SECTION 1

The digital trade era – challenges and opportunities for developing countries

Chapter 1

The impact of digital technologies on developing countries' trade

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Abstract

Using the World Trade Organization (WTO) Global Trade Model (GTM), a recursive, dynamic computable general equilibrium model, we examine the potential future impact of technological innovations, in the form of robotization and use of artificial intelligence (AI), servicification of the production process, and falling trade costs due to the rise of online markets and platforms on the trade of developing countries. The simulations show that technological change will boost trade growth, as a result of both falling trade costs and the more intensive use of information and communications technology (ICT) services. On average, between now and 2030 global trade growth would be 2 percentage points per annum higher as a result of digital technologies. Further, developing countries' trade growth would be 2.5 percentage points per annum higher and the increase in their share of global trade will be more pronounced the faster they are able to catch up technologically. Another finding from the simulations is that services exports will become a bigger part of global trade, making up more than a quarter of total trade by 2030, and technological changes tend to increase the share of services imports in manufacturing gross output. Finally, these technological developments do not appear to portend a reshoring or localization of production, suggesting that future technological change can go in hand in hand with continuing globalization.

** The contents of this chapter are the sole responsibility of the authors and are not meant to represent the position or opinions of the WTO or its members.*

Table 1: List of regions, sectors and factors of production

Regions	Sectors	Factors of production
ASEAN	Agriculture	Capital
Brazil	Chemical and petrochemicals	Land
China	Communication	Natural resources
European Union (28)	Electronic equipment	Skilled labour
India	Financial services and insurance	Unskilled labour
Japan	ICT services and consultancy	
Rest of Latin America	Other machinery and motor vehicles	
MENA	Metals	
Nigeria	Mining and extraction	
Other Asia	Other business services	
Other Developed Countries	Other goods	
Rest of the World	Other services	
SSA	Processed food	
United States	Trade	
	Transport	
	Utilities and construction	

On the production side, firms display profit maximizing behaviour, choosing the optimal mix of factor inputs and intermediate inputs. There are five production factors: high-skilled labour, low-skilled labour, capital, sector-specific natural resources and land. Capital accumulation is recursive dynamic. Hence, the current period capital stock is equal to the capital stock in the previous period minus depreciation plus investment. Investment flows to regions with higher rates of return. Capturing many features of the global economy in a detailed way requires us to abstract from one important feature: agents are not forward-looking and different periods are only connected through the adjusting stock of capital.

2. The baseline projection

To explore the impact of new technologies and digitalization, we need to compare that scenario with a baseline projection of the world economy until 2030. As noted in the previous section, this baseline assumes business-as-usual with the pace of technological change based on past trends. The baseline is constructed using projections about the future evolution of GDP per capita, population, labour force and skills up to 2030 that are available from various international sources and organizations. More specifically, GDP per capita growth is based on actual International Monetary Fund (IMF) data until 2014. From 2015 we use the Organisation for Economic Co-operation and Development (OECD) Shared Socioeconomic Pathways projections, SSP2 (Dellink et al., 2017). Data on population and labour force growth come from United Nations population projections, medium variant for 2015 (UN, 2015).

Introduction

In the last 30 years, technological advancements in information and communications technology (ICT), by supporting the development of digital markets and platforms, have significantly impacted the way in which goods, services and information are bought, sold and exchanged. More cross-border trade is now digital in nature – a trend that is likely to continue in the future.

Qualitative analysis can be useful to identify the ways in which these new technologies and digitalization can affect international trade. In this chapter, we complement this qualitative analysis with quantitative projections about changes in the size and patterns of international trade using the WTO Global Trade Model (GTM), a recursive dynamic computable general equilibrium (CGE) model with multiple sectors and production factors, intermediate linkages, non-homothetic preferences (consumer preferences in which expenditures shares for goods and services are not constant but vary with income), and investment linkages between countries (see Aguiar et al., 2019). This quantitative exercise serves three important goals. First, it disciplines the qualitative predictions, as it forces analysts to translate their storylines into quantitative "shocks" or changes in a micro-founded economic model. Second, the use of a general equilibrium model implies that the indirect effects of economic changes are all taken into account. And third, the fact that the model is computable makes it possible to go beyond qualitative predictions and provide quantitative projections on the magnitude of the effects of the new technologies on international trade.

