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Industries without smokestacks

Telecommunication and ICT-based services trade

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Abstract: This paper provides a basic understanding of the nature of emerging key information and communication technologies, and establishes the distance of countries from high-quality access to the internet—the necessary threshold one needs to cross in order to make use of such technologies. The paper underlines the importance of governments creating a more open and competitive environment to attract infrastructure investment (in terms of fibre-optic rings and cable links, among others), and foster rivalry among suppliers of devices and mainly services, thereby benefiting users with lower prices and better-quality services so as to steer societies away from being marginalized by the information and communication technology revolution.

Keywords: economic development, innovation, least developed country, technological change, growth
JEL classification: L86, L96, O10, O33

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1 Introduction: moving towards the new economy

It is unquestionable that we are witnessing a major technological revolution, with respect to which the medium- and long-term economic and social implications are not yet clear. Even if one agrees with the view advanced by Robert J. Gordon[1] that the improvements in economic welfare and wellbeing of earlier broad-based innovations (1870–1970) far surpasses the gains delivered by the spate of new information and communications technologies (ICTs), the latter is having an unmistakable effect on families, firms, and governments.

ICTs have shortened distances; allowed for instantaneous communications across the globe at a quasi-zero cost; improved to an unimagined degree access to information; and led the creation of a myriad of new business ventures. ICTs are also promoting collaborative arrangements in physical and virtual spaces to mobilize people, and channel resources, time, and energy to economic endeavours, and social and political causes.[2] It is important to underline that—as defined in this paper—ICTs are a new set of technologies (and platforms) that cannot be considered to be among computers and telecom services considered 'state of the art' until the mid to late 1990s.

These new technologies—as described in Section 2—are nothing short of revolutionary. They facilitate the creation, diffusion, *and* use of new ideas and products, empowering users in their capacities as citizens, producers, and consumers, as well as managers of firms, cities, and governments. Countries will be faced with the challenge of creating an environment that is conducive to appropriating these technologies—no matter where generated—and ensuring that their population is connected and has the means to use the available innovations. The very concept of a 'knowledge-based economy'[3] will change: using the new ICTs proficiently will possibly be of greater relevance than generating them from both a production and trading perspective.

For developing countries, the new-generation ICTs open the opportunity to at least partially bridge the gap with advanced economies, to the extent that such ICTs will be both more affordable and user-friendly. A fundamental step is to lower transaction costs, remove the barriers to the local supply of devices and services, and undertake joint public–private initiatives to radically facilitate connectivity with the internet. The more fluid is the access to and exchange of information, the more individuals, firms, and governments will be able to explore the opportunity frontier in terms of ideas, markets, and solutions to citizens' problems.

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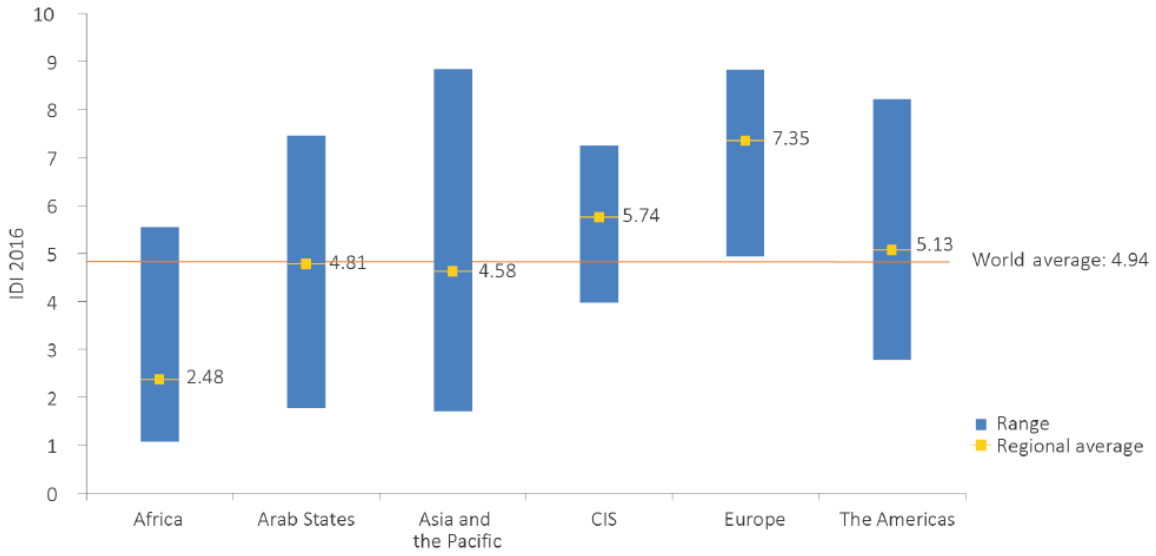
[1] See, for instance, Gordon (2016). He argues that total factor productivity (TFP) gains arising out of earlier advances (1920–70) would be over three times that observed since 1970.

[2] An ITU study concerning the impact of broadband diffusion on productivity and economic growth concludes that the contribution is significant and tends to increase with the so-called 'network effects' (ITU 2012) See also World Bank (2009) and the major new World Bank (2016) publication on the subject.

[3] For earlier views, see Abramowitz and David (1996).

ICTs hold the greatest promise for poorer countries. Yet the distance from the more advanced economies remain significant, with Africa in the lowest bracket and significantly below the world (Figure 1).[4]

Figure 1: ICT Development Index (IDI) by region compared with the global average, 2016



Source: ITU—*Measuring the Information Society Report*, 2016.

The objective of this paper is to provide a basic understanding of the nature of emerging key ICT technologies, and establish the distance of countries and their citizens from high-quality access to the internet—the necessary threshold one needs to cross in order to make use of such technologies. Having crossed the threshold, there are many possibilities, including the export of services, which was once the realm of very few developing countries—those with an elastic supply of English-speaking skilled labour.

Following this introduction, Section 2 lists and briefly discusses the ongoing ICT revolution and its dominant feature: *connectedness and mobility*. No single paper would be able to list the innovations streaming from individuals, laboratories, and firms, at what appears to be an increasing rate. At this point, it is also still unclear whether such innovations will allow developing countries to significantly bridge the distance to developed and emerging economies, while strengthening their position in the production and export of goods and services. Still, some early evidence shows a narrowing trend, taking into account the dissemination of the

[4] See ITU (2016). The IDI—which aims to reflect ICT development—is calculated by combining a total of 11 indicators on: ICT infrastructure and access (fixed telephone subscriptions, mobile-cellular subscriptions, international internet bandwidth, percentage of households with a computer, and percentage of households with internet access); use (percentage of individuals using the internet, fixed-broadband subscriptions, and active mobile-broadband subscriptions); and skills (mean years of schooling and gross enrolment ratio). For the calculation of the IDI, the indicators are weighted (ICT access and ICT use 0.4 each, and ICT skills 0.2), resulting in an IDI value between 0 and 10. Note that the concepts of 'access' and 'use'—and their components—do not have a universal meaning and are sometimes used interchangeably in the literature.

smartphone, the multipurpose technology that may indeed help developing countries come closer to the frontier.

It is axiomatic that only by *accessing* the internet will countries be able to use ICT-related innovations. Access fundamentally depends on the ability to connect to mobile, Wi-Fi, cable, radio, and other networks, using the most efficient means—broadband (as opposed to earlier technologies, such as ADSL-based dial-up services). In Section 3 the discussion focuses on where countries stand with respect to access and use of broadband services and along their quality gradient. It is unquestionable that progress has been made on both fronts, though it appears that coverage has moved faster than quality, quasi-universally measured by the speed at which data are transmitted. This paper thus describes the *connectivity frontier* based on two parameters—the extent of broadband coverage and transmission speeds—and measures the distance countries stand from the frontier and over time.

Section 4 defines the new *access paradigm*—the ICT foundation for connecting people and markets—that will enable a far larger number of countries to enter service export markets, moving beyond the more traditional outsourcing model, of which India is the most successful case. The question therefore is how to provide high-quality, affordable, safe connection to the internet to the vast majority of the population of developing countries.

This final section underlines the importance of creating a more open and competitive environment to attract infrastructure investment (in terms of fibre-optic rings and cable links, among others), and foster rivalry among suppliers of devices and mainly services, thereby benefiting users—be they individuals, firms, or governments—with lower prices and better-quality services. Although important for all countries, it is critically so for developing economies.

But governments in coming years will have to do more, namely attracting major players such as Alphabet and Facebook, to partner in the provision of cost-effective infrastructure and service provision. These companies have the potential to transform the ICT environment by providing access at quasi-zero cost in order to expand 'viewership', which can be made consistent with the public interest. Governments would need to think outside of the box—while looking for public–private partnerships—if they are to successfully steer their societies from being marginalized by the ICT revolution and make the most intelligent and effective use of the stream of new technologies changing the global economic, social, and political landscape.

2 The ICT revolution in brief

Few would question that there is an ongoing revolution in the ICT space, with momentous and unclear implications for the way we live, interact, consume, produce, and manage firms, cities, and other jurisdictions. Analysts struggle to bring together in a coherent way the implications for humanity of the flow of innovations due to the difficulty of establishing both their direct and indirect effects beyond the short-term. Thus, any synthesis, as attempted in this section, is fraught with difficulties.

One way to visualize the changes is to think about successive layers.

- The core of the 'onion' is the process of *codification and digitalization of information*, now five to six decades old, and which allowed information to be processed by digital computers. For many years this stood at the centre of technological change. In the 'computer age', the basic relationship was between people (and organizations) (P) and the machine (with its prohibitive innards—the integrated circuit, and the software to run and perform tasks) (M): *P to M*.
- The second layer was built around *connectivity and mobility*, promoted fundamentally by the growing ubiquity of smartphones. It is now at the centre of the ICT revolution. The machine functionality relies on applications (apps) most of which are free and immediately accessible, a far cry from the earlier age of the computer and unfriendly software languages. All transactions are migrating to hand-held devices: selling and buying in marketplaces and through e-commerce; paying, borrowing, and depositing with financial institutions, bank and non-bank; interacting with government and other institutions; and becoming active parts of social networks. The organization is no more at the centre, but civil society and individual initiatives backed by an expanding universe of opportunities. The connectivity and mobility layer may be summarized by the notion of people to people (*P to P).*
- The third layer is in the making: the *internet of things* (IoT), allowed by the collapsing prices of sensors, data processing, and connectivity, this time among sensors. Although wearables drew attention, far more relevant is the fact that the IoT technology allows all human and machine processes to be instantaneously monitored. It might sound like the Brave New World, but in fact has enormous implications for the sustainability of human life on Earth, with the potential not only to measure and monitor the footprint of human activity, but to make cities and other agglomerations far more 'intelligent', economizing on resources and optimizing their allocation. This would be Big Data at work. In this layer, the dominant relationship is sensor to sensor: *S to S*.
- The final layer—the contours of which can only be sensed today—will be driven by *artificial intelligence*, the ability of machines not only to operate without human intervention, but to learn, reason, and correct 'mistakes' by interacting with the environment and other machines. Individual robots are not exactly the expression of this outer layer, although they do capture the imagination, mainly as humanoids; it is the unmediated relationship among learning and adapting machines that will characterize this ICT. In this coming era, the fundamental relationship is machine to machine, without—costly and inefficient—human intervention: *M to M*.

