Measuring the Information Society Report 2017

Volume 1

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Foreword

It is my pleasure to present to you the latest edition of the *Measuring the Information Society Report*. This annual report presents a global and regional overview of the latest developments regarding information and communication technologies (ICTs), based on internationally comparable data and agreed methodologies. It aims to provide ITU Member States with an objective assessment of countries' ICT performance by highlighting areas of success stories and areas that need further improvement.

The release of this report comes after the successful conclusion of the World Telecommunication Development Conference (WTDC), held in Buenos Aires, Argentina, where we adopted a Strategic Plan and Action Plan that will provide future direction and guidance to the ITU Telecommunication Development Sector (ITU-D), including its work on statistics.

Based on ITU data collections, the report gives an overview of the long-term telecommunication/ICT trends. Analysis shows an overall upward trend in the availability of communication services, driven by rapid growth in broadband, with a growing predominance of mobile over fixed services. Globally, the number of mobile-cellar subscriptions grew from 2005 to 2017 from 33.9 per 100 inhabitants to an estimated 103.5. In the least developed countries (LDCs), the growth has been more impressive, increasing from 5.0 in 2005 to an estimated 70.4 in 2017.

These trends are brought further into evidence by the ICT Development Index (IDI). The IDI is a powerful tool for monitoring progress towards a global information society and is a core feature of this report. The latest IDI ranks the performance of 176 economies with regard to ICT infrastructure, use and skills, allowing for comparisons to be made between countries and over time. The most important aspect of the IDI is that countries should track their own year on year progress and make policy adjustments to grow their countries' telecommunication/ICT sector.

This year's Index shows that there has been continued improvement in IDI performance by the great majority of countries. The average value for all economies in the Index rose by 0.18 points between IDI 2016 and IDI 2017, reaching 5.11 points, the first time that it has exceeded the halfway point along its scale. Improvements have been most significant among countries in the middle of the IDI rankings, many of which are middle-income developing countries, testifying to the fact that these countries are catching up with the top performers when it comes to ICT development. But LDCs as well improved their average IDI value, by 0.15 points during the year, close to the overall average growth recorded. Mobile broadband is the driving force behind this trend, bringing online previously unconnected individuals and catering for the ubiquitous data needs of the ICT ecosystem. Worldwide, active mobile-broadband subscriptions increased from 11.5 per 100 inhabitants to 56.4 in only 7 years. Here as well, growth in LDCs was even stronger, from 0.4 in 2010 to 22.3 in 2017, offering hope that they are on a path to catch up with the rest of the world.

Recent developments in ICT markets have led to the adoption of proposals for change in the composition of the Index. A revised set of indicators will be introduced from IDI 2018 which should add further insights into the performance of individual countries and the relative performance of countries at different development levels.

Over and above reporting on the overall telecommunication/ICT progress achieved, the IDI also shows that the digital divide between more and less connected countries remains a challenge which needs to be addressed if inclusive information societies are to contribute to the achievement of the Sustainable Development Goals (SDGs). Digital divides are also evident within countries, for example between urban and rural areas and between age groups. In many countries, urban residents and young people are more likely to be online than rural dwellers and the elderly. Women are less likely than men to make use of the Internet in most countries, but are more under-represented online in developing countries, particularly in LDCs, than in developed countries.

This year's report also features a chapter presenting IDI findings at regional level and compares different regions. Given that there is a strong correlation between economic development and IDI performance, there are considerable differences between geographic regions in the levels of ICT development reflected by the IDI, and significant variation in the experiences of individual countries within each region.

Drawing conclusions from the report, it is clear that the area of ICTs is very dynamic and that another digital revolution is approaching- one which will transform business, government and society. Four key developments are at the heart of this revolution: the Internet of Things (IoT), cloud computing, big data analytics, and artificial intelligence (AI). These are described in greater detail in the last chapter of the report.

All these trends are interrelated. Fully harnessing the economic and social benefits of these developments requires efficient and affordable physical infrastructures and services, more advanced user skills, and internationally comparable benchmarks and indicators supported by enabling public policies. Promising ICT applications in areas such as manufacturing, precision agriculture, government, education, health care, smart cities, and smart transportation, will contribute to accelerating the attainment of the SDGs. Reliable and meaningful measures of the deployment and use of advanced ICTs are critical. This topic will undoubtedly be dealt with further in future editions of the *Measuring the Information Society Report*.

For the first time, this year's report features country profiles highlighting the ICT market structure and the latest developments in 192 economies worldwide. Each profile includes an overview of the policy and regulatory initiatives undertaken, as well as the current status of network roll-out and service uptake. These profiles are presented in Volume 2 of the Measuring Information Society Report. The profiles seek to highlight the achievements by each country and I am confident that these profiles will also help in identifying good practices as well as future challenges specific to each country.

It is my hope that this report will not only be of value to actors within the ITU membership (policy-makers, regulators, the ICT industry, academia) but to others also working towards the building of an inclusive global information society.

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Chapter 1. The current state of ICTs

Key findings

The latest data on ICT development from ITU show continued progress in connectivity and use of ICTs. There has been sustained growth in the availability of communications in the past decade, led by growth in mobile cellular telephony and, more recently, in mobile broadband. Growth in fixed and mobile-broadband infrastructure has stimulated Internet access and use.

Mobile-cellular networks are increasingly pervasive and now dominate the provision of basic telecommunication services. The number of mobile-cellular subscriptions worldwide now exceeds the global population, although many individuals, especially in developing countries, still do not use a mobile phone. The number of fixed-telephone subscriptions has continued to fall, dropping below 1 billion worldwide, and is particularly low in the least developed countries (LDCs).

There has been rapid growth in mobile-broadband services. The number of mobile-broadband subscriptions worldwide now exceeds 50 per 100 inhabitants, enabling improved access to the Internet and online services. The introduction of new mobile technologies is accelerating this trend, with LTE or higher capabilities now available to most mobile users. There has been slower growth in the number of fixed-broadband subscriptions worldwide, although this now marginally exceeds that for fixed telephone lines.

There are substantial digital divides between countries and regions, and between developed and developing countries, particularly LDCs. There are twice as many mobile-broadband subscriptions per 100 inhabitants in developed countries compared to developing countries, while the gap between more-connected developing countries and LDCs has grown in recent years. Mobile-broadband subscription rates are much higher in Europe and the Americas than in other regions, and more than three times those in Africa. Subscribers in developed countries also tend to benefit from higher bandwidth than those in developing countries.

These divides are evident in Internet use as well as connectivity. More than half of all households worldwide now have access to the Internet, although the rate of growth appears to have fallen below 5 per cent a year. Households in developed countries are almost twice as likely to be online as those in developing countries and more than five times as likely as those in LDCs. There are similar differences between rates of access for individual users. People in Europe are more than three times more likely to access the Internet regularly than those in Africa, and are likely to benefit from higher access speeds when doing so.

There is a significant gender digital divide. Data compiled by ITU suggest that this digital gender gap is relatively small in developed countries, more pronounced in developing countries and substantial in LDCs, where only one in seven women is using the Internet compared with one in five men. The gender digital divide in Africa appears to have grown significantly over the past five years.

Young people are more likely to be online than their elders. The proportion of people aged between 15 and 24 who are online is estimated to be over 70 per cent worldwide, compared with just 48 per cent of the population overall. Elderly people are less likely to be connected.

Chapter 1. The current state of ICTs

1.1 Introduction

This chapter presents a global overview of principal trends in information and communications technology (ICT) access and use that can be observed through data sets which are annually gathered and assessed by ITU. It is divided into six sections:

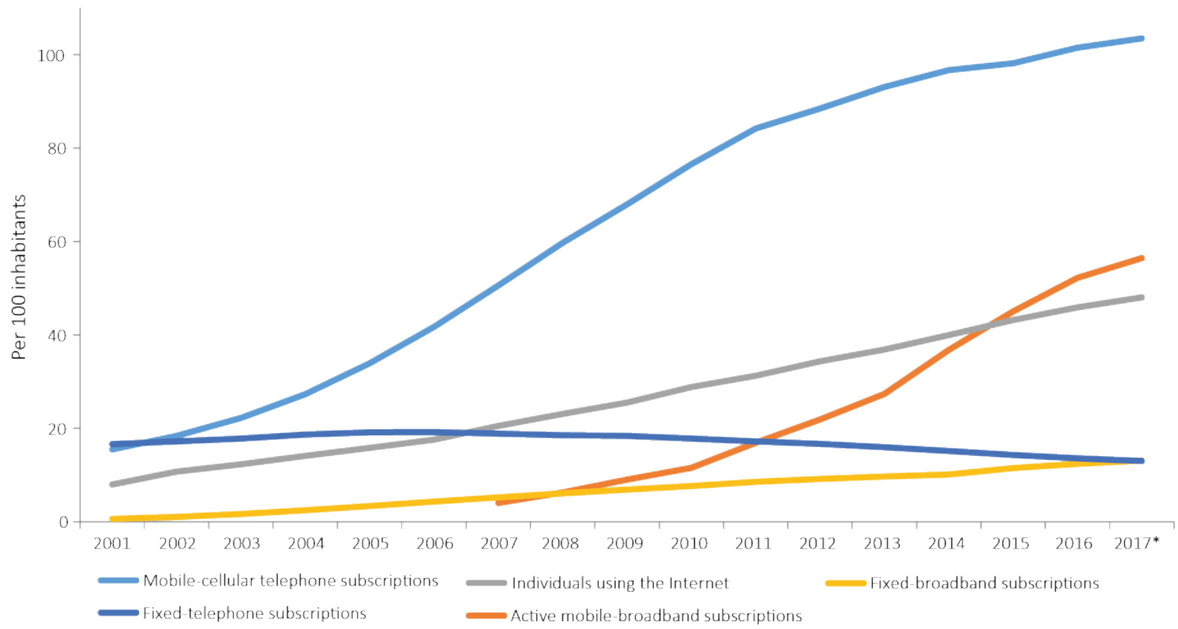
- This introductory section summarizes overall global trends and outlines developments in network coverage and available bandwidth;
- Section 1.2 describes basic communications networks;
- Section 1.3 describes trends in broadband access;
- Section 1.4 describes trends in Internet access and use;
- Section 1.5 considers digital divides within society;
- Section 1.6 presents a summary and conclusion.

An overview of global ICT developments since the turn of the century is set out in Chart 1.1.

Three broad trends can be observed from this chart:

- The first is the long-term upward trend in the availability of communication services in general. The decade following the end of the World Summit on the Information Society (WSIS) in 2005 has seen an upsurge in mobile-cellular telephony, leading to near-saturation penetration rates in developed countries and many developing countries. This was complemented from around the start of the present decade by an upsurge in mobile-broadband take-up, particularly in developed countries, though this has yet to reach levels of access and use comparable to those for mobile telephony.

Chart 1.1: Global ICT developments, 2001-2017*



Notes: * ITU estimate.
Source: ITU.

- The second long-term trend is the growth in broadband – defined in this report as services with speeds of 256 kbits/s and above. Broadband did not really begin to make a mark on communications services until the early years of this century, but after that its growth accelerated quickly. Between 2007 and 2017, fixed-broadband subscriptions increased by 183 per cent. Active mobile-broadband subscriptions grew extremely rapidly, from 4.0 subscriptions per 100 population in 2007 to an estimated 56.4 subscriptions per 100 population in 2017. The bandwidth available has also risen rapidly, particularly in developed countries. This growth in broadband, which shows no signs of faltering, has enabled much more extensive and effective use to be made of the Internet and is facilitating today's growth in advanced services.

- The third long-term trend is the growing predominance of mobile over fixed services. Mobile cellular subscriptions now make up more than 90 per cent of voice subscriptions, and more than 98 per cent of those in least developed countries (LDCs).[1] The number of fixed-telephone subscriptions has steadily declined in recent years, however, by 22.5 per cent since 2007, as increasing numbers of people have preferred mobile to fixed access. Mobile subscriptions have also been predominant in the broadband market, now accounting for just over 80 per cent of broadband subscriptions worldwide (though this has been accompanied by an increase in fixed-broadband penetration).

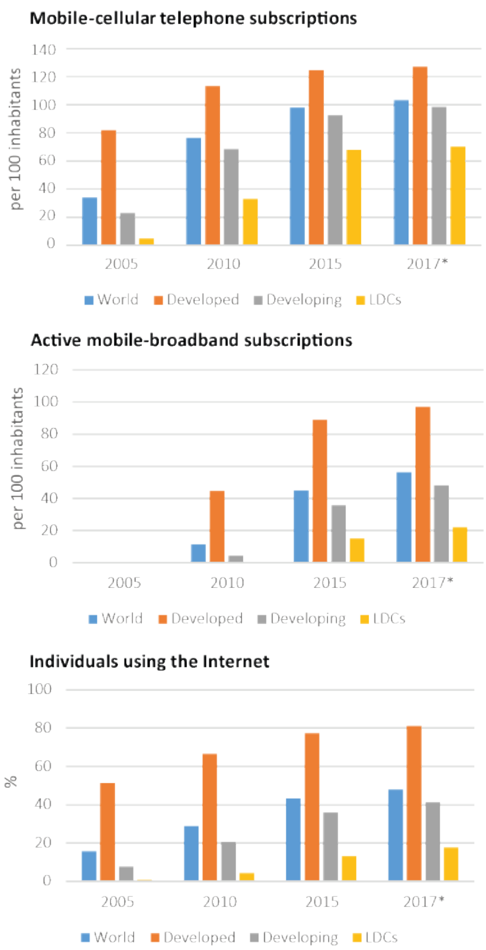
Caution is required when comparing data for mobile and fixed penetration rates such as these, as subscriptions do not equate with subscribers. It is much more common, for example, for mobile subscribers to have more than one subscription than is the case for subscribers to fixed networks. At the same time, however, mobile subscriptions are more often linked to individual use, while fixed network subscriptions are often shared by several people.

As with broadband, the capabilities of mobile networks and devices have improved rapidly, particularly since smartphones became widely available some ten years ago, enabling them to deliver more effective Internet access, and stimulating operators to roll out mobile-broadband in response to growing demand.

There are significant differences in subscription levels, where all three of these trends are concerned, between countries at different levels of development and in different regions. These are illustrated, for three selected indicators, in Charts 1.2 and 1.3.

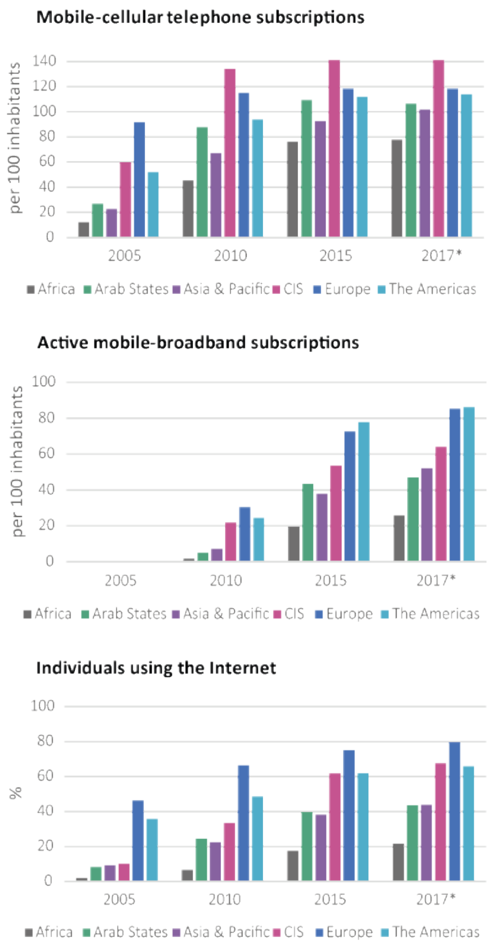
Chart 1.2 shows that there is a strong association between development status and ICT access and use. Developed countries have a significant lead over developing countries in mobile-cellular subscriptions, and approximately twice as many active mobile-broadband subscriptions and Internet users per 100 population as developing countries. LDCs fall behind developing countries in general by similar margins. At the regional level (Chart 1.3), it is clear that Europe, the Americas

Chart 1.2: Global ICT access and use, selected years, by development status



Notes: * ITU estimate.
Source: ITU.

Chart 1.3: Global ICT access and use, selected years, by region



Notes: * ITU estimate.
Source: ITU.

and the Commonwealth of Independent States (CIS) regions are ahead of other regions in all three indicators, with Africa well behind the Asia and the Pacific and Arab States regions.

1.2 Basic communication networks

1.2.1 Network coverage

The growing preponderance of mobile-cellular subscriptions over fixed-telephone subscriptions has been one of the most prominent trends in ICTs since the beginning of the century, with mobile networks establishing themselves as the consumer norm in today's communications markets. Only one country in the ICT Development Index (IDI) 2017 (Monaco) recorded more fixed-telephone than mobile-cellular subscriptions. This growing preponderance is particularly marked in developing countries, especially LDCs, and in Africa, where fixed lines are often very expensive, not available, or only available after a lengthy waiting period.

The predominance of mobile over fixed network subscriptions reflects the much wider geographical availability of mobile networks in most national markets, especially in rural areas of developing countries, where the improved supply of connectivity following mobile network deployment has facilitated growing demand. As mobile networks have become more available at lower prices, some users have subscribed to mobile networks in addition to keeping their fixed subscriptions, while some new subscribers have chosen to use mobile networks only and some fixed subscribers have chosen to drop their fixed subscriptions in favour of mobile.

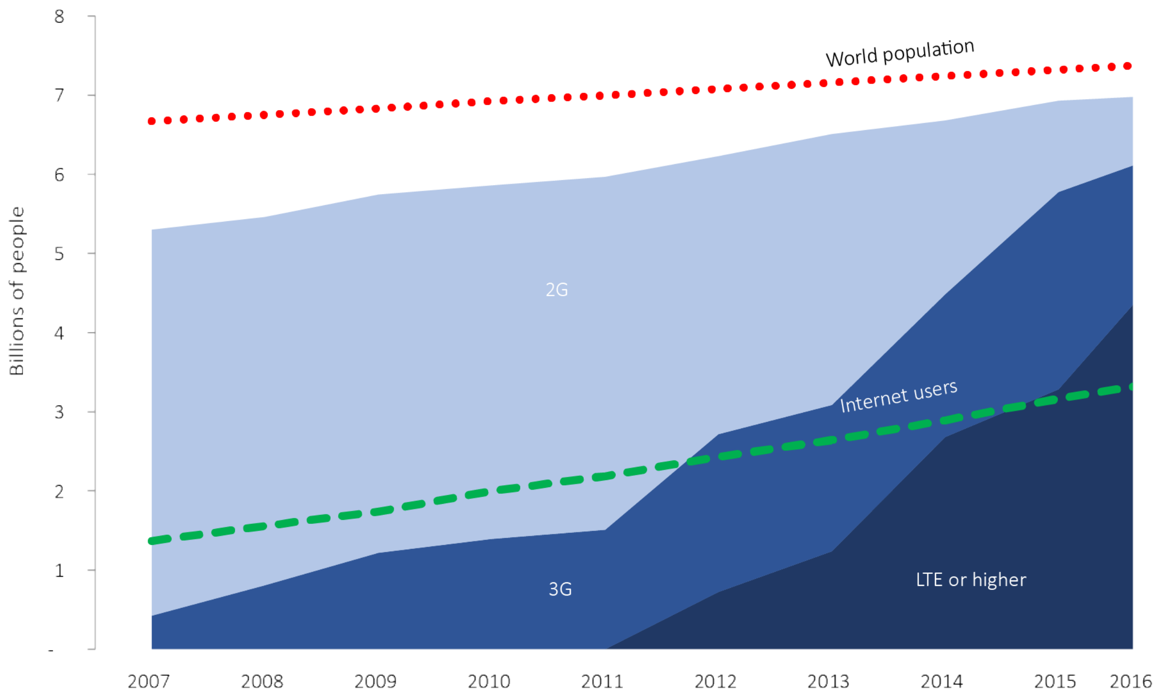
Improvements in the capabilities of mobile networks have also played an important part where this trend is concerned. The transition from 2G to 3G and higher-quality mobile networks, capable of effective delivery of Internet services, is illustrated in Chart 1.4. Most mobile subscribers worldwide now have access to higher-quality networks (though these have been slower to arrive in developing than in developed countries). Chart 1.4 also shows, however, that this transition has not been immediately paralleled by a comparable upsurge in the number of Internet users.