"More cross-border trade is now digital in nature – a trend that is likely to continue in the future."

The GTM is used to explore the impact of three technological trends on the magnitude and patterns of international trade. The first trend is robotization and greater use of artificial intelligence (AI). AI can be defined as the ability of a digital computer or computer-controlled robot to perform tasks commonly associated with humans, such as the ability to reason, generalize or learn from past experience. Important branches of AI, such as machine learning, rely on computing power to sift through big data to recognize patterns and make predictions without being explicitly programmed to do so. The second trend is the more intensive use of ICT services by other sectors in the economy, which we term as "servicification".[1] The third trend we examine is the reduction in trade costs because of new digital technologies. Digital technologies are expected to reduce trade costs by improving customs procedures, increasing the efficiency of logistics and reducing the costs of communication and contract enforcement (for example, through the use of blockchain). Further, various studies have shown that trade costs for online trade, i.e. e-commerce, are lower than for offline trade (see, for example, Lendle et al., 2016).

In order to quantify the impact of new technologies and digitalization, we first construct a baseline scenario for the world economy up to the year 2030 in which the digital trends mentioned above are assumed not to gather speed over time. Instead, the baseline assumes business-as-usual with previous trends simply continuing to 2030. These business-as-usual developments include differential productivity growth across sectors based on past rates to capture the phenomenon of structural change, changing income elasticities as countries grow richer, changes in the trade to income ratio, and variation in the savings rate that depends on changing demographic or life cycle factors (Fouré et al., 2013).

The structure of the chapter is as follows. The next section describes the WTO GTM that is used to project the future impacts of these technologies on global trade, and then it presents the baseline scenario for the world economy when using gross domestic product (GDP), population and labour force projections from various international organizations. The following section discusses the emerging technological trends that are the focus of this chapter and describe how they are quantified and introduced into the GTM. The next section discusses the simulation results and compares the core and convergence scenarios with the baseline. Finally, the last section concludes.

Methodology

In this section, we first describe the model used and then the construction of the baseline, which could be characterized as a middle-of-the-road scenario for the global economy.

1. WTO Global Trade Model

The WTO GTM is calibrated to the Global Trade Analysis Project (GTAP) database, Version 9.2, which has 141 regions and 57 sectors, implying that baseline shares are equal to actual shares. We use an aggregation with 16 sectors, 14 regions and 5 factors of production, as displayed in Table 1. The sectoral aggregation includes the sectors of interest related to digitalization of the economy, such as telecommunications, business services and electronic equipment. The 14 regions, a mix of developing and developed countries from across the world, include the Association of Southeast Asian Nations (ASEAN), Brazil, China, European Union (28),[2] India, Japan, Rest of Latin America, Middle East and North Africa (MENA), Nigeria, Other Asia, Other Developed Countries, Rest of the World, Sub-Saharan Africa (SSA) and the United States. Of the 14 regions included in the simulation, 10 can be classified as developing,[3] which enables us to shed light on how the newly emerging countries are affected by digitalization.

Each region features a representative agent collecting factor income and tax revenues and spending this (under the assumption of utility maximization) on private consumption, government consumption and savings. Savings are collected by a hypothetical global trust, which allocates investment across different regions. In the simulations on the digitalization of the economy, one wants to take into account changes in foreign investment. This requires specifying how foreign investment flows across borders. In the simulations, we assume that investment flows across regions so that the rate-of-return on investment is equalized.

Changes in the number of skilled and unskilled workers are inferred from projections on education levels by the International Institute for Applied Systems Analysis (IIASA) (Samir and Lutz, 2017).[4] We use changes in the share of the tertiary educated as a proxy for changes in the share of skilled workers.