At this juncture it is the second layer and its implications that are of most interest. It is *mobility with connectedness* centred on the smartphone that will possibly bring the most relevant changes for developing economies. Massive digitization of information (voice, data, images); being transmitted at increasing speeds; stored and processed at faster rates; and use of which—for production, trade, education, and entertainment activities—is being carried to ever more friendly environments, causing changes that may improve the lot of firms and entrepreneurs in developing countries. A glimpse of ongoing transformation is captured by the projected growth of internet protocol (IP) traffic globally, and the increase in mobile share (Table 1).

Table 1: IP traffic by type and mobile share, 2015 (actual), 2016–20 (projected), petabyte per month

Global IT traffic	2015	2016	2017	2018	2019	2020	CAGR 2015–20 (percentage)
Fixed internet	49,494	60,160	73,300	89,012	108,102	130,758	21.5
Managed IP*	19,342	22,378	25,303	28,155	30,750	33,052	11.3
Mobile data	3,685	6,180	9,931	14,934	21,708	30,564	52.7
Total	75,521	88,719	108,533	132,101	160,561	194,374	20.8
Mobile share (percentage of total)	5	7	9	11	14	16	–
Smartphones share (percentage of mobile access)	89	91	93	95	97	98	–

Note: 1 PB (petabyte) = 1,000,000 GB (gigabytes); * includes corporate IP WAN (wide area network) traffic and IP transport of television and video on demand (VoD). CAGR = compound annual growth rate.

Source: Based on data from Cisco (available at www.cisco.com/c/dam/en/us/solutions/collateral/service-provider/visual-networking-index-vni/complete-white-paper-c11-481360.pdf?referring_site=RE&pos=4&page=http://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/mobile-white-paper-c11-520862.html) and author's own calculations.

It is thus important at the outset to underline that mobile technology is the pre-eminent multipurpose technology in the world. Its dissemination has reached a point that one can envision that most of the population in developing countries will have in their hands smartphones (and their variants, such as phablets) capable of connecting them to people, markets, and services, and not radically different to those living in developed countries. Prices are falling while the realm of potential applications is fast expanding, with more than an estimated two million apps (!) available for Android and iOS operating systems (Table 2).

Table 2: Global average selling prices of smartphones worldwide and the number of apps available in major app stores (approximate value), 2010–16

	2010	2011	2012	2013	2014	2015	2016*	CAGR (percentage)
Average smartphone prices (US$)	440	420	381	333	310	305	283	–7.1
Google Play (thousands of apps)	38	200	500	850	1,300	1,400	2,200	96.7
Apple Store (thousands of apps)	150	425	585	850	1,200	1,500	2,000	54.0

Note: * Projection.

Source: author's own calculations based on data from Statista (available at www.statista.com).

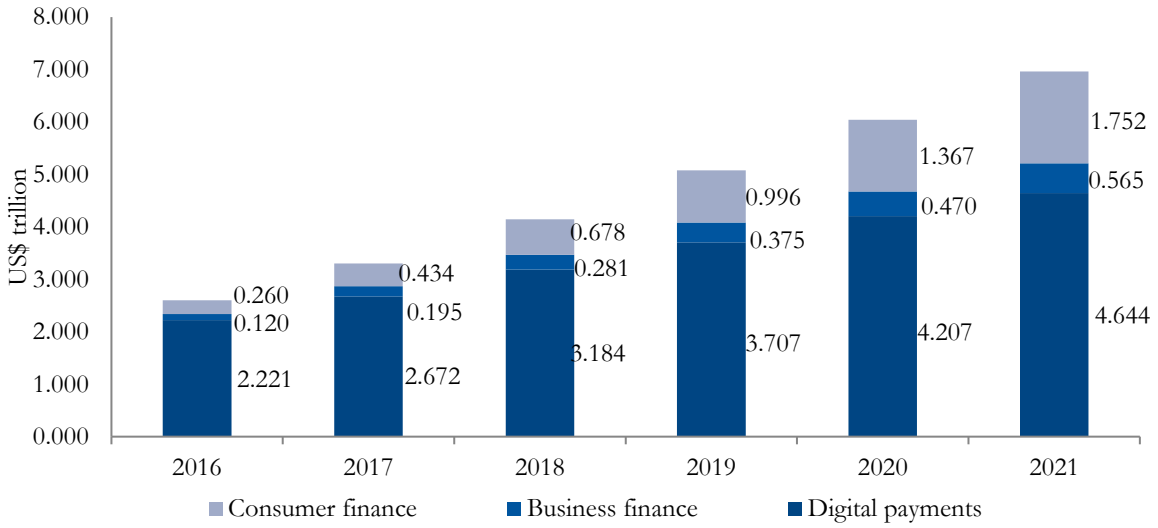
Maybe the most important aspect is how *user-friendly* most applications are, which allows people with limited education to search for and manipulate information; transact in multiple virtual spaces; and substitute services for goods in economic activities.

- Information is the building block of knowledge: accessing it with the help of *search engines* (Google, Yahoo, Bing, Baidu in China, and Yandex in Russia) has already radically transformed the way people purposely strive for economic citizenship. And the intelligent use of information is leveraged by distance education as it becomes more

available and affordable, allowing people to be educated and trained at a fraction of the usual cost.

- Transactions that used to occur in physical settings are occurring on virtual platforms such as *marketplaces*, Amazon and Alibaba being the quintessential examples, in addition to eBay and Flipkart (the latter in India). They perform two fundamental roles: e-commerce and, as importantly, hosting virtual stores at quasi-zero cost, which dramatically lowers entry barriers.
- *Fintechs*, capable of providing in the digital realm multiple financial services, an instrument of financial inclusion and business transaction facilitation, will likely capture a growing share of digital payments, business, and consumer finance, without resort to physical banks and branches. It is estimated that between 2016 and 2021, *Fintechs* will grow at an average annual rate of 21.1 per cent, and achieve approximately US$7 trillion in transaction value, with the fastest expansion in consumer finance (Figure 2).

Figure 2: Transaction value in the Fintech market, 2014–19 (US$ trillion)

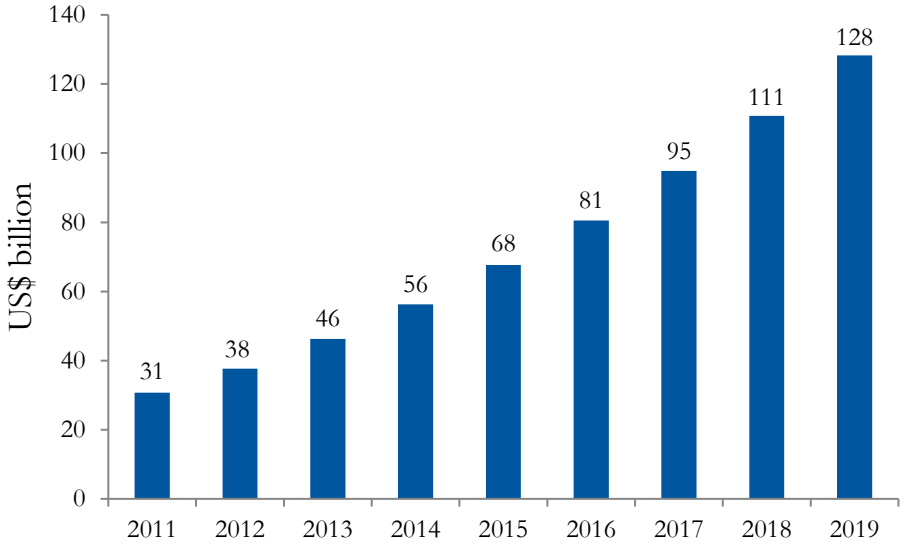


Source: author's own elaboration based on data from Statista (available at www.statista.com/outlook/295/100/fintech/worldwide#).

Finally, the very nature of economic activity is changing:

- With distance manufacturing, one will be able to export concepts, ideas, designs, and prototypes—the latter helped by 3D printers—and materialize them close to consumers.
- With fast-growing cloud computing (Figure 3), one does not need in-house or even nearby data-processing machines and/or facilities—only connection to such facilities irrespective of their location; and ditto for storage space, as long as one is connected to remote storage facilities.

Figure 3: Size of cloud computing and hosting market worldwide, 2011–19 (US$ billion)



Source: Author's own elaboration based on data from Statista (available at www.statista.com/statistics/500541/worldwide-hosting-and-cloud-computing-market/).

These technologies are convergent in a fundamental sense: they point to facility of use and lower entry barriers, as initial fixed costs of setting up (and operating) a business venture or a manufacturing facility are substituted for variable costs, namely the purchase of a service.[5] To take advantage of them, the first step is to connect to the internet, and connectedness has been at the core of 'digital inclusion'.

3 Access to information and the connectivity imperative

It should be said at the outset that although ICTs are having a transformative effect on a global scale, many if not most countries still face significant barriers to their most effective use.

First, the level of education and degree of literacy, which were once quasi-binding barriers, have been softened by the ICT revolution through a multiplicity of user-friendly applications, starting with search engines and the ability to look for answers for literally any question. Yet basic skills remain an important lever to make effective use of such technologies and appropriate extant opportunities. Second, trade and regulatory barriers that, if not impeding, make it more difficult and costly for people to purchase devices (mobile and otherwise), and connect themselves to the internet with the help of broadband providers. Finally, the provision of physical

[5] It is, of course, possible to make the contrary argument, as many point to an emerging fourth industrial revolution, with intelligent systems-driven manufacturing based on intense machine-to-machine communications, the widespread use of robots, and other frontier components (see, for instance, Brynjolfsson and McAfee 2015). This being the case, developing countries would be left behind not only due to the difficulties inherent in using and maintaining such complex manufacturing technology, but the fact that the process becomes more knowledge intensive and value migrates to intellectual property products.

infrastructure—such as energy—is quite critical, although numerous initiatives are attempting to simplify the requirements for the use of new-generation ICTs.