1.2.2 Mobile cellular subscriptions

Chart 1.5 presents the growth in mobile-cellular subscriptions worldwide, and the number of subscriptions per 100 population, since 2005. The total number of mobile-cellular subscriptions has increased from 2.20 billion in 2005 to 5.29 billion in 2010, 7.18 billion in 2015 and an estimated 7.74 billion in 2017. The number of subscriptions per 100 population has grown from 33.9 in 2005 to 76.6 in 2010, 98.2 in 2015 and an estimated 103.5 in 2017.

As noted above, it is important to distinguish between the number of subscriptions, shown in Chart 1.5, and the number of subscribers. The number of subscriptions worldwide now exceeds the global population, with subscriptions also

Chart 1.4: Changing mobile coverage by type of network, 2007-2016

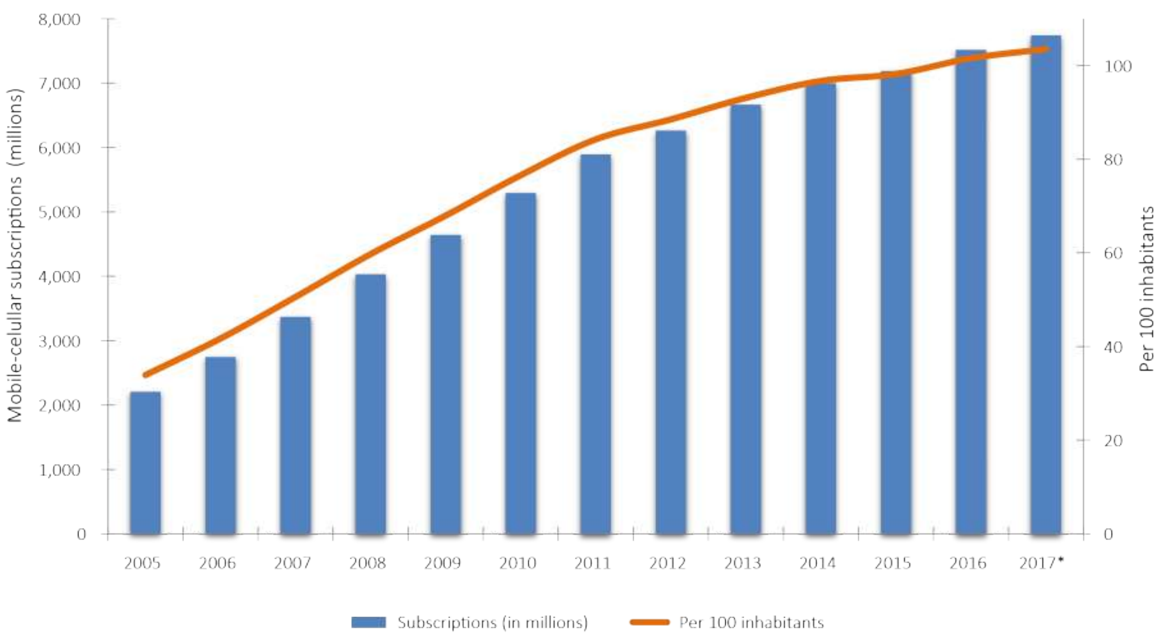


Source: ITU.

exceeding population in 112 of the 176 countries included in IDI 2017 (see Annex 2).

There are several reasons for the difference between data for subscriptions and subscribers, the extent of which varies between countries. These include the proportion of subscriptions which are held by businesses and other organizations, and the tendency for users to have more than one subscription in order to

Chart 1.5: Global mobile-cellular subscriptions, total and per 100 inhabitants, 2005–2017*



Notes: * ITU estimate.
Source: ITU.

take advantage of differential prices offered by competing operators or to compensate for weaknesses in different operators' network coverage.

As highlighted in *Measuring the Information Society Report 2016* (ITU, 2016b), additional indicators – such as the number of mobile phone users or mobile phone owners – need to be gathered in order to enable more accurate assessments of mobile uptake. Household survey data from developing countries show that a significant proportion of the population presently does not use mobile-cellular services at all. In those developing economies for which recent household data are available, close to 20 per cent of the population, on average, still do not use a mobile phone.[2] The proportion of phone ownership is even lower in some large developing economies – including Bangladesh, India, Indonesia and Pakistan – where more than 40 per cent of the population do not own a mobile phone.[3]

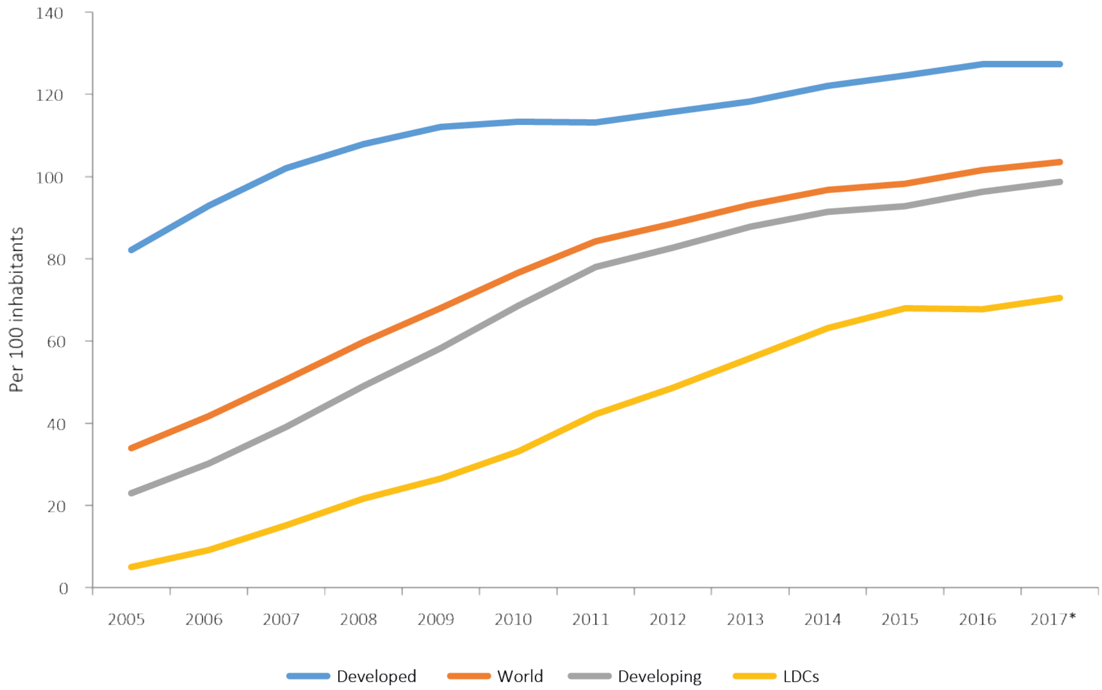
Although the global subscription rate for mobile-cellular telephony is high, as shown in Charts 1.6 and 1.7, there are marked differences between developed and developing countries, and between different ITU world regions.[4]

Chart 1.6 shows that there are substantial margins between the penetration rates for developed and developing countries, and for LDCs. The gap between developed countries and developing countries narrowed somewhat – from 35.2 to 28.6 subscriptions per 100 population – between 2011 and 2017, as developed countries moved towards market saturation, while the margin between developed countries overall and LDCs also narrowed – from 35.8 to 28.2 subscriptions per 100 population – but these still represent very substantial digital divides.

Chart 1.7 shows that only one of the ITU regions, Africa, now has a penetration rate for mobile-cellular subscriptions below 100 per 100 population. The rates of growth for most world regions have tailed off in recent years as mobile-cellular penetration has approached market saturation, with the highest recent regional growth rate being experienced in the Asia and the Pacific region. After steady growth in the decade to 2015, the figures for Africa have also been relatively stable during the past two years.

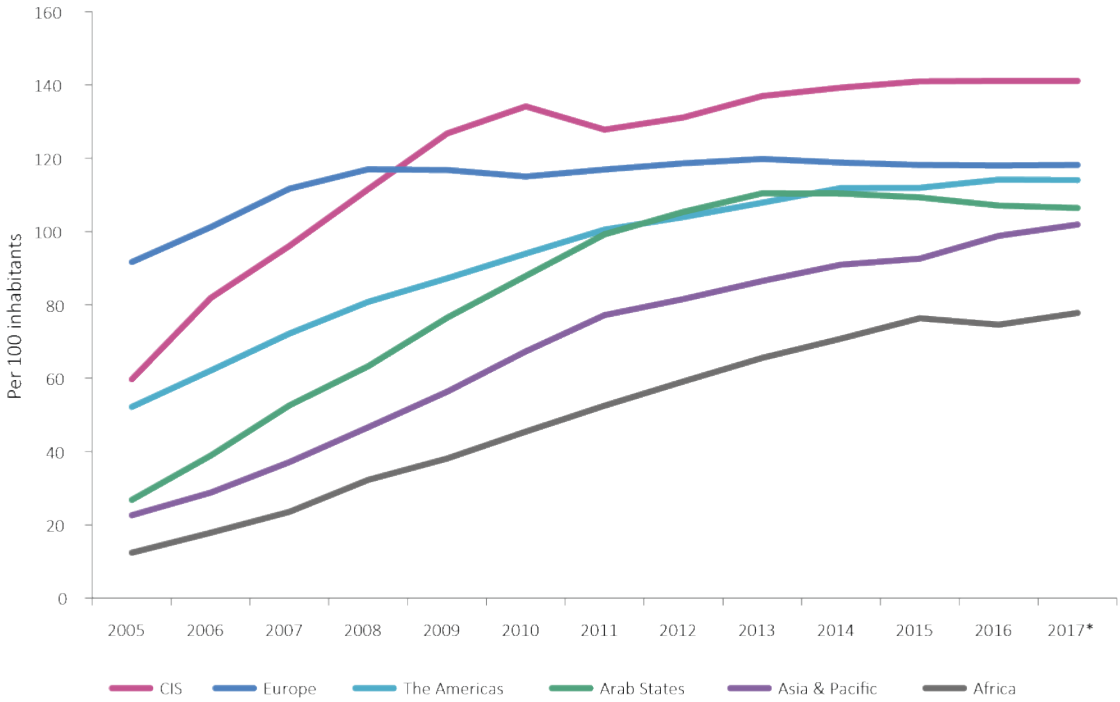
Data analysis at this global and regional level does not address differences in access to telephony between different social groups within the

Chart 1.6: Mobile cellular subscriptions per 100 inhabitants by level of development, 2005–2017*



Notes: * ITU estimate.
Source: ITU.

Chart 1.7: Mobile cellular subscriptions per 100 inhabitants by region, 2005–2017*



Notes: * ITU estimate.
Source: ITU.

population of different countries (see section 1.5) or variations in national geography. There are still rural areas in some developing countries which are not adequately covered by a mobile-cellular signal, while the lower incomes which prevail in rural areas of some countries are also likely to reduce take-up and usage. Levels of educational experience may be an additional factor in some cases. Differences in mobile-cellular usage within a number of developing countries were illustrated in *Measuring the Information Society Report 2016* (ITU, 2016b: 170).

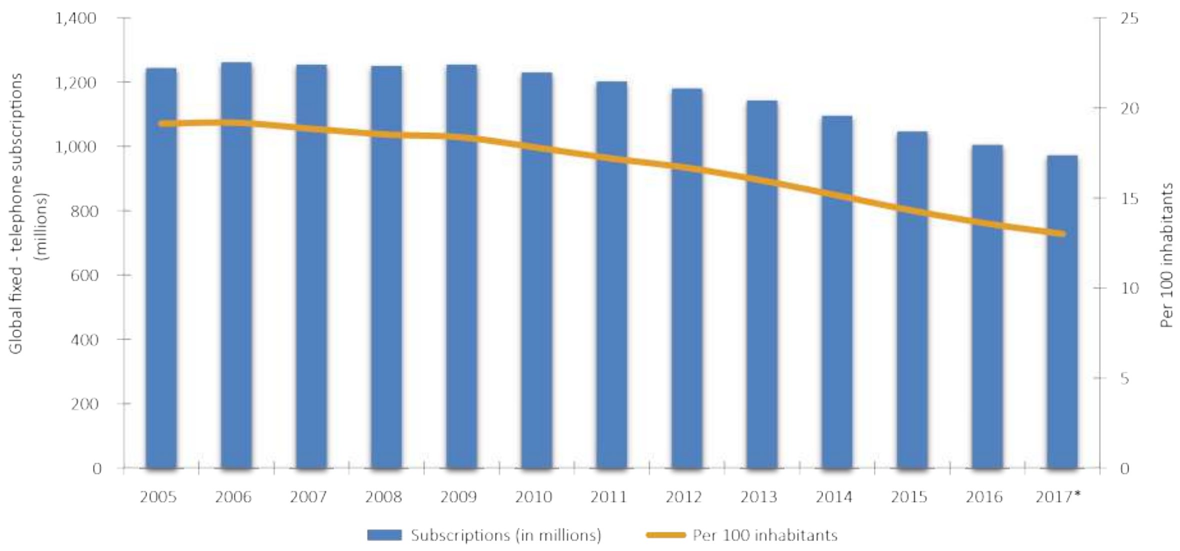
1.2.3 Fixed-telephone subscriptions

The growth in mobile-cellular subscriptions worldwide in recent years has been accompanied by a fall in the number of fixed-telephone subscriptions. The total number of these subscriptions has fallen from a peak of 1.26 billion in 2006 to 1.00 billion in 2016 and an estimated 972 million in 2017. Chart 1.8 illustrates this gradual decline in both subscriptions and the number of subscriptions per 100 population since 2006.

As with mobile-cellular subscriptions, there are marked differences between the penetration rates for fixed telephony in developed and developing countries, and in different world regions. These are illustrated in Charts 1.9 and 1.10. These show that there has been a steady decline in the fixed-telephone subscription rate in both developed and developing countries, and in most regions, since 2005, with this decline setting in more recently in the CIS region than in other regions.

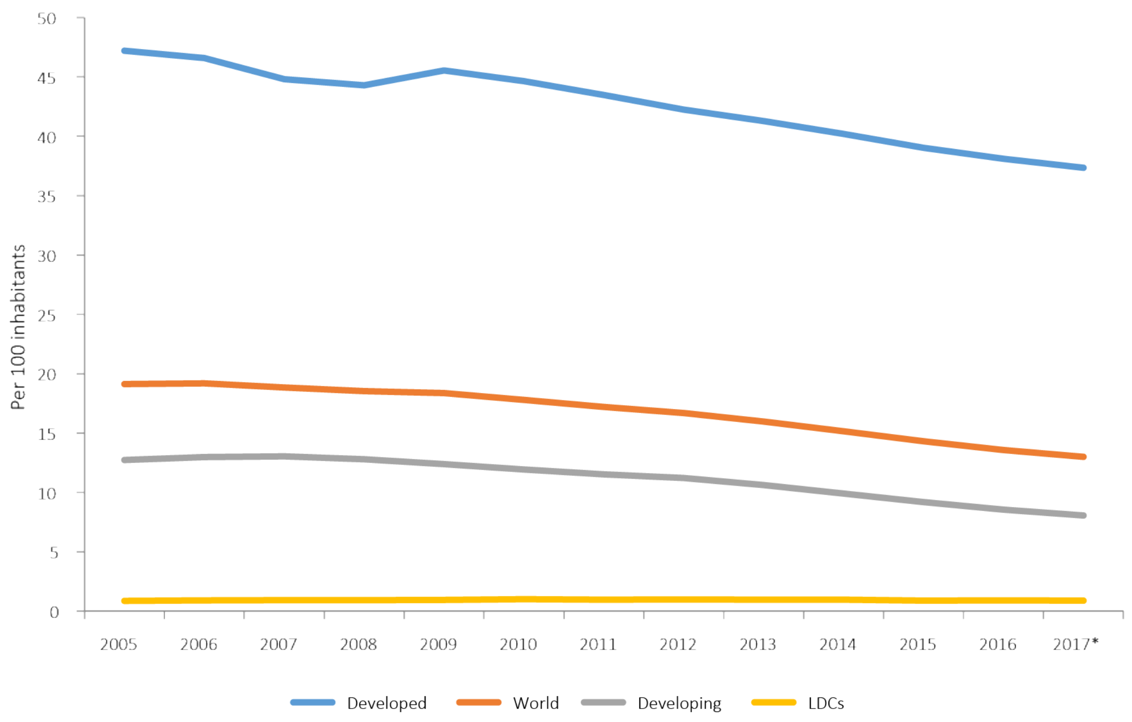
The low level of fixed telephony in developing countries has persisted since before the introduction of mobile telephony, and reflects historically low levels of fixed infrastructure deployment. Penetration rates in the LDC group of countries have been at or below 1.0 per 100 population throughout the period under review, while those for Africa have fallen from 1.5 to 1.0 per 100 population since 2005. As many as 26 countries recorded fixed-telephone penetration rates below 1.0 per 100 population in the IDI 2017, including three LDCs which recorded no fixed-telephone subscriptions whatsoever (the Democratic Republic of Congo, Guinea and Guinea-Bissau).

Chart 1.8: Global fixed-telephone subscriptions, total and per 100 inhabitants, 2005–2017*



Notes: * ITU estimate.
Source: ITU.