All the other parameters of the GTM are set at standard values provided by the GTAP 9.2 database. However, to allow for changes in the amount of land and natural resources employed, we assume supply elasticities equal to one for these factors. This means that prices for these resources need to rise by 1 per cent to coax out an additional 1 per cent increase in their supply. We depart from the standard GTAP specification in modelling savings[5] and instead follow the approach in Fouré et al. (2013) to model the gross savings rate as a function of GDP and demographic variables. Targeting the savings rates to the projections from a macroeconomic model makes the evolution of savings more realistic. We allow for differential productivity growth across sectors based on historical data; a detailed description of the estimation used to generate the trends is provided in Bekkers et al. (2018). The results of the baseline projection of the global economy up to 2030 are shown in Table 2. Global GDP growth per capita is projected to average 2.61 per cent per annum

Table 2: Baseline projection of global economy to 2030, per cent

	Average yearly growth from 2015 to 2030 of			
	GDP per capita	Population	Low-skilled labour	High-skilled labour
ASEAN	4.33	0.90	0.44	3.43
Brazil	2.69	0.64	0.30	2.26
China	5.98	0.19	-0.70	2.91
European Union (28)	1.51	0.06	-1.04	1.11
India	5.01	1.02	0.92	3.78
Japan	1.28	-0.35	-2.01	0.58
Rest of Latin America	2.60	0.96	0.63	3.01
MENA	2.81	1.39	1.02	3.92
Nigeria	4.04	2.47	2.42	5.59
Other Asia	2.58	1.18	1.09	2.94
Other Developed Countries	1.25	0.90	-0.47	1.26
Rest of the World	3.59	0.05	-0.59	0.42
SSA	3.36	2.52	2.85	5.51
United States	1.61	0.67	-0.34	0.94
Global	**2.61**	**0.93**	**-0.28**	**1.66**
Developing countries	**4.06**	**1.08**	**-0.56**	**5.13**

Source: GDP projections from OECD Shared Socioeconomic Pathways; Population from UN World Population Projections; high-skilled and low-skilled labour supply from IIASA, assuming that high-skilled are tertiary educated and low-skilled are primary and secondary educated.

Table 3: Overview of trends modelled in the core and convergence scenarios

Trends	Core scenario	Convergence scenario
Robotization and digitalization	Differential productivity growth by sector and region as a function of scope for technological change and digital readiness.	Differential productivity growth across sectors as in core scenario but with lagging regions catching up to 25 per cent best performing regions.
Servicification	Doubling of the share of ICT services and consultancy used by other sectors. Constant growth in the share across regions.	Doubling of the share of ICT services and consultancy used by other sectors. Faster growth in the share in lagging regions.
Falling trade costs	Reductions in iceberg trade costs as a result of new technologies and e-commerce. Identical reductions across different regions.	Reductions in iceberg trade costs as a result of new technologies and e-commerce. Trade costs in lagging pairs of countries converge to 25 per cent best performing pairs of countries.

until 2030, with developing countries' per capita GDP growing significantly faster at 4.06 per cent per annum.

Trends in digital technology

To study the impact of digitalization on global trade, we explore several trends associated with it quantitatively. They include the: (i) reallocation of tasks in production because of robotization and the use of AI; (ii) servicification of the production process from the increasing use of ICT services in the rest of the economy; and (iii) falling trade costs as a result of digitalization in logistics and the rise of e-commerce. For each of these, we develop a core scenario and a convergence scenario, where we assume there is a faster adoption of digital technologies by developing countries than in the core scenario (see Table 3). For each of the trends, we discuss the economic rationale behind its inclusion, the way we obtain the size of the future changes and how it is introduced and analysed in the GTM. A more detailed technical description with estimation results of these trends and relationships is provided in Bekkers et al. (2018).

1. Robotization and automation

The robotization or automation of production is increasing around the world. According to the International Federation of Robotics, there are more than 2.4 million industrial robots operating in factories around the world.[6] In the manufacturing sector alone, there are now 99 robot units per 10,000 employees, compared to the average global density of 66 units just a few years ago. The automotive industry is the largest customer industry with 30 per cent of total robots, ahead of electrical/electronics (25 per cent), metal and machinery (10 per cent), plastics and chemical products (5 per cent) and food and beverages (3 per cent). Asia is the world's largest industrial robot market, followed by Europe and the Americas. At the same time, AI is going mainstream as its deployment now extends beyond the technology sector. It can be seen as a form of automation in which the computing ability of machines is substituted for human intelligence and expertise (Aghion et al., 2019). Robotization and AI lift productivity but also make production more capital intensive (Acemoglu and Restrepo, 2018). One possible

implication of robotization and AI for trade is that even some labour-intensive goods currently produced in poor countries will eventually be reshored to capital-abundant counties as robots and AI make production there more cost-efficient.

