apply to services such as on subsidies and the movement of natural persons.⁷²

As discussed in the previous subsections and in Section C.4, cross-border spill-overs resulting from innovation are likely to intensify in the digital age for several reasons.

First, more innovation is taking place in digital industries with more important knowledge spill-overs, strengthening the case for governments to support innovation and for international cooperation to expand positive international spill-overs and encourage national governments to support innovation.

Second, the positive network effects of innovation policies in digital equipment industries for downstream digitally enabled industries across the world increase as digital equipment industries become more and more pivotal by producing general-purpose technologies, and the uptake of digital technologies across industries increases. This also strengthens the case for governments to support innovation and for international cooperation to encourage national governments to support innovation and to facilitate positive international spill-overs. At the same time, however, the “winner-takes-all” characteristics of many digital industries lead to heavily concentrated markets and large monopoly profits which lend themselves to the applications of strategic innovation policy. This, in turn, calls for cooperation measures aimed at limiting the negative cross-border effects from such policies.

There is a risk that the general-purpose nature of many digital technologies may encourage governments to classify an increasing share of technology as dual-use. Some scholars argue that this could lead to a decoupling of technologies in different countries. According to Petri (2019), under decoupling, the risk of negative spill-overs through appropriation of global monopoly profits might be smaller, because markets would not be global anymore. However, decoupling would also limit positive international spill-over effects from innovation and thus be a drag to global economic growth. In this context, Ciuriak (2019a) argues that a digital Article XXI is necessary to deal with the security risks of the digital economy. The growth of IoT and its linkages with many crucial sectors such

as telecommunications, transportation and the power grid could lead to national security vulnerabilities. According to Ciuriak (2019a), the existing Article XXI of the GATT, which refers to an “emergency”, is not appropriate for such national security vulnerabilities.

A complete assessment of innovation policies and their consequences for international cooperation would need to take both positive and negative effects into account in order to reach a balanced and efficient outcome. For a number of reasons, it is difficult to assess whether cross-border effects from innovation policies imply net benefits or net losses for third countries (see Section C), implying that it is not easy to determine the best policy to cooperate internationally.

First, the effects are highly context-specific. Different effects pull in different directions, and different country characteristics, such as market share in targeted products or the country’s position in global value chains, have a large impact. Moreover, governments enact policies that aim to promote or limit both positive and negative cross-border effects. For instance, local content requirements prevent positive demand effects from benefitting foreign upstream industries. IP protection chapters in international trade agreements can limit knowledge spill-overs, as can merger and acquisition screenings based on nationality, or eligibility criteria based on nationality, for subsidies or government procurement.

Second, policies as different as R&D subsidies and antitrust laws can create a whole range of cross-border effects, from knowledge spill-overs to supply or demand effects, and it depends on the details of these measures which effects dominate (see the examples in Section C). Moreover, the net negative international spill-overs of a policy intervention could be more than offset by its positive domestic welfare effects.

A crucial trade-off is the one between positive spill-over effects on technological progress in other countries, on the one hand, and the negative spill-over effects because of appropriation of monopoly profits, on the other hand. Borota, Defever and Impullitti (2019) compare the strategic profit-shifting effect of policies to promote domestic innovation with their positive spill-over effects on other countries. They find that the positive external effects of innovation subsidies, through higher growth and higher consumer surplus, dominate the international business-stealing effect (profits shifting to the country providing the subsidies).⁷³ These results support earlier results by Haaland and Kind (2008), who also show that cooperative levels of subsidies are larger than non-cooperative levels.

Borota, Defever and Impullitti (2019) also show that the gains from cooperation are larger if there is FDI between cooperating countries. The reason is that, with FDI, international innovation spill-overs would be larger through foreign affiliates. In a similar way, the trade-off between the negative spill-over effects through the appropriation of monopoly profits and the positive spill-over effects through the impact on innovation in other countries would change significantly if countries cooperated on tax policy. In such a case, the strategic advantage of appropriating monopoly profits in the digital economy would become smaller. This would make the innovation spill-overs relatively more important, implying that a higher level of innovation promotion would be optimal.

The results in Borota, Defever and Impullitti (2019) are highly relevant for one of the most important questions at hand: do innovation subsidies generate net positive or net negative spill-overs, if the positive effects on innovation are compared to the negative profit-shifting effects? Borota, Defever and Impullitti (2019) seem to suggest that domestic innovation subsidies are, on the whole, positive. However, this does not imply that we can conclude that all policies fostering domestic innovation are beneficial for other countries. Although the results are derived in a quality ladder model in which the firm producing the highest quality good captures the entire market, thus featuring “winner-takes-all” outcomes, technological leaders change frequently in such a model, thus limiting monopoly profits. The question is whether this is also the case in the current digital markets, with the network externalities and acquisitions of technological leaders limiting competition.⁷⁴

Many digital innovation policies, such as improving (digital) infrastructure, stimulating R&D activities in general purpose technologies, or digital skills development, tend to be horizontal and thus not targeted at specific industries. These policies are typically less distortive than policies that are targeted at specific industries, even if they can generate positive and/or negative international spill-overs. Also, a distinction can be made between policies with only minimal, indirect spill-over effects, such as education policy, and policies with larger, more direct spill-over effects, such as trade restrictions. Finally, policies differ in terms of the size of spill-over effects in proportion to domestic policy objectives.

Rodrik (2020) criticizes the dominant approach, arguing that the case for international cooperation based on the existence of cross-border spill-overs is weaker than what most economists claim. In his view, global cooperation is justified in only two instances: with global public goods featuring

a commons problem (excessive use of public or common resources), and in the presence of “beggar-thy-neighbour” policies featuring negative cross-border spill-overs. An example of the former is climate change mitigation policies, with the costs borne by individual countries and the benefits enjoyed by all countries. An example of the latter is import tariffs imposed by large countries to obtain terms of trade gains with the risk that countries end up in a sub-optimal equilibrium with high tariffs imposed by all countries.

Rodrik (2020) claims that many internationally regulated policies are more “beggar-thyself” than “beggar-thy-neighbour”. An example is subsidies. The international spill-over effects of subsidies are positive, because subsidies drive down global prices. At the same time, they are costly for countries providing them, because the costs of the subsidies are larger than the gains for the producers receiving them. Hence subsidies are more “beggar-thyself” than “beggar-thy-neighbour”, according to Rodrik. He argues that, for such policies, restrictive international disciplines are not desirable, because local knowledge is often essential to take the best policy decisions, national policy makers should have the autonomy to take their own decisions, and capture by special interests is at least as likely at the supra-national level as at the national level.

For the reasons mentioned, being reserved about international cooperation on policies with weak global public good or beggar-thy-neighbour features seems a solid approach. As mentioned in the overall introduction to this section, the autonomy of countries to pursue domestic policy objectives should be traded off against the negative spill-over effects of such policies, and the presence or absence of negative spill-over (or “beggar-thy-neighbour”) effects is a matter of degree and thus open to discussion. The example of subsidies is illustrative in this respect. As discussed earlier in this subsection, R&D subsidies generate positive spill-over effects on other countries, but they can also generate negative spill-over effects through the appropriation of monopoly profits in winner-takes-all markets. Rodrik (2020) lists other examples of policies mainly implemented for domestic reasons and not to beggar the neighbour, such as weak IP protection, industrial policies and data localization policies. For each of these policies, the size of spill-overs is subject to discussion.

(v) *The policy space argument*

Since the beginning of the 21st century, the political and scholarly debate regarding the impact of advancements in international trade disciplines on

"policy space" has intensified. Policy space is defined as the margin of manoeuvre available to governments to adopt the most appropriate mix of economic policies to achieve their development goals and thus deal with international disciplines (Hoekman, 2005; Mayer, 2009). It has been argued, in particular, that provisions in regional agreements and multilateral disciplines prevent developing-country governments from using government policy instruments which would otherwise help them achieve their development objectives (Akyüz, 2008; DiCaprio and Gallagher, 2006; Page, 2007). For example, Singh and Jose (2016) point out that currently developed countries were not constrained in their use of government policy to promote economic development, but that such policies are now curbed by legal agreements, such as those governed by the WTO.

When considering economic contributions to the policy space discussion, it is important to keep in mind the context.

First, as explained in Section B, all WTO members pursue some form of government policy, focused increasingly on innovation. This signals a broad consensus among WTO members regarding the fact that such policies are useful and that governments should be allowed to use them, even if they need to be disciplined by WTO rules. The question of how much policy space developing countries should have is thus not about whether governments should be allowed to use innovation or even industrial policies or not.

Second, Section D.2 explained how existing WTO disciplines represent a negotiated compromise aimed at allowing member governments to pursue legitimate development policy objectives while at the same time limiting the negative spill-overs of members' policies on their trading partners. Existing WTO rules prohibit the use of certain instruments, discipline the use of others, and impose no restriction on the use of yet other instruments. Moreover, they provide special flexibilities for developing countries. The policy space debate focuses on whether some of these rules – in particular those on local content requirements and on subsidies – are too restrictive and prevent developing countries from using policy tools that would help them achieve their development objectives.

From an economic perspective, the policy space debate raises two main questions in relation to innovation policies. The first question concerns the relative effectiveness of different innovation policy tools, that is, the question of the optimal design of innovation policies. If there is a strong case for developing countries to use some of the policy tools that are subject to more stringent disciplines, then

there may be a case for additional flexibilities. The second question concerns the nature and size of the international spill-overs associated with the different policy tools.

With regard to the first question, Section C showed that while some innovation policies tend to raise domestic and overall welfare in particular when they address market failures, there are cases where innovation policies have negative international spill-overs that may more than offset the positive domestic welfare effects. Similarly, Section C showed that there is no consensus regarding the optimal design of innovation policies. Part of the reason for this lack of consensus is that these questions are empirical, and the empirical evidence on the effects of innovation policies is thin.

With regard to the second question, Section C also showed that, while a number of innovation policy instruments can have negative international spill-overs, empirical evidence on the size of these spill-overs is scarce. However, the rapid economic growth of some emerging countries with active industrial policies could raise the negative spill-over effects. Because of their bigger role in the global economy, the impact on other countries of policies with negative spill-over effects has become larger. This is the case, for example, for subsidies, weak protection of IPRs, or weak enforcement of competition law.

A few economic arguments have been invoked specifically in favour of more policy space for developing countries to conduct innovation policies, to ensure that they have fewer commitments in the multilateral trading system. First, policies to promote technological development are likely to be different for countries close to and far from the technology frontier, the most advanced level of technology in the world (Aghion *et al.*, 2005; Landesmann and Stollinger, 2019). Countries close to the technological frontier may tend to focus on promoting R&D activities and on the efficient interaction between public and private research efforts. Countries further away from the technological frontier, by contrast, may attempt to benefit from the "advantage of backwardness" (Gerschenkron, 1962) through the absorption of technology from countries at the technology frontier, for example through trade, foreign direct investment and direct technology transfers. This requires different types of policies, for example in the area of IPRs.