Increasingly (as argued in Section 4), integration into global information, production, and trade networks will depend on enlightened policies and bold public–private initiatives, as well as governments giving up pursuit of contradictory objectives such as protecting telecom incumbents against new service providers or raising revenues by taxing imports of devices. Aligning policy and assuming a proactive stance to enable citizens in developing countries to cross the access threshold is the first step to moving towards a gradual convergence of opportunities across the digital—and income—divide.

While the convergence over the 'digital divide' is still in the future, the ongoing ICT revolution launches some bridges across the development chasm. Crossing them depends on developing countries closing in on the *connectivity* frontier—defined in terms of the extent of internet access and the corresponding speed.

Let us discuss each in turn, beginning with the degree of broadband coverage. In this respect there have been pronounced gains among developing and emerging economies, mostly centred on mobiles (Table 3). Taking two extremes from a regional perspective, in Europe in 2010 the sum total of fixed and mobile broadband subscriptions per 100 inhabitants was 54.1, expanding to 107.8 in 2015; in Africa the gains were far more pronounced, from 2.0 to 17.9, with the Europe/Africa ratio decreasing from 27 to 6 in five years. There is still a considerable gap, but progress in access seems unmistakable.

Table 3: Broadband subscribers (per 100 inhabitants), mobile, fixed, and total, major regions, 2005, 2010–15

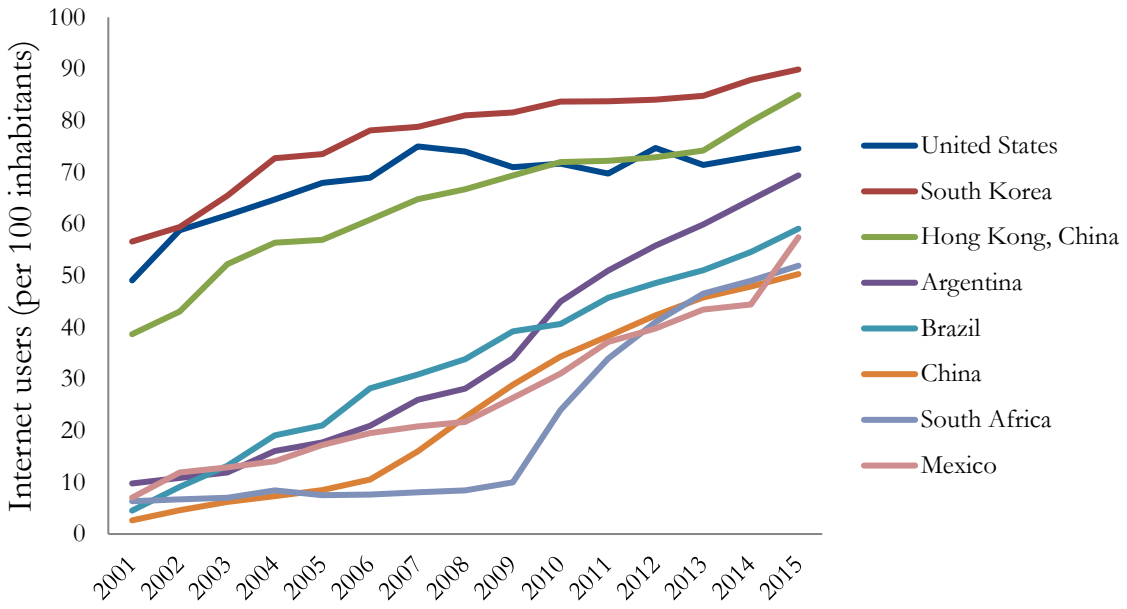
Region	Type	2005	2010	2011	2012	2013	2014	2015	2016*	CAGR 2010–15
Africa	Mobile	N/A	1.8	4.6	8.5	10.3	13.3	19.0	29.3	59.2
	Fixed	0.0	0.2	0.2	0.2	0.3	0.4	0.5	0.7	23.2
	Total	0.0	2.0	4.8	8.7	10.6	13.7	19.5	30.0	57.0
Arab states	Mobile	N/A	5.1	13.1	16.1	27.3	35.5	42.8	47.6	45.1
	Fixed	0.3	1.9	2.2	2.6	3.2	3.6	4.2	4.8	16.7
	Total	0.3	7.0	15.3	18.7	30.6	39.1	47.0	52.4	39.9
Asia and Pacific	Mobile	N/A	7.4	11.0	15.3	18.5	29.4	37.7	42.6	33.9
	Fixed	2.2	5.5	6.4	7.0	7.8	7.9	8.9	10.5	11.4
	Total	2.2	12.9	17.4	22.3	26.3	37.3	46.6	53.1	26.6
Europe	Mobile	N/A	30.5	39.4	49.1	56.1	65.6	72.8	76.6	16.6
	Fixed	10.9	23.6	24.8	25.7	27.7	28.3	29.2	30.0	4.1
	Total	10.9	54.1	64.2	74.8	86.0	93.9	102.0	106.6	12.0
Americas	Mobile	N/A	24.6	34.1	41.9	55.7	67.3	74.6	78.2	21.3
	Fixed	7.5	14.0	15.0	15.8	17.0	17.5	18.4	18.9	5.1
	Total	7.5	38.6	49.1	57.7	72.7	84.8	93.0	97.1	16.6

Note: * estimated.

Source: based on ITU data (available at www.itu.int/en/ITU-D/Statistics/Pages/stat/default.aspx) and author's own elaboration.

World Bank data allow a look at actual use (not controlling for type of access), namely the proportion of internet users for individual countries (Figure 4). In the last 15 years, emerging economies have narrowed the gap with respect to the United States, South Korea, and Hong Kong, with coverage growing at far faster rates. Indeed, while coverage in the United States grew by 4.5 per cent per annum (pa), South Africa expanded by 17 per cent pa, and China attained a rate of 25.3 per cent pa, with half the population still with limited use. Quasi-universal coverage—that is 85 per cent of the population—will likely be achieved within the next decade.

Figure 4: Internet users per 100 inhabitants,[6] 2001–15, developed and emerging economies

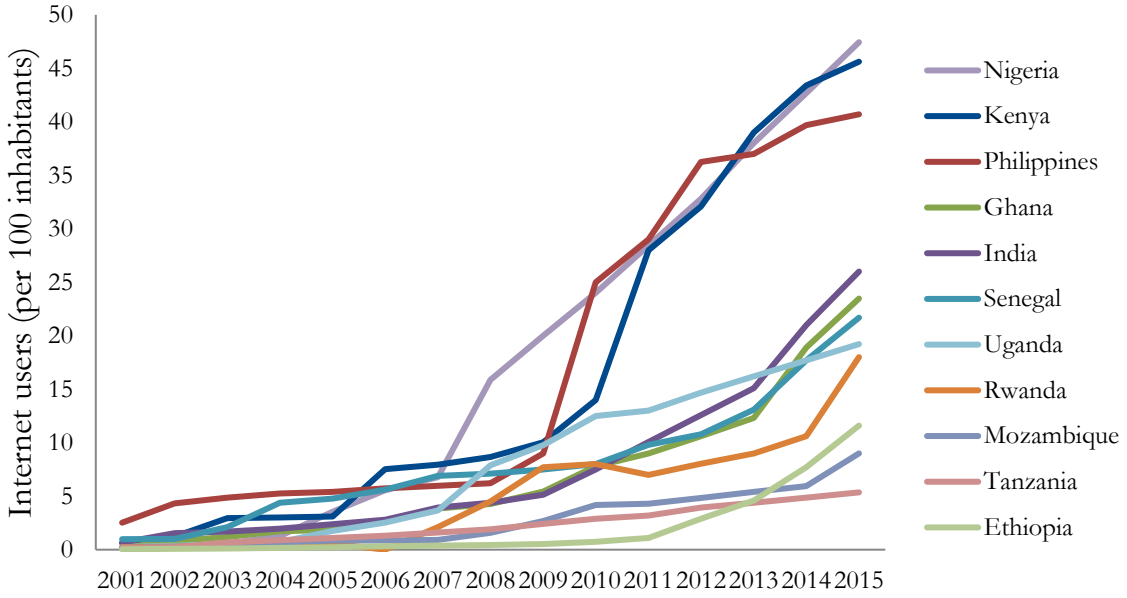


Source: author's elaboration based on World Bank data (available at http://databank.worldbank.org/data/reports.aspx?source=2&series=IT.NET.USER.P2&country=#).

During that 15-year period, sub-Saharan countries have also made major strides, with Nigeria, Kenya, Ghana, and Senegal becoming good examples of countries growing from very small bases (Figure 5). Kenya's growth of internet use in such a relatively short period is impressive—as is that of Ghana, Senegal, and Rwanda. It is no coincidence that a number of significant mobile-based services initiatives have taken place in Kenya, for internet access and use is fundamentally a phenomenon of the diffusion of mobile devices, mostly smartphones (and advanced 3G/4G networks).

[6] Defined by the World Bank as individuals who have used the internet (from any location) in the last 12 months, via computer, mobile phone, personal digital assistant, games machine, digital TV, etc.