Taking into account these ideas, robotization is introduced into the GTM in two ways. First, we exogenously increase the share of capital income until 2030 based on the historical trend. Second, we increase productivity growth in certain sectors and countries that current research suggests are likely to gain from automation (Bitkom and Fraunhofer, 2014; Boston Consultancy Group, 2015; Friedrich et al., 2011; McKinsey Global Institute, 2015). The leading sectors include financial services and insurance and the automotive sector, while the countries in the technology frontier include the European Union (28), Japan and the United States.

"Technological change will boost trade growth."

2. Servicification

One way in which digitalization is likely to affect the sectoral structure of production is through servicification, with the use of ICT services by other sectors of the economy growing over time. To project this trend into the GTM, we calculated the change in the share of ICT services – more specifically the share of "computer programming, consultancy and related activities" and "information service activities" – in the World Input-Output Database (WIOD) from 2000 to 2016 (Timmer et al., 2015). This share turns out to have doubled during the period. Thus, in the core scenario, we assume that the share of ICT services used by other sectors will grow at a constant rate of 3.8 per cent in all regions, which means that the share doubles in 15 years. In the convergence scenario, the share grows more rapidly in countries that start out with a lower share of ICT services.

3. Reduction in trade costs from digitalization and e-commerce

New technologies are expected to lead to a reduction of trade costs by improving efficiency in such areas as trade finance, logistics, and custom procedures and risk management (McDaniel and Norberg, 2019). For instance, blockchain could reduce the expense and time required to facilitate trade finance transactions that depend on third-party lending or insurance, as well as improve management of supply chains by providing real-time information on the origin and movement of goods. Blockchain may also be used to improve detection of illicit trade flows and deter illegitimate efforts to circumvent trade rules.

To calculate how much these new technologies are going to reduce trade costs, we employ a structural gravity structure (Head and Ries, 2001) and estimate how much logistics and other customs-related variables (taken from the World Bank's Doing Business database) affect trade. In the convergence scenario, we assume that countries with poor performance in terms of the different measures of logistics and customs converge to the level of the country that performs at a level equal to 75 per cent of the level achieved by the top performer.

In particular, we assume that laggard countries close half of the gap with the 75 per cent best performing country. In the core scenario, we assume identical trade cost reductions across regions and sectors, subject to the constraint that the trade-weighted average reduction in trade costs is identical to that in the convergence scenario.

The other important source of trade cost reduction from digital technologies is the creation and growth of online markets as more and more consumers and firms turn to these sites and platforms to make their purchases. The United Nations Conference on Trade and Development (UNCTAD) estimates that global e-commerce transactions in 2017 amounted to US$ 29 trillion, with the number of online shoppers growing to 1.3 billion people.[7] E-commerce transactions between businesses (B2B) accounted for 88 per cent of online transactions with business-to-consumer (B2C) sales accounting for the remainder. Slightly more than a tenth of all B2C sales in 2017 were cross-border e-commerce transactions, which reached a value of US$ 420 billion. The magnitude of these flows suggests that digital markets are creating trade opportunities for many countries.