Second, it can be argued that market failures are bigger for countries with lower levels of development and thus require more corrective policies. Aghion, Boulanger and Cohen (2011) argue that capital market imperfections limiting the growth of sectors with high growth potential and knowledge spill-

overs on the rest of the economy are more severe for developing countries. Empirically they show that the positive impact of sectoral state aid on both the share of exports and the number of patents is larger for countries that are less financially developed. Hence, in less financially developed countries there is a stronger argument to support sectors with high growth potential and knowledge spill-overs.

Third, agglomeration forces become stronger in the digital services-based economy (Eckert, 2019). High-skilled workers and companies in digital industries tend to flock together in large cities with many other workers and companies with the same specialization. This has been documented within economies. However, similar agglomeration forces are active at the international level, thus potentially leading to economic divergence between the core of the global economy and the periphery. Therefore, countries in the periphery need policy space to avoid being stuck in the periphery of the digital economy.

Fourth, low-income countries tend to be specialized in products with low value-added, low technology growth, and few technological spill-overs into other sectors. Many low-income countries also have low levels of export diversification, which is harmful for economic development. Innovation policy could be useful to build up capabilities in more sophisticated products. This means that low-income countries could benefit from larger-scale government intervention to change patterns of comparative advantage. Rich countries tend instead to be already specialized in sophisticated goods and thus need less policy space to conduct innovation policy. Policies to change the pattern of comparative advantage might be at odds with the obligations of countries in the multilateral trading system, for example on IPRs, local content requirements and subsidies. This fourth argument is related to the first argument, because countries trying to get closer to the technological frontier will attempt to do so by changing their pattern of comparative advantage.

The main economic argument against more policy space aligns with the main arguments against the use of industrial policy in general: if government failure is omnipresent, industrial policy will be counterproductive. In such cases, governments will be captured by special interest groups leading to support of vested interests and subsidies to inefficient firms stifling dynamics in the economy. It would then be better to tie the hands of national policymakers limiting the use of different types of (industrial) policies. Exemptions from international commitments for developing countries would only backfire, as they constrain national policymakers less and thus give more space to national interests.

The literature on the reform lock-in effects of membership of international organizations provides arguments for why it can be beneficial for countries to have multilateral trade commitments (Drabek and Bacchetta, 2004; Francois, 1997; Lamy, 2012; Staiger and Tabellini, 1999).

The conclusion of the discussion on policy space is that there are economic arguments both in favour and against more policy space for developing countries to pursue innovation policies. The weight of these arguments depends on the context and the specific policies examined. To keep this section brief, this report does not go into the details of specific policies. However, although there is little empirical evidence on the extent of the spill-over effects of innovation policies, and thus of granting developing countries more policy space to conduct innovation policies, it can be observed that some developing countries have displayed spectacular growth rates, thus increasing their weight in the global economy.

There is also a risk that countries will introduce additional national policies to shelter themselves from the international spill-over effects of other governments' policies. This might lead to further protectionism, thus limiting the free flow of goods, services and capital. As a matter of fact, such measures have already been taken or are under discussion. Two examples can be given. First, in some countries there is a discussion about reforming competition and merger policies with the aim of maintaining competitiveness *vis-à-vis* countries with pro-active industrial policies (Jenny and Neven, 2019). Phrased differently, merger policy should be adapted to take into account the spill-over effects of industrial policies, such as subsidies by other countries. Second, many countries are starting to screen foreign investments more intensively (UNCTAD, 2019). This is happening partly as a response to the industrial policies of trading partners.

(b) Thinking ahead about cooperation on innovation policies

In light of the changes in innovation policies and their effects brought about by digitalization, and of the fact that existing multilateral and, to a large extent, regional rules were negotiated before the digital era, this subsection asks whether the current multilateral trading system adequately supports innovation and addresses discriminatory temptations.

(i) *Support measures*

In the digital economy, financial support for R&D represents the instrument of choice of innovation

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INDUSTRIAL POLICY, INNOVATION AND GLOBAL RULES

Industrial policy is back with a vengeance. The COVID-19 pandemic has highlighted for many countries the need to develop reliable domestic (or at least regional) supply chains for medical products. The employment shock that accompanied the lockdowns has also rendered the good-jobs challenge (i.e. employment challenge) that most countries faced even before the crisis even more acute. And the rise of China as a technological leader in many domains has pushed governments in the United States and Europe into more active industrial and innovation strategies in response. As this valuable report puts it, “a defining feature of new industrial policies is the focus on innovation, technological development and upgrading, and the role of investment in promoting it” (see Section B.2(c)).

The foundational agreements of the present world trade regime – and the World Trade Organization itself – are the product of an intellectual legacy that is increasingly inappropriate to the existing needs of the world economy. Under the narrative that prevailed throughout the 1990s and 2000s, governments’ roles in directing economic activity were limited, economic prosperity was best pursued through deep economic integration, with restrictions on what governments could do behind their borders, and most large economies in the world were converging toward similar market-economy principles. None of these hypotheses looks compelling in today’s world.

In a world where economic policies diverge, and health crises and technological transformations have severe implications for labour markets and hence for social peace, the global economy needs to be constructed on different principles. In particular, there must be healthy respect for national sovereignty, and the limited political capital for international cooperation

must be spent on areas where the returns from establishing global regimes are truly high. As I have argued elsewhere (Rodrik, 2020), these are the areas characterized either by global public goods (such as efforts to tackle climate change or pandemics) and by “beggar-thy-neighbour” policies (such as the exercise of monopoly power or tax havens).

As this report argues, the spread of digital technologies is creating all kinds of new ways for a nation’s policies to create spill-overs for other nations. Knowledge, after all, is the quintessential public good that knows no borders. It is not clear, however, whether this fact strengthens the case for more global rules. On the other side of the argument, we also have to contend with the facts that markets for technology are inherently imperfect, that these market imperfections call for more government intervention, and that the scope for disagreement among countries on which policy interventions are legitimate and desirable becomes considerably broader.

While international dialogue to sort out some of these disagreements and to ensure that governments understand the motivations and reasoning of others is always useful, there is no guarantee that such dialogue will always produce agreement on rules. And under these circumstances, we may need to resign ourselves to the reality rather than push for the impossible (or sign toothless agreements).

Existing WTO disciplines in the areas of subsidies, local content rules, TRIPS and government procurement all raise potential problems from this perspective.

Imagine that a government identifies a data-intensive activity as a source of important technological externalities for

the home economy, and encourages that activity through subsidies, local content requirements or government procurement, in a manner that falls afoul of international trade rules. Should a trade partner or international organization be allowed to second-guess whether (a) these policies have valid economic justification (i.e., whether there is a plausible positive externality), and (b) the government has selected the right policy intervention in light of the administrative and political realities on the ground? My answer would be no, insofar as such policies are not true “beggar-thy-neighbour” policies. If the government has made the right choices, the policy should be allowed to stand, even if there are negative spill-overs which may affect other nations. And if the government is making a mistake, it will be that government’s taxpayers and consumers who will bear the brunt of the costs.

Another example where there might be a stronger argument for global rules is the abuse of market power in international markets. Suppose a government restricts the export of an advanced technology in which it has near-monopoly power globally, and does so in order to raise prices on world markets (and not for national security reasons). This would be a clear instance of a beggar-thy-neighbour policy. International rules against such conduct – a version of global anti-trust – would be appropriate.

My point is that we cannot assume that more international spill-overs automatically implies the need for more international rules. The lesson from the post-1990s push for hyper-globalization is that international rules can overshoot. We should not repeat the mistake in an era where national sovereignty will exert stronger centrifugal pressures – for good as well as bad reasons.

policies (see Section B). Available evidence suggests that such financial support promotes innovation, which may be underprovided in the absence of government intervention. It also shows that cross-border effects from innovation are likely to intensify in the digital age (see Section C). At the same time, R&D subsidies are covered by the disciplines of the SCM Agreement (see Section D.1) and by provisions on subsidies in RTAs which tend to replicate what is found in the SCM Agreement. The issue of subsidies in the context of digital trade is not addressed explicitly in RTAs.

One area of possible reform in support of innovation with positive international spill-overs relates to expanding the flexibility for governments to use R&D subsidies to address agreed and targeted global public policy objectives (Curtis, 2016). As explained in Section D.2, the SCM Agreement included certain R&D subsidies in the non-actionable category, but the provisions regarding non-actionable subsidies, which only applied provisionally for five years, ending 31 December 1999, were not extended. In the current context, R&D subsidies, such as publicly funded research grants to scientific laboratories at universities, which have not been challenged in a significant way because they are considered pre-competitive or non-specific, could become an issue of contention as they become more common. As pointed out by Maskus and Saggi (2013), in the era of global investment networks, the number of grants which generate knowledge that, for a paid licence, ends up in the hands of private enterprises that develop products for trade, may increase. Before expanding the policy space to explicitly permit R&D subsidies that address global public policy objectives, a first step would be to clarify, upon further study, the relationship between public research grants and subsidies disciplines under the SCM Agreement.

Another, more general, argument in favour of re-examining the disciplines on subsidies in the data-driven economy is that data has very strong "public good" characteristics and thus generates risk-return metrics that favour public investment over private investment (Ciuriak, 2019b).

A concern with regard to support for innovation relates to the risk that governments may either attempt to restrict positive international spill-overs arising as a result of their support, or provide less support than would be globally optimal. The benefits from R&D subsidies, including the lower unit cost of serving a larger (international) market may extend beyond national boundaries.

As noted by Maskus and Saggi (2013), this is because knowledge is difficult to appropriate in one location

and international leakages of the benefits from R&D subsidies and investment may even be higher with global investment networks. Successful start-ups having benefited from government support may be acquired by foreign multinationals, raising questions about the location of the benefits arising from these start-ups. The embodiment of value in intangible assets (intellectual property), the intangible character of digital products transacted across borders, and the prevalence of electronic payments, all facilitate the circulation of revenue, which can end up in tax havens.

Where this is the case, national policymakers will need to figure out how to ensure that their own citizens (and taxpayers) acquire the benefits from national policies, and to fight the perception that most of the benefits (e.g. income-generated benefits, productivity gains or job creation) leak abroad (Guellec and Paunov, 2018). This raises the question of how governments will address the issue of territoriality. How the benefits are shared will have a strong influence on the efficiency of policies, but also on their legitimacy.

International cooperation may help to share the benefits arising from knowledge or from international flows of data (see the discussion below) linked to national policies between countries. In the absence of appropriate sharing mechanisms, national governments may not provide enough support to innovation if they fear that most of the benefits from the innovation they support will leak abroad. Maskus and Saggi (2013) propose an agreement on access to basic science and technology to foster the international dissemination of publicly funded research. Patents, being the result of such publicly funded research, would be put in common research pools.