Figure 5: Internet users per 100 inhabitants, 2001–15, developing economies

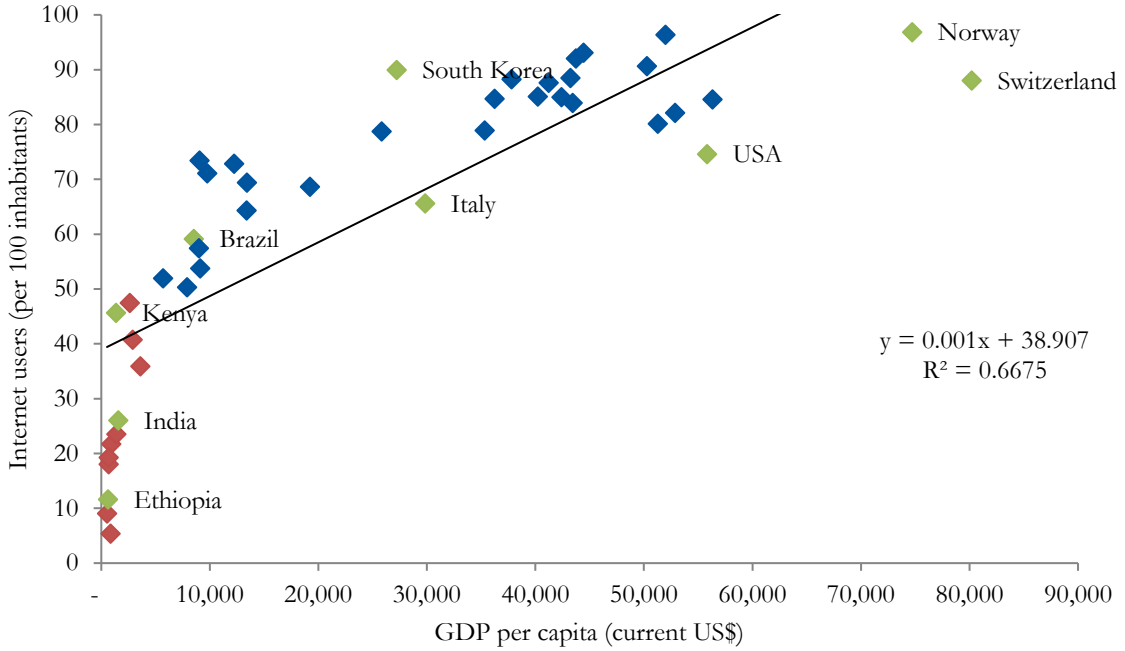


Source: author's elaboration based on World Bank data (available at http://databank.worldbank.org/data/reports.aspx?source=2&series=IT.NET.USER.P2&country=#).

Figures 6 and 7 provide a complementary assessment of cross-country differences relating internet use to gross domestic product (GDP) per capita. Among the more developed economies, South Korea stands out; in the developing economies cluster, Kenya and Nigeria are indeed 'above the curve'.[7] It is noteworthy that India, often regarded as a country with important initiatives with respect to digital inclusion, appears to be significantly below the curve in view of its very large rural population below the poverty line, living in areas under-serviced by basic infrastructure. It also calls attention to the fact that use seems to be invariant at low levels of per capita income, with other factors at work to explain cross-country differences, including supply-side elements that determine the price and availability of equipment and services (see Section 4).

[7] See Schumann and Kende (2013). A combination of government ability and commitment to attract infrastructure investment (such as the East African Submarine Cable System sponsored by the World Bank and the Development Bank of Southern Africa, and the East Africa Marine System, the responsibility of the Kenyan government, with collaboration from Etisalat Emirates Telecommunications Corporation) and open up to a variety of service providers (as well as device suppliers) has been instrumental in making Kenya a standout in Africa, with the highest bandwidth per person in Africa, the fastest speeds, and one of the lowest costs for use of the internet.

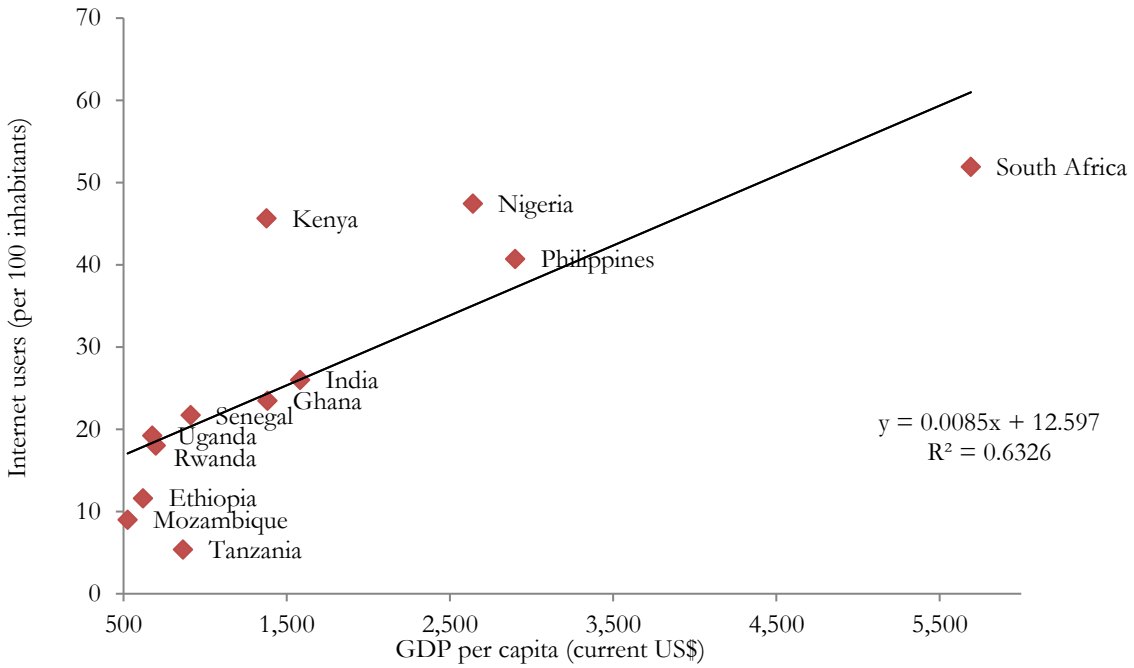
Figure 6: Internet users per 100 inhabitants and GDP per capita, selected countries



Note: Selected countries are: South Africa, Germany, Argentina, Australia, Austria, Belgium, Brazil, Canada, Chile, China, South Korea, Denmark, Egypt, Spain, United States, France, Netherlands, Hong Kong, Hungary, India, Ireland, Israel, Italy, Malaysia, Mexico, Norway, Poland, Portugal, United Kingdom, Russia, Singapore, Sweden, Switzerland, Turkey, New Zealand, Kenya, Ghana, Senegal, Mozambique, Ethiopia, Rwanda, Tanzania, and the Philippines.

Source: author's elaboration based on World Bank data (available at http://databank.worldbank.org/data/reports.aspx?source=2&series=IT.NET.USER.P2&country=#).

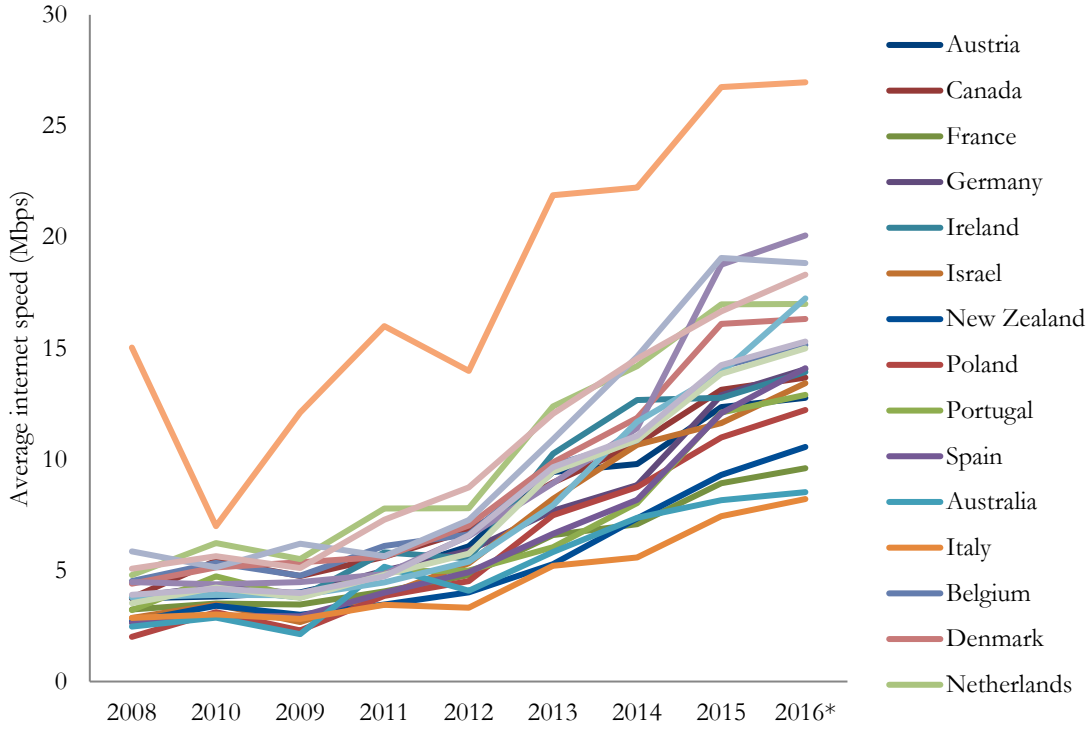
Figure 7: Internet users per 100 inhabitants and GDP per capita, developing countries subset



Source: author's elaboration based on World Bank data (available at http://databank.worldbank.org/data/reports.aspx?source=2&series=IT.NET.USER.P2&country=#)..

In this paper, *quality* of access is measured by data transmission speeds (Figures 8 and 9). While average speeds have increased, the relative gap between the more advanced and other economies seems to have widened in recent years, most likely due to the fact that speed suffered as coverage increased; most providers announce maximum speeds but traffic moves at far lower average speeds. Although coverage, driven by the dissemination of mobile devices, initially outpaced the ability of telecoms and providers to offer high-quality access, they seem to be catching up. Increasing speed generally depends on infrastructure investments, the return on which until recently was less attractive unless one could find a large number of paying users willing to purchase traditional broadband and related services. A number of public and private initiatives targeted at developing economies are attempting to provide low-cost, high-quality (mobile) connections in order for them to jump the speed barrier that separates them from developed countries.