Chart 1.9: Fixed-telephone subscriptions per 100 inhabitants by level of development, 2005–2017*



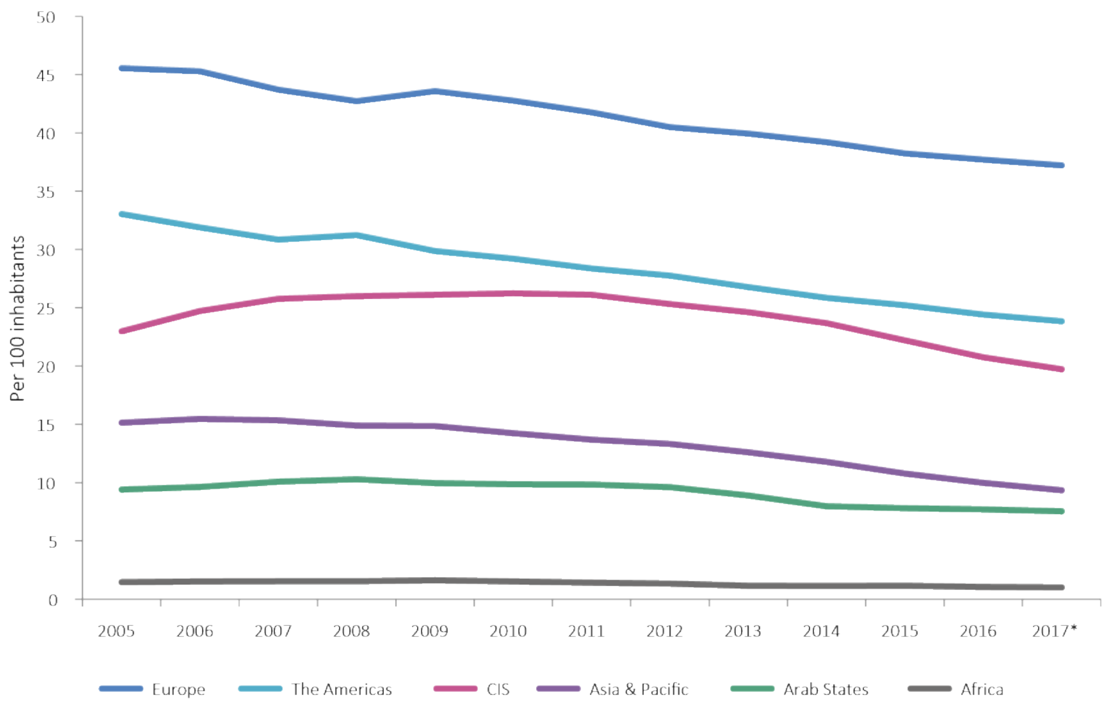
Notes: * ITU estimate.
Source: ITU.

1.3 Trends in broadband access

Broadband networks and services are increasingly central to economic and social life, and to prospects for development, in both developed and developing countries. Access to broadband, as a result, has become a more fundamental indicator of ICT performance and potential than access to voice telephony and other basic services.

A variety of definitions has been used for broadband in analyses from different sources,

Chart 1.10: Fixed-telephone subscriptions per 100 inhabitants by region, 2005–2017*



Notes: * ITU estimate.
Source: ITU.

some of these changing over time as more bandwidth has become available. For the purposes of this chapter, and of the IDI reported in Chapters 2 and 3, broadband is defined as services with speeds of 256 kb/s and above.

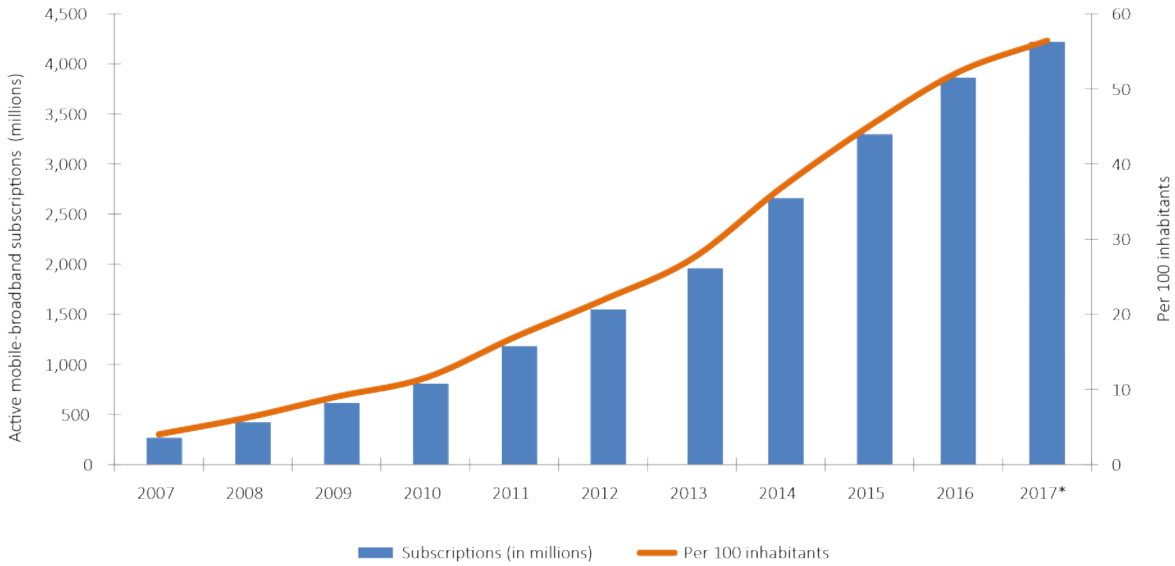
As with voice telephony, mobile networks and devices now provide the majority of broadband access in most countries. Only 6 of the 176 economies included in IDI 2017 recorded higher levels of fixed-broadband than mobile-broadband penetration (Comoros, Cuba, Equatorial Guinea, Eritrea, Guyana and Palestine[5]), four of these recording very low levels of access in both modes. It should be noted, in this context, that fixed-broadband subscriptions are more likely to be shared by several people than mobile-broadband subscriptions. Fixed-broadband speeds are also usually higher than mobile-broadband speeds.

1.3.1 Active mobile-broadband subscriptions

The number and penetration rate of active mobile-broadband subscriptions have grown rapidly since mobile-broadband networks first became available in the middle of the previous decade. Growth in these subscriptions has broadly mirrored that for mobile-cellular subscriptions, but with a time lag and at a lower level, since around 2010, with a faster growth rate being experienced since around 2013. The advent of smartphones and tablets has accelerated the use of mobile-broadband alongside more extensive network deployment. This suggests that many people who started with a voice-only mobile phone subscription have switched to smartphones with mobile-broadband. Smartphone traffic is expected to exceed computer traffic by 2020, while traffic from wireless and mobile devices will then account for two-thirds of all IP traffic.[6]

Chart 1.11 illustrates the growth that has taken place in active mobile-broadband subscriptions globally since these were first recorded in 2007. The total number of subscriptions has risen from 268 million in 2007 to 807 million in 2010, 3.30 billion in 2015 and an estimated 4.22 billion in 2017. The global penetration rate has risen from 4.0 per 100 population in 2007 to 11.5 in 2010, 45.1 in 2015 and an estimated 56.4 in 2017. Two countries in IDI 2017 (Australia and Finland) recorded penetration rates for mobile-broadband above those for mobile-cellular subscriptions.

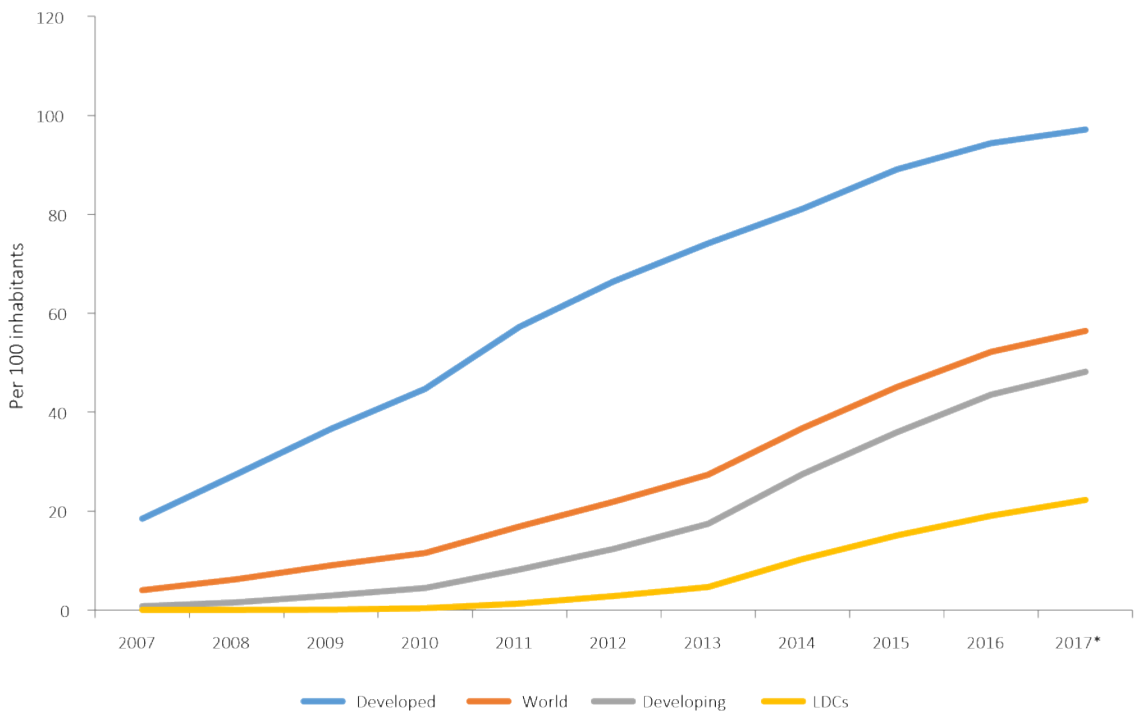
Chart 1.11: Global active mobile-broadband subscriptions, total and per 100 inhabitants, 2007–2017*



Notes: * ITU estimate.
Source: ITU.

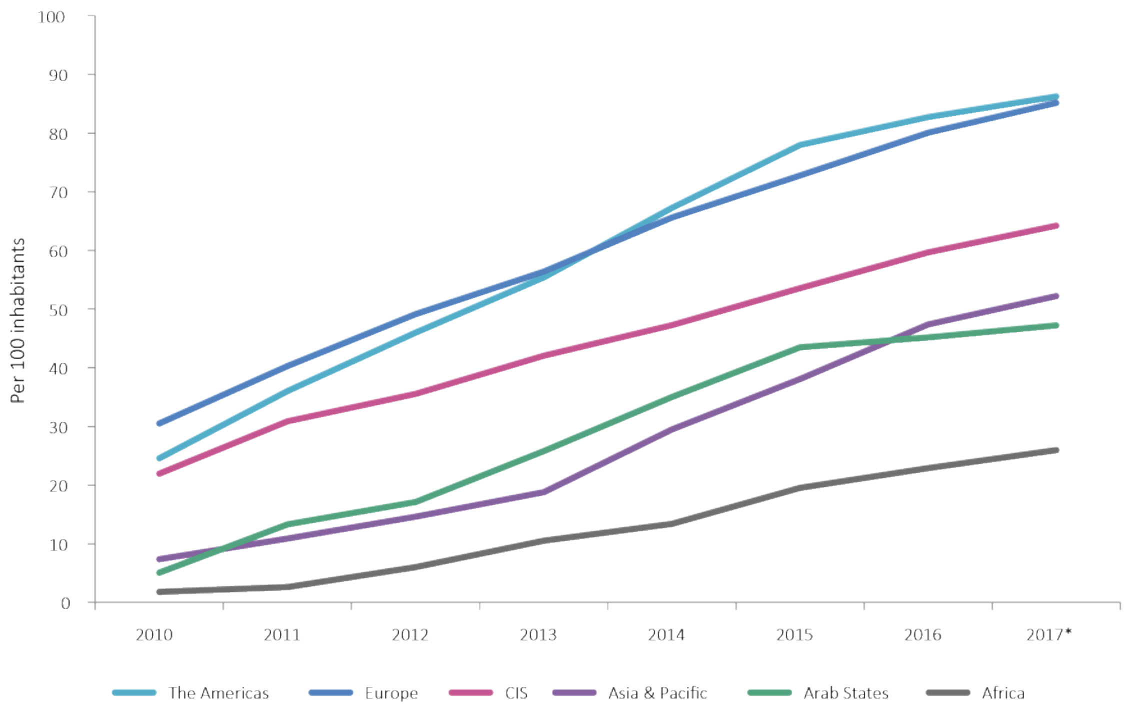
Once again, there are marked differences between the experience in developed and developing countries and in different world regions, with an upward trend comparable to that for mobile-cellular subscriptions at lower subscription levels. These differences are illustrated in Charts 1.12 and 1.13.

Chart 1.12: Active mobile-broadband subscriptions per 100 inhabitants by level of development, 2007–2017*



Notes: * ITU estimate.
Source: ITU.

Chart 1.13: Active mobile-broadband subscriptions per 100 inhabitants by region, 2010–2017*



Notes: * ITU estimate.
Source: ITU.

The penetration rate for mobile-broadband in developed countries has almost reached 100 per 100 population, just over twice that for developing countries and more than four times that for LDCs. The gap between developed and developing countries has narrowed slightly between 2012 and 2017, from 54.1 to an estimated 49.0 percentage points. That between developing countries as a whole and LDCs, however, has risen from 9.5 subscriptions per 100 population in 2012 to an estimated 25.9 per 100 population in 2017. This suggests that LDCs may presently be falling further behind where this important indicator is concerned.

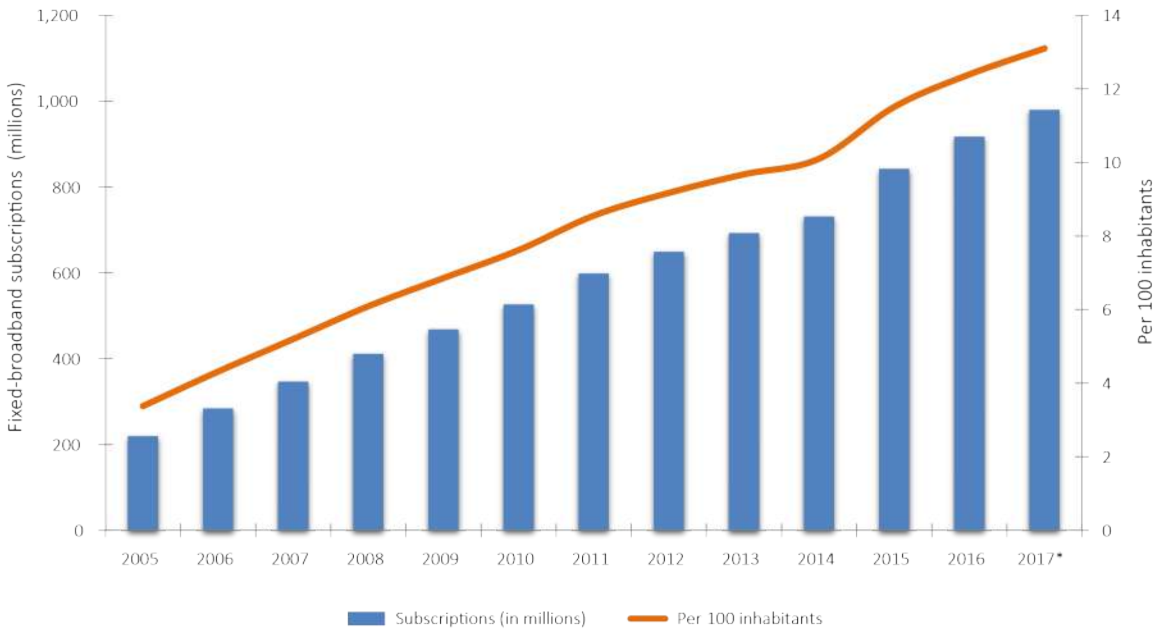
Chart 1.13 shows similarly marked differences between regions to those noted for mobile-cellular subscriptions, with high penetration rates in Europe and the Americas, medium rates in the CIS, Asia and the Pacific and Arab States regions, and much lower penetration rates in Africa. The growth rates for most regions have been broadly similar, but with a significant slowdown in growth in the Arab States since 2015. The growth rate in Africa is also slightly below that in most other regions.

1.3.2 Fixed-broadband subscriptions

As with fixed and mobile telephony, the number and penetration rate for fixed-broadband subscriptions fall far below those for mobile-broadband. Although the indicators for fixed and broadband subscriptions are not directly comparable (see above), the figure for fixed-broadband subscriptions is less than a quarter of that for active mobile-broadband subscriptions and just 18.8 per cent of all broadband subscriptions.

Worldwide, the number of fixed-broadband subscriptions has risen from 220 million in 2005 to 526 million in 2010, 842 million in 2015 to an estimated 979 million in 2017 (a figure which, for the first time, exceeds the estimate for fixed-telephone subscriptions). This rate of growth has been, to some extent, dependent on the prior availability of fixed-telephone networks, which are much less widespread in many developing countries, and particularly LDCs, than they are in developed countries. Concern has been expressed in previous *Measuring the Information Society Reports* and other analyses about the potential importance of fixed-broadband connectivity in

Chart 1.14: Global fixed-broadband subscriptions, total and per 100 inhabitants, 2005–2017*



Notes: * ITU estimate.
Source: ITU.

enabling developing countries to maximize the use of more advanced communications services.[7]

Chart 1.14 illustrates the growth which has taken place in fixed-broadband subscriptions globally since 2005. The differences between the experience of developed and developing countries, and the experiences of different regions, are set out in Charts 1.15 and 1.16.

Charts 1.15 and 1.16 illustrate the extent to which fixed-broadband networks are more prevalent in developed countries, and in the Europe region, than they are elsewhere. The level of fixed-broadband access is also notably lower in the Arab States region than it is in the Americas, the CIS region and the Asia and the Pacific region. Together with the slower rate of growth in mobile-broadband identified in Chart 1.13, this suggests that the Arab States region is falling behind other developing regions in broadband access, irrespective of access mode.