(ii) *Intellectual property*

This report has analysed the contribution of the IP system, and the WTO TRIPS Agreement in particular, to the productive functioning of the innovation ecosystem. Given that the text of the TRIPS Agreement was largely settled almost three decades ago (WTO, 2015), prior to the first impact of internet uptake on global commerce, it is remarkable that the essential principles for governance of the knowledge economy set out in TRIPS remain broadly adaptable to the dramatically transformed innovation landscape witnessed today.

Nonetheless, given the far-reaching impact of digital disruption for the IP system, it would seem timely, at least in technical terms, for a fresh consideration of TRIPS in its contemporary context. Indeed, TRIPS negotiators have provided for regular, biennial

reviews of the overall agreement, which has offered opportunities to take account of new technological developments. Equally, the WTO Work Programme on E-commerce includes consideration of a range of IP matters with bearing on the TRIPS Agreement.

Some issues have been raised in the TRIPS Council: for instance, a 2016 submission to the TRIPS Council called on members to assert the principle that "exceptions and limitations available in physical formats should also be made available in the digital environment."⁷⁵ However, substantive work on these matters in the regular TRIPS Council has been limited, and the prospects are slim in the short term for a systematic review and update of the TRIPS Agreement as such. Yet, outside the WTO, norm-setting activity has proceeded apace in areas which have a direct bearing on TRIPS and which respond to technological innovation.

The year after TRIPS entered into force, the World Intellectual Property Organization (WIPO) concluded the WIPO Copyright Treaty and the WIPO Performances and Phonograms Treaty (the WIPO Internet Treaties),⁷⁶ which updated and applied standards for copyright and related rights to the digital environment, in a manner complementary to and coherent with the TRIPS Agreement's standards; the majority of WTO members have ratified and given effect to these multilateral treaties.⁷⁷

More recently, numerous RTAs have been concluded with provisions on IP that go well beyond the requirements of the TRIPS Agreement (see Section D.2), for instance with specific attention to the protection and enforcement of IP rights in the online environment (WTO, 2018a) and the regulation of digital products (which are often defined in terms of IP rights), as well as responding to other technological developments such as the emergence of biotech medicines and the increasing use of traditional knowledge in the innovation ecosystem. The approach such agreements take to questions such as internet service liability for IP infringement, and the exhaustion of IP rights that apply to traded digital products, may be critical in shaping the future market for creative content (Meier-Ewert and Gutierrez, 2020).

Hence, even in the absence of general momentum towards a substantive review of TRIPS, there is much to be gained from a systematic, inclusive understanding of the overall trends in norm-setting for the digital environment that has been undertaken through various bilateral and regional avenues, to lead to a clearer understanding of their accumulated impact for the regulation of digital trade (Burri, 2020).

More generally, effective policymaking for sustainable and inclusive innovation will require a solid foundation of understanding of the linkages between trade and innovation with sustainable development, and the roles of the IP system in reinforcing this linkage (Taubman, 2020). The linkages between trade policy, innovation policy and the IP system are complex, diverse across countries and sectors, and in constant evolution, and require extensive collaborative networks across national jurisdictions. At the international level, therefore, an important challenge is to understand and to recognize the complexity and diversity of approaches, while at the same time working internationally in a way that is "holistic, realistic, and inclusive in a global context" (Taubman, 2020).

Fortunately, it is now possible for this understanding to be founded on a growing body of empirical data and practical experience. For instance, as described above, the TRIPS Council now has on record a rich catalogue of innovation policies reported by a diverse range of members, illustrating how the IP system has been deployed in diverse contexts to promote innovation.⁷⁸ Developed-country members have filed almost 200 reports on technology transfer measures in connection with their obligations under TRIPS Article 66.2. While detailed systematic analysis of these two sources of practical experience has, so far, been limited, they exemplify the prospects for developing more grounded and inclusive insights into the range of policy measures being applied in an adaptable way to ensure innovation contributes to sustainable development across the WTO membership, as well as identifying coherent themes and potential normative gaps or areas for clarification and progressive development.

Hence, in considering TRIPS and innovation, it is important to consider both the general principles of TRIPS, or what the international rules say, and how WTO members have operated in diverse ways within the TRIPS framework to implement their innovation policies and to promote their innovation goals.

This more systematic groundwork for policy development should equip members and policymakers with a greater capacity to adapt and apply existing tools more effectively to achieve contemporary goals for inclusive and welfare-enhancing innovation, as well as creating the means for greater access to global markets for innovators and creators in remote or resource-poor locations. These prospects are enhanced as greater access to the internet is coupled with a burgeoning trade in IP rights as such, as IP transactions form part of global value chains and even trade in IP, as such, now that content such as music, books and cinematic works can be traded

free of the traditional media (such as discs and tapes) on which they used to be distributed (Field, 2015). For example, the “app economy” – enabled by digital platforms on which software applications are traded directly – offers access for small innovators or microenterprises to global markets that did not exist 10 years ago (Taubman, 2020).

National IP systems therefore continue to be adapted and refined within the framework of TRIPS, responding to the current needs of the knowledge economy, even in the absence of parallel adaptation of the provisions of TRIPS itself. Many WTO members have updated and developed their IP rules to respond to the opportunities and the new parameters produced by the digital economy, and have notified these developments to the TRIPS Council. The innovative eTRIPS gateway now provides systematic access to this rich vein of material. Implementing the broad principles of the TRIPS Agreement in the current knowledge economy remains compatible with the exploration of diverse and nationally tailored policy options in relation to innovation and achieving domestic diversity within a rules-based framework. This approach would respond to the principle, set out in the UN 2030 Agenda for Sustainable Development, that called for respect for “each country’s policy space and leadership to implement policies for poverty eradication and sustainable development, while remaining consistent with relevant international rules and commitments.”⁷⁹

(iii) Competition

As discussed in Section C, the digital world poses new challenges to regulators and competition authorities in their work to ensure that markets foster and deliver innovation efficiently (Anderson *et al.*, 2020). In that regard, while e-commerce has the potential to increase competition within retail markets, several characteristics of digital markets and electronic platforms have raised new questions and concerns in relation to anti-competitive practices intrinsic to traditional markets, such as abuse of dominance, anti-competitive agreements and mergers.

First, there may be a heightened risk of the abuse of dominance, created by a combination of Big Data and machine-learning, that can amplify network effects, strengthening leaders’ dominance and deterring further market entry (OECD, 2016). These may lead to “winner-takes-all” markets (Gökçe Dessemond, 2019) and geographical concentration, and may ultimately hinder innovation, to the detriment of consumers. Second, technology and/or digital platforms that permit or oblige firms to monitor and adapt prices raise additional questions in relation to anti-competitive

agreements (OECD, 2017). Third, with regard to mergers, questions over the competitive effects of the acquisition of innovative start-ups or nascent firms by dominant incumbents have sparked a debate on how effective merger control regimes can reduce the risk of so-called “killer acquisitions”, in which firms acquire nascent competitors only to discontinue the target’s innovation projects, thereby pre-empting the emergence of future competition (OECD, 2020). Furthermore, new zero-pricing models have put in question traditional parameters focusing on monetary aspects, such as prices or turnover values, and put in evidence the value of innovation and data privacy as public goods in need of protection (OECD, 2018b).

In this context, both government regulation and competition law enforcement have an important role to play in ensuring competition and helping to diffuse innovation. Governments may adopt pro-competitive regulatory regimes, e.g. to foster knowledge-sharing by improving access to data, while also ensuring adequate levels of consumer protection, taking into account consumers’ need for data privacy and security. Similarly, exceptions to the application of competition policy in order to support innovation can be put in place (e.g. regarding technology transfer agreements, joint ventures and/or merger control). Competition enforcement action can help to keep markets open and prevent anti-competitive practices from acting as barriers to trade (Anderson *et al.*, 2019). In the digital age, competition authorities are called upon to make complex enforcement decisions (OECD, 2018b). Regarding digital platforms, for instance, it is necessary to take proper account of the dynamics created by such platforms as two-sided markets, with consumers enjoying free services (in exchange for access to their data) on one side of the market, and advertisers facing platforms as business partners with considerable market power on the other side. In the same vein, the potential for dynamic competition, i.e. the possibility of monopoly positions becoming eroded over time as a result of technological advances, needs to be taken into consideration (Motta and Peitz, 2020).

While digital markets, in particular in combination with the global opportunities created by international trade liberalization, can lead to enhanced competition in many instances, their potentially global reach can also result in dominant positions by market leaders, anti-competitive agreements or mergers harmful to competition that adversely affect several economies at once (World Economic Forum, 2019). Relevant firms can thus come under scrutiny in multiple jurisdictions. In turn, this presents a risk of conflicting decisions, based on assessments of the competitive situation in each jurisdiction and potentially

according to varying assessment criteria. In that regard, cooperation between competition authorities can help in coordinating competition responses and exchanging best practices (Anderson *et al.*, 2018a; Anderson *et al.*, 2019; Baldwin, 2014).

At the same time, as previously discussed, global markets have brought into focus the links between competition policy and industrial and innovation policies (OECD, 2009). Some countries consider that merger policy should be adapted to provide more leeway to build and support companies large enough to contest global markets and create markets for innovative products. Other countries have voiced concerns about using competition policy for strategic industrial policy aimed at appropriating monopoly profits in the global market through the support of national champions. In this context, international dialogue and cooperation can help to enhance mutual understanding and awareness of policy effects. Relevant cooperation and experience-sharing has taken and is taking place in various fora, such as in the context of international trade negotiations, in particular RTAs (see section D.2.(b)(iii)) and, in the past, in the WTO Working Group on Trade and Competition,⁸⁰ but also through the work of organizations such as the International Competition Network (ICN), UNCTAD and the OECD.

(iv) Investment in infrastructure and human capital

An important component of digital innovation policies consists in building digital capabilities and digital infrastructure (see Sections B and C and WTO, (2018)). Public funding is the primary source of finance, followed by private sector investment and public-private partnerships, respectively. To promote and facilitate investment in broadband infrastructure or the digital industry, governments also focus 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.

Foreign direct investment promotes innovation in host countries through various channels, including through direct investments to develop R&D in host countries (e.g. establishment of R&D and tech labs), backward linkages (i.e., domestic companies becoming suppliers of MNCs, which in turn require the adoption, adaptation and eventually creation of new technologies and new techniques), and

forward linkages (i.e. domestic firms acquiring more sophisticated inputs from MNCs). However, these benefits of FDI do not accrue automatically. To reap the maximum benefits from FDI, a sound policy environment for investors, including one consistent with GATS obligations and commitments on commercial presence (mode 3), is paramount.