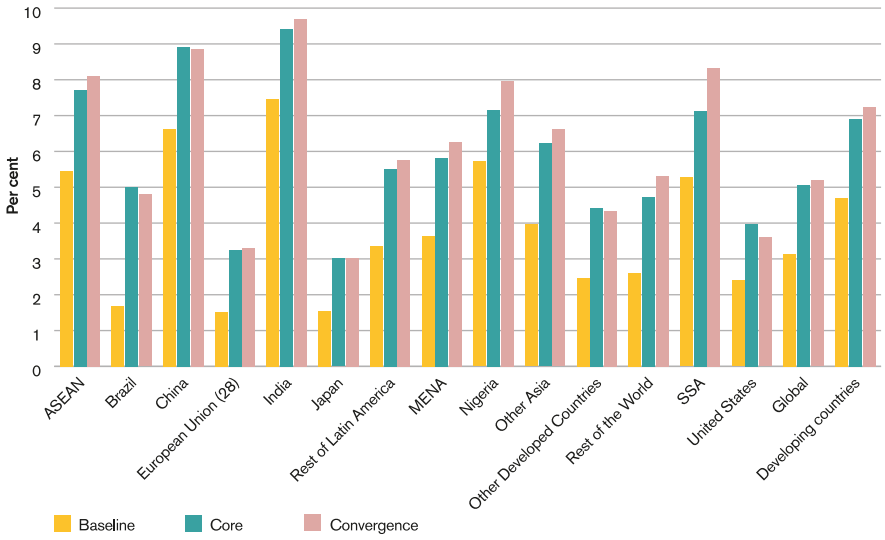
By reducing search costs, the internet and e-commerce platforms can facilitate market transactions, including cross-border trade (see e.g. Borenstein and Saloner, 2001; Cairncross, 2001). This is borne out by the empirical literature, which finds that e-commerce reduces distance-related trade costs (Ahn et al., 2011; Clarke, 2008; Freund and Weinhold, 2004; Hortaçsu, 2009; Lendle et al., 2016). E-commerce shrinks the distance between buyer and seller – by nearly a third according to Lendle et al. (2016) – facilitating more exchange.

To determine the reduction in trade costs from e-commerce, we first project the growth of e-commerce up to 2030. This is derived from regressing online sales in the European Union and in the United States on macroeconomic variables (GDP growth) and using the resulting coefficient estimates and our GDP projections from the OECD SSP2 to calculate their future growth. It is assumed that domestic and cross-border e-commerce grow at the same rate. Second, using the estimates of Lendle et al. (2016) that e-commerce reduces distance by a third, we back out the equivalent reduction in trade costs implied by the growth of e-commerce.

Simulation results

In this section, we combine the technological trends to generate a core scenario and a convergence scenario. The core scenario projects forward trends in the new technologies discussed earlier – robotization, servicification and digitalization that reduce trade costs. The convergence scenario differs from the core scenario in one significant way: it assumes more rapid catch-up of developing economies to the technological leaders. For example, in the case of robotization, we assume that lagging regions catch up to the top quartile (or 25th percentile). While we do not delve into what actions lagging regions need to take to catch up with the technological leaders, there is no shortage of proposals or ideas.[8] The core and convergence scenarios are summarized in Table 3.

Figure 1: Trade growth in the baseline and in the core and convergence scenarios to 2030



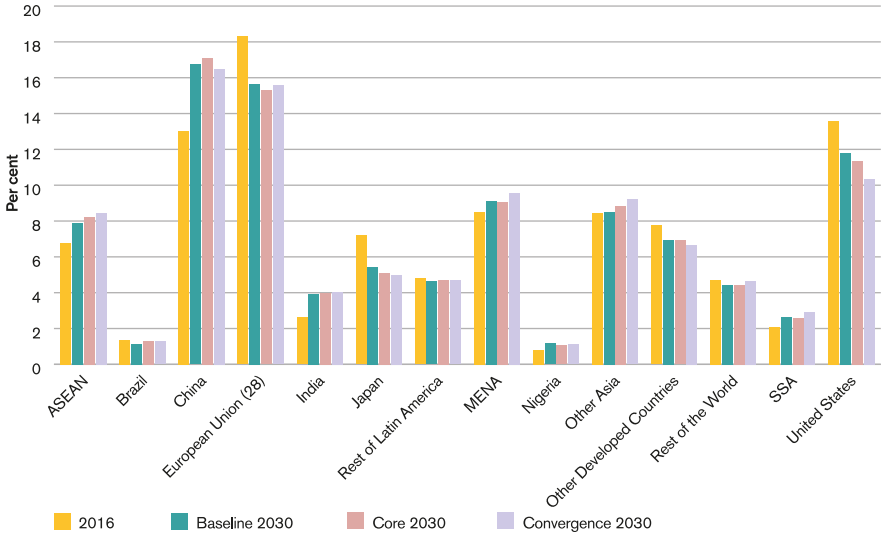
Source: GTM simulations.