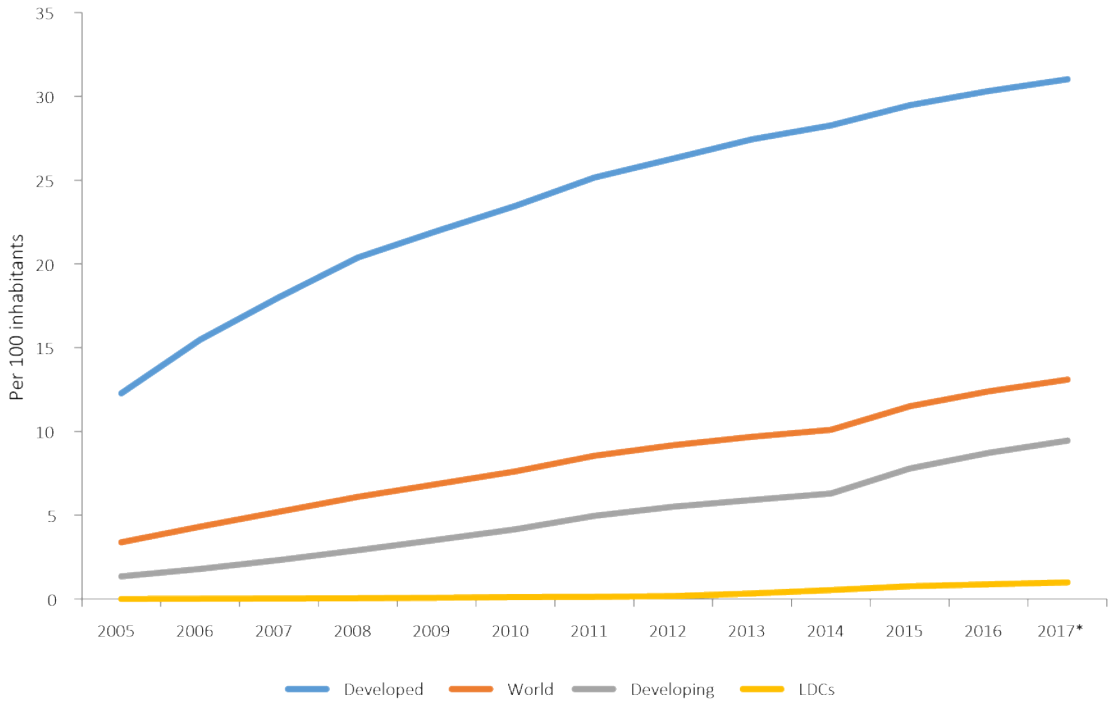
The most striking feature of these charts, however, is the exceptionally low penetration rates that they show for LDCs and Africa. The ITU Africa region, with a population of almost 1 billion, is estimated to have only some 4 million fixed-broadband subscriptions in 2017, fewer than the number of fixed-broadband subscriptions in Belgium, which has a population of less than 11.5 million. There are estimated to be less than 10 million fixed-broadband subscriptions in LDCs, approximately 1.0 per cent of the global total, though LDCs include 13 per cent of world population.[8]

Chart 1.17 shows the uneven distribution of fixed-broadband subscriptions by speed. Chart 1.17 also shows the much greater reliance of low-income countries, where broadband is concerned, on mobile access, which may prove a constraint if fixed access proves to be more appropriate for the use of future high-specification services. In any event, the bandwidth available through mobile networks in African and other LDCs is generally much less per user than is the case in developed countries and high-income developing countries.

1.4 Internet access and use

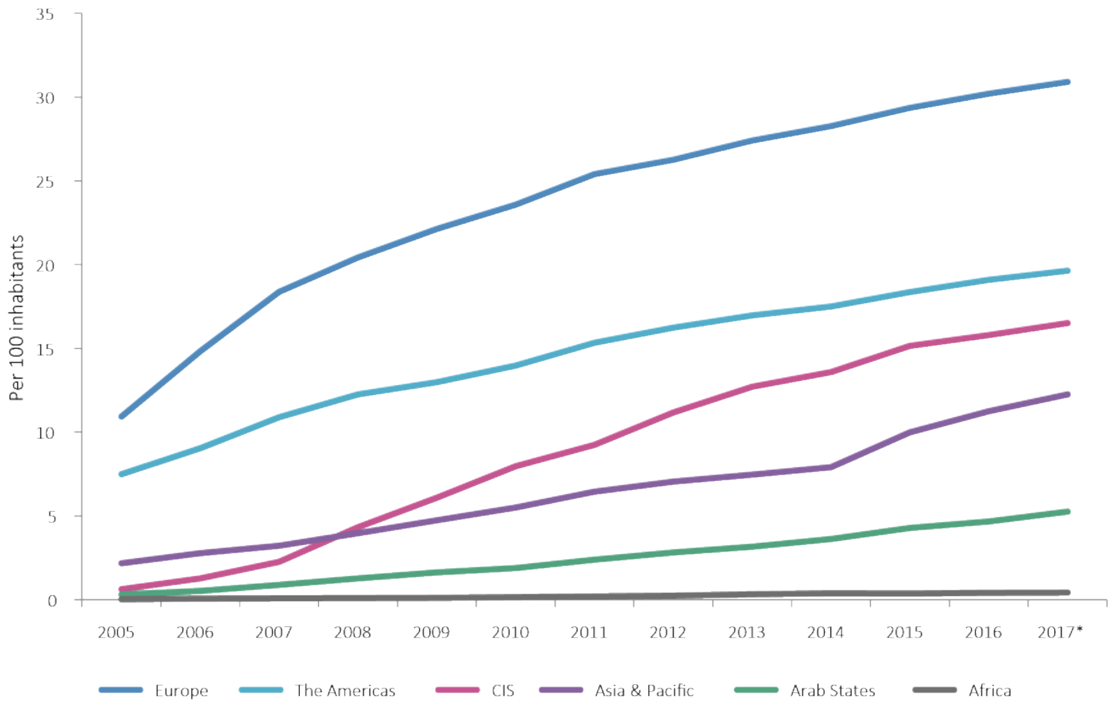
Data communications have replaced voice communications as the most important use of both fixed and mobile networks during the period since WSIS. Access to and use of the Internet have become critically important not just in terms of ICTs but also in prospects for economic and social development, including achievement of the Sustainable Development Goals.

Chart 1.15: Fixed-broadband subscriptions per 100 inhabitants by level of development, 2005–2017*



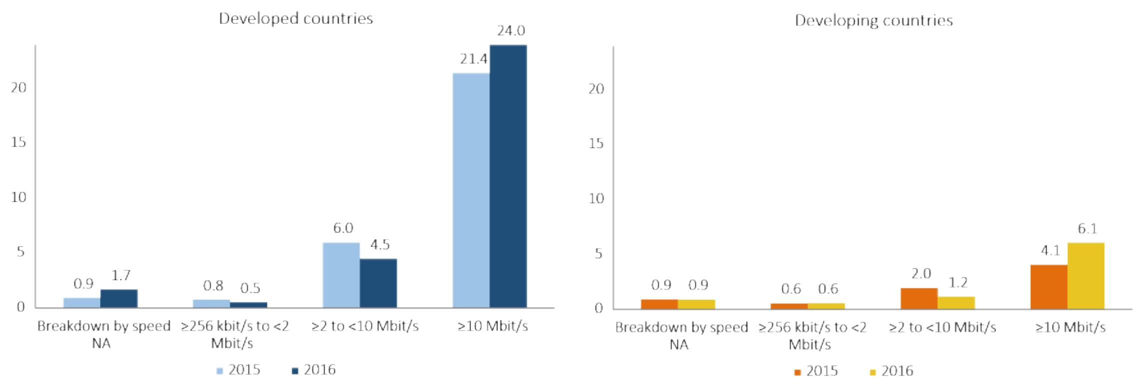
Notes: * ITU estimate.
Source: ITU.

Chart 1.16: Fixed-broadband subscriptions per 100 inhabitants by region, 2005–2017*



Notes: * ITU estimate.
Source: ITU.

Chart 1.17: Fixed-broadband subscriptions per 100 inhabitants, by speed, 2015-2016



Source: ITU.

Household access to the Internet is the most effective way of enabling an inclusive information society in which all people, irrespective of age, gender, disability, or economic or social context, can access the Internet and the resources which it makes available. Household access can be supplied through either fixed or mobile connectivity, and may be shared among family members. Many of the broadband strategies that have been adopted by governments seek to enable access for all households nationwide as a means of achieving universal access to the Internet.

The latest ITU data estimate that more than half of the world's households (53.6 per cent) now have access to the Internet at home, compared with less than 20 per cent in 2005 and just over 30 per cent in 2010. Chart 1.18 shows that the proportion of households with Internet access around the world grew steadily, by between 7.5 and 13.5 per cent each year, between 2005 and 2015, but that the rate of growth in the last two years has been slower, at or below 5.0 per cent.

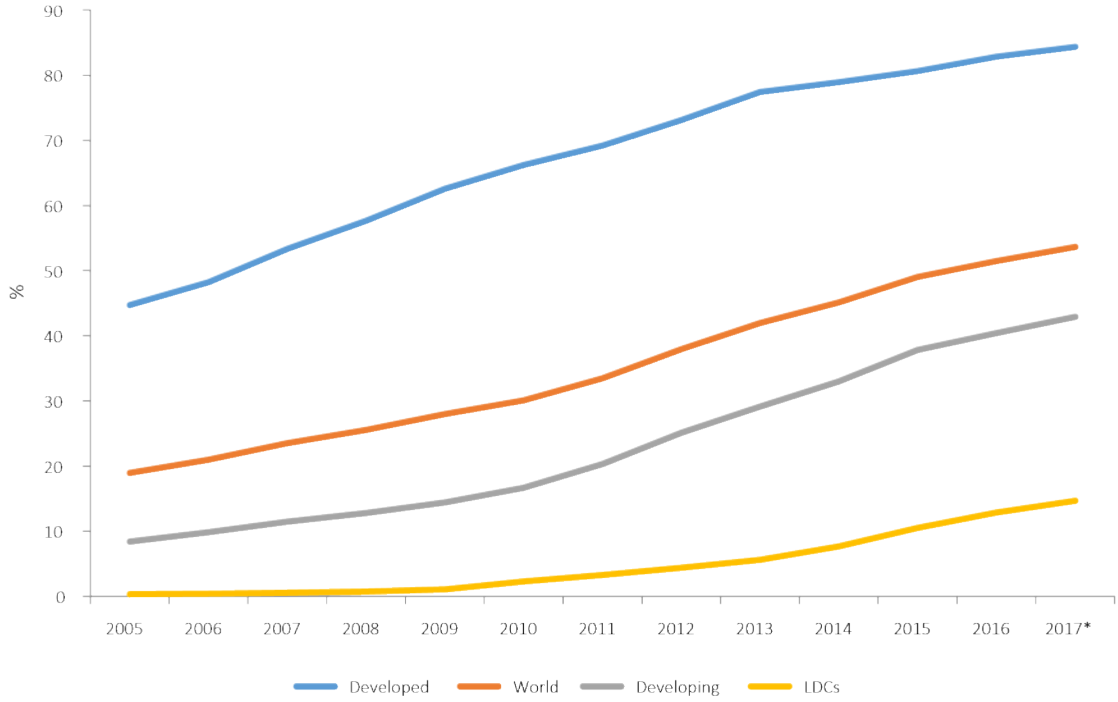
Charts 1.18 and 1.19 show that the digital divides between developed and developing countries and between regions that were observed for fixed and mobile connectivity earlier in this chapter are also evident in levels of household access to the Internet.

ITU's Connect 2020 targets, agreed to in 2014, call for 50 per cent of households in developing countries, and 15 per cent of households in LDCs, to have Internet access by 2020. By 2017, it is estimated that 84.4 per cent of households in developed countries will have Internet access, compared with 42.9 per cent in developing countries and just 14.7 per cent in LDCs. As can be seen from Chart 1.18, the gap between LDCs and developing countries in general appears to be widening, though the figure for LDCs is now close to achieving the Connect 2020 target set in 2014. Progress towards the Connect 2020 targets will be reviewed at ITU's Plenipotentiary Conference in 2018.

Chart 1.19 reveals that there are similarly large differences between different world regions. Europe has the highest proportion of households with Internet access, almost 85 per cent, while the CIS and Americas regions also record figures well over 50 per cent. There has been particularly rapid growth in household access to the Internet in the CIS region since 2008. The Arab States and the Asia and the Pacific region both record just under half of households having Internet access. The figure for Africa, however, is much lower, at 18.0 per cent, though this has continued a steady rise since 2010, when it was 3.9 per cent.

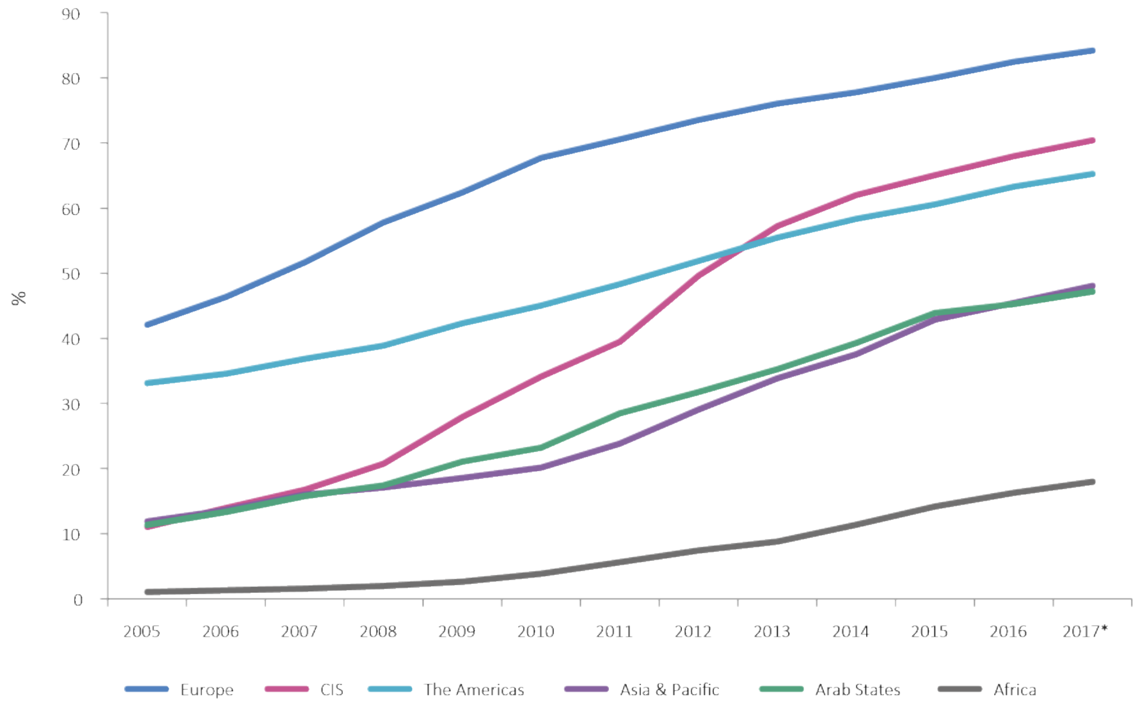
Not surprisingly, ITU data on the number of individuals using the Internet show a pattern broadly similar to those for household access to the Internet. Chart 1.20 shows the growth in the global number of individuals using the Internet and the proportion of the world's population using the Internet. ITU estimates that the number of individuals using the Internet will exceed 3.5 billion in 2017, representing 48.0 per cent of the world population. This compares with 1.0 billion (15.8 per cent) in 2005, 2.0 billion (28.9 per cent) in 2010 and 3.15 billion (43.2 per cent) in 2015, continuing a steady upward trend throughout the period.

Chart 1.18: Global proportion of households with access to the Internet, 2005–2017*



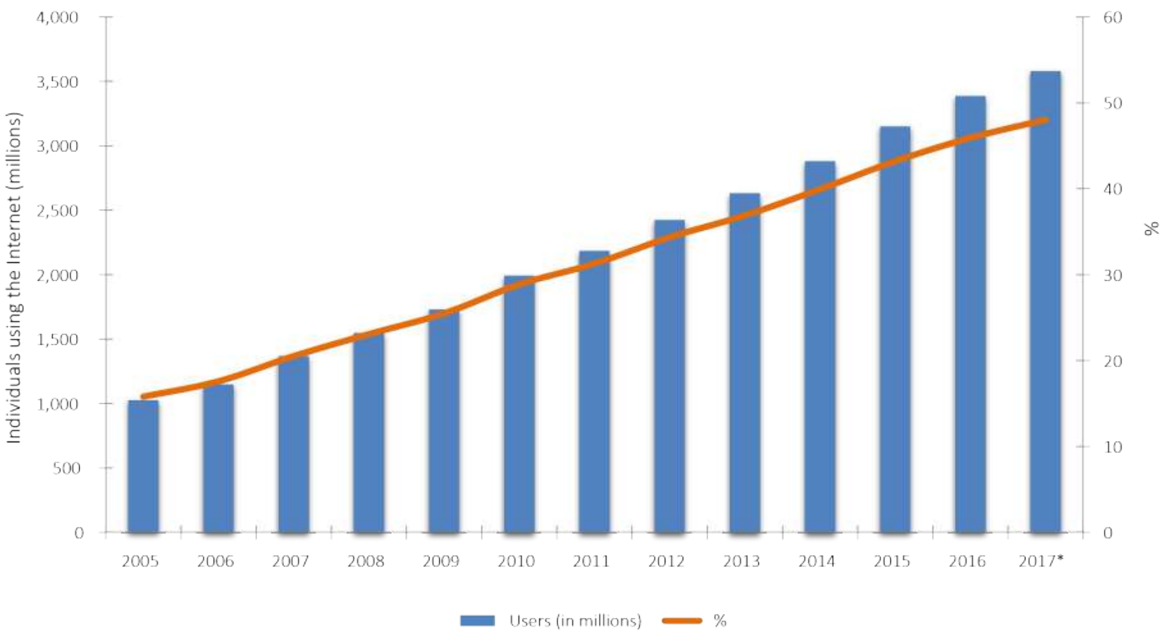
Notes: * ITU estimate.
Source: ITU.

Chart 1.19: Proportion of households with access to the Internet by region, 2005–2017*



Notes: * ITU estimate.
Source: ITU.

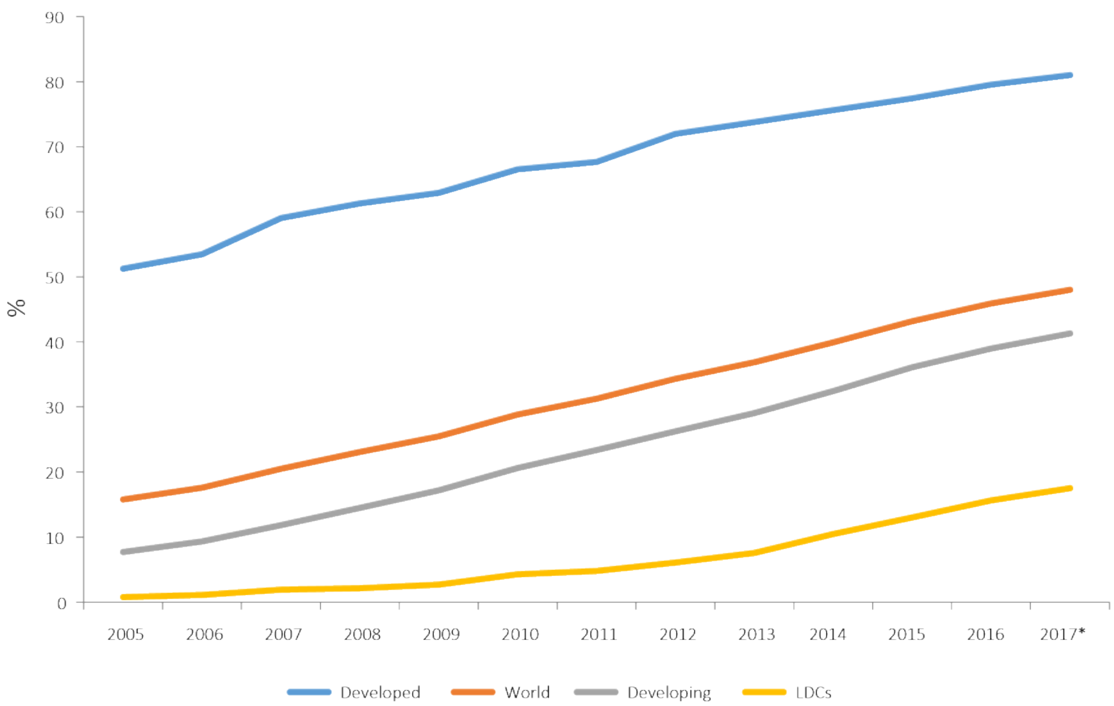
Chart 1.20: Individuals using the Internet, 2005–2017*



Notes: * ITU estimate.
Source: ITU.