The 2017 Joint Ministerial Statement on Investment Facilitation for Development, issued by a group of WTO members at the WTO Ministerial Conference in Buenos Aires, as well as the subsequent Joint Ministerial Statement in November 2019, may also be seen against this backdrop. The initiative on investment facilitation, which does not cover market access, investment protection and investor-state dispute settlement, focuses on the development and promotion of more transparent and efficient investment frameworks. The focus on investment facilitation comes with the recognition that in today's integrated global economy, expanding investment flows depend on simplifying and speeding up procedures, not just liberalizing policies. Indeed, in many cases the bottlenecks, inefficiencies and uncertainties that investment facilitation seeks to address arise from red tape, bureaucratic overlap, or out-of-date procedures, which serve no clear policy purpose but can become costly impediments to investment.

The focus of the structured discussions on investment facilitation for development, currently involving 104 members, has therefore been on the elements of a framework that would:

- improve the transparency and predictability of investment measures (e.g. publication/notification of investment-related measures, enquiry points/single windows, notification of investment-related measures, and opportunity for prior comment on draft laws and regulations);
- streamline and speed up administrative procedures and requirements, such as the procedural aspects of investment applications, approval processes, formalities and documentation requirements, fees and charges, and the establishment of one-stop shop/single windows;
- enhance international cooperation, information-sharing, the exchange of best practices, and relations with relevant stakeholders, including dispute prevention; and
- facilitate greater developing-member and LDC participation in global investment flows.

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.

A key dimension of the digital divide is that of the divide between developing and developed countries, in terms of access as well as skills for 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 explained in WTO (2018a), international cooperation, in particular in the context of the WTO, including in the form of Aid for Trade, 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. 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.

According to UNCTAD (2018), while developing countries used targeted policies to encourage technology transfers from foreign firms through FDI, this has become much more complicated in the digital economy, where technology and data analytics are sometimes considered trade secrets (e.g. Kowalski, Rabaioli and Vallejo (2017)). As trade secrets are increasingly being protected in trade and investment agreements, it is difficult for governments to use the traditional FDI policies for encouraging transfers of digital technologies such as algorithms.

The rules applied to source-code-sharing are another example. Source code, the list of programming commands necessary to understand and modify how software works, is usually protected by copyright and is often kept confidential to protect proprietary information. Some recently negotiated trade and investment agreements incorporate specific provisions on treatment of source code, including the commitment 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. Issues related to source code and transfers of technology have been raised in the context of the WTO Work Programme on E-Commerce and the Joint Statement Initiative on E-Commerce which involves 82 members (in August 2020) working towards WTO negotiations on trade related aspects of electronic commerce aimed at further enhancing the benefits of e-commerce for businesses, consumers and the global economy.

(v) *Movement of natural persons*

The empirical evidence discussed in Section C.3 suggests that highly skilled migrants positively contribute to innovation in the knowledge economy. Developed countries generally put in place policies to attract highly skilled migrants, but attraction of highly skilled migrants is also an important policy objective in several developing countries. In developing countries, however, innovation is more likely impacted by emigration rather than by immigration of highly skilled individuals, as diasporas can generate net positive gains for the migrant's home countries.

Facilitating the temporary mobility of technically trained and entrepreneurially skilled personnel, research professionals and graduate students between countries may have some advantages compared to encouraging permanent migration when it comes to promoting innovation (Maskus and Saggi, 2013). First, evidence suggests that the temporary relocation of such personnel between countries is an important vector of international technology transfer. Second, the temporary mobility of skilled personnel among R&D and production facilities may facilitate the development of global innovation networks. Last but not least, it may help avoid the perceived pitfalls of permanent “brain drain”, depriving developing countries of talent.

A number of governments have already committed to opening their markets to the supply of R&D services and other (skilled) professional services by other members, through WTO, RTA or labour market arrangements (e.g. the presence of natural persons, per GATS mode 4) and guest worker programmes (see Section D.2). Despite this progress, however, significant restraints remain in place and it can be costly and difficult to get the required work visas. The GATS clearly offers a framework for the negotiation of further commitments under mode 4 between WTO members (see Section D.2(b)). Otherwise, a concept proposed by Maskus and Saggi (2013) would be to facilitate the free circulation of technical and

entrepreneurial talent among the member nations of an innovation zone, permitting them to be deployed freely in the associated innovation networks.⁸¹ However, ways to structure such an arrangement in a manner consistent with GATS obligations, such as MFN, and scheduled commitments would need to be taken into consideration. As much as possible, the certification of skills acquired in different professions and in different countries would need to be recognized by the other members.

(vi) Government procurement

As discussed in Section D.2, the GPA and government procurement chapters in RTAs can positively contribute to innovation procurement by opening domestic government procurement markets to innovative goods and services from foreign suppliers and establishing international rules that enable and facilitate innovation procurement.

The Committee on Government Procurement has undertaken important work relevant to innovation policies in the framework of committee work programmes that were agreed at the conclusion of the GPA renegotiation in 2012.⁸² The topics of the work programmes include sustainability in government procurement, increasing participation in government procurement procedures by MSMEs, and the collection and reporting of statistics.

The Work Programme on Sustainable Procurement examines the objectives of sustainable procurement: ways in which the concept of sustainable procurement is integrated into national and sub-national procurement policies, and how sustainable procurement can be practised in a manner consistent with the principle of “best value for money” and with international trade obligations. The concept of sustainability in government procurement covers a number of aspects and has various meanings in different jurisdictions, such as the protection of the environment, social dimensions (e.g. human rights and/or working conditions and proactive measures to support the participation of particular social groups), and creating sustainable economic opportunities (e.g. innovation research/investment, open competition, supply chain competitiveness and the promotion of small businesses).⁸³ Overall, the Work Programme on Sustainable Procurement provides an opportunity for all interested parties to carry forward the discussion regarding these issues and to identify how sustainable procurement can be used as a tool to facilitate access to innovative goods and services and stimulate innovation.

In relation to the integration of MSMEs into government procurement markets, the GPA's design already

creates opportunities for innovative entrants in several ways and can thus facilitate MSME participation in international procurement (see Section D.2.(b)(vii)). The Work Programme on SMEs seeks to explore how GPA parties can facilitate SME participation in government procurement while complying with international trade obligations and avoiding discriminatory measures that distort open procurement. The discussions in the framework of this work programme indicate that the approaches of GPA parties to promoting SME access to procurement markets differ. There is thus scope for further cooperation and reflection on which policies are most conducive to achieving greater SME participation and stimulating SME innovation.

In the framework of the work programme on the collection and reporting of statistical data, GPA parties are, among other things, actively involved in discussions on potentially introducing the expanded use of innovative electronic tools for compiling, presenting and exchanging information on government procurement in the GPA context. Such discussions build on GPA parties' experience with e-procurement tools and the ongoing technological advances.

(vii) Data management

Data have become a central element of economic activities, and data policies an integral part of innovation policies and a growing number of jurisdictions have passed new regulations to address data-related policy issues such as data privacy, consumer protection, and national security. As discussed in Section C, in light of the relative novelty of this field and the corresponding scarcity of studies, it is important to examine the relationship between data policies and innovation further to understand what the long-term effects of such policies are and to further substantiate the evidence that has been collected thus far.

Data privacy protection

WTO (2018) argues that if lax privacy policies can confer an advantage on domestic digital industries relative to digital industries in countries with stricter policies, 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 Section C). If further research confirms that, indeed, weaker privacy protection favours domestic innovation, the rationale for cooperation against a race to the bottom on privacy protection will be reinforced.

Provisions related to personal data found in the e-commerce chapters of RTAs range from commitments to adopt measures to protect personal data to cooperation. A more specific type of provision, often complementing the commitment to adopt measures to protect personal data, refers to taking into account international standards or practices in developing standards of personal information protection or measures for the protection of personal information. A limited number of RTAs, mostly negotiated by the European Union, include a chapter dedicated to personal data protection. Many of these provisions are idiosyncratic, establishing specific principles, such as purpose limitation, data quality and proportionality, transparency, security, right to access, rectification and opposition, and restrictions on onward transfers. Other provisions address the protection of sensitive data and enforcement mechanisms.

Data localization

As discussed in Section C, the limited available evidence clearly supports the idea that, for data to flourish as an input to innovation, it benefits from flowing as freely as possible, given necessary privacy protection policies. This may, at least in part, explain why binding rules on cross-border data transfers and localization restrictions have been introduced in a number of RTAs (see Section D.2(b)) and have been discussed in the context of the Trade in Services Agreement and WTO e-commerce negotiations.

At the same time, however, UNCTAD (2018), together with a number of other experts, argues that most developing countries do not have policies regarding the control and use of data, and that before accepting any restrictions of their policy space in this area, they should develop their own national data policies. Mayer (2018) suggests that the absence of well-defined data policies risks causing developing country data to be controlled by whomever gathers and stores data and then has exclusive and unlimited rights to those data. Along similar lines, Gehl (2018) argues in favour of a balanced national data governance regime to avoid the risks of purely free or heavily regulated data policies, which in his view may stifle innovation. UNCTAD (2018) argues that localization rules were extensively used by the developed countries in the earlier phase of digitalization, and are still being used, and that rules that restrict the use of data localization provisions would limit the ability of governments to gain from FDI to build their national digital technological capacity and skills. Ideally, the design of national data policies should be informed by sufficient evidence on the effects of data policies on innovation and welfare.

In fact, rather than constraining governments, international cooperation may help them develop their national policies. As discussed in relation with support measures, with enough information on the effects of data policies, international cooperation may help share the benefits arising from international flows of data linked to national policies between countries. In the absence of appropriate sharing mechanisms, national governments may be reluctant to provide foreign multinationals with access to national data (e.g. from the public health system) if the benefits generated by the exploitation of such data are not shared (Guellec and Paunov, 2018).

(viii) Digital trade/trade in services

Trade is an important vector of technological transfer and innovation (see Section C). Eliminating obstacles to digital trade in particular has a role to play in promoting digital innovation. Section D.2 discussed how international cooperation fosters innovation and addresses the negative externalities brought about by restrictive policies affecting digital trade in goods and services.

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” (see Section B and WTO, 2018a). 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. R&D services, ranging from equipment purchases and testing protocols to grant management and accounting and beyond, are often heavily regulated in favour of domestic providers (Maskus and Saggi, 2013). These policies restrict access for and the operation of foreign services suppliers, and they may also take a toll on innovation as well as on the broader economy.

International cooperation in the WTO or in RTAs can help governments to open up and stimulate competition in their digital services sectors, which can make an important contribution to the promotion of digital innovation. The WTO and RTAs also have a role to play in preventing the introduction and possible spread of barriers to cross-border digital trade, and in making cross-border digital trade an engine of development. A number of issues, including

the extension of the moratorium on the imposition of customs duties on electronic transmissions, are under discussion at the WTO in the context of the Work Programme on E-Commerce. At the same time discussions are proceeding amongst a growing number of WTO members in the context of the Joint Statement Initiative on E-Commerce (see WTO, 2018a).