We then examine the effect of digitalization, across the baseline, core and convergence scenarios, by comparing the trajectory of the following variables of interest: (i) annual trade growth; (ii) the share of developing countries in global trade; (iii) changes in the sectoral and geographical distribution of trade and production; (iv) the share of imported services in manufacturing output; and (v) the contribution of services and goods to total trade.

Figure 1 displays the impact of the technological trends on annual trade growth in the baseline, core and convergence scenarios. Trade growth is higher in all regions in the core and convergence scenarios, reminding us how international trade and technological change often go hand in hand. On average, annual trade growth is 3.14 per cent in the baseline, 5.07 per cent in the core scenario and 5.19 per cent in the convergence scenario. As expected, developing regions exhibit stronger trade growth in the convergence scenario, where we assume digital catch-up by developing countries up to the 25th percentile. Their trade grows 7.23 per cent per annum in the convergence scenario compared to 6.91 per cent in the core scenario and 4.70 per cent in the baseline scenario. This last result implies that countries that are currently not on the technological frontier are not trapped there and could make rapid advances in their trade.

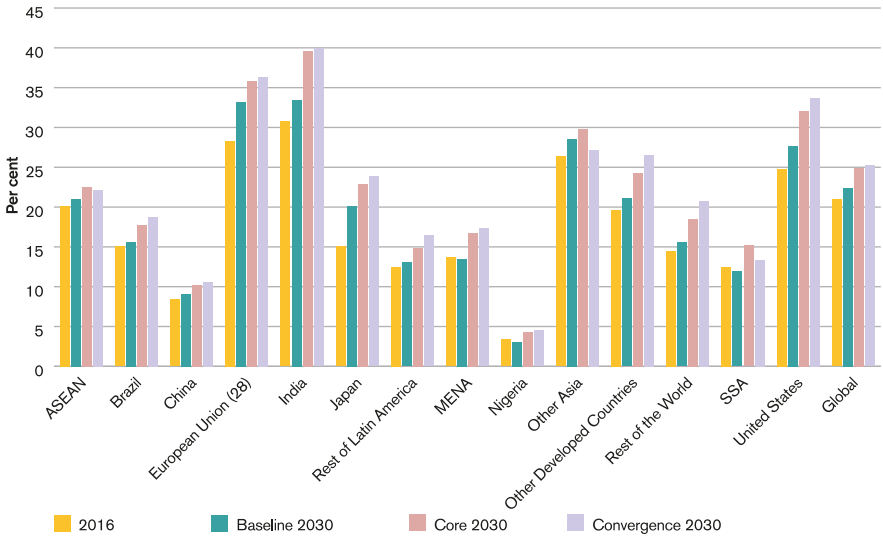
In Figure 2, we show the change in the regional shares in global exports. China continues to increase its share of trade and becomes the biggest exporter in the world. Developed economies like the European Union, Japan and the United States experience an erosion in their market share. Further, the figure

Figure 2: Country and regional share of global exports in 2016 and 2030 in the baseline and in the core and convergence scenarios



Source: GTM simulations.

Figure 3: Sectoral composition of global trade in 2016 and 2030 in the baseline and in the core and convergence scenarios



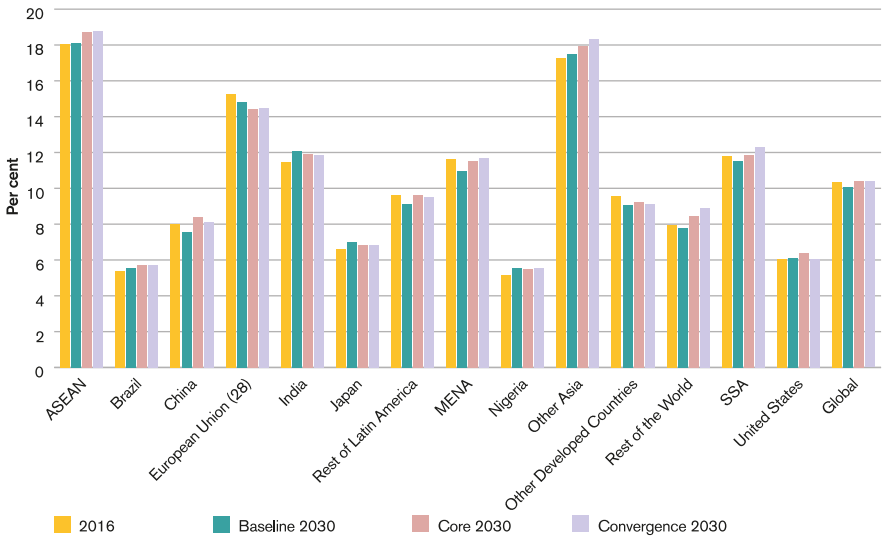
Source: GTM simulations.