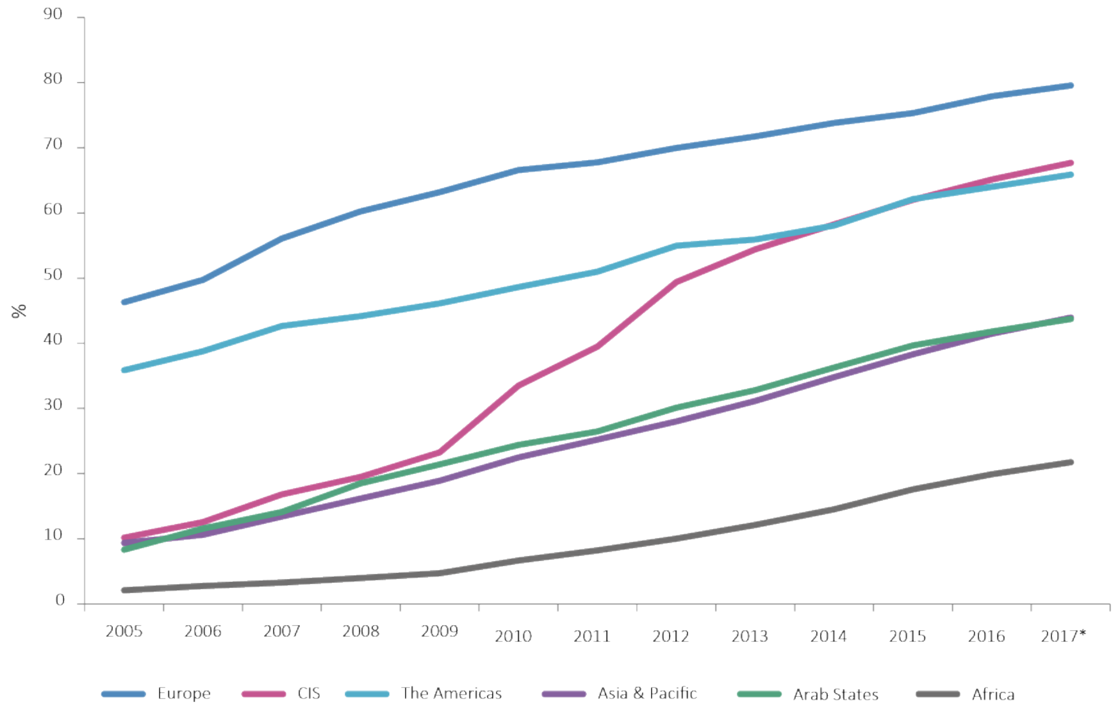
As with household access, Charts 1.21 and 1.22 show that there are considerable differences in the experience of countries in different development categories and in different regions. Chart 1.21 shows the evolution in the number of individual users in countries with different development status during the period 2005–2017. This shows a substantial digital divide between developed

Chart 1.21: Proportion of individuals using the Internet by development status, 2005–2017*



Notes: * ITU estimate.
Source: ITU.

Chart 1.22: Proportion of individuals using the Internet by region, 2005–2017*



Notes: * ITU estimate.
Source: ITU.

countries, in which 81.0 per cent of individuals are now estimated to use the Internet, and developing countries, in which the figure is 41.3 per cent, and a similar digital divide between these groups of countries and LDCs, for which the comparable figure is 17.5 per cent.

ITU's Connect 2020 targets, agreed to in 2014, called for the proportion of individuals using the Internet (i.e. those using the Internet at least once within a three-month period) to reach 50 per cent in developing countries, and 20 per cent in LDCs, by 2020.

Chart 1.22 presents findings for the same indicator by ITU region, and shows outcomes similar to those identified for household access. Europe is again the region with the highest outturn figure for this indicator, while the CIS region and the Americas also have figures well above 50 per cent, the CIS region having made particularly strong gains between 2009 and 2013. Outturn figures for the Arab States and Asia and the Pacific regions are approaching 50 per cent and should, at current rates of growth, reach or exceed that target by the end of the decade. The figure for Africa is steadily growing but, at 21.8 per cent, is well below that for any other region.

1.5 Digital divides within society

There are significant differences in the levels of Internet adoption by different groups within society. Particular attention has been paid to the digital gender gap, while increasing attention is also being paid to differences between age groups.

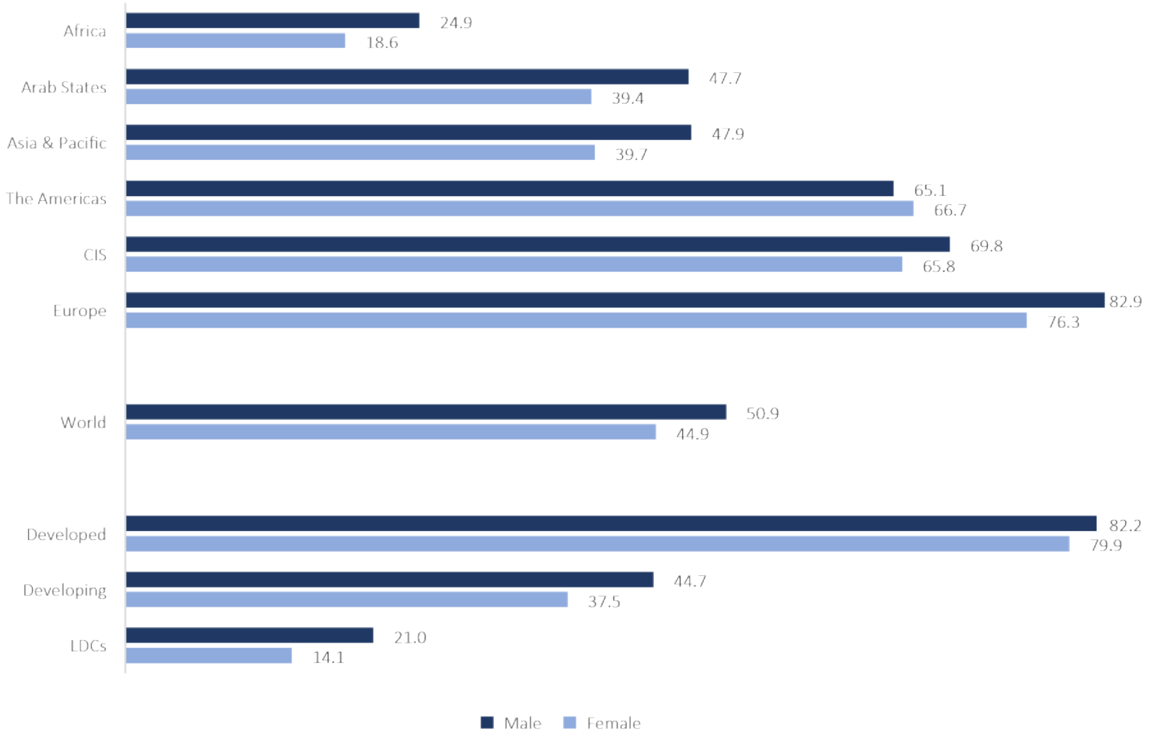
Gender equality

There has been increasing international concern in recent years about gender imbalance in access to the Internet and other ICTs. Addressing this imbalance was among the priorities identified by the United Nations General Assembly in its ten-year review of the outcomes of WSIS in 2015. Added significance is attached to this by the Sustainable Development Goals, which include an explicit commitment to enhance the use of ICTs to promote women's empowerment.[9] ITU's Connect 2020 targets seek to ensure that gender equality among Internet users is reached by 2020.

Although there is a need for more gender-disaggregated data to be developed, the latest data compiled by ITU suggest that the proportion of men using the Internet is higher than the proportion of women doing so in two-thirds of countries worldwide. Internet penetration rates for men and women, and the gender gap between men and women, are illustrated in Charts 1.23 and 1.24.

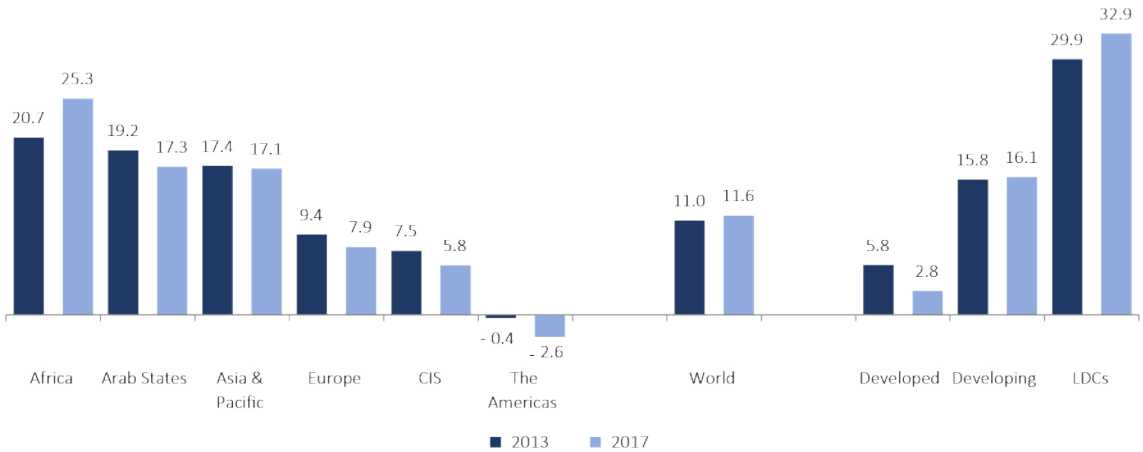
These charts suggest that the digital gender gap fell between 2013 and 2017 in developed

Chart 1.23: Internet penetration rates for men and women, 2017*



Notes: * Estimates. Penetration rates in this chart refer to the number of women/men using the Internet, as a percentage of the respective total female/male population.
Source: ITU.

Chart 1.24: Internet user gender gap, percentages, 2013 and 2017*



Notes: * Estimates. The gender gap represents the difference between the Internet user penetration rates for males and females relative to the Internet user penetration rate for males, expressed as a percentage.
Source: ITU.

countries, where more than 80 per cent of the population is now estimated to be online. The gap in developed countries is now estimated to be just 2.8 per cent. It is much more pronounced, at 16.1 per cent, in developing countries, where overall Internet access is 41.3 per cent, just over half the rate in developed countries. The digital gender gap is most pronounced, rising to 32.9 per cent, in LDCs, where overall Internet usage is lowest, including just 17.5 per cent of the population. In LDCs, only one out of seven women is using the Internet compared with one out of five men.

The gender gap is also more pronounced in Africa, where the majority of LDCs are concentrated, than in other ITU regions. While the gap has fallen in other regions since 2013, it is estimated to have increased in Africa between 2013 and 2017, from 20.7 to 25.3 percentage points. This suggests that, while Internet access rates in Africa are currently increasing, men are disproportionately represented in that increase.

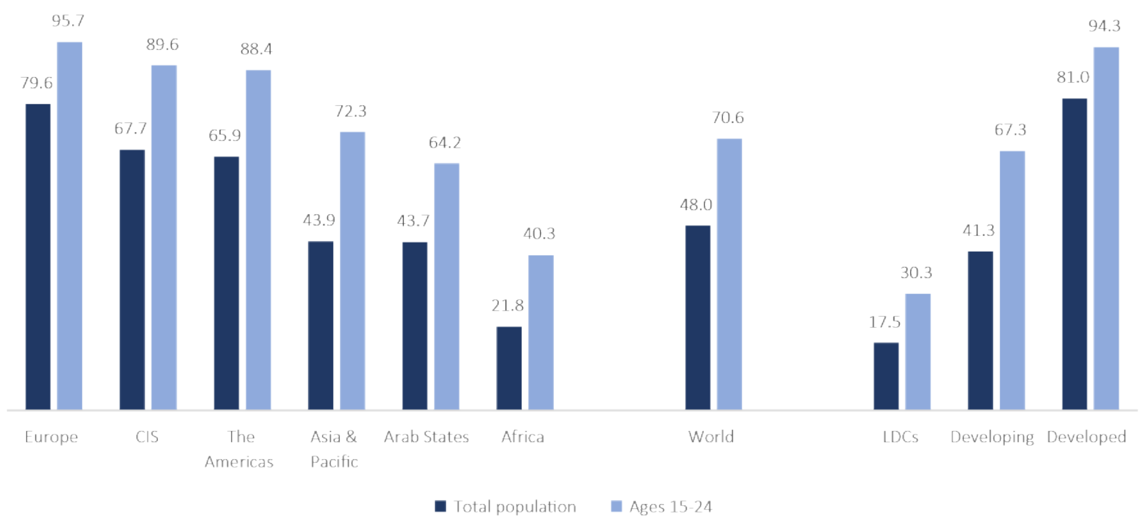
Evidence from household surveys suggests that the digital gender gap is strongly associated with indicators of other socio-economic disadvantages experienced by women in many societies, such as fewer years spent in education and lower levels of income. There is a particularly strong association between gender parity in tertiary education and gender parity in Internet use. The only region where a higher proportion of women than men are using the Internet, for example, is the Americas, where countries also score highly on gender parity in tertiary education. The association between the digital gender gap and structural inequalities between men's and women's access to education and income implies that efforts to address these structural inequalities will be essential if the goal of gender equality in ICT access is to be achieved.

Differences between age groups

Young people, particularly those aged between 15 and 24, have been more particularly strongly engaged with the Internet. As indicated in Charts 1.25 and 1.26, the proportion of people in this age group who are using the Internet, 70.6 per cent worldwide, is much higher than the proportion of the total population which is online (48.0 per cent). This higher rate of Internet adoption by young people is apparent in all development categories and regions. In LDCs, 35.1 per cent of individuals using the Internet fall into this age group, which forms 20.3 per cent of their population, compared with just 13.0 per cent in developed countries (where they comprise 11.2 per cent of the population).

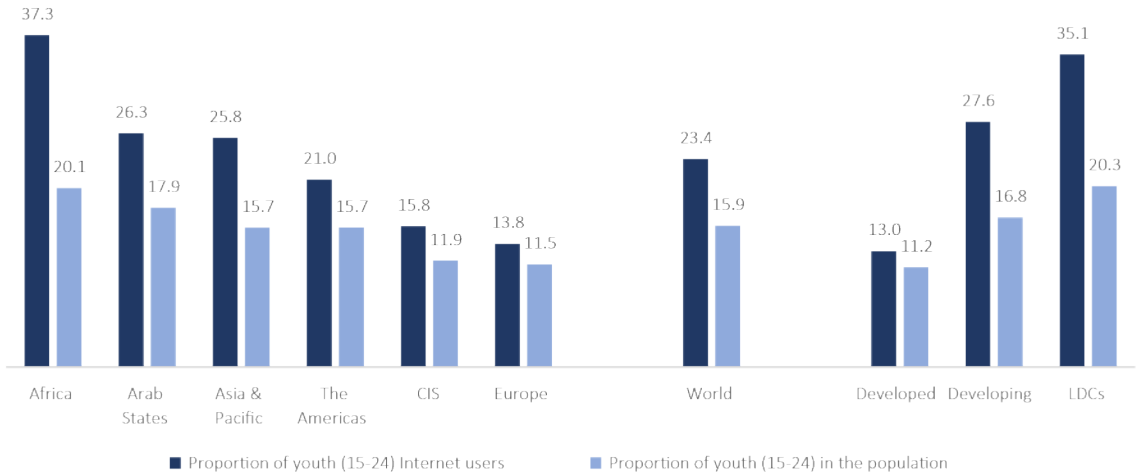
While young people have been particularly enthusiastic adopters of the Internet, significantly lower rates of adoption are found in older age groups. The 2016 edition of this *Report* found that, in most countries, Internet adoption among those aged over 75 is below 10 per cent, adding that possible explanations include lower incomes,

Chart 1.25: Proportion of individuals using the Internet, by age, 2017*



Notes: * Estimates. Proportions in this chart refer to the number of people using the Internet, as a percentage of the total population, and the number of people aged 15-24 using the Internet, as a percentage of the total population aged 15-24, respectively.
Source: ITU.

Chart 1.26: Young people aged 15–24 as a proportion of population and of Internet users, 2017*



Notes: * Estimates. Proportions in this chart refer to the number of people aged 15-24 using the Internet, as a percentage of the total population using the Internet, and the number of people aged 15-24, as a percentage of the total population, respectively.
Source: ITU.

lower educational attainment, social isolation, medical problems and psychological barriers such as anxiety about computers and the Internet.[10]

1.6 Summary and conclusion

Progress continues to be made in connectivity and use of ICTs in all world regions, but digital divides and inequalities continue to affect the extent to which the Information Society is contributing towards the economic and social development of different regions, countries, households and individuals.

Several long-term trends are evident. The substantial growth in mobile-cellular telephony which took place following WSIS (2003–2005) has greatly increased access to basic communications services. Mobile communications have become much more widespread, and are particularly predominant in developing countries. Recent years have also seen rapid growth in broadband networks and services, particularly mobile-broadband. This has enabled much greater use of ICTs for Internet and thereby for applications that support economic development and individual empowerment.

The digital divides that are apparent in access to and use of both basic and broadband communications, however, remain substantial. Developed countries have significantly higher subscription and penetration rates for basic communications, broadband and Internet, while particularly low subscription and penetration rates are evident in LDCs. People in Europe and high-income countries in North America and parts of the Asia and the Pacific region are also much more likely to be connected and to make full use of the Internet than those in other regions, particularly Africa. There is some evidence that the gap between LDCs and other developing countries may be increasing, raising concerns about possible impacts on efforts to achieve the Sustainable Development Goals.

Digital divides are also evident within countries, for example between urban and rural areas and between age groups. Urban residents and young people are more likely to be online in many countries than are rural dwellers and the elderly. Particular concern has been expressed about the digital gender gap. Women are less likely than men to make use of the Internet in most countries, but are more underrepresented online in developing countries than in developed countries, and are especially underrepresented in LDCs.