The global economy may also benefit from more international cooperation on the use of export controls, import restrictions or investment screening for dual-use digital technologies, given the general-purpose nature of many of those technologies.

The GATS obligations and commitments and their enforcement through dispute settlement can help tackle trade barriers that stifle innovation to the detriment of consumers and user industries (e.g. creation of local monopolies, forcing local transaction processing, restrictions on branch network expansion, restrictions on introduction of new products), while ensuring a balance between public policy objectives and trade liberalization.

Trade in services discussions among WTO members contribute to cooperation on innovation-related policies at the multilateral level. Among the issues that have been addressed in recent months in WTO bodies such as the Council for Trade in Services are cybersecurity measures. Discussion has focused on how such measures might interfere with trade by, for example, *de facto* discriminating against foreign suppliers, and how they should, instead, be designed in a manner that is least trade-restrictive. If so, these measures would also avoid creating obstacles to innovation in such an important realm of development of technological solutions. In addition, discussions related to classification of evolved ICT services have taken place in the GATS Committee on Specific Commitments over a number of years.

While there is no doubt that the private sector will continue to find innovative ways through which ICTs can contribute to economic growth, "governments and international organisations have a crucial role in both enabling this to happen and ensuring that the poor and marginalised can benefit" (Unwin, 2017). Moreover, many of the policy and legal responses that arise from an unanticipated shift in services trade from commercial presence to cross-border supply, have a variety of interjurisdictional consequences for both trade and innovation policies. Enhanced efforts at collaboration among governments will help complement and coordinate national initiatives (Tuthill, Carzaniga and Roy, 2020).

(ix) Tax policy

International capital tax bases have become increasingly mobile in the last decades. This has been caused by two phenomena. First, changes in regulation have made capital more mobile. Second, in the digital economy economic transactions consist of increasing flows of services supplied online and the increased online supply of a few so-called digitalized products that were once, or can also be, conveyed on physical carrier media. This trend has made it easier for companies to shift their tax base around and locate their statutory profits in low tax areas.

The more mobile tax base has provoked two policy reactions. First, tax rates on capital have decreased substantially over time as countries have attempted to keep an attractive tax environment (Devereux *et al.*, 2002; Egger, Nigai and Strecker, 2019). Second and more recently, governments are attempting to come up with different ways to tax the revenues of (large) companies in the digital economy.

Both policies have an important industrial policy component although for the first policy this is more obvious than for the second. Tax policy *vis-à-vis* (international) companies aims at creating an attractive business environment and can thus be seen as a type of horizontal government policy. The decline in the capital tax base is considered to be problematic from an equity perspective, as it has raised taxes on less mobile tax bases such as labour.

Attempts to tax large companies in the digital economy seem to be partly focused on raising enough tax revenues in the digital economy but they may also have a direct industrial policy angle. The largest digital companies globally mainly come from a small number of countries, and so attempts to tax their revenues by other countries have been considered by these countries as attempts to target their companies with additional taxes in markets with winner-takes-all characteristics.

In this context, as discussed previously in this report, governments use two tax incentives that directly target innovative activity: R&D tax credits and super deductions, and IP boxes (reduced tax on the profits from innovation). While, in theory, patent boxes may incentivize R&D, in practice they induce tax competition by encouraging firms to shift their IP royalties into different tax jurisdictions (Bloom, Van Reenen and Williams, 2019; Hall, 2020). In most developed economies, the share of company assets that is intangible has grown in recent years. As many of these intangibles, which are often IP covered by some form of exclusivity right, do not have a physical location,

they can easily be moved to a low tax jurisdiction (Dischinger and Riedel, 2011; Mutti and Grubert, 2009). This allows firms to pay royalties for the use of the IP to the low-tax country, creating income there and cost in the high-tax country, reducing the total taxes to be paid (Bartelsman and Beetsma, 2003). In response to this strategy, governments tend to lower tax rates on their income in an effort to persuade firms to keep their IP assets at home to retain skilled jobs and R&D in the country. Wasteful tax competition has been found both for US states and across the OECD and the European Union.⁸⁴

Overall, three conclusions can be drawn from a review of the literature on R&D tax incentives (Hall, 2020). First, tax incentives for innovation should be even larger than they are already. Second, those for larger economies are more important for global welfare. Third, given the existence of cross-border spill-overs and the need to avoid wasteful tax competition, these policies would achieve higher welfare if they were better coordinated between countries. In fact, countries are already working on coordinating their tax policies in the OECD (See Section D.2(c)). According to Hall (2020), the nexus requirement of base erosion and profit-shifting has already eliminated the ability to simply benefit from transferring patents.⁸⁵ As a result, the impact of patent boxes on patent ownership transfer may disappear in the future.

4. Conclusions

This section has considered international cooperation and disciplines relevant to digital innovation policies.

Section D.2 showed how the multilateral trading system makes a major contribution to innovation worldwide and to the diffusion of technologies by stimulating competition from foreign firms and linkages with foreign firms through importing, exporting or supplying multinationals. Through multiples rounds of tariff reductions and through disciplines incorporating basic principles such as non-discrimination, transparency, reciprocity, or the prohibition of unnecessarily trade-restrictive measures combined with a preservation of policy space for addressing important societal concerns, the GATT and the WTO have promoted trade and, thereby, innovation. WTO disciplines, while pre-dating the emergence of digitalization, continue to promote trade and innovation in the digital world. Moreover, the multilateral trading system provides certainty, while also promoting cooperation and enabling flexible responses to new problems. The WTO agreements thus ensure certainty and flexibility, which are crucial for deploying innovation-related policies.

Section D.2 went on to review how RTAs address innovation policy. It found that, while only a limited number of RTAs include provisions explicitly addressing industrial and innovation policy, many other provisions in RTAs can both constrain and support industrial and innovation policy in the digital age. While some of the latter provisions replicate or build on existing WTO agreements, many other provisions establish new commitments. These new obligations cover various issues, including data protection and localization, competition and IP in the digital era.

Finally, Section D.2 describes how various international organizations play an important role in international cooperation on innovation by favouring harmonization and mutual recognition of standards and regulatory framework, addressing IP-related issues as well as tax and competition issues, tackling challenges in ICT infrastructure, and supporting digital inclusion and MSME participation.

Section D.3 discussed where and why digitalization and digital innovation policies are creating new needs for international cooperation and possibly for new and updated international disciplines on innovation policy instruments. It argued that the rising importance of data as an input in production and of data fluidity leads to increasing demands for new international rules on data transfer, data localization and privacy. It also argued that the positive network effects of innovation policies in digital equipment industries for downstream digitally enabled industries across the world increase as digital equipment industries become pivotal, by producing general-purpose technologies, thus strengthening the case for international cooperation to encourage national governments to support innovation. At the same time, however, it warned that the “winner-takes-all” characteristics of many digital industries could lead to applications of strategic innovation policy, which would in turn bring about a necessity for cooperation measures aimed at limiting the negative cross-border effects from such policies.

Building on this analysis and based on the limited evidence regarding cross-border spill-overs of innovation policies available in the literature, Section D.3 examined more closely the need for international cooperation in a number of specific areas.

International cooperation in the WTO and RTAs can contribute to the promotion of digital innovation by helping governments to open up and stimulate competition in their digital services sectors. The WTO and RTAs also have a role to play in preventing the introduction and possible spread of barriers to cross-border digital trade and in making it an engine of development.

One question raised is whether, in the digital world, it may make sense to explore ways to expand the flexibility for governments to use R&D subsidies with important positive international spill-overs.

It is also argued that international cooperation may help design a mechanism to share the benefits arising from innovation policies between countries. In the absence of such a mechanism, national governments may not provide enough support for innovation, if they fear that most of the benefits from the innovation they support will leak abroad.

International cooperation could help promote innovation in the digital world by encouraging and facilitating investment in broadband infrastructure or the digital industry. FDI promotes innovation in host countries through direct investments to develop R&D, backward linkages and forward linkages. To reap the maximum benefits from FDI, a sound policy environment for investors, consistent with GATS obligations and commitments on commercial presence, is paramount. Ongoing discussions regarding the joint statement initiative on investment facilitation, aimed at expanding investment flows by simplifying and speeding up procedures, could further promote investment in broadband infrastructure or the digital industry. Aid for Trade 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.

Empirical evidence suggests that highly skilled foreign workers positively contribute to innovation in the knowledge economy. Policies to attract highly skilled migrants have been put in place in both developed and developing countries. Commitments in the context of the WTO or RTAs or other international agreements could also help further open markets to the supply of research and development services and other (skilled) professional services by suppliers of other members, through the presence of natural persons (GATS mode 4).

Data policies have become an integral part of innovation policies, and a growing number of jurisdictions have passed new regulations to address data-related policy issues such as data privacy, consumer protection, and national security. It is important to examine the relationship between data policies and innovation further to understand what the long-term effects of such policies are. With enough information on the effects of data policies, international cooperation may help share the benefits arising from international flows of data between countries.

Limitations to data flows, or data localization policies, often stem from privacy or security concerns, and therefore an effort to harmonize standards for data protection across countries or to develop mutual recognition criteria could build trust, and help prevent the spread of excessively restrictive data policies or a possible race to the bottom in terms of privacy and security standards.

While, in many instances, digital markets can lead to enhanced competition, their potentially global reach can also result in dominant positions by market leaders, anti-competitive behaviour or mergers and acquisitions harmful to competition. International dialogue and cooperation on competition policies may help to enhance mutual understanding and awareness of policy effects. Global markets have brought into focus the links between competition policy and industrial and innovation policies. Some tensions exist between, on the one hand, the desire to adapt competition and merger policy to provide more leeway to build and support companies large enough to contest global markets and create markets for innovative products, and on the other hand, concerns about using competition policy for strategic industrial policy purpose aimed at appropriating monopoly profits in the global market through the support of national champions. In this context, international dialogue and cooperation can help to enhance mutual understanding and awareness of policy effects. Relevant cooperation and experience-sharing has taken and is taking place in various fora, such as in certain RTAs and in organizations such as the International Competition Network (ICN), UNCTAD and the OECD.

Finally, both economic arguments in favour and against more policy space for developing countries to pursue innovation policies are discussed in this section. The weight of these arguments depends on the context and the specific policies examined. Although there is little empirical evidence on the size of the spill-over effects of innovation policies and thus of granting more policy space to conduct innovation policies to developing countries, it can be observed that some developing countries have displayed spectacular growth, suggesting that the cross-border spill-overs of their national policies may also have expanded.