shows that the export share of developing countries rises more in the convergence scenario than in the core scenario, suggesting some positive impact from technological catch-up. Their share of global exports rises to 62.4 per cent by 2030 in the convergence scenario, whereas it rises only to 61.3 per cent in the core scenario without catch-up. More notably, this pattern holds as well for SSA, whose share is projected to increase to 2.9 per cent in the convergence scenario compared to 2.6 per cent in the core scenario.

Figure 3 presents the change in the sectoral composition of global trade. The share of services in global trade rises for most regions in the baseline scenario, and more so in both the core and convergence scenarios. This is because trade costs fall more for the services sectors and servicification increases the use of services in the economy and thus also in trade. Globally, the share of services trade in total trade rises to 24.9 per cent in the core scenario and to 25.2 per cent in the convergence scenario, compared to 22.4 per cent in the baseline scenario.

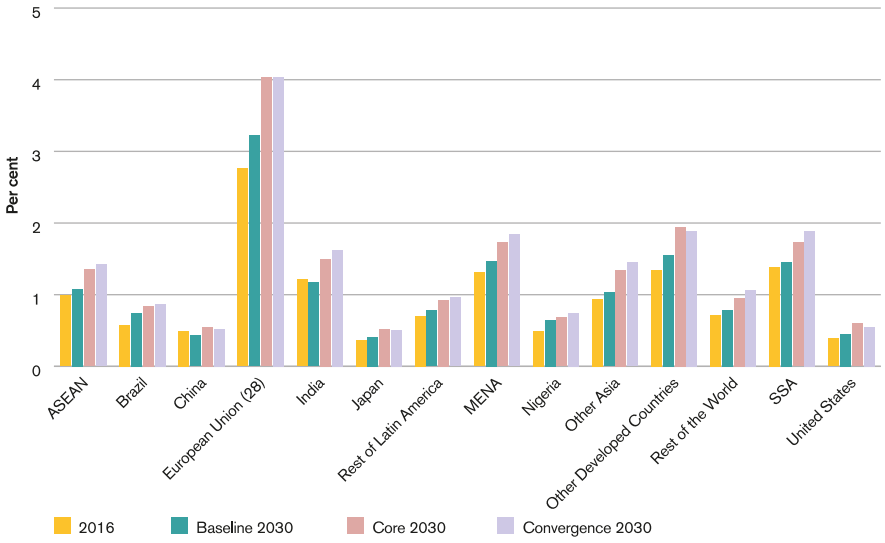
Figure 4 exhibits the impact of these technological trends on the organization of value chains. For most regions, the share of imported intermediates in gross output rises in both the core and convergence scenarios. This is because trade costs are falling, thus making it more attractive to employ imported intermediates in production. Further, Figure 5 displays the share of imported services in manufacturing (gross) output. The figure shows that technological developments have even stronger effects on the use of services imports in manufacturing, which results from the combination of falling trade costs and servicification

Figure 4: Impact of technological trends on the organization of value chains in 2016 and 2030 in the baseline and in the core and convergence scenarios: the share of intermediate imports in gross output



Source: GTM simulations.

Figure 5: Impact of technological trends on the organization of value chains in 2016 and 2030 in the baseline and in the core and convergence scenarios: the share of services intermediate imports in manufacturing gross output



Source: GTM simulations.

leading to more imports of ICT services. Some have argued that the growth of automation and other labour-saving technologies such as 3D printing may encourage multinationals to move towards localized supply chains and reduce production abroad (Gebler et al., 2014). However, this conjecture is not supported by our simulation results, as it does not appear that robotization or the rising share of capital in income in developed economies would lead to the reshoring of manufacturing activity and thus reduced imports of foreign intermediates.