ITU adopted the Connect 2020 targets – which focus on access and use of broadband and Internet, with particular attention to developing countries, LDCs, gender equity and affordability – at its Plenipotentiary Conference in 2014. Progress toward achieving these will be reviewed at the next Plenipotentiary Conference in 2018.

Endnotes

1 Calculated as mobile-cellular subscriptions as a proportion of the total of mobile-cellular plus fixed-telephone subscriptions.

2 This will be affected by variations in the proportion of young children in the population, which is significantly higher in many developing countries.

3 See ITU, 2016b and ITU, 2017a.

4 These differ from the regions used in other UN data sets – see Volume 1 Chapter 2 of this *Report*.

5 Palestine is not an ITU Member State; the status of Palestine in ITU is the subject of Resolution 99 (Rev. Busan, 2014) of the ITU Plenipotentiary Conference.

6 See ITU, 2016b: 183. For a discussion of evolving trends, see ITU, 2017a.

7 See e.g. the *Reports* for 2014 (ITU, 2014: Chapter 5) and 2015 (ITU, 2015: Chapter 5).

8 United Nations Office of the High Representative for the Least Developed Countries, Landlocked Developing Countries and Small Island Developing States, "LDCs in Facts and Figures", available from http://unohrlls.org/about-ldcs/facts-and-figures-2/.

9 Sustainable Development Goal Target 5.B: Enhance the use of enabling technology, in particular information and communications technology, to promote the empowerment of women.

10 Van Deursen and Helsper, 2015.

Chapter 2. The ICT Development Index – global analysis

Key findings

The ITU ICT Development Index (IDI) is a unique benchmark of the level of ICT development in countries across the world. The IDI combines eleven indicators on ICT access, use and skills, capturing key aspects of ICT development in one measure that allows for comparisons to be made between countries and over time. IDI 2017 covers 176 economies worldwide. Comparison with IDI 2016 shows that progress has continued to be made in ICT access and use in almost all countries. However, it also demonstrates that there are still great disparities in ICT development between more and less connected countries which need to be addressed if inclusive information societies are to contribute to the achievement of sustainable development and other international goals.

Iceland tops the IDI rankings in 2017, with an IDI value of 8.98. It is followed by six other countries in Europe and three economies in the Asia-Pacific region which have competitive ICT markets that have experienced high levels of ICT investment and innovation over many years. Countries at the top of the IDI distribution also have high levels of economic prosperity, literacy and other skills that enable citizens to take full advantage of access to communications.

The average value for all economies in the Index rose by 0.18 points between IDI 2016 and IDI 2017, reaching 5.11 points, the first time that it has exceeded the halfway point along its scale. As in IDI 2016, improvements were particularly significant among countries in the middle of the distribution, many of which are middle-income developing countries, although there were only limited changes in positions in the rankings. The most substantial improvements in IDI value were recorded by Namibia, the Islamic Republic of Iran and Gabon, all of whose values rose by 0.50 points or more. All but eight countries improved their overall IDI values.

As in previous years, the ICT use sub-index grew more rapidly, by 0.31 points, than did the access and skills sub-indices, both of which rose by an average 0.10 points. The most significant contribution to improvements in IDI values was made by the indicator for mobile-broadband subscriptions, the average value for which rose by 12.9 per cent during the year. The indicator for fixed-telephone subscriptions, by contrast, continued to show a gradual decline in the majority of countries.

The reduction of the digital divide between more and less connected countries continues to be challenging. The gap between the highest and lowest performing countries in the Index rose to 8.02 points (out of 10.0) in IDI 2017. As in previous years, there is a strong association between economic and ICT development, with least developed countries (LDCs) filling 37 of the 44 places in the lowest (least connected) quartile of the distribution. LDCs improved their average IDI value by 0.15 points during the year, compared with 0.22 points for other developing countries, suggesting that they may be falling further behind in ICT development.

Recent developments in ICT markets have led to the adoption of proposals for change in the composition of the Index. A revised set of indicators will be introduced from IDI 2018 which should add further insights into the performance of individual countries and the relative performance of countries at different development levels.

Chapter 2. The ICT Development Index – global analysis

2.1 Introduction

This chapter introduces the ITU Information and Communication Technology Development Index (ICT Development Index, or IDI), which brings together indicators concerned with ICT access, use and skills into a single comparative measure of development towards the information society. It presents findings from the latest edition of the Index (IDI 2017) for 176 economies for which data are available, assesses the experience of top-performing and most dynamic countries, and relates these findings to development status and the digital divide. Analysis of IDI 2017 from a regional perspective can be found in Chapter 3.

Section 2.2 describes the objectives, conceptual framework and methodology of the IDI, and reports on changes that will be introduced into the Index from 2018 following recommendations by the ITU Expert Group on Telecommunication/ICT Indicators (EGTI) and the ITU Expert Group on ICT Household Indicators (EGH).

Section 2.3 presents and analyses global findings for IDI 2017 and for its access, use and skills sub-indices, and compares these with those for IDI 2016. Regional outcomes are analysed in Chapter 3.

Section 2.4 analyses IDI 2017 in relation to the digital divide, including the relative performance of least connected countries (LCCs) and least developed countries (LDCs).

A brief summary of the chapter can be found in section 2.5.

2.2 The ICT Development Index

The IDI is a composite index that combines 11 indicators into one benchmark measure that can be used to monitor and compare developments in ICTs between countries and over time. The IDI was developed by ITU in 2008 in response to ITU Member States' request to establish an overall ICT index, was first presented in *Measuring the Information Society Report 2009* (ITU, 2009), and has been published annually since then.[1]

The findings for IDI 2017, which are presented in this chapter, were calculated using data for the end-of-year 2016, and assess progress by comparing these data with those for IDI 2016 (calculated using data for end-of-year 2015).

Objectives

The main objectives of the IDI are to measure:

- the *level and evolution over time* of ICT developments within countries and of their experience relative to other countries;
- progress in ICT development *in both developed and developing countries*;
- the *digital divide*, i.e. differences between countries in terms of their levels of ICT development; and
- the *development potential* of ICTs and the extent to which countries can make use of them to enhance growth and development in the context of available capabilities and skills.

The Index is designed to be global and reflect changes taking place in countries at different levels of ICT development. It therefore relies on a limited range of data sets which can be established with reasonable confidence in countries at all levels of development.

Conceptual framework

The recognition that ICTs can be development enablers, if applied and used appropriately, is critical to countries that are moving towards information or knowledge-based societies, and is central to the IDI's conceptual framework. The ICT development process, and a country's transformation to becoming an information society, can be depicted using the three-stage model illustrated in Figure 2.1:

- **Stage 1: *ICT readiness*** – reflecting the level of networked infrastructure and ***access*** to ICTs;
- **Stage 2: *ICT use*** – reflecting the level of ***intensity*** of ICTs in the society; and
- **Stage 3: *ICT impact*** – reflecting the ***results/outcomes*** of more efficient and effective ICT use.

Advancing through these stages depends on a combination of three factors: the availability of ICT infrastructure and *access*, a high level of ICT *usage*, and the capability to use ICTs effectively, derived from relevant *skills*. These three dimensions – ***ICT access, ICT use*** and ***ICT skills*** – therefore form the framework for the IDI.

The first two stages correspond to two major components of the IDI: ICT access and ICT use.

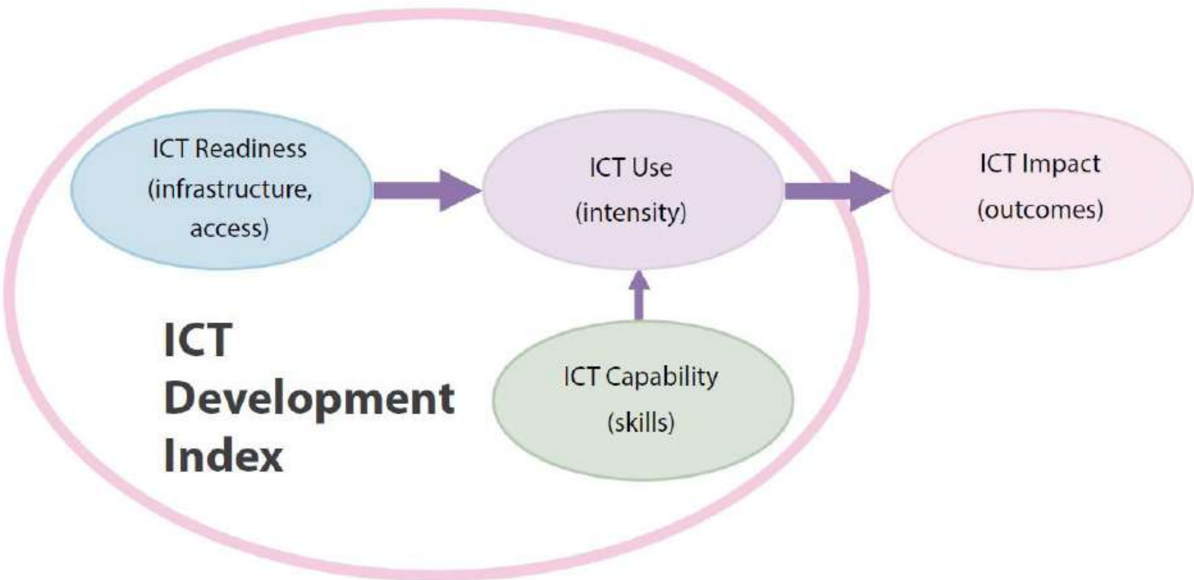
Reaching the final stage, and maximizing the impact of ICTs, crucially depends on ICT skills. ICT and other skills determine the effective use that is made of ICTs, and are critical to leveraging their full potential for social and economic development. Economic growth and development will remain below potential if economies are not capable of exploiting new technologies and reaping their benefits. The IDI therefore also includes proxy indicators concerned with capabilities within countries, which affect people's ability to use ICTs effectively.

A single indicator cannot track progress in all three of these components of ICT development. It is therefore necessary to construct a composite index, which seeks to capture the evolution of the information society as it goes through stages of development, taking into consideration technology convergence and the emergence of new technologies.

Based on this conceptual framework, the IDI is divided into the following three sub-indices, which are illustrated, with their component indicators, in Figure 2.2:

- ***Access sub-index*:** This sub-index captures ICT readiness, and includes five infrastructure and access indicators (fixed-telephone subscriptions, mobile-cellular telephone subscriptions, international Internet bandwidth per Internet user, households with a computer, and households with Internet access);
- ***Use sub-index*:** This sub-index captures ICT intensity, and includes three intensity and usage indicators (individuals using the Internet, fixed-broadband subscriptions and mobile-broadband subscriptions);

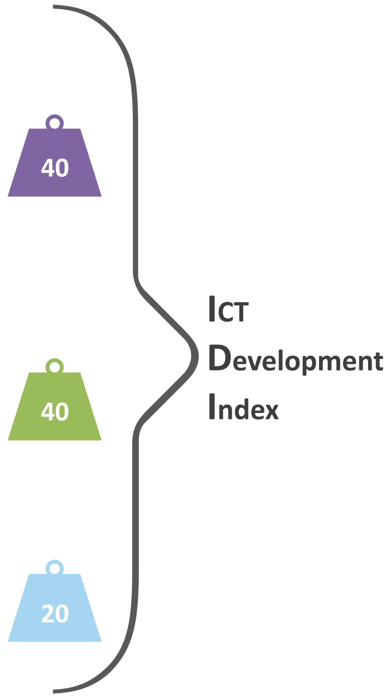
Figure 2.1: Three stages in the evolution towards an information society



Source: ITU.

Figure 2.2: ICT Development Index – indicators, reference values and weights

ICT access	Reference value	(%)
1. Fixed-telephone subscriptions per 100 inhabitants	60	20
2. Mobile-cellular telephone subscriptions per 100 inhabitants	120	20
3. International Internet bandwith (bit/s) per internet user	2’158’212*	20
4. Percentage of households with a computer	100	20
5. Percentage of households with Internet access	100	20
ICT use	**Reference value**	**(%)**
6. Percentage of individuals using the Internet	100	33
7. Fixed-broadband subscriptions per 100 inhabitants	60	33
8. Active mobile-broadband subscriptions per 100 inhabitants	100	33
ICT skills	**Reference value**	**(%)**
9. Mean years of schooling	15	33
10. Secondary gross enrolment ratio	100	33
11. Tertiary gross enrolment ratio	100	33



Note: * This corresponds to a log value of 6.33, which was used in the normalization step.
Source: ITU.

- ***Skills sub-index*:** This sub-index seeks to capture capabilities or skills that are important for ICTs. It includes three proxy indicators (mean years of schooling, gross secondary enrolment, and gross tertiary enrolment). As these are proxy indicators, rather than directly measuring ICT-related skills, the skills sub-index is given less weight in the computation of the IDI than the other two sub-indices.[2]

The choice of indicators included in these sub-indices reflects the corresponding stage of transformation to the information society. The indicators in each sub-index may therefore be revised to reflect changes in technology and markets over time, and improvements in the availability and quality of data.

Some of the indicators in the Index are more susceptible to rapid change than others. The speed with which mobile infrastructure can be deployed, for example, has enabled improvements to be made more rapidly in mobile-cellular access and mobile-broadband usage than has been experienced with fixed-telephone and fixed-broadband. These indicators are also likely to be affected by changes in regulation and in the degree of competition within relevant markets.

Experience has shown that economies which are more open to innovation in technology and services, and which are more competitive, tend to achieve better outcomes in access and usage than those where infrastructure and service deployment are more constrained.

Other changes in regulations – for example, in the legal framework for user identification or subscriber identification module (SIM) registration – may lead to reductions in the number of *subscriptions* to mobile networks, which will have a downward impact on indicators for mobile-cellular and mobile-broadband subscriptions without necessarily reducing the number of individual *subscribers*.

Some additional challenges of interpretation arise in relation to the indicator for mobile-cellular subscriptions, which now exceeds 100 per 100 population in a majority of economies within the Index. A number of reasons have been identified for this, including the choice by many users to hold multiple subscriptions in order to take advantage of differential on-net/off-net prices and/or to compensate for variations in the extent of network coverage. Adjustments to the indicator framework that will be introduced in IDI 2018, described below, should mitigate this problem, as well as that described in the previous paragraph.

The indicator for international Internet bandwidth is vulnerable to sudden change in individual countries, resulting from the deployment of significant new infrastructure, such as new cable landing points. It should be noted that, as this indicator is concerned with the amount of bandwidth available per Internet user, it will vary with *both* the availability of bandwidth *and* the number of Internet users. An increase in Internet users, in the absence of increased bandwidth, will lead to a reduction in the value of the indicator used in the calculation of the Index.

The indicators in the skills sub-index are gathered by the United Nations Educational, Scientific and Cultural Organization Institute for Statistics (UIS), primarily to measure educational performance, and are used as proxies for ICT skills in the IDI. These educational indicators tend to move more slowly than the ICT indicators in the access and use sub-indices. Where sharp changes are reported in these indicators, this may result from changes in the statistical methodology used in individual countries.

Methodology

The current IDI includes 11 indicators. A detailed definition of each indicator is provided in Annex 1.

The indicators used to calculate the IDI were selected on the following criteria:

- The relevance of a particular indicator in contributing to the main objectives and conceptual framework of the IDI: For example, the selected indicators must be relevant to both developed and developing countries, and should reflect, so far as possible, the framework's three components as described above;

- Data availability and quality: Data are required for a large number of countries, as the IDI is a global index. There is a shortage of ICT-related data, especially on usage, in the majority of developing countries. In addition, as indicators which are directly related to ICT skills are not available for most countries, it has been necessary to use proxy rather than direct indicators in the skills sub-index;

- The results of various statistical analyses: Principal components analysis (PCA) is used to examine the underlying nature of the data and explore whether their different dimensions are statistically well-balanced.

While the core methodology of the IDI has remained the same since it was first published, adjustments are made year-on-year in accordance with the criteria listed above, while also reflecting the dynamic nature of the ICT sector and related data availability.

The indicators included in the IDI and its sub-indices are regularly reviewed by ITU, in consultation with experts. Indicator definitions and the IDI methodology are discussed in the Expert Group on Telecommunication/ICT Indicators (EGTI) and the Expert Group on ICT Household Indicators (EGH) (see Box 2.1).

Changes to the IDI from 2018

A number of changes to the IDI will be made with effect from IDI 2018, as a result of decisions taken by an extraordinary meeting of the EGTI and the EGH, which took place in Geneva from 1 to 3 March 2017. The main objective of this extraordinary meeting was to discuss, debate and agree on a revised set of indicators to be included in the IDI. Input documents were prepared by a special EGTI/EGH subgroup, formed following a joint EGTI/EGH meeting in October 2016, and by an independent group of experts.

The extraordinary meeting adopted a total of 14 indicators to be included in the IDI with effect from IDI 2018, compared with the present list of 11 indicators.

Two existing indicators will be dropped from the IDI (both of which are currently in its access sub-index):

- fixed-telephone subscriptions per 100 inhabitants; and

- mobile-cellular subscriptions per 100 inhabitants.

Box 2.1: The ITU Expert Group on Telecommunication/ICT Indicators and the ITU Expert Group on ICT Household Indicators

Much of ITU's work in the area of indicator definitions and methodologies is carried out through its two expert groups, EGTI[3] and EGH.[4] Created in 2009 and 2012, respectively, these expert groups review and revise ITU's supply-side and demand-side statistics, and discuss methodological issues and new indicators. Both groups, which are open to all ITU members and to experts in ICT statistics and data collection, work through online discussion forums and face-to-face meetings. They periodically report to the World Telecommunication/ICT Indicators Symposium, ITU's main forum on ICT statistics. Interested experts are invited to join the EGTI and/or EGH discussion to share experiences, contribute to discussions and participate in the decision-making process.

The indicator concerning fixed-broadband subscriptions will be transferred from the use sub-index to the access sub-index. It will also be modified to measure fixed-broadband subscriptions – in tiers representing broadband speed – as a percentage of total fixed-broadband subscriptions. Five indicators will be added to the Index:

- percentage of population covered by mobile networks (at least 3G and at least long-term evolution (LTE/WiMax) (access sub-index);
- mobile-broadband Internet traffic per mobile-broadband subscription (use sub-index);
- fixed-broadband Internet traffic per fixed-broadband subscription (use sub-index);
- percentage of individuals who own a mobile phone (use sub-index);
- proportion of individuals with ICT skills (skills sub-index).

The inclusion of five new indicators in the IDI necessitates additional efforts by countries to collect the data in 2017 for the indicators to be included in IDI 2018. It is especially important to improve data availability for the two indicators on Internet traffic and the indicators on mobile phone ownership and ICT skills, for which data currently only exist for about one-third of countries. Ensuring data availability is a prerequisite for the inclusion in the IDI.

Data sets in this report

Data for IDI 2017 were collected at the beginning of 2017 and refer to the end of year 2016.

Data for IDI 2016, which are used for comparative purposes in this report, have been adjusted to take account of corrections and updates to data that were published in the 2016 edition of the *Report*.