Endnotes

- 1 All WTO legal texts may be consulted via https://www.wto.org/english/docs_e/legal_e/legal_e.htm.
- 2 National treatment is the principle of giving other countries' goods, services or intellectual property rights treatments no less favourable than the one provided to one's own nationals. GATT Article III requires that imported products be treated no less favourably than the same or similar domestically produced goods once they have passed customs. GATS Article 17 and TRIPS Article 3 also deal with national treatment for services and intellectual property protection.
- 3 The Human Genome Project is a multinational consortium that produced publicly available research results on the human genome and, in the process, resulted in advances in, for example, genomic sequencing and data handling technologies that have had important commercial applications as well as important applications in medicine. For example, the rapid sequencing of virus genomes is speeding up the search for therapies and vaccines to deal with new viruses.
- 4 Pursuant to GATS Article XV, WTO members recognize that, in certain circumstances, subsidies may have distortive effects on trade in services and they have entered into negotiations with a view to developing the necessary multilateral disciplines to avoid such trade-distortive effects and to address the appropriateness of countervailing procedures. Those negotiations have not concluded so far.
- 5 The approach in the SCM Agreement with respect to "specificity" reflects the expectation that subsidies carry the potential to be more trade-distorting the more specific they are. In this regard, in economic terms, the more closely targeted a subsidy is towards its intended beneficiaries, the more concentrated its relative price effect will tend to be. In many circumstances, this could be taken to imply a higher probability that the subsidy is distorting. A subsidy to a single industry rather than to many industries, for example, could impart a narrow advantage. The more broadly subsidy recipients are defined, then, the more "spread out" and shallower will be the likely subsidy impact.
- 6 Assistance was further limited to a specific list of costs exclusively used for research (personnel, instruments, equipment, land, buildings, consultancy services, overheads, materials and supplies).
- 7 LDCs are designated as such by the United Nations (see Article 27.2(a) in conjunction with Annex VII(a) of the SCM Agreement). Also relevant is WTO official document number WT/MIN(01)/17, Decision adopted at the Doha Ministerial Conference on 14 November 2001, paragraph 10.5.
- 8 These are treated like LDCs until their GNP per capita has reached US\$ 1,000 per annum. Once this threshold (calculated in constant 1990 US\$) has been reached for three consecutive years, they are treated like other developing members in accordance with Article 27.2(b) of the SCM Agreement (transition period of eight years from date of entry into force of the WTO Agreement, i.e., through end-2002). Also relevant is WT/MIN(01)/17, Decision adopted at the Doha Ministerial Conference on 14 November 2001, paragraphs 10.1 and 10.4.
- 9 Article 27.2(b) of the SCM Agreement. Also relevant is 1 WT/MIN(01)/17, Decision adopted at the Doha Ministerial Conference on 14 November 2001, paragraph 10.5.
- 10 Sauvé (2016) highlights that governments can adopt alternative industry support measures without violating the TRIMs Agreement.
- 11 For further details, see https://www.wto.org/english/tratop_e/inftec_e/inftec_e.htm.
- 12 GATT, Trade in Pharmaceutical Products, 25 March 1994, official document number L/7430. Available at https://www.wto.org/gatt_docs/English/SULPDF/91770009.pdf.
- 13 The Pharma Agreement is a dynamic agreement with a built-in negotiating mandate: participants agreed to regularly review the Agreement to update and expand the list of products covered. A fifth review should start any time.
- 14 Australia, Brunei Darussalam, Canada, Chile, Lao People's Democratic Republic, Myanmar, Singapore, Uruguay, Joint Ministerial Statement affirming commitment to ensuring supply chain connectivity amidst the COVID-19 situation, 6 April 2020. Available at <https://www.mti.gov.sg/-/media/MTI/Newsroom/Press-Releases/2020/03/Updated-Joint-Ministerial-Statement-on-supply-chain-connectivity-as-of-6-april.pdf>.
- 15 Available at <https://perma.cc/WWG4-JRAC>.
- 16 Communication from New Zealand and Singapore, "Response to the COVID-19 Pandemic: Ensuring the Free Flow of Trade in Essential Goods for Combating the COVID-19 Pandemic", 16 April 2020, WTO official document number G/C/W/777. Available at <https://docs.wto.org/>.
- 17 See the introductory statement at an informal meeting of EU trade ministers of 16 April 2020 (https://ec.europa.eu/commission/commissioners/2019-2024/hogan/announcements/introductory-statement-commissioner-phil-hogan-informal-meeting-eu-trade-ministers_en). In June 2020, the Ottawa Group also circulated a comprehensive proposal for permanent and tariff elimination on healthcare goods, proposing to expand coverage of and participation in the existing ITA and pharmaceutical sectoral initiatives. It is also proposed to accelerate certain trade facilitation reforms and to simplify import licensing procedures (see WTO official document number WT/GC/217 – available at <https://docs.wto.org/>).
- 18 We use the term "technical standards" for easy reference only and as shorthand for a wide range of regulatory measures, including those covered and defined by the TBT Agreement (Annex 1.1, 1.2 and 1.3, respectively): "technical regulations" (mandatory), "standards" (voluntary) and "conformity assessment procedures". However, these three terms may be also be used when a point concerns a specific type of TBT measure only.
- 19 For more details, see the TBT Handbook at https://www.wto.org/english/res_e/publications_e/tbttrade_e.pdf
- 20 For a summary of these technologies, see WTO (2018a), pages 28-35.
- 21 So far, most COVID-19-related TBT notifications were reported as temporary (i.e. often applying for a period of six months), and covered a wide range of products, including personal protection equipment (PPE), medical equipment, medical supplies and medicines. The objective of these notifications broadly fell into three main categories: streamlining certification procedures, ensuring the safety of medical goods, and making food available by relaxing technical regulations. For further information on TBT and COVID-19, see the WTO information note of 20 May 2020, "Standards, Regulations and COVID-19 – what actions taken by WTO members?", available at https://www.wto.org/english/tratop_e/covid19_e/standards_report_e.pdf.
- 22 One example is Canada's "Regulations Amending the Food and Drug Regulations" (notified to the TBT Committee in 2017. See WTO official document number G/TBT/N/CAN/525).

- 23 Participants: Australia, Brazil, Canada, Japan and the United States. The International Medical Devices Regulators Forum and its Medical Device Single Audit Program aim to reduce duplication and promote more efficient and effective use of regulator resources for faster approval of innovative devices.
- 24 Notifications made under Article 10.7 of the TBT Agreement. See <http://tbtime.wto.org/en/AgreementNotifications/Search>.
- 25 WTO official document number G/TBT/1/Rev.14.
- 26 WTO official document number G/TBT/1/Rev.14.
- 27 WTO official document number G/TBT/1/Rev.14.
- 28 For further discussion on research regulations, see Maskus and Saggi (2013).
- 29 For further details on how AI impacts international trade, see WTO (2018), page 140.
- 30 "Dual-use" regulations can include other technologies, such as nuclear power. See, for example, WTO official document number G/TBT/N/CZE/198/Add.1, notified to the TBT Committee by the Czech Republic:
- "The purpose of the proposed legislation is to establish an updated list of dual-use nuclear items in relation to Prevention of Technical Barriers obligations laid down in the new Atomic Act and to existing State supervision of dual-use items, including the authorisation of export and import. The implementing decree also lays down new content requirements for documentation for licensed activities and the scope of registered data on dual-use items and how it is retained, including its delivery to the State Office for Nuclear Safety. [...]"
- 31 For instance, a recent European Commission Report (EC Report, 2020a) on the safety of AI, IoT and robotics describes the key benefits of these technologies as follows:
- "Beyond productivity and efficiency gains, AI also promises to enable humans to develop intelligence not yet reached, opening the door to new discoveries and helping to solve some of the world's biggest challenges: from treating chronic diseases, predicting disease outbreaks or reducing fatality rates in traffic accidents to fighting climate change or anticipating cybersecurity threats."
- 32 International cooperation on AI was also the object of the 8-9 June 2019 "G20 Ministerial Statement on Trade and Digital Economy" (<https://www.mofa.go.jp/files/000486596.pdf>), the annex of which lays down the "G20 AI Principles", which in turn, drew from the OECD AI Principles (<https://www.oecd.org/going-digital/ai/principles/>), adopted in May 2019 by the OECD member countries.
- 33 For additional details, see the integrated Government Procurement Market Access Information Resource (e-GPA) portal of the WTO, available at <https://e-gpa.wto.org>.
- 34 See https://www.wto.org/english/tratop_e/serv_e/telecom_e/tel23_e.htm.
- 35 See https://www.wto.org/english/tratop_e/serv_e/12-tel_e.htm.
- 36 See https://www.wto.org/english/tratop_e/serv_e/telecom_e/tel23_e.htm.
- 37 See WTO official document W/2/Rev.1, 16 January 1997, also included in the GATS scheduling guidelines, S/L/92, 28 March 2001 (<https://docs.wto.org/dol2fe/Pages/SS/directdoc.aspx?filename=q:/S/L/92.pdf&Open=True>).
- 38 See https://www.wto.org/english/tratop_e/covid19_e/covid19_e.htm.
- 39 See <https://patents.google.com/> and <https://patentscope.wipo.int/search/en/search.jsf>.
- 40 Permissive licence available at <https://www.medtronic.com/content/dam/medtronic-com/global/Corporate/covid19/documents/permissive-license-open-ventilator.pdf>.
- 41 See list of measures of regarding trade-related intellectual property rights, available at https://www.wto.org/english/tratop_e/covid19_e/trade_related_ip_measure_e.htm.
- 42 Source: OECD Creditor Reporting System (<https://stats.oecd.org/Index.aspx?DataSetCode=crs1>). Aid for Trade support to e-commerce for the year 2018 was calculated according to the UNCTAD analytical framework used for the E-trade for All initiative. This includes support to the seven areas of e-commerce: (1) e-commerce assessments, (2) ICT infrastructure and services, (3) payments, (4) trade logistics, (5) legal & regulatory framework, (6) skills development and (7) financing for e-commerce.
- 43 Other relevant provisions found in RTAs include tariffs reduction commitments on innovation-related products. For instance, tariffs applied by non-participants to the WTO Information Technology Agreement (ITA) on products covered by the ITA remain generally high. Their level of tariff concessions on ITA products has not recorded significant changes over the years. This is true both for the level of bound tariffs and the binding coverage (i.e. the percentage of tariff lines inscribed in the schedule with a bound duty) (WTO, 2017). However, the preferential tariffs of some of these products are lower than the MFN tariffs for some non-participants to the ITA.
- 44 Other common provisions on subsidies establish transparency and countervailing duty disciplines (Rubini, 2020).
- 45 Some RTAs without any provisions on subsidies related to services trade, such as the RTA between Australia and Singapore, incorporate a provision calling for future consultation and negotiation on subsidies related to trade in services.
- 46 As discussed in Section D.2(b)(iii), recent RTAs incorporate specific provisions on competition and state-owned enterprises.
- 47 Unlike many other areas discussed in this subsection, IP commitments agreed in RTAs must be provided to all WTO members.
- 48 Some RTAs further expand the enforcement obligations by requiring that border authorities have ex officio authority to detain suspected counterfeit or pirated goods, and to order their destruction.
- 49 See https://www.wipo.int/copyright/en/activities/internet_treaties.html.
- 50 Other digital IP 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 (WTO, 2018).
- 51 In the context of some bilateral investment treaties, certain industrial policy measures were the subject of investor-state dispute settlement (ISDS) procedures. In recent years, some bilateral investment treaties have, however, been modified to clarify the nature of protection afforded to investors, limit the recourse to ISDS or abrogate the ISDS provisions.
- 52 Other provisions found in RTAs could be relevant to investment and industrial policy. For instance, strict rules of origin in RTAs can lead to the re-localization of certain parts of productions to avoid facing additional tariffs (Francis, 2019).
- 53 Unlike the TRIMS Agreement, these performance requirements provisions often apply to both goods and services industries.