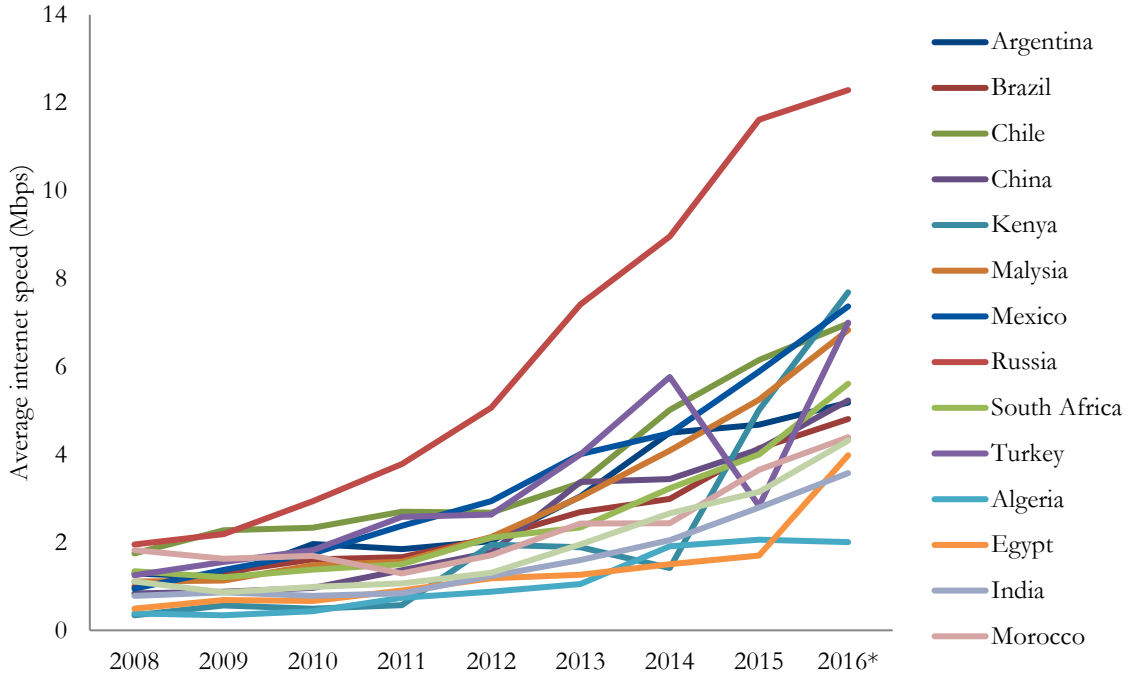
Figure 8: Average speed (megabytes per second (Mbps), 2008—16, selected countries



Note: numbers for 2016 refer to 2Q16.

Source: author's elaboration based on Akamai Faster Forward, 'The State of the Internet' quarterly reports (avaliable at www.akamai.com/us/en/our-thinking/state-of-the-internet-report/state-of-the-internet-connectivity-visualization.jsp).

Figure 9: Average speed (Mbps), 2008–16, selected emerging and developing economies



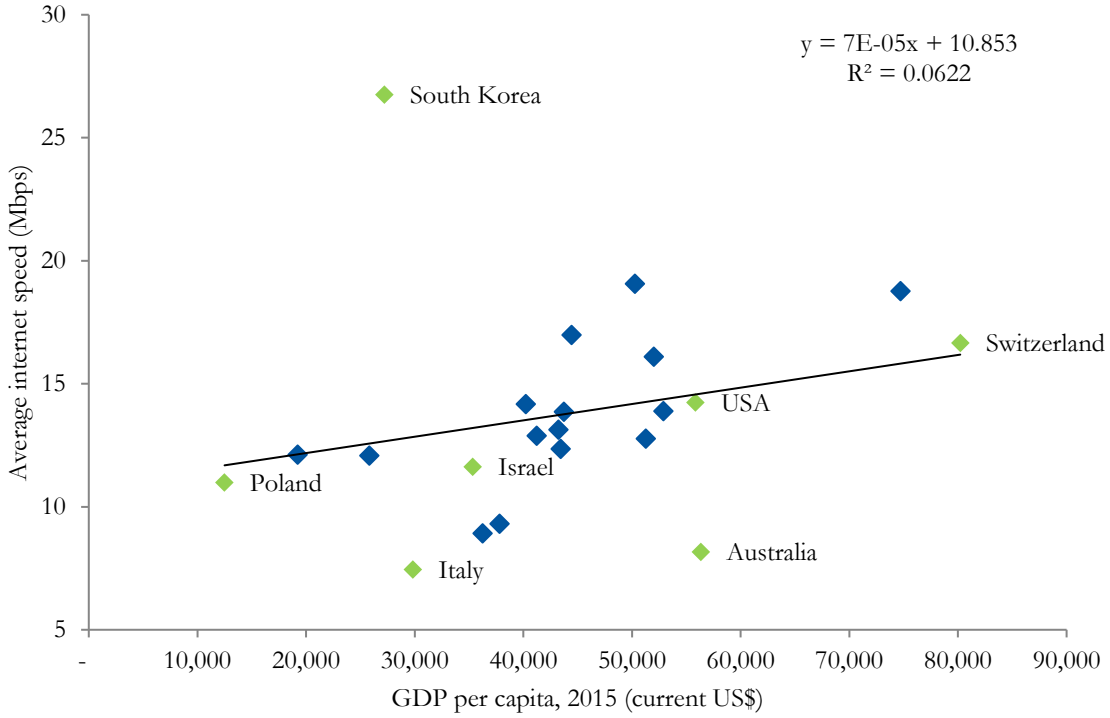
Note: numbers for 2016 refer to 2Q16.

Source: author's elaboration based on Akamai Faster Forward, 'The State of the Internet' quarterly reports (avaliable at www.akamai.com/us/en/our-thinking/state-of-the-internet-report/state-of-the-internet-connectivity-visualization.jsp).

Figure 10 relates average transmission speed to GDP per capita for 10 relevant economies, with most countries not diverging far from the fitted line. One significant exception is again Kenya, which, consistent with its standing when compared to other developing countries with respect to coverage, stands above the curve for its level of income per capita. It is also a country with a number of public–private initiatives to provide better access and services.[8]

[8] Among the 10 countries listed in Table 4, Kenya and South Africa are the only two in sub-Saharan Africa in this database.

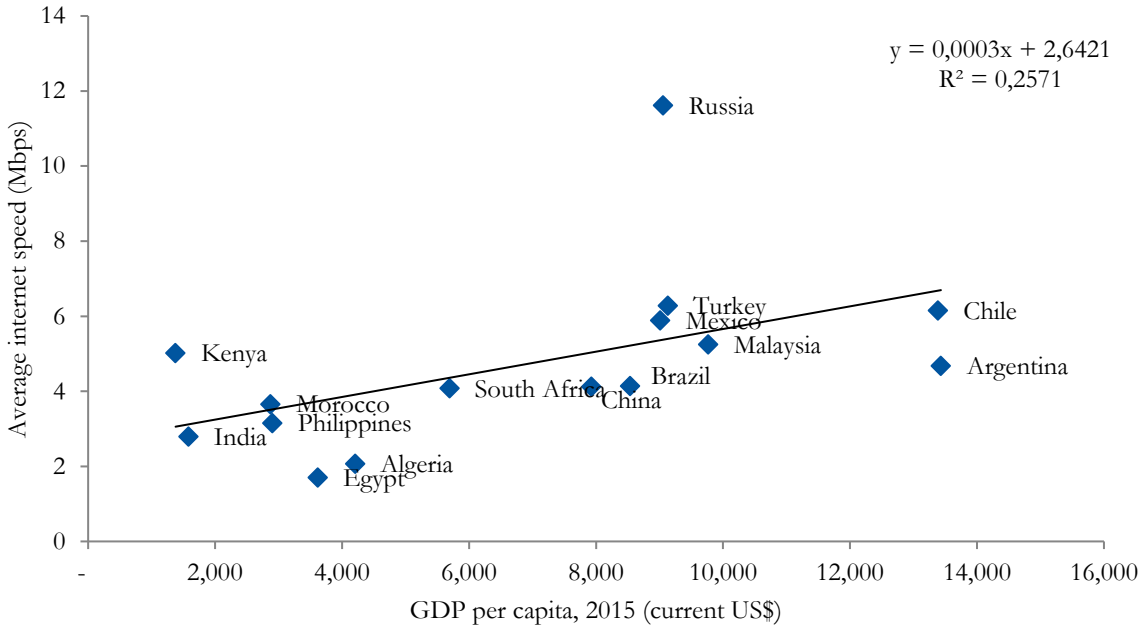
Figure 10: Internet average speed and GDP per capita, selected developed economies



Note: selected countries are South Korea, Sweden, Norway, Netherlands, Switzerland, Denmark, United States, Belgium, Singapore, United Kingdom, Canada, Germany, Ireland, Austria, Portugal, Spain, Israel, Poland, New Zealand, France, Australia, and Italy.

Source: author's elaboration based on Akamai Faster Forward, 'The State of the Internet' quarterly reports (avaliable at www.akamai.com/us/en/our-thinking/state-of-the-internet-report/state-of-the-internet-connectivity-visualization.jsp) and World Bank data.

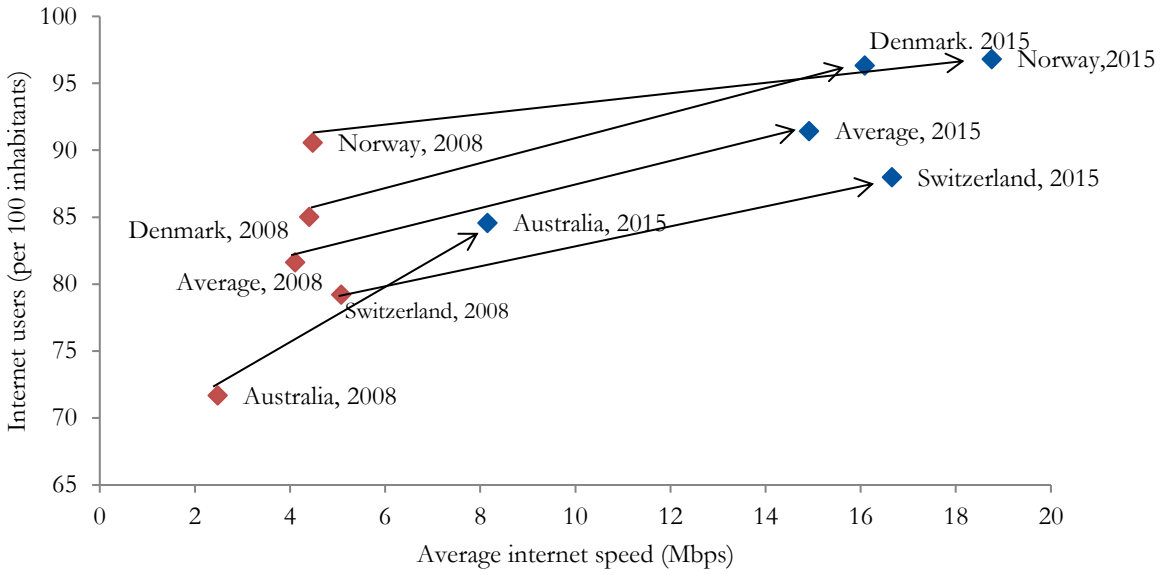
Figure 11: Internet average speed and GDP per capita, selected emerging and developing economies



Source: author's elaboration based on Akamai Faster Forward, 'The State of the Internet' quarterly reports (avaliable at www.akamai.com/us/en/our-thinking/state-of-the-internet-report/state-of-the-internet-connectivity-visualization.jsp) and World Bank data.