IDI 2017 was computed using the same methodology as in previous years, applying the following steps (see also Figure 2.2 and Annex 1):

- Preparation of the complete data set: This step included the filling in of missing values using a variety of statistical techniques;
- Normalization of data: This is required to transform the values of IDI indicators into the same unit of measurement. The chosen normalization method is the distance to a reference value, either 100 or a value obtained through an appropriate statistical procedure;
- Rescaling of data: The data were rescaled on a scale from 0 to 10 to compare the values of the indicators and the sub-indices;
- Weighting of indicators and sub-indices: Indicator weights were chosen based on the results of principal components analysis. The access and use sub-indices were given equal weight (40 per cent each), while the skills sub-index was given lesser weight (20 per cent) as it is based on proxy indicators.

Table 2.1: IDI values and changes in value, 2017 and 2016

	IDI 2017						IDI 2016						Change in average value 2017-2016
	Average value*	Min.	Max.	Range	StDev	CV	Average value*	Min.	Max.	Range	StDev	CV	
IDI	5.11	0.96	8.98	8.02	2.22	43.52	4.93	0.89	8.80	7.91	2.23	45.31	0.18
Access sub-index	5.59	1.38	9.54	8.16	2.14	38.25	5.49	1.20	9.54	8.34	2.16	39.30	0.10
Use sub-index	4.26	0.04	8.94	8.90	2.49	58.41	3.95	0.04	8.90	8.87	2.50	63.26	0.31
Skills sub-index	5.85	1.37	9.28	7.90	2.18	37.23	5.75	1.30	9.18	7.88	2.18	37.93	0.10

Note: *Simple averages. StDev= Standard deviation, CV= Coefficient of variation.
Source: ITU.

2.3 Global IDI analysis

The IDI 2017 results maintain the upward trend in IDI values that has been apparent since the inception of the IDI, but also show that there continue to be great differences in the levels of ICT development between countries and regions around the world. The average IDI value among the 176 economies included in IDI 2017 was 5.11, up 0.18 points (3.72 per cent) from IDI 2016. Individual economies' IDI values in IDI 2017 range from a low of 0.96 in Eritrea to a high of 8.98 in Iceland (within a possible range from 0.0 to 10.0). The gap between the highest and lowest values increased from 7.91 to 8.02 points between IDI 2016 and IDI 2017.

Summary data for the IDI and its three sub-indices in 2017 and 2016 are set out in Table 2.1. Full details of the rankings and values for the Index and sub-indices in both years are set out in Tables 2.2 to 2.5. Tables 2.7, 2.9 and 2.11, presented later in this chapter, rank countries according to the change in value they have achieved during the course of the year in the overall Index and in the access and use sub-indices.

Data for IDI 2016 in these and subsequent tables have been recalculated to accommodate changes arising from corrections and updates to the data received since publication of the *Measuring the Information Society Report 2016* (ITU, 2016b). They may therefore differ from the IDI 2016 values published in the 2016 *Report.*

Table 2.1 presents changes in average value (the sum of the values for all countries in the Index divided by the number of those countries). This shows that the average IDI value rose by 0.18 points during the year, from 4.93 to 5.11. Almost exactly half of the economies in the Index had IDI values above (89) and below (87) the average value in IDI 2017. As in the year between IDI 2015 and IDI 2016, the average value for the use sub-index between IDI 2016 and 2017 (which rose by 0.31 points, from 3.95 to 4.26 points) grew more rapidly than those for the access and skills sub-indices, which both rose by 0.10 points.

The IDI results for all economies included in IDI 2016 and IDI 2017 are set out in Table 2.2, while results for the access, use and skills sub-indices are set out in Tables 2.3, 2.4 and 2.5. The economies listed in Table 2.2 have been divided into four quartiles according to their IDI 2017 rankings, as follows:

- The high quartile includes the 44 top-ranked economies, from Iceland, with an IDI value of 8.98, to Portugal, with an IDI value of 7.13;
- The upper-middle quartile includes the 44 economies ranked next below these, from the Russian Federation, with an IDI value of 7.07, to Suriname, with an IDI value of 5.15;
- The lower-middle quartile includes the next group of 44 economies, from Albania, with an IDI value of 5.14, to Sao Tome and Principe, with an IDI value of 3.09;
- The low quartile is made up of the 44 least connected countries (LCCs), from Lesotho, with an IDI value of 3.04, to Eritrea, with an IDI value of 0.96.

Overall distribution of IDI rankings

The country with the highest IDI ranking in 2017 is Iceland, with an IDI value that has risen from 8.78 in 2016 to 8.98 in 2017.

Table 2.2: IDI rankings and values, 2017 and 2016

Economy	Rank 2017	IDI 2017	Rank 2016	IDI 2016
Iceland	1	8.98	2	8.78
Korea (Rep.)	2	8.85	1	8.80
Switzerland	3	8.74	4	8.66
Denmark	4	8.71	3	8.68
United Kingdom	5	8.65	5	8.53
Hong Kong, China	6	8.61	6	8.47
Netherlands	7	8.49	10	8.40
Norway	8	8.47	7	8.45
Luxembourg	9	8.47	9	8.40
Japan	10	8.43	11	8.32
Sweden	11	8.41	8	8.41
Germany	12	8.39	13	8.20
New Zealand	13	8.33	12	8.23
Australia	14	8.24	16	8.08
France	15	8.24	17	8.05
United States	16	8.18	15	8.13
Estonia	17	8.14	14	8.16
Singapore	18	8.05	20	7.85
Monaco	19	8.05	18	8.03
Ireland	20	8.02	19	7.90
Austria	21	8.02	24	7.70
Finland	22	7.88	21	7.83
Israel	23	7.88	22	7.71
Malta	24	7.86	25	7.65
Belgium	25	7.81	23	7.70
Macao, China	26	7.80	29	7.55
Spain	27	7.79	27	7.61
Cyprus	28	7.77	31	7.30
Canada	29	7.77	26	7.64
Andorra	30	7.71	28	7.58
Bahrain	31	7.60	30	7.46
Belarus	32	7.55	32	7.29
Slovenia	33	7.38	33	7.20
Barbados	34	7.31	37	7.11
Latvia	35	7.26	40	7.05
Croatia	36	7.24	42	6.96
St. Kitts and Nevis	37	7.24	35	7.18
Greece	38	7.23	38	7.08
Qatar	39	7.21	36	7.12
United Arab Emirates	40	7.21	34	7.18
Lithuania	41	7.19	41	6.97
Uruguay	42	7.16	48	6.75
Czech Republic	43	7.16	39	7.06
Portugal	44	7.13	44	6.88
Russian Federation	45	7.07	43	6.91
Slovakia	46	7.06	47	6.84
Italy	47	7.04	46	6.84
Hungary	48	6.93	49	6.74
Poland	49	6.89	50	6.73
Bulgaria	50	6.86	53	6.66
Argentina	51	6.79	52	6.68
Kazakhstan	52	6.79	51	6.72
Brunei Darussalam	53	6.75	54	6.56
Saudi Arabia	54	6.67	45	6.87
Serbia	55	6.61	55	6.51
Chile	56	6.57	59	6.28
Bahamas	57	6.51	58	6.29
Romania	58	6.48	61	6.23
Moldova	59	6.45	63	6.21
Costa Rica	60	6.44	57	6.29
Montenegro	61	6.44	56	6.30
Oman	62	6.43	64	6.14
Malaysia	63	6.38	62	6.22
Lebanon	64	6.30	65	6.09
Azerbaijan	65	6.20	60	6.25
Brazil	66	6.12	67	5.89
Turkey	67	6.08	72	5.66
Trinidad & Tobago	68	6.04	71	5.71
TFYR Macedonia	69	6.01	68	5.88
Jordan	70	6.00	66	5.97
Kuwait	71	5.98	70	5.75
Mauritius	72	5.88	75	5.51
Grenada	73	5.80	77	5.39
Georgia	74	5.79	73	5.59
Armenia	75	5.76	74	5.56
Antigua & Barbuda	76	5.71	76	5.48
Dominica	77	5.69	69	5.76
Thailand	78	5.67	79	5.31
Ukraine	79	5.62	78	5.31
China	80	5.60	83	5.17
Iran (I.R.)	81	5.58	85	5.04
St. Vincent & the Grenadines	82	5.54	80	5.27
Bosnia and Herzegovina	83	5.39	81	5.23
Colombia	84	5.36	84	5.12
Maldives	85	5.25	86	4.97
Venezuela	86	5.17	82	5.22
Mexico	87	5.16	90	4.87
Suriname	88	5.15	94	4.77
Albania	89	5.14	89	4.90
Seychelles	90	5.03	92	4.80
Mongolia	91	4.96	87	4.91
South Africa	92	4.96	88	4.91
Cape Verde	93	4.92	91	4.83
Panama	94	4.91	93	4.80
Uzbekistan	95	4.90	103	4.48
Peru	96	4.85	97	4.61
Ecuador	97	4.84	101	4.52
Jamaica	98	4.84	96	4.63
Tunisia	99	4.82	95	4.70
Morocco	100	4.77	98	4.57
Philippines	101	4.67	100	4.52
Algeria	102	4.67	106	4.32
Egypt	103	4.63	104	4.44
St. Lucia	104	4.63	99	4.53
Botswana	105	4.59	102	4.51
Dominican Rep.	106	4.51	107	4.26
Fiji	107	4.49	105	4.34
Viet Nam	108	4.43	108	4.18
Kyrgyzstan	109	4.37	110	4.06
Tonga	110	4.34	109	4.13
Indonesia	111	4.33	114	3.85
Bolivia	112	4.31	115	3.84
Paraguay	113	4.18	111	4.02
Gabon	114	4.11	118	3.62
Libya	115	4.11	112	3.93
Ghana	116	4.05	113	3.88
Sri Lanka	117	3.91	116	3.77
Namibia	118	3.89	123	3.33
El Salvador	119	3.82	117	3.62
Belize	120	3.71	120	3.54
Bhutan	121	3.69	119	3.58
Timor-Leste	122	3.57	127	3.11
Palestine	123	3.55	122	3.42
Guyana	124	3.44	121	3.44
Guatemala	125	3.35	125	3.19
Syria	126	3.34	124	3.32
Samoa	127	3.30	129	2.95
Cambodia	128	3.28	128	3.04
Honduras	129	3.28	126	3.14
Nicaragua	130	3.27	132	2.85
Côte d'Ivoire	131	3.14	134	2.84
S. Tomé & Principe	132	3.09	131	2.91
Lesotho	133	3.04	130	2.94
India	134	3.03	138	2.65
Myanmar	135	3.00	140	2.59
Zimbabwe	136	2.92	133	2.85
Cuba	137	2.91	135	2.80
Kenya	138	2.91	137	2.67
Lao P.D.R.	139	2.91	144	2.43
Nepal	140	2.88	139	2.60
Vanuatu	141	2.81	136	2.75
Senegal	142	2.66	142	2.48
Nigeria	143	2.60	143	2.44
Gambia	144	2.59	145	2.43
Sudan	145	2.55	141	2.56
Zambia	146	2.54	149	2.19
Bangladesh	147	2.53	146	2.37
Pakistan	148	2.42	148	2.21
Cameroon	149	2.38	150	2.14
Mozambique	150	2.32	147	2.23
Mauritania	151	2.26	152	2.08
Uganda	152	2.19	158	1.90
Rwanda	153	2.18	151	2.10
Kiribati	154	2.17	155	2.04
Mali	155	2.16	153	2.05
Togo	156	2.15	159	1.86
Solomon Islands	157	2.11	154	2.04
Djibouti	158	1.98	161	1.80
Afghanistan	159	1.95	165	1.71
Angola	160	1.94	156	2.00
Benin	161	1.94	157	1.92
Burkina Faso	162	1.90	163	1.74
Equatorial Guinea	163	1.86	160	1.82
Comoros	164	1.82	162	1.78
Tanzania	165	1.81	164	1.73
Guinea	166	1.78	166	1.71
Malawi	167	1.74	169	1.58
Haiti	168	1.72	168	1.63
Madagascar	169	1.68	167	1.70
Ethiopia	170	1.65	171	1.42
Congo (Dem. Rep.)	171	1.55	170	1.48
Burundi	172	1.48	172	1.39
Guinea-Bissau	173	1.48	173	1.38
Chad	174	1.27	174	1.06
Central African Rep.	175	1.04	176	0.89
Eritrea	176	0.96	175	0.96

Note: Palestine is not an ITU member State; the status of Palestine in ITU is the subject of Resolution 99 (rev. Busan, 2014) of the ITU Plenipotentiary Conference.
Source: ITU.

Table 2.3: IDI access sub-index rankings and values, 2017 and 2016

Economy	Rank in access sub-index 2017	IDI access sub-index 2017	Rank in access sub-index 2016	IDI access sub-index 2016
Luxembourg	1	9.54	1	9.54
Iceland	2	9.38	2	9.32
Hong Kong, China	3	9.22	3	9.16
United Kingdom	4	9.15	4	9.12
Malta	5	9.02	6	8.96
Germany	6	8.93	5	8.97
Korea (Rep.)	7	8.85	7	8.90
Switzerland	8	8.85	8	8.83
Japan	9	8.80	9	8.73
Netherlands	10	8.65	10	8.62
France	11	8.64	13	8.55
Singapore	12	8.61	12	8.56
Sweden	13	8.55	11	8.58
Denmark	14	8.39	14	8.35
Austria	15	8.38	15	8.31
New Zealand	16	8.34	20	8.16
United States	17	8.27	17	8.18
Monaco	18	8.26	16	8.21
Israel	19	8.17	21	8.16
Estonia	20	8.16	18	8.18
Belgium	21	8.15	19	8.16
Bahrain	22	8.14	27	7.92
Ireland	23	8.14	22	8.13
United Arab Emirates	24	8.11	23	8.07
Barbados	25	8.04	24	8.05
Australia	26	8.00	28	7.90
Norway	27	8.00	26	8.00
Andorra	28	7.99	25	8.01
Spain	29	7.98	31	7.84
Canada	30	7.93	30	7.86
Portugal	31	7.91	34	7.77
Slovenia	32	7.91	29	7.87
Qatar	33	7.90	32	7.80
Belarus	34	7.87	37	7.69
Cyprus	35	7.86	33	7.78
Macao, China	36	7.83	35	7.73
Hungary	37	7.78	38	7.65
Greece	38	7.76	36	7.73
Croatia	39	7.60	41	7.46
Poland	40	7.58	42	7.41
St. Kitts and Nevis	41	7.57	39	7.63
Moldova	42	7.56	43	7.32
Kazakhstan	43	7.55	40	7.48
Brunei Darussalam	44	7.47	47	7.25
Latvia	45	7.41	44	7.31
Finland	46	7.35	46	7.28
Italy	47	7.33	48	7.23
Oman	48	7.32	45	7.30
Uruguay	49	7.28	52	7.17
Russian Federation	50	7.23	54	7.12
Slovakia	51	7.22	50	7.19
Saudi Arabia	52	7.21	49	7.20
Serbia	53	7.20	53	7.16
Trinidad & Tobago	54	7.18	57	6.94
Czech Republic	55	7.14	55	7.08
Kuwait	56	7.12	51	7.17
Lithuania	57	7.11	56	6.97
Mauritius	58	7.04	61	6.78
Montenegro	59	7.03	58	6.87
Romania	60	6.98	60	6.80
Bahamas	61	6.97	66	6.67
Malaysia	62	6.93	67	6.67
Lebanon	63	6.92	63	6.70
Argentina	64	6.87	59	6.81
Bulgaria	65	6.83	62	6.78
Chile	66	6.79	65	6.69
Iran (I.R.)	67	6.74	76	6.33
Antigua & Barbuda	68	6.73	70	6.55
TFYR Macedonia	69	6.66	69	6.56
Azerbaijan	70	6.62	64	6.69
Ukraine	71	6.60	72	6.45
Armenia	72	6.52	71	6.46
Seychelles	73	6.46	73	6.36
Costa Rica	74	6.40	74	6.35
Dominica	75	6.34	68	6.60
Grenada	76	6.32	78	6.20
St. Vincent and the Grenadines	77	6.31	75	6.35
Turkey	78	6.30	80	6.11
Georgia	79	6.26	77	6.21
Brazil	80	6.25	79	6.19
Maldives	81	6.22	82	6.04
Morocco	82	6.06	83	5.99
Jordan	83	6.03	81	6.08
Panama	84	5.95	84	5.81
Colombia	85	5.88	86	5.74
Bosnia and Herzegovina	86	5.84	85	5.74
Suriname	87	5.83	89	5.38
Cape Verde	88	5.76	87	5.53

Economy	Rank in access sub-index 2017	IDI access sub-index 2017	Rank in access sub-index 2016	IDI access sub-index 2016
China	89	5.58	90	5.37
South Africa	90	5.48	91	5.29
Thailand	91	5.48	88	5.39
Egypt	92	5.40	93	5.23
Jamaica	93	5.29	97	5.02
Mexico	94	5.28	95	5.04
Uzbekistan	95	5.24	98	4.96
St. Lucia	96	5.17	94	5.16
Venezuela	97	5.15	92	5.28
Algeria	98	5.14	102	4.83
Tunisia	99	5.11	99	4.96
Ecuador	100	4.93	104	4.78
Botswana	101	4.90	101	4.84
Peru	102	4.90	107	4.68
Fiji	103	4.88	100	4.90
Philippines	104	4.87	103	4.81
Indonesia	105	4.85	108	4.68
Albania	106	4.80	105	4.70
Libya	107	4.80	111	4.58
Viet Nam	108	4.75	110	4.64
El Salvador	109	4.75	106	4.68
Mongolia	110	4.74	96	5.03
Sri Lanka	111	4.66	112	4.52
Tonga	112	4.64	113	4.43
Syria	113	4.58	109	4.66
Kyrgyzstan	114	4.54	114	4.43
Guatemala	115	4.52	115	4.38
Gabon	116	4.51	116	4.36
Bolivia	117	4.42	119	4.26
Paraguay	118	4.41	117	4.30
Namibia	119	4.39	120	4.23
Ghana	120	4.36	122	4.20
Guyana	121	4.36	118	4.27
Dominican Rep.	122	4.30	121	4.20
Nicaragua	123	4.19	124	4.02
Cambodia	124	4.16	125	4.01
Bhutan	125	4.09	126	3.95
Honduras	126	4.08	123	4.04
Belize	127	4.07	127	3.88
Côte d'Ivoire	128	3.92	130	3.72
Timor-Leste	129	3.84	128	3.74
Gambia	130	3.77	129	3.73
Lesotho	131	3.72	134	3.52
S. Tomé & Principe	132	3.69	131	3.62
Vanuatu	133	3.65	132	3.57
Samoa	134	3.64	136	3.43
Kenya	135	3.63	133	3.56
Nepal	136	3.62	138	3.24
India	137	3.60	139	3.24
Senegal	138	3.57	135	3.48
Myanmar	139	3.48	144	3.09
Lao P.D.R.	140	3.47	143	3.17
Zimbabwe	141	3.40	137	3.31
Palestine	142	3.35	141	3.21
Pakistan	143	3.34	142	3.18
Sudan	144	3.23	140	3.23
Nigeria	145	3.16	146	3.01
Mali	146	3.16	145	3.07
Bangladesh	147	3.05	147	2.99
Mauritania	148	2.96	148	2.91
Zambia	149	2.85	149	2.77
Cameroon	150	2.84	152	2.72
Burkina Faso	151	2.82	153	2.72
Solomon Islands	152	2.81	150	2.73
Equatorial Guinea	153	2.71	155	2.68
Togo	154	2.71	158	2.58
Rwanda	155	2.67	157	2.58
Djibouti	156	2.63	163	2.48
Benin	157	2.63	151	2.73
Angola	158	2.62	154	2.69
Comoros	159	2.59	159	2.53
Afghanistan	160	2.56	162	2.48
Mozambique	161	2.53	156	2.64
Tanzania	162	2.52	160	2.51
Guinea	163	2.51	164	2.45
Uganda	164	2.46	166	2.31
Guinea-Bissau	165	2.43	165	2.39
Cuba	166	2.40	169	2.12
Haiti	167	2.37	161	2.49
Ethiopia	168	2.35	168	2.16
Kiribati	169	2.32	170	2.05
Madagascar	170	2.29	167	2.29
Malawi	171	2.18	172	1.95
Burundi	172	2.14	171	2.04
Chad	173	2.01	173	1.84
Congo (Dem. Rep.)	174	1.68	174	1.79
Central African Rep.	175	1.57	176	1.20
Eritrea	176	1.38	175	1.32

Note: Palestine is not an ITU member State; the status of Palestine in ITU is the subject of Resolution 99 (rev. Busan, 2014) of the ITU Plenipotentiary Conference.
Source: ITU.