- 54 Most global value chains remain regional rather than global in character, though less so in services than in manufacturing.
- 55 See https://www.wto.org/english/tratop_e/serv_e/12-tel_e.htm.
- 56 See https://www.wto.org/english/tratop_e/serv_e/telecom_e/tel23_e.htm.
- 57 Other regulatory practices related to anti-competitive behaviours of major suppliers, although covered by the Reference Paper's general competition safeguard, but not explicitly mentioned, include requirements of operators to: allow customers to retain the same telephone number (number portability) and to use an equal number of digits to access telecommunications services (dialling parity); ensure interoperability of roaming on mobile networks; and guarantee non-discriminatory access to facilities owned or controlled by major suppliers and needed to supply telecommunications services, including submarine cables, satellites, and poles and ducts.
- 58 Beyond RTAs, the exchange of personal data for commercial purposes has been negotiated in specific agreements by some countries (e.g. the EU-US Privacy Shield Framework).
- 59 The Additional Protocol to the Pacific Alliance Framework Agreement further explains that the provision prohibiting requirement concerning the location of computing facilities shall not prevent a party from conditioning the receipt of an advantage or continuing to receive an advantage in accordance with the provision on performance requirements found in the agreement's investment chapter.
- 60 The main provision in the CPTPP regarding the electromagnetic compatibility of information technology equipment products requires each party to demand positive assurance that these products meet a standard or technical regulation for electromagnetic compatibility to accept a supplier's declaration of conformity.
- 61 Official development aid, including Aid for Trade, is also a means by which some countries cooperate on issues related to industrial policy. For instance, the Japan International Cooperation Agency (JICA) manages different projects aimed at promoting industrial development, including value chain development, from agriculture and the processing industry to the manufacturing and services sectors.
- 62 ISO/TC 279 – see <https://www.iso.org/committee/4587737.html>.
- 63 See <https://www.worldbank.org/en/programs/all-africa-digital-transformation>.
- 64 See <https://www.oecd.org/tax/treaties/multilateral-convention-to-implement-tax-treaty-related-measures-to-prevent-beps.htm>.
- 65 See <https://ecomconnect.org/>.
- 66 See <https://www.unido.org/our-focus/advancing-economic-competitiveness/investing-technology-and-innovation/competitiveness-business-environment-and-upgrading/information-and-communications-technology/programmes/business-information-centres>.
- 67 See <https://etradeforall.org/development-solution/worldbank-e-trade-development/>.
- 68 This is further described in Section C.4.
- 69 Gautier and Lamesch (2020) analyse GAFAM mergers and acquisitions and find that most of their acquisitions have been driven by asset acquisitions. Firms buy valuable innovations, functionalities or R&D to strengthen their main segments. By doing so, they improve their products' ecosystems and reinforce their already strong market positions. They find no evidence that this intense merger-and-acquisition activity leads to more global competition between the GAFAM firms, nor for evidence of so-called killer mergers which attempt to stifle competition. However, they use a narrow definition of killer mergers. Mergers are only classified as killer mergers if they are in the core segment of the acquirer and if product supply of the firm taken over continues under the same brand name.
- 70 Although firms are increasingly based in multiple countries and owned by residents from multiple countries, governments are still engaged in strategic industrial policy, as described in Section B.
- 71 Export controls on dual use technologies are regulated in multilateral export control regimes such as the Australia Group, the Wassenaar Arrangement, the Nuclear Suppliers Group and the Missile Technology Control Regime.
- 72 The international regulation of specific topics such as data and services trade is discussed in more detail in Section D.3(b).
- 73 The researchers find these results in a two-country dynamic quality ladder model of innovation. Their main result follows from the finding that the international cooperative level of innovation subsidies is larger than the (Nash) equilibrium level of subsidies in which countries maximize their own welfare.
- 74 The cited model also assumes free trade, with innovation gains passing on to foreign consumers.
- 75 "Electronic Commerce and Copyright", submitted by Brazil in WTO official document number JOB/IP/19 on 12 December 2016.
- 76 See https://www.wipo.int/copyright/en/activities/internet_treaties.html.
- 77 As of August 2020, the WIPO Copyright Treaty had 107 contracting parties, and the WIPO Performances and Phonograms Treaty had 106.
- 78 See https://www.wto.org/english/tratop_e/trips_e/innovationpolicytrips_e.htm.
- 79 "Transforming our world: the 2030 Agenda for Sustainable Development", Resolution adopted by the General Assembly on 25 September 2015, A/RES/70/1 (UN General Assembly, 2015).
- 80 For further background, see https://www.wto.org/english/tratop_e/comp_e/comp_e.htm.
- 81 Maskus and Saggi (2013) propose working toward a plurilateral agreement, presumably under the auspices of GATS.
- 82 See Decision on the Outcomes of the Negotiations under Article XXIV:7 of the Agreement on Government Procurement, 30 March 2012, GPA/113 dated 2 April 2012.
- 83 See WTO official document number GPA/W/341, dated 30 May 2017 (available at <https://docs.wto.org>).
- 84 See Bloom, Griffith, and Van Reenen (2002) for the OECD; Corrado, Hulten and Sichel (2009) for 10 EU countries; and Wilson (2009) for US states.
- 85 The nexus approach requires a link between the income benefiting from the IP regime and the extent to which the taxpayer has undertaken the underlying R&D that generated the IP asset (OECD, 2015).

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Technical notes

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 WTO 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.

The Netherlands with respect to 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.

There are no WTO definitions of “developed” and “developing” economies. Members announce for themselves whether they are “developed” or “developing” economies. The references to developing and developed economies, as well as any other sub-categories of members used in this report, are for statistical purposes only, and do 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 data supplied in the World Trade Report 2020 are valid as of 1 September 2020.

Composition of regions and other economic groupings				
Regions				
North America				
Bermuda	Canada*	Mexico*	Saint Pierre and Miquelon	United States of America*
South and Central America and the Caribbean				
Anguilla	Brazil*	Ecuador*	Montserrat	Suriname*
Antigua and Barbuda*	Cayman Islands	El Salvador*	Nicaragua*	Trinidad and Tobago*
Argentina*	Chile*	Grenada*	Panama*	Turks and Caicos Islands
Aruba, the Netherlands with respect to	Colombia*	Guatemala*	Paraguay*	Uruguay*
Bahamas**	Costa Rica*	Guyana*	Peru*	Venezuela, Bolivarian Republic of*
Barbados*	Cuba*	Haiti*	Saint Kitts and Nevis*	
Belize*	Curaçao**	Honduras*	Saint Lucia*	
Bolivia, Plurinational State of*	Dominica*	Jamaica*	Saint Martin	
Bonaire, Sint Eustatius and Saba	Dominican Republic*	Martinique	Saint Vincent and the Grenadines*	
Europe				
Albania*	Denmark*	Iceland*	Netherlands*	Spain*
Andorra**	Estonia*	Ireland*	North Macedonia*	Sweden*
Austria*	Finland*	Italy*	Norway*	Switzerland*
Belgium*	France*	Latvia*	Poland*	Turkey*
Bosnia and Herzegovina**	Germany*	Liechtenstein*	Portugal*	United Kingdom*
Bulgaria*	Gibraltar	Lithuania*	Romania*	
Croatia*	Greece*	Luxembourg*	Serbia**	
Cyprus*	Greenland	Malta*	Slovak Republic*	
Czech Republic*	Hungary*	Montenegro*	Slovenia*	
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**	

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**	Gambia*	Mauritania*	Sierra Leone*	
Middle East				
Bahrain, Kingdom of*	Israel*	Lebanese Republic**	Saudi Arabia, Kingdom of*	Yemen*
Iran**	Jordan*	Oman*	Syrian Arab Republic**	
Iraq**	Kuwait, the State of*	Qatar*	United Arab Emirates*	
Asia				
Afghanistan*	Guam	Maldives*	Pakistan*	Timor-Leste**
American Samoa	Hong Kong, China*	Marshall Islands	Palau	Tokelau
Australia*	India*	Micronesia, Federated States of	Papua New Guinea*	Tonga*
Bangladesh*	Indonesia*	Mongolia*	Philippines*	Tuvalu
Bhutan**	Japan*	Myanmar*	Pitcairn	Vanuatu*
Brunei Darussalam*	Kiribati	Nauru	Samoa*	Viet Nam*
Cambodia*	Korea, Democratic People's Republic of	Nepal*	Singapore*	Wallis and Futuna Islands
China*	Korea, Republic of*	New Caledonia	Solomon Islands*	
Cook Islands	Lao People's Democratic Republic*	New Zealand*	Sri Lanka*	
Fiji*	Macao, China*	Niue	Chinese Taipei*	
French Polynesia	Malaysia*	Northern Mariana Islands	Thailand*	
Regional trade agreements				
Andean Community (CAN)				
Bolivia, Plurinational State of	Colombia	Ecuador	Peru	
Association of Southeast Asian Nations (ASEAN)				
Brunei Darussalam	Indonesia	Malaysia	Philippines	Thailand
Cambodia	Lao People's Democratic Republic	Myanmar	Singapore	Viet Nam
Caribbean Community (CARICOM)				
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
Central African Economic and Monetary Community (CAEMC)				
Cameroon	Chad	Congo	Equatorial Guinea	Gabon
Central African Republic				