We now define the connectivity frontier as the distribution of countries across the internet use—average speed gap (Figures 11 and 12). The frontier dynamics are captured over the interval 2008–14. The differences between these two years provide country-specific absolute and relative movements. The figures suggest a fast-moving frontier and confirm widespread cross-country gains. Among developed countries, the gains are mostly concentrated in speed, while for developing economies the period shows major strides in coverage.

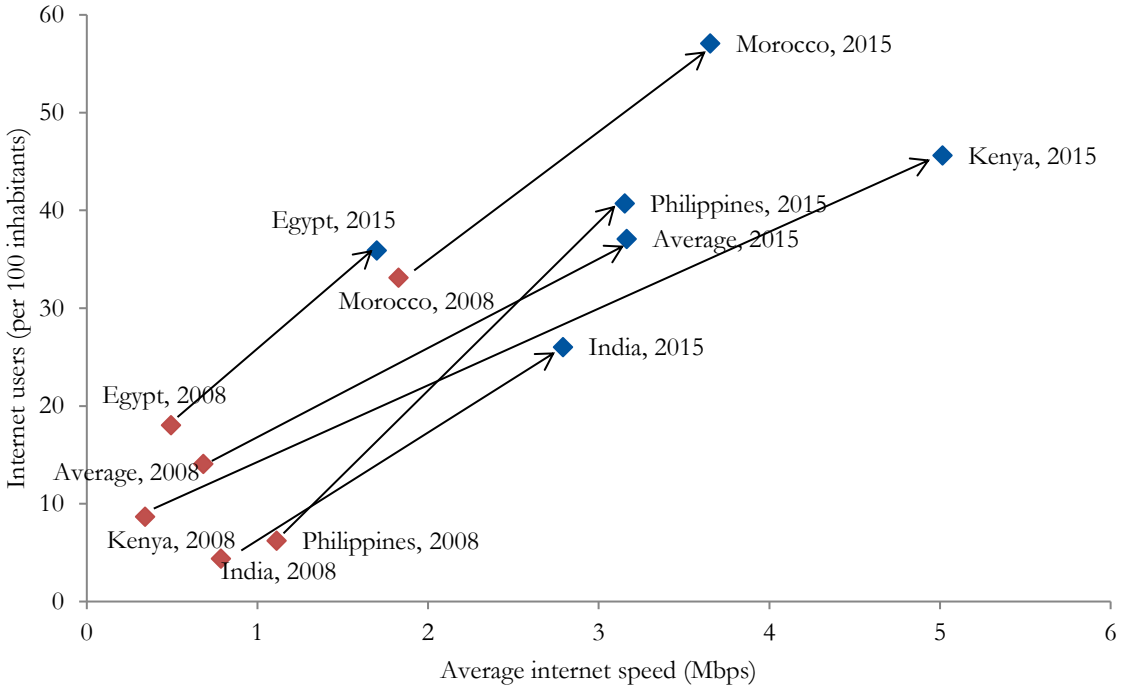
Figure 12: The moving connectivity frontier, 2008–14, selected developed economies



Source: author's elaboration based on Akamai Faster Forward, 'The State of the Internet' quarterly reports (avaliable at www.akamai.com/us/en/our-thinking/state-of-the-internet-report/state-of-the-internet-connectivity-visualization.jsp) and World Bank data.

For these economies, approaching the connectivity frontier is a precondition for the effective use of key technologies and platforms, capable of facilitating the production and export of services (and goods) which until recently were outside their realm, or with respect to which these countries had at most marginal participation.

Figure 13: The moving connectivity frontier, 2008–14, selected developing economies



Source: author's elaboration based on Akamai Faster Forward, 'The State of the Internet' quarterly reports (avaliable at www.akamai.com/us/en/our-thinking/state-of-the-internet-report/state-of-the-internet-connectivity-visualization.jsp) and World Bank data.

Despite the importance of the dissemination of hand-held devices and similar general-purpose technologies, their usefulness as a transformative instrument will still depend on robust connectivity and the quality of ICT infrastructure, as well as the factors that determine the intensity of use. Obviously, the technologies and platforms discussed in Section 2 are not a *deus ex machina* of trade, be it in goods or services. Nevertheless, they do provide the first breakthrough for developing countries that might shorten the long ascent towards relevance in world trade flows, beyond the now past commodity super cycle. As noted in the next section, countries would do well to mobilize resources required for universal access and high-quality connectivity, and attract providers by lowering entry barriers, in addition to undertaking trade facilitation and related economic reforms to make sure they capture ICT-opened opportunities.

4 ICTs and services trade: a half-opened door to developing countries

At the outset, it should be noted that trade in services is already responsible for an estimated 25 per cent share of global trade (and 55 per cent in value added) and is growing at rates significantly above trade in goods. It is therefore not hard to argue for the importance of countries investing in the enabling conditions to capture a share of this market. Among those enabling conditions, it appears that ICTs will play a critical role.

When discussing ICTs and trade, it is important to differentiate between first- and second-generation *ICT-based* services trade. India has been the quintessential example of a successful trade strategy focusing on the cross-border supply of business and other advanced services,

characterized by intensive use of first-generation ICTs (computers and high-speed satellite and cable links), and high levels of transportability and tradability (see Anand et al. 2015). Grounded on a combination of an elastic supply of English-speaking, well-educated professionals, and telecoms infrastructure that connected the country to the rest of the world, India's service exports grew at a very fast rate since the mid-1990s. By 2000, India's exports of business services already amounted to US$16 billion, and since then India's share of world service exports tripled to over 3 per cent by 2013. A few other developing countries such as the Philippines, which shared some of the same endowments as India, followed the strategy, breaking into the cross-border supply of business services.[9]

Yet ICTs have moved considerably beyond computers and company-centred technologies capable of connecting them with buyers through exclusive links. This paper focuses on the *second generation* of service exports, which the ongoing ICT revolution of this decade is beginning to expand to developing countries. The new ICT—as argued in Section 2—is fundamentally different, for it empowers people individually, entrepreneurs, small and medium-sized firms to break into markets that until now have been closed to them. It does not mean that infrastructure is unnecessary, but new ICTs open new doors for connectivity, including to citizens of countries with smaller economies and lower per capita income.

A recent World Bank and World Trade Organization (2015) report noted the importance of ICTs to promote trade benefiting the poor. In discussing policies to maximize the gains from trade for the poor, by 'integrating markets and improving the enabling environment', the report underlines the importance of access to (and use of, we would add) ICTs. This would be instrumental to facilitate transportation logistics and the management of the supply chain; to allow for business process outsourcing (in the example of India); or to offer online freelancing and other decentralized modes of connecting customers and providers, and other forms of cross-border trade in services (GATS Mode 1).[10] Importantly, the report states that 'export survival rates appear to be significantly higher for firms participating in e-commerce [which] is facilitating the participation of a greater number of smaller firms in international trade' (World Bank Group and World Trade Organization. (2015: 46–7).[11]

Granted, the evidence is still scattered and of an anecdotal nature regarding the growth in service exports from developing countries that can be traced back to new-generation ICT investments. At the same time, as shown in Section 2, such ICTs are changing the competitive landscape in ways that lower entry barriers for countries not as well-endowed as India, among others. *This is*

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[9] The Philippines and India are also at the forefront of ICT service exports, defined as computer and communications services (telecommunications and postal and courier services) and information services (computer data and news-related). In 2015, they made up 70.4 per cent and 67.5 per cent of total service exports. See http://data.worldbank.org/indicator/BX.GSR.CCIS.ZS?view=map.

[10] The General Agreement on Trade in Services (GATS) defines four modes of supply. *Cross-border supply* (Mode 1) covers services flows from the territory of one country into the territory of another country. *Consumption abroad* (Mode 2) refers to situations in which a service consumer (e.g., tourist, patient) moves into another country's territory to obtain a service. *Commercial presence* (Mode 3) implies that a service supplier of one country establishes a territorial presence in another country. Finally, *presence of natural persons* (Mode 4) consists of persons of one country entering the territory of another country to supply a service (e.g., accountants, doctors, teachers).

[11] The reference with respect to e-commerce is Suominen (2014).

what is new. Exactly because it is new—an emerging trend—it is still little understood and documented, while statistics are fraught with definition problems and data capture.

The scope of activities in this true next-generation 'industry without smokestacks' in which developing countries can reposition themselves is not only large, but also hard to anticipate, as the ICT revolution reduces transaction costs along a multiplicity of dimensions relevant to exporters. Moreover, the human capital requirements in the new environment are based less on engineering and hard sciences, and more on creativity and tacit knowledge. Even the concept of 'user-friendly' is changing to allow massive deployment of new technologies that will facilitate the production and export of services, and without resort to software engineers, computer scientists, and highly skilled professionals.

There are, however, some additional relevant considerations. ICTs in and of themselves do not radically change a country's comparative advantage, but help overcome geographical, language, and other barriers that previously isolated countries and regions. In this sense, it enhances the possibility of a country playing to its advantages. Indeed, as markets become more integrated, economic signals reach agents with less noise, allowing for more effective and timely responses. Critically, the growing flow of information allows economic agents to have a better grasp of available opportunities, while new platforms in a few years have transformed the ability of local entrepreneurs to reach consumers literally quasi-anywhere. Yet, there is considerable 'homework' to be done for developing economies to profit from the ICT revolution.

One aspect that needs attention is the fact that sub-Saharan countries are to a large degree excluded from the main discussions around ICT trade, a clear disadvantage for the development of the sector. Thus, for instance, both the Information Technology Agreement (ITA)[12] and the Agreement on Basic Telecommunications Services (BTA)[13] include only Mauritius and Seychelles, and Côte d'Ivoire, respectively. It would be of relevance if more sub-Saharan countries were actively involved in the discussions.[14] After all, the potential to exploit new ICT technologies depends on initiatives to improve the so-called enabling environment for trade.