In these figures, we find a substantial gap between the baseline and core scenario outcomes but not as big a difference between the core and convergence results. For instance, developing countries' trade grows at least two percentage points more per annum in the core scenario than in the baseline scenario (6.91 per cent annually compared to 4.70 per cent annually), but only 0.3 percentage points more in the convergence scenario compared to the core scenario (7.23 per cent annually compared to 6.91 per cent annually). One possible interpretation that can be put on this conclusion is that the global spread of digital technologies, even in the absence of significant technological catch-up by poor countries, is sufficient to cause a sizeable uptick in developing countries' participation in international trade. But even if this is the answer one draws, this does not mean that greater investments in ICT infrastructure and creating a policy environment more conducive to the digital economy are not priorities for developing countries. There are other valuable policy goals beyond trade – such as improving access to education and increasing innovation

and economic growth – that these policies will advance. The difference between the convergence and core outcomes – which is positive – is only one measure of the value of getting policies right on the digital economy.

Conclusion

In this chapter we examined the expected impact of new digital technologies on the international trade of developing countries until 2030. We employed a recursive dynamic CGE model to generate a baseline trajectory of the world economy based on GDP, population, labour force and skill projections from different international agencies. We then introduced the three trends associated with the development of digital technologies and that are likely to shape the future – robotization and adoption of AI, the servicification of the production process and the fall in trade costs due to the rise of e-commerce – into a core scenario. We also considered a variant, the convergence scenario, in which technologically lagging countries and regions are able to catch up to the technological level of the top quartile.

The simulation results we obtain lead us to the following observations.

First, technological change will boost trade growth. On average, between now and 2030 annual trade growth would be 2 percentage points per annum higher – 5.19 per cent per annum in the convergence scenario instead of 3.14 per cent per annum in the baseline – as a result of digital technologies. Over the same period, developing countries' trade would grow by 2.5 percentage points per annum more as a result of technology – 7.33 per cent per year in the convergence scenario compared to 4.7 per cent yearly in the baseline scenario. Developing countries' share of global trade increases in both the core and convergence scenarios but rises more in the latter scenario, with technological catch-up providing a significant tailwind.

Second, the share of services in global trade rises in both the core and convergence scenarios because trade costs fall more for the services sectors and servicification increases the use of services in the economy. By 2030, services would make up 25.2 per cent of total trade in the convergence scenario compared to 22.4 per cent in the baseline.

Finally, contrary to some conjectures, the rise of robotization and AI, which makes production more capital intensive, does not appear to portend a reshoring or localization of production from developing countries.

Endnotes

[1] We distinguish this process, which focuses on the greater use of services as inputs to manufacturing, from "servitization", which refers to manufacturers offering services as complements to or substitutes for the goods that they produce. See, for example, Lanz and Maurer (2015) and Crozet and Milet (2017).

[2] While this chapter was being finalized, the United Kingdom withdrew from the European Union on 31 January 2020. However, negotiations on the post-Brexit trade arrangement between the United Kingdom and the European Union (27) had not yet started, and thus it was not possible

to include a post-Brexit scenario in the baseline and counterfactual projections.

[3] The 10 regions are ASEAN, Brazil, China, India, Rest of Latin America, MENA, Nigeria, Other Asia, Rest of the World and SSA.

[4] IIASA is an international institute that conducts policy-oriented research into problems that are too complex to be solved by a single country or discipline – such as climate change, energy security and sustainable development. See https://www.iiasa.ac.at/.

[5] In the GTAP model, the utility of consumers is assumed to be a Cobb Douglas function of expenditures and savings so that savings is always a constant share of GDP.

[6] See https://ifr.org/downloads/press2018/Executive%20Summary%20WR%20 2019%20Industrial%20Robots.pdf.

[7] See https://unctad.org/en/pages/PressRelease.aspx?OriginalVersionID=505.

[8] They include expanding digital capabilities (e.g. broadband), investing in research and development (R&D), improving the legal and regulatory environment, upgrading the education and skills of the population, strengthening intellectual property protection, bolstering privacy and better protecting personal data, facilitating online payments, etc.

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