Common Market for Eastern and Southern Africa (COMESA)				
Burundi	Eritrea	Madagascar	Somalia	Zimbabwe
Comoros	Eswatini	Malawi	Sudan	
Democratic Republic of the Congo	Ethiopia	Mauritius	Tunisia	
Djibouti	Kenya	Rwanda	Uganda	
Egypt	Libya	Seychelles	Zambia	
Economic Community of West African States (ECOWAS)				
Benin	Côte d'Ivoire	Guinea	Mali	Senegal
Burkina Faso	Gambia	Guinea-Bissau	Niger	Sierra Leone
Cabo Verde	Ghana	Liberia	Nigeria	Togo
European Free Trade Association (EFTA)				
Iceland	Liechtenstein	Norway	Switzerland	
European Union				
Austria	Denmark	Hungary	Malta	Slovenia
Belgium	Estonia	Ireland	Netherlands	Spain
Bulgaria	Finland	Italy	Poland	Sweden
Croatia	France	Latvia	Portugal	
Cyprus	Germany	Lithuania	Romania	
Czech Republic	Greece	Luxembourg	Slovak Republic	
Gulf Cooperation Council (GCC)				
Bahrain, Kingdom of	Oman	Qatar	Saudi Arabia, Kingdom of	United Arab Emirates
Kuwait, the State of				
Southern Common Market (MERCOSUR)				
Argentina	Brazil	Paraguay	Uruguay	Venezuela, Bolivarian Republic of
North American Free Trade Agreement (NAFTA)				
Canada	Mexico	United States of America		
Pacific Alliance				
Chile	Colombia	Mexico	Peru	
Southern African Development Community (SADC)				
Angola	Eswatini	Malawi	Namibia	Tanzania
Botswana	Lesotho	Mauritius	Seychelles	Zambia
Comoros	Madagascar	Mozambique	South Africa	Zimbabwe
Democratic Republic of the Congo				
South Asia Free Trade Agreement (SAFTA)				
Afghanistan	Bhutan	Maldives	Pakistan	Sri Lanka
Bangladesh	India	Nepal		
West African Economic and Monetary Union (WAEMU)				
Benin	Côte d'Ivoire	Mali	Senegal	Togo
Burkina Faso	Guinea-Bissau	Niger		

Other groups				
African, Caribbean and Pacific countries (ACP)				
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	Gambia	Mauritania	São Tomé and Príncipe	Vanuatu
Comoros	Ghana	Mauritius	Senegal	Zambia
Congo	Grenada	Micronesia, Federated States of	Seychelles	Zimbabwe
Cook Islands	Guinea	Mozambique	Sierra Leone	
Africa				
<i>North Africa</i>				
Algeria	Egypt	Libya	Morocco	Tunisia
Sub-Saharan Africa				
<i>Western Africa</i>				
Benin	Gambia	Guinea-Bissau	Mauritania	Senegal
Burkina Faso	Ghana	Liberia	Niger	Sierra Leone
Cabo Verde	Guinea	Mali	Nigeria	Togo
Côte d'Ivoire				
<i>Central Africa</i>				
Burundi	Central African Republic	Congo	Equatorial Guinea	Rwanda
Cameroon	Chad	Democratic Republic of the Congo	Gabon	São Tomé and Príncipe
<i>Eastern Africa</i>				
Comoros	Kenya	Mayotte	Seychelles	Sudan
Djibouti	Madagascar	Reunion	Somalia	Tanzania
Eritrea	Mauritius	Rwanda	South Sudan	Uganda
Ethiopia				
<i>Southern Africa</i>				
Angola	Eswatini	Malawi	Namibia	Zambia
Botswana	Lesotho	Mozambique	South Africa	Zimbabwe
Asia				
<i>East Asia</i>				
China	Japan	Korea, Republic of	Mongolia	
Hong Kong, China	Korea, Democratic People's Republic of	Macao, China	Chinese Taipei	
<i>Southeast Asia</i>				
Brunei Darussalam	Lao People's Democratic Republic	Myanmar	Singapore	Timor-Leste
Cambodia	Malaysia	Philippines	Thailand	Viet Nam
Indonesia				

<i>South Asia</i>				
Afghanistan	Bhutan	Maldives	Pakistan	Sri Lanka
Bangladesh	India	Nepal		
<i>Oceania</i>				
Australia	Tuvalu	Kiribati	New Zealand	Solomon Islands
Nauru	Fiji	Marshall Islands	Papua New Guinea	Tonga
Palau	Indonesia	Micronesia, Federated States of	Samoa	Vanuatu
Asia-Pacific Economic Cooperation (APEC)				
Australia	Hong Kong, China	Mexico	Russian Federation	Thailand
Brunei Darussalam	Indonesia	New Zealand	Singapore	United States of America
Canada	Japan	Papua New Guinea	Chinese Taipei	Viet Nam
Chile	Korea, Republic of	Peru		
China	Malaysia	Philippines		
BRICS				
Brazil	China	India	Russian Federation	South Africa
G20 members				
Argentina	China	India	Korea, Republic of	South Africa
Australia	European Union	Indonesia	Mexico	Turkey
Brazil	France	Italy	Russian Federation	United Kingdom
Canada	Germany	Japan	Saudi Arabia, Kingdom of	United States of America
Least-developed countries (LDCs)				
Afghanistan	Comoros	Lao People's Democratic Republic	Niger	Timor-Leste
Angola	Democratic Republic of the Congo	Lesotho	Rwanda	Togo
Bangladesh	Djibouti	Liberia	São Tomé and Príncipe	Tuvalu
Benin	Eritrea	Madagascar	Senegal	Uganda
Bhutan	Ethiopia	Malawi	Sierra Leone	Vanuatu
Burkina Faso	Gambia	Mali	Solomon Islands	Yemen
Burundi	Guinea	Mauritania	Somalia	Zambia
Cambodia	Guinea-Bissau	Mozambique	South Sudan	
Central African Republic	Haiti	Myanmar	Sudan	
Chad	Kiribati	Nepal	Tanzania	
Six East Asian Traders (SEAT)				
Hong Kong, China	Malaysia	Singapore	Chinese Taipei	Thailand
Korea, Republic of				

*WTO members

**Observer governments

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WTO members

(As of 1 September 2020)

Afghanistan	Ghana	North Macedonia, Republic of
Albania	Greece	Norway
Angola	Grenada	Oman
Antigua and Barbuda	Guatemala	Pakistan
Argentina	Guinea	Panama
Armenia	Guinea-Bissau	Papua New Guinea
Australia	Guyana	Paraguay
Austria	Haiti	Peru
Bahrain, Kingdom of	Honduras	Philippines
Bangladesh	Hong Kong, China	Poland
Barbados	Hungary	Portugal
Belgium	Iceland	Qatar
Belize	India	Romania
Benin	Indonesia	Russian Federation
Bolivia, Plurinational State of	Ireland	Rwanda
Botswana	Israel	Saint Kitts and Nevis
Brazil	Italy	Saint Lucia
Brunei Darussalam	Jamaica	Saint Vincent and the Grenadines
Bulgaria	Japan	Samoa
Burkina Faso	Jordan	Saudi Arabia, Kingdom of
Burundi	Kazakhstan	Senegal
Cabo Verde	Kenya	Seychelles
Cambodia	Korea, Republic of	Sierra Leone
Cameroon	Kuwait, the State of	Singapore
Canada	Kyrgyz Republic	Slovak Republic
Central African Republic	Lao People's Democratic	Slovenia
Chad	Republic	Solomon Islands
Chile	Latvia	South Africa
China	Lesotho	Spain
Colombia	Liberia	Sri Lanka
Congo	Liechtenstein	Suriname
Costa Rica	Lithuania	Sweden
Côte d'Ivoire	Luxembourg	Switzerland
Croatia	Macao, China	Chinese Taipei
Cuba	Madagascar	Tajikistan
Cyprus	Malawi	Tanzania
Czech Republic	Malaysia	Thailand
Democratic Republic of the	Maldives	Togo
Congo	Mali	Tonga
Denmark	Malta	Trinidad and Tobago
Djibouti	Mauritania	Tunisia
Dominica	Mauritius	Turkey
Dominican Republic	Mexico	Uganda
Ecuador	Moldova, Republic of	Ukraine
Egypt	Mongolia	United Arab Emirates
El Salvador	Montenegro	United Kingdom
Estonia	Morocco	United States of America
Eswatini	Mozambique	Uruguay
European Union	Myanmar	Vanuatu
Fiji	Namibia	Venezuela, Bolivarian Republic of
Finland	Nepal	Viet Nam
France	Netherlands	Yemen
Gabon	New Zealand	Zambia
Gambia	Nicaragua	Zimbabwe
Georgia	Niger	
Germany	Nigeria	

Previous World Trade Reports

The future of services trade

2019



Services have become the most dynamic component of global trade, yet the extent of services' contribution to global trade is not always understood. *The World Trade Report 2019* attempts to remedy this by examining how trade in services is evolving and why services trade matters.

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

2018



The *World Trade Report 2018* examines how digital technologies – 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 estimates how global trade may be affected by these technologies over the next 15 years.

Trade, technology and jobs

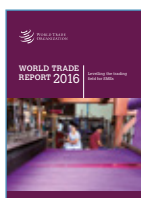
2017



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

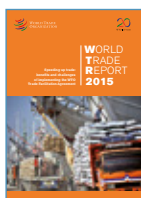
2016



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

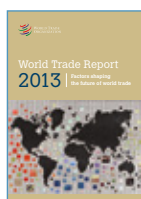
2014



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

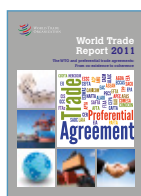
2012



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

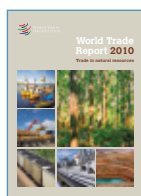
2011



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

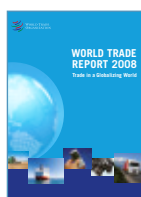
2009



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

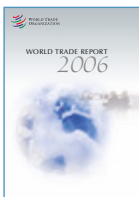
2007



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

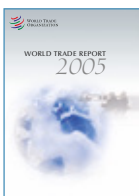
2006



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

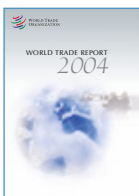
2005



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

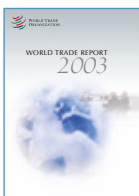
2004



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 2020

In the digital age, a growing number of governments have adopted policies aimed at boosting growth through innovation and technological upgrading. The *World Trade Report 2020* looks at these trends and at how trade and the WTO fit with them.

A defining feature of government policies adopted in recent years has been their support of the transition towards a digital economy. Trade and trade policies have historically been important engines for innovation. In particular, the multilateral trading system has contributed significantly to the global diffusion of innovation and technology by fostering predictable global market conditions and by underpinning the development of global value chains. As data become an essential input in the digital economy, firms rely more on intangible assets than on physical ones, and digital firms are able to reach global markets faster without the amount of physical investment previously necessary in other sectors. Success in the digital economy will depend on openness, access to information and communication technology (ICT) goods and services, collaboration on research projects, and the diffusion of knowledge and new technology.

The *World Trade Report 2020* shows that there is a significant role for international cooperation to make the pursuit of digital development and technological innovation more effective, while minimizing negative spill-overs from national policies. The WTO agreements, reached a quarter of a century ago, have proved to be remarkably forward-looking in providing a framework that has favoured the development of ICT-enabled economies across all levels of development. Further international cooperation at the WTO and elsewhere would enable continued innovation and reduce trade tensions to help international markets function more predictably.

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