Among the most important are: the progressive reduction of tariff and non-tariff barriers (combined with preference schemes for the least developed); systematic efforts at trade facilitation, including improvements in procedures for border management; and the provision of trade finance (see World Bank Group and World Trade Organization 2015). In addition, the upgrading of transportation and related physical and 'soft' infrastructure (such as trade logistics and regulations), by increasing competition in the provision of such services, has become critical.

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[12] The ITA was concluded in December 1996 and includes 82 countries who are committed to completely eliminating taxes and tariffs on ICT products, such as computers, telecommunications equipment, semiconductors, semiconductor manufacturing and testing equipment, software, and scientific instruments.

[13] The BTA is an annex to the GATS, implemented in 1998. The agreement aims to improve telecommunications services and equipment providers by facilitating the use of public basic telecommunication services, such as voice telephone, data transmission, fixed and mobile satellite systems and services, and mobile data services, among others.

[14] Interestingly, neither the ITU (2016) nor the World Bank (2016) mention the importance of African countries being an active part of those agreements.

In a not so distant past, access to landlines meant people and businesses were connected. Since the 1990s connectivity meant the availability of an infrastructure that enabled larger businesses and high-end consumers to link up to the rest of the world. Now connectivity needs to be understood in a radically different way. It means *high-quality (in terms of speed and stability), universal, affordable, open and safe mobile (and desktop) access to the internet*—let us refer to this as the new *access paradigm*.

Infrastructure is still needed, and clearly depends on the country's ability to attract providers of cable and other links, as Kenya—for instance—has successfully achieved in recent years. Historically, most African countries lack adequate backbone services due to the fact that they went straight to mobile networks, without investing in connectivity first. On the other hand, in developed countries fixed-line networks came first, allowing a progressive expansion in the infrastructure required for high-quality, fast connections.

It is likely that in 10–15 years the changes driven by ICTs will far surpass our current ability to predict their impact on developing countries and their ability to access markets. Yet without putting in place a set of solid, enlightened, and forward-looking policies, it is unlikely that countries will be able to capture the opportunities available in a fast-growing market. Their role will be to attract service providers of infrastructure and services, and to create an environment in which agents have both the incentives and the ability to procure the means to leverage the limited resources of these countries with some of the revolutionary ICTs, which bridge in new ways the development cleavage.

Access is the foundation. This paper posits that what will allow people to acquire the skills to become ICT-literate, more active citizens, and to respond to market opportunities, is a commitment by governments to the adherence to the new *access paradigm*, facilitating the use of services. In particular, access will be increasingly central to exploiting possibilities in export markets hitherto simply unavailable, bridging geographical and economic distance, connecting buyers and sellers of goods *and* services.

The relationship between access and use can be further explored with the help of Table 4, which zooms in on 10 sub-Saharan countries, and looks at the IDI[15] (ICT access and infrastructure, use, and skills). Globally, the data suggest that 'access and infrastructure' are less problematic than 'use', and even more so among the sample of countries considered here. Those can be divided into three groups, with South Africa, Ghana, Nigeria, and Kenya at the top in terms of IDI; Tanzania, Mozambique, and Ethiopia at the bottom; and Senegal, Rwanda, and Uganda in the middle. Although the 'use' variable seems to be correlated with per capita income, at very low levels this correspondence seems to break down, as already noted (see Figures 6 and 7). There appears to be other 'demand-side' factors at work.

'Use' and 'access' are obviously closely related; after all, use presupposes access.[16] If technology—the key driver of access—can be considered exogenous to the countries of our sample, the prices of services (and equipment) are not. This is possibly the key lever. One

[15] See footnote 4 for the definition of IDI.

[16] A simple regression for the 10-country sample shows that the 'use' variable is weakly related to per capita income, but more strongly associated with 'access'. A one-point improvement in access is correlated with a 0.65 gain in 'use'.

potentially relevant policy implication is that countries should 'lean with the wind' and improve access further by opening up to competition to force prices of come down and to facilitate access—and thereby use—of improved ICTs by broader segments of the population.

Table 4: IDI components, selected African countries, 2016

Country	IDI	Infrastructure and access	Use	Skills
South Africa	5.03	5.46	4.00	6.23
Ghana	3.99	4.74	3.03	4.44
Kenya	2.99	3.54	2.05	3.76
Nigeria	2.72	2.96	2.28	3.13
Average (A)	2.62	3.29	1.74	3.04
Senegal	2.53	3.59	1.64	2.17
Rwanda	2.13	2.65	1.47	2.42
Uganda	1.94	2.37	1.27	2.43
Mozambique	1.75	2.90	0.62	1.74
Tanzania	1.65	2.65	0.30	2.33
Ethiopia	1.51	2.11	0.82	1.71
Global average (B)	4.94	5.58	3.91	5.74
B/A	1.886	1.696	2.247	1.888

Source: own calculations based on ITU data (available at www.itu.int/net4/ITU-D/idi/2016).

If access is the foundation and entry point to take advantage of last-generation ICTs, the question for many developing countries is how to adopt the new access paradigm and guarantee more widespread use of ICTs in the face of scarce resources. To what extent can governments leverage appropriate policies, partnerships, and cooperative arrangements in order to make new technologies and platforms as widely available as possible? Although there is no single recipe that fits all, most countries still have significant adoption barriers, many of which are 'self-inflicted'.

From this perspective, a starting point is an assessment of the country-specific barriers that discourage infrastructure investment and reduce competition for the supply of devices (desktop and mobile) and the provision of services. To the extent that such barriers are significant or even binding, they need to be removed, in so far as the price—and quality—of products and services are determinants of their diffusion. From this perspective, policy and regulatory reform that attract investment in key infrastructure and facilitate entry and promote competition in both markets (devices and services) is the first step for countries to create an enabling environment for ICTs to fulfil their potential.

In the last few years, African countries have experienced an increase in competition for the provision of telecom services, with the entry of new companies into the market. All countries

except Ethiopia have between three and six operators, a significant number. In the 10-country sample, in six known instances market entry occurred since 2010, with one new entry each in Kenya and Tanzania in 2015, a far cry from the days of state monopolies. The notable exception is Ethiopia, which has a single public operator (Table 5). Market dynamism—as evidenced by shifts in the major incumbent market shares—is more clearly observed in Nigeria, Rwanda, Tanzania, South Africa, Mozambique, and Senegal. More generally, the landscape appears to be more, not less, competitive, despite a trend towards technological convergence, which more often than not led to the overlap of markets (despite eventual mergers). Therefore, the ability of countries to attract new players appears to have never been as great as in the last five years or so.

Table 5: Market share of mobile operators, selected sub-Saharan countries

Country	Number of providers	Market share of the main provider (percentage)		Year of last entry
		2010	2016	
Nigeria	4*	62**	40	2012
Ghana	6	50	48	2011
Ethiopia	1	100	100	–
Kenya	5	70	65	2015
Rwanda	3	76	46	2012
Tanzania	7	40	31	2015
South Africa	5	51	38	n.a
Mozambique	3	60	49	2012
Senegal	3	64**	55	n.a
Uganda	5***	n/a	n/a	2014

Note: * Only GSM providers; ** 2012 data; *** main providers.

Source: author's elaboration based on national regulatory agencies.

Have these indications of market rivalry translated into lower prices of telecommunications services? Table 6 presents services price data for the 10-country sample and sub-Saharan economies' average in nominal terms and normalized by GDP per capita (with reference to the average of sub-Saharan countries). Some countries stand out as high-price environments in both nominal and normalized terms, both for fixed-line broadband access and the smartphone basket, such as Ethiopia—a state monopoly. At the other end of the spectrum stand Nigeria, Uganda, and Ghana, while South Africa presents a positive picture in normalized terms.

Table 6: Price of telecommunication services, selected sub-Saharan countries (US$)

Country	Least expensive broadband service (1GB)	Normalized by per capita income**	Least expensive smartphone basket*	Normalized by per capita income**
South Africa	5.3	1.5	15.6	4.3
Nigeria	4.8	2.9	6.4	3.8
Ghana	3.9	4.4	7.8	8.9
Kenya	2.9	3.3	21.5	24.5
Senegal	8.4	14.5	8.4	14.5
Tanzania	0.9	1.6	10.3	18.7
Rwanda	4.0	9.0	n/a	n/a
Uganda	3.6	8.4	3.6	8.4
Ethiopia	7.7	19.5	21.1	53.5
Mozambique	2.9	8.7	21.5	64.3
SSA Average	12.4	12.4	67.4	67.4

Note: * includes 1GB, 100 minutes of voice and 100 SMS (data, voice, and SMS); ** normalized with respect to the ratio of the country's and sub-Saharan Africa's 2015 GDP per capita.

Source: author's own elaboration based on data from Research ICT Africa (available at www.researchictafrica.net/pricing/ramp.php).

What inferences can be drawn from both tables? First, and as expected, it does not seem that a state monopoly is conducive to low prices. Second, although one would need to take a closer look to establish the reason why in some instances the presence of a large number of operators has not translated into lower prices for all services, in general this is the case. Tanzania, for instance, with seven operators, offers the lowest priced broadband services and a reasonably priced smartphone basket; so does Ghana. Kenya and South Africa—with five operators each—and Nigeria with four are also quite competitive on broadband and other services, above all when prices are normalized. Overall Uganda is a successful case in lowering entry barriers, attracting newcomers, and offering competitive prices. Third, and more generally, a competitive landscape seems to favour broader access to ICT services, and thus their more intensive use, such as in Kenya and Nigeria (Figure 7). Still, the relationship does not necessarily hold—as is the case for Tanzania, significantly 'below the curve'.

Consumers, in developing countries above all, should have at their disposal the best cost–performance combination available in the market with a minimum tariff/tax wedge: inexpensive but powerful devices such as smartphones, and a variety of service providers competing in national (and regional) markets. Regional trade arrangements may require countries to agree to regional infrastructure investments (such as in fibre-optic rings), and to open their markets in recognition of the importance of new technologies to modernize the provision of services and spur trade.

However, governments can go further by actively engaging key service providers such as Alphabet (Google) and Facebook, which have plans to connect people in developing countries and more isolated regions at a quasi-zero cost. It is their ability to rope in users/consumers—'the more the merrier'—and the enormous network economies of scale that are making them the economic powerhouses of this age. To a significant degree, by connecting people they serve

the public interest. If in the process they capture more consumers to their services, they also provide the means for low-cost digital inclusion.

Similarly, access can be 'traded' for advertising time, mainly in urban areas. In other words, such areas can be 'wired' and access made conditional on the willingness of users to spend time being exposed to ads. Governments can negotiate—in the name of their citizens—maximum free time for a minimum advertising time. In the face of limited resources, this may be regarded as a feasible—and pragmatic—way for cities (mainly) in poor countries to move up the digital gradient. There will be a growing number of possibilities of this nature in coming years, signifying one more avenue for digital inclusion and crossing the access threshold.

A final point: policy makers need to think creatively, 'outside the box', to leverage the market and attract technologies that dramatically lower the cost of access, and recognize initiatives with similar objectives.[17] If in wealthier and more advanced economies local and even national governments may have enough resources to 'wire' the country in recognition of the importance of high-speed access, in most developing countries that is not the case. Thus, in addition to removing obstacles for people to access devices on the most competitive basis, and lowering entry barriers and promoting competition among service providers, including infrastructure investors, governments need to experiment with new models of public–private cooperation to bring the country the new access paradigm and improve the lives of their citizens.

References

Abramovitz, M., and P. David (1996). 'Technological Change and the Rise of Intangible Investments: The U.S. Economy's Growth-Path in the Twentieth Century'. In OECD, *Employment and Growth in the Knowledge-Based Economy*. Paris: OECD.

Anand, R., K. Kochhar, and S. Mishra (2015). 'Make in India: Which Exports can Drive the Next Wave of Growth?'. IMF Working Paper 119. Washington, DC: IMF.

Brynjolfsson, E., and A. Mcafee (2015). *The Second Machine Age*. New York: W.W. Norton.

Gordon, R. (2016). *The Rise and Fall of American Growth: The U.S. Standards of Living since the Civil War*. Princeton, NJ: Princeton University Press.

International Telecommunication Union (2012). 'The Impact of Broadband on the Economy'. Geneva: ITU.

International Telecommunication Union (2016). 'Measuring the Information Society Report'. Geneva: ITU.

[17] Among the most important are the *Telecom Infra Project*, which look for connectivity solutions in strategic network areas such as access, backhaul, and core and management; and *OpenCellular*, a Facebook initiative for a low-cost, open-source hardware and software solution that will support from 2G to LTE networks, amplifying mobile network signals, with each box supporting up to 1,500 connections and covering a radius of up to 10 km.

Schumann, R., and M. Kende (2013). 'Lifting Barriers to Internet Development in Africa: Suggestions for Improving Connectivity'. Report for the Internet Society. London: Analysys Mason Limited.

Suominen, K. (2014). 'Aid for eTrade: Accelerating the Global eCommerce Revolution'. CSIS Europe Working Paper. Washington, DC: CSIS.

World Bank (2009). *Information and Communications for Development 2009: Extending Reach and Increasing Impact*. Washington, DC: World Bank.

World Bank (2016). *Internet for Development: The World Development Report 2016*. Washington, DC: World Bank.

World Bank Group and World Trade Organization. (2015). *The Role of Trade in Ending Poverty*. Geneva: World Trade Organization.

Appendices

Table A1: Internet user per 100 inhabitants, developed and emerging economies

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
United States	49.1	58.8	61.7	64.8	67.9	68.9	75.0	74.0	71.0	71.7	69.7	74.7	71.4	73.0	74.5
South Korea	56.6	59.4	65.5	72.7	73.5	78.1	78.8	81.0	81.6	83.7	83.8	84.1	84.8	87.9	89.9
Hong Kong, China	38.7	73.1	52.2	56.4	56.9	60.8	64.8	66.7	69.4	72.0	72.2	72.9	74.2	79.9	84.9
Argentina	9.8	10.9	11.9	16.0	17.7	20.9	25.9	28.1	34.0	45.0	51.0	55.8	59.9	64.7	69.4
Brazil	4.5	9.2	13.2	19.1	21.0	28.2	30.9	33.8	39.2	40.7	45.7	48.6	51.0	54.5	59.1
China	2.6	4.6	6.2	7.3	8.5	10.5	16.0	22.6	28.9	34.3	38.3	42.3	45.8	47.9	50.3
South Africa	6.3	6.7	7.0	8.4	7.5	7.6	8.1	8.4	10.0	24.0	33.9	41.0	46.5	49.0	51.9
Mexico	7.0	11.9	12.9	14.1	17.2	19.5	20.8	21.7	26.3	31.0	37.2	39.7	43.5	44.4	57.4

Source: Statista.

Table A2: Internet users per 100 inhabitants, developing economies

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Nigeria	0.1	0.3	0.6	1.3	3.5	5.5	6.8	15.9	20.0	24.0	28.4	32.8	38.0	42.7	47.4
Kenya	0.6	1.2	2.9	3.0	3.1	7.5	7.9	8.7	10.0	140	28.0	32.1	39.0	43.4	45.6
Philippines	2.5	4.3	4.9	5.2	5.4	5.7	5.9	6.2	9.0	25.0	29.0	36.2	37.0	39.7	40.7
Ghana	0.2	0.8	1.2	1.7	1.8	2.7	3.9	4.3	5.4	7.8	9.0	10.6	12.3	18.9	23.5
India	0.7	1.5	1.7	1.9	2.4	2.8	3.9	4.4	5.1	7.5	10.1	12.6	15.1	21.0	26.0
Senegal	0.9	1.0	2.1	4.4	4.8	5.6	6.9	7.1	7.5	8.0	9.8	10.8	13.1	17.7	21.7
Uganda	0.2	0.4	0.5	0.7	1.7	2.5	3.7	7.9	9.8	12.5	13.0	14.7	16.2	17.7	19.2
Rwanda	0.2	0.3	0.4	0.4	0.6	0.0	2.1	4.5	7.7	8.0	7.0	8.0	9.0	10.6	18.0
Ethiopia	0.0	0.1	0.1	0.2	0.2	0.3	0.4	0.4	0.5	0.7	1.1	2.9	4.6	7.7	11.6
Mozambique	0.2	0.3	0.4	0.7	0.9	0.8	0.9	1.6	2.7	4.2	4.3	4.8	5.4	5.9	9.0
Tanzania	0.2	0.2	0.7	0.9	1.1	1.3	1.6	1.9	2.4	2.9	3.2	3.9	4.4	4.9	5.4

Source: author's elaboration based on World Bank data.

Table A3: Average speed (Mbps), selected countries

	2008	2009	2010	2011	2012	2013	2014	2015	2016
Austria	3.7	3.8	4.0	4.9	6.1	9.4	9.8	12.3	12.8
Canada	3.8	5.4	4.7	5.6	6.8	8.9	10.7	13.1	13.7
France	3.2	3.5	3.5	4.1	4.8	6.6	7.1	8.9	9.6
Germany	3.8	4.3	3.9	4.9	5.9	7.7	8.8	12.9	14.1
Ireland	3.8	4.1	3.8	5.8	5.5	10.3	12.7	12.8	13.9
Israel	2.9	3.5	2.7	3.9	5.3	8.2	10.7	11.6	13.4
New Zealand	2.7	3.4	3.0	3.5	4.0	5.3	7.3	9.3	10.6
Poland	2.0	3.1	2.3	3.9	4.5	7.5	8.8	10.9	12.2
Portugal	3.2	4.7	3.8	4.9	4.9	6.0	8.0	12.1	12.9
Spain	2.6	2.9	2.9	4.0	4.9	6.6	8.2	12.1	14.1
Australia	2.5	2.9	2.1	5.2	4.1	5.8	7.4	8.1	8.5
Italy	2.9	3.0	2.8	3.4	3.3	5.1	5.6	7.4	8.2
Belgium	4.5	5.3	4.8	6.1	6.6	9.7	10.9	14.2	15.1
Denmark	4.4	5.1	5.4	5.6	7.0	9.8	11.9	16.1	16.3
Netherlands	4.8	6.2	5.5	7.8	7.8	12.4	14.2	16.9	16.9
Norway	4.5	4.4	4.5	4.8	6.5	8.9	11.4	18.8	20.1
Singapore	3.8	3.9	3.9	4.5	5.4	7.9	11.7	13.9	17.2
South Korea	15.0	6.9	12.1	16.0	13.9	21.9	22.2	26.7	26.9
Sweden	5.9	5.1	6.2	5.6	7.3	10.9	14.6	19.1	18.8
Switzerland	5.1	5.6	5.1	7.3	8.7	12.0	14.5	16.7	18.3
United Kingdom	3.5	4.2	3.8	4.8	5.7	9.4	10.9	13.8	14.9
United States	3.9	4.2	3.9	4.7	6.6	9.6	11.1	14.2	15.3

Source: author's elaboration based on Akamai Faster Forward, 'The State of the Internet' quarterly reports.

Table A4: Average speed (Mbps), selected emerging and developing economies

	2008	2009	2010	2011	2012	2013	2014	2015	2016
Argentina	1.3	1.2	1.9	1.8	2.0	3.1	4.5	4.7	5.2
Brazil	1.0	1.3	1.6	1.7	2.1	2.7	2.9	4.1	4.8
Chile	1.7	2.3	2.3	2.7	2.7	3.4	5.0	6.1	6.9
China	0.8	0.9	1.0	1.4	1.8	3.4	3.4	4.1	5.2
Kenya	0.3	0.6	0.5	0.6	1.9	1.9	1.4	5.0	7.7
Malaysia	1.1	1.1	1.5	1.6	2.1	3.0	4.1	5.2	6.8
Mexico	1.0	1.4	1.7	2.4	2.9	4.0	4.5	5.9	7.4
Russia	1.9	2.2	2.9	3.8	5.1	7.4	8.9	11.6	12.3
South Africa	1.3	1.2	1.4	1.5	2.1	2.3	3.2	4.0	5.6
Turkey	1.2	1.6	1.8	2.6	2.6	4.0	5.8	2.8	7.0
Algeria	0.4	0.3	0.4	0.7	0.9	1.0	1.9	2.1	2.0
Egypt	0.5	0.7	0.7	0.9	1.2	1.3	1.5	1.7	3.9
India	0.8	0.9	0.8	0.8	1.2	1.6	2.0	2.8	3.6
Morocco	1.8	1.6	1.7	1.3	1.7	2.4	2.4	3.7	4.4
Philippines	1.1	0.9	1.0	1.1	1.3	1.9	2.7	3.1	4.3

Source: author's elaboration based on Akamai Faster Forward, 'The State of the Internet' quarterly reports.