Table 2.4: IDI use sub-index rankings and values, 2017 and 2016

Economy	Rank in use sub-index 2017	IDI use sub-index 2017	Rank in use sub-index 2016	IDI use sub-index 2016
Denmark	1	8.94	1	8.90
Switzerland	2	8.88	3	8.76
Norway	3	8.82	2	8.77
Korea (Rep.)	4	8.71	4	8.56
Iceland	5	8.70	5	8.44
Sweden	6	8.40	6	8.36
United Kingdom	7	8.38	8	8.13
Luxembourg	8	8.30	7	8.17
Netherlands	9	8.28	9	8.10
Hong Kong, China	10	8.21	14	7.95
Japan	11	8.15	10	8.07
New Zealand	12	8.08	11	8.03
Monaco	13	8.01	12	8.01
Finland	14	7.99	13	7.97
Estonia	15	7.97	15	7.95
Australia	16	7.97	16	7.74
France	17	7.93	17	7.61
Germany	18	7.77	23	7.35
Macao, China	19	7.72	19	7.54
United States	20	7.67	18	7.56
Cyprus	21	7.61	33	6.63
Ireland	22	7.59	22	7.38
Bahrain	23	7.53	20	7.48
Singapore	24	7.45	21	7.44
Austria	25	7.39	30	6.74
Israel	26	7.34	29	6.92
Canada	27	7.27	25	7.01
Spain	28	7.23	27	6.97
Belgium	29	7.22	28	6.95
Malta	30	7.16	32	6.73
United Arab Emirates	31	7.09	24	7.07
Qatar	32	7.07	26	6.99
Andorra	33	7.07	31	6.74
Uruguay	34	7.03	38	6.20
St. Kitts and Nevis	35	6.76	34	6.53
Slovakia	36	6.67	40	6.14
Latvia	37	6.65	37	6.25
Lithuania	38	6.63	39	6.18
Czech Republic	39	6.62	35	6.44
Belarus	40	6.54	42	6.05
Croatia	41	6.45	41	6.05
Italy	42	6.35	43	6.03
Barbados	43	6.30	46	5.88
Brunei Darussalam	44	6.30	44	5.98
Bulgaria	45	6.23	48	5.86
Lebanon	46	6.20	50	5.80
Costa Rica	47	6.18	49	5.85
Malaysia	48	6.17	45	5.94
Slovenia	49	6.16	53	5.69
Portugal	50	6.15	54	5.67
Russian Federation	51	6.13	47	5.87
Argentina	52	5.96	51	5.79
Greece	53	5.82	58	5.47
Jordan	54	5.73	57	5.52
Oman	55	5.71	64	5.12
Hungary	56	5.71	61	5.28
Brazil	57	5.69	56	5.58
Kazakhstan	58	5.69	55	5.63
Saudi Arabia	59	5.68	36	6.32
Bahamas	60	5.59	60	5.33
Romania	61	5.59	66	5.08
Azerbaijan	62	5.55	52	5.70
Serbia	63	5.54	59	5.37
Poland	64	5.47	62	5.24
Chile	65	5.39	67	4.86
Montenegro	66	5.38	63	5.21
TFYR Macedonia	67	5.36	65	5.09
Thailand	68	5.33	68	4.78
China	69	5.27	71	4.63
Moldova	70	5.12	70	4.71
Trinidad & Tobago	71	5.07	72	4.51
Kuwait	72	4.99	73	4.42
Turkey	73	4.92	77	4.18
Maldives	74	4.80	74	4.30
Dominica	75	4.78	69	4.73
Mexico	76	4.65	75	4.27
St. Vincent and the Grenadines	77	4.61	84	3.89
Suriname	78	4.55	78	4.18
Bosnia and Herzegovina	79	4.52	76	4.21
Georgia	80	4.47	80	4.09
Antigua & Barbuda	81	4.46	81	4.06
Mauritius	82	4.44	90	3.78
Armenia	83	4.42	88	3.85
Albania	84	4.42	85	3.88
Colombia	85	4.11	87	3.85
Tunisia	86	4.11	82	3.96
Cape Verde	87	4.11	79	4.10
Dominican Rep.	88	4.04	95	3.49
Grenada	89	4.04	89	3.78
Peru	90	3.96	94	3.55
Venezuela	91	3.94	83	3.95
Jamaica	92	3.94	92	3.64
Uzbekistan	93	3.93	103	3.23
Ecuador	94	3.92	99	3.34
South Africa	95	3.91	86	3.86
Mongolia	96	3.90	91	3.64
Gabon	97	3.85	112	2.77
Botswana	98	3.73	93	3.60
Philippines	99	3.70	96	3.44
Morocco	100	3.68	97	3.40
St. Lucia	101	3.68	98	3.39
Viet Nam	102	3.65	105	3.18
Ghana	103	3.55	100	3.29
Iran (I.R.)	104	3.54	111	2.78
Seychelles	105	3.47	101	3.24
Fiji	106	3.44	106	3.10
Bolivia	107	3.38	114	2.40
Algeria	108	3.38	110	2.92
Namibia	109	3.36	118	2.16
Tonga	110	3.35	108	3.08
Egypt	111	3.35	104	3.20
Panama	112	3.32	102	3.24
Paraguay	113	3.29	107	3.10
Bhutan	114	3.21	109	3.08
Indonesia	115	3.19	117	2.22
Ukraine	116	3.17	113	2.56
Timor-Leste	117	3.00	125	2.02
Kyrgyzstan	118	2.91	116	2.25
Cambodia	119	2.56	122	2.09
Côte d'Ivoire	120	2.50	121	2.10
Myanmar	121	2.43	128	1.84
Palestine	122	2.42	115	2.25
Belize	123	2.29	124	2.07
El Salvador	124	2.25	127	1.86
Mozambique	125	2.24	123	2.07
Lesotho	126	2.15	119	2.15
Zimbabwe	127	2.10	120	2.12
Libya	128	1.98	129	1.75
Samoa	129	1.94	145	1.23
Zambia	130	1.93	148	1.17
Sri Lanka	131	1.91	130	1.69
Lao P.D.R.	132	1.90	149	1.11
Honduras	133	1.89	132	1.63
Uganda	134	1.87	146	1.22
Guatemala	135	1.78	140	1.45
Sudan	136	1.78	126	1.87
S. Tomé & Principe	137	1.77	137	1.49
Senegal	138	1.76	131	1.64
Kenya	139	1.76	144	1.23
Nicaragua	140	1.73	152	1.00
Nepal	141	1.73	134	1.52
Vanuatu	142	1.63	139	1.47
Syria	143	1.63	133	1.53
India	144	1.62	142	1.25
Guyana	145	1.62	136	1.51
Mauritania	146	1.62	141	1.29
Nigeria	147	1.58	135	1.52
Rwanda	148	1.58	138	1.47
Bangladesh	149	1.41	147	1.17
Gambia	150	1.34	151	1.01
Cuba	151	1.30	143	1.25
Pakistan	152	1.24	154	0.95
Mali	153	1.19	153	0.97
Cameroon	154	1.16	157	0.84
Burkina Faso	155	1.13	155	0.89
Togo	156	1.06	166	0.49
Angola	157	1.03	150	1.10
Djibouti	158	0.99	160	0.73
Malawi	159	0.94	156	0.85
Afghanistan	160	0.83	167	0.48
Guinea	161	0.83	159	0.74
Equatorial Guinea	162	0.82	158	0.74
Solomon Islands	163	0.81	161	0.73
Tanzania	164	0.75	162	0.64
Haiti	165	0.75	170	0.41
Ethiopia	166	0.72	165	0.54
Congo (Dem. Rep.)	167	0.68	171	0.41
Benin	168	0.63	164	0.55
Madagascar	169	0.51	163	0.58
Kiribati	170	0.49	168	0.45
Chad	171	0.49	174	0.17
Burundi	172	0.45	169	0.42
Guinea-Bissau	173	0.36	175	0.12
Comoros	174	0.28	172	0.26
Central African Rep.	175	0.24	173	0.21
Eritrea	176	0.04	176	0.04

Note: Palestine is not an ITU member State; the status of Palestine in ITU is the subject of Resolution 99 (rev. Busan, 2014) of the ITU Plenipotentiary Conference.
Source: ITU.

Table 2.5: IDI skills sub-index, rankings and values, 2017 and 2016

Economy	Rank in skills sub-index 2017	IDI skills sub-index 2017	Rank in skills sub-index 2016	IDI skills sub-index 2016
Australia	1	9.28	2	9.10
Korea (Rep.)	2	9.15	3	9.08
United States	3	9.05	1	9.18
Greece	4	9.00	4	9.01
Belarus	5	8.93	5	8.96
Denmark	6	8.87	6	8.87
New Zealand	7	8.81	8	8.77
Slovenia	8	8.79	7	8.87
Iceland	9	8.75	20	8.40
Finland	10	8.73	10	8.65
Norway	11	8.71	9	8.70
Ireland	12	8.65	16	8.48
Russian Federation	13	8.62	14	8.55
Netherlands	14	8.59	12	8.56
Ukraine	15	8.56	11	8.57
Austria	16	8.56	21	8.38
Germany	17	8.54	23	8.36
Spain	18	8.50	19	8.41
Chile	19	8.49	25	8.30
Canada	20	8.47	17	8.44
Andorra	21	8.44	18	8.43
Lithuania	22	8.44	13	8.55
Estonia	23	8.43	15	8.54
Israel	24	8.38	22	8.38
Poland	25	8.35	24	8.35
Belgium	26	8.31	26	8.27
Argentina	27	8.30	28	8.18
Czech Republic	28	8.27	27	8.25
Grenada	29	8.26	64	6.99
Japan	30	8.22	35	7.97
Switzerland	31	8.21	31	8.15
Hong Kong, China	32	8.19	33	8.11
United Kingdom	33	8.17	29	8.18
Latvia	34	8.17	32	8.12
Bulgaria	35	8.17	34	8.04
Sweden	36	8.15	30	8.17
Singapore	37	8.14	56	7.27
Croatia	38	8.11	38	7.79
France	39	8.06	36	7.94
Turkey	40	7.97	39	7.72
Cyprus	41	7.93	43	7.68
Macao, China	42	7.91	59	7.19
Italy	43	7.86	41	7.69
Barbados	44	7.85	42	7.69
Monaco	45	7.70	40	7.70
Hungary	46	7.70	37	7.82
Venezuela	47	7.64	44	7.63
Saudi Arabia	48	7.57	55	7.30
Serbia	49	7.57	48	7.48
Slovakia	50	7.54	45	7.57
St. Kitts and Nevis	51	7.53	46	7.55
Mongolia	52	7.51	58	7.23
Portugal	53	7.50	47	7.51
Georgia	54	7.49	53	7.34
Kazakhstan	55	7.48	50	7.41
Bahamas	56	7.41	49	7.43
Montenegro	57	7.37	54	7.34
Iran (I.R.)	58	7.32	66	6.96
Albania	59	7.26	52	7.36
Romania	60	7.25	51	7.37
Uruguay	61	7.18	62	7.02
Cuba	62	7.16	57	7.25
Costa Rica	63	7.05	61	7.04
Libya	64	6.99	63	6.99
Kyrgyzstan	65	6.96	67	6.96
Armenia	66	6.94	60	7.17
Malta	67	6.94	68	6.86
Moldova	68	6.89	65	6.97
Colombia	69	6.81	75	6.44
Thailand	70	6.72	81	6.21
Brazil	71	6.71	92	5.89
Azerbaijan	72	6.67	73	6.47
Bahrain	73	6.65	72	6.50
Luxembourg	74	6.65	71	6.59
Peru	75	6.54	70	6.60
Ecuador	76	6.53	77	6.37
Jordan	77	6.49	69	6.68
Mauritius	78	6.43	74	6.45
Sri Lanka	79	6.41	76	6.41
Algeria	80	6.29	87	6.10
China	81	6.28	93	5.89
Bosnia and Herzegovina	82	6.23	79	6.27
Brunei Darussalam	83	6.23	78	6.31
Dominica	84	6.23	86	6.11
Palestine	85	6.22	82	6.18
Philippines	86	6.20	85	6.11
Uzbekistan	87	6.17	88	6.04
Antigua & Barbuda	88	6.16	83	6.17
Qatar	89	6.09	89	6.03
Oman	90	6.07	97	5.83
TFYR Macedonia	91	6.03	84	6.13
Panama	92	6.01	94	5.89
South Africa	93	6.00	80	6.23
Bolivia	94	5.96	91	5.89
Mexico	95	5.93	100	5.74
Dominican Rep.	96	5.89	90	5.90
St. Vincent and the Grenadines	97	5.85	96	5.86
Fiji	98	5.83	102	5.68
Belize	99	5.80	99	5.81
Jamaica	100	5.78	98	5.83
Malaysia	101	5.70	95	5.87
Kuwait	102	5.69	108	5.59
Tonga	103	5.68	107	5.61
Botswana	104	5.67	101	5.69
Tunisia	105	5.67	103	5.68
Trinidad & Tobago	106	5.67	104	5.67
Egypt	107	5.66	113	5.33
United Arab Emirates	108	5.63	106	5.63
Indonesia	109	5.54	110	5.48
Paraguay	110	5.52	114	5.28
St. Lucia	111	5.46	109	5.52
Samoa	112	5.37	112	5.44
Viet Nam	113	5.31	115	5.25
Seychelles	114	5.28	119	4.79
Guyana	115	5.26	105	5.66
Lebanon	116	5.23	111	5.46
Kiribati	117	5.20	116	5.18
El Salvador	118	5.11	117	5.02
Suriname	119	4.97	120	4.72
Cape Verde	120	4.89	118	4.89
India	121	4.73	124	4.29
Nicaragua	122	4.51	126	4.23
S. Tomé & Principe	123	4.50	123	4.33
Honduras	124	4.44	122	4.36
Ghana	125	4.43	121	4.44
Morocco	126	4.35	129	4.09
Syria	127	4.28	127	4.22
Maldives	128	4.25	128	4.15
Timor-Leste	129	4.14	130	4.01
Guatemala	130	4.13	125	4.29
Namibia	131	3.96	131	3.85
Cameroon	132	3.87	136	3.60
Bhutan	133	3.86	132	3.84
Gabon	134	3.86	133	3.81
Kenya	135	3.79	134	3.76
Lao P.D.R.	136	3.78	137	3.60
Nepal	137	3.73	139	3.50
Bangladesh	138	3.72	138	3.51
Zimbabwe	139	3.58	140	3.38
Nigeria	140	3.53	145	3.13
Lesotho	141	3.48	141	3.37
Vanuatu	142	3.47	135	3.65
Comoros	143	3.38	142	3.33
Solomon Islands	144	3.33	143	3.27
Togo	145	3.22	144	3.16
Myanmar	146	3.21	146	3.06
Benin	147	3.18	148	3.06
Zambia	148	3.13	147	3.06
Congo (Dem. Rep.)	149	3.03	149	3.01
Cambodia	150	2.98	150	3.00
Pakistan	151	2.95	151	2.78
Afghanistan	152	2.94	154	2.65
Côte d'Ivoire	153	2.88	157	2.57
Madagascar	154	2.80	152	2.77
Gambia	155	2.75	153	2.66
Sudan	156	2.75	155	2.62
Djibouti	157	2.69	156	2.59
Senegal	158	2.62	166	2.17
Tanzania	159	2.49	161	2.33
Malawi	160	2.45	163	2.30
Angola	161	2.41	158	2.43
Rwanda	162	2.40	160	2.42
Haiti	163	2.35	162	2.33
Uganda	164	2.29	159	2.43
Equatorial Guinea	165	2.24	164	2.27
Guinea	166	2.23	165	2.19
Burundi	167	2.23	170	2.01
Mauritania	168	2.15	169	2.02
Mali	169	2.12	167	2.15
Ethiopia	170	2.11	173	1.71
Mozambique	171	2.06	172	1.74
Eritrea	172	1.97	168	2.10
Guinea-Bissau	173	1.82	171	1.87
Central African Rep.	174	1.61	174	1.61
Burkina Faso	175	1.59	175	1.48
Chad	176	1.37	176	1.30

Note: Palestine is not an ITU member State; the status of Palestine in ITU is the subject of Resolution 99 (rev. Busan, 2014) of the ITU Plenipotentiary Conference.
Source: ITU.

Six other countries in Europe (Switzerland, Denmark, the United Kingdom, the Netherlands, Norway and Luxembourg) fall within the top ten economies in the rankings, along with three economies in the Asia and the Pacific region (the Republic of Korea, which topped the rankings in 2016; Hong Kong (China); and Japan, which moved into the top ten rankings at the expense of Sweden). The range of IDI values among these ten top-ranking countries has increased, from 0.40 points in 2016 to 0.56 points in 2017.

All these countries have achieved high levels of ICT development as a result of high levels of investment in ICT infrastructure, high-quality networks, and high levels of take-up of services by consumers. These high-performing countries also rank towards the top of the rankings for gross national income (GNI) per capita and other economic indicators.

There has been relatively little change in the IDI rankings for most economies between 2016 and 2017. Only six countries (Croatia, Uruguay, Suriname, Uzbekistan, Uganda and Afghanistan) rose by more than five places in the rankings between 2016 and 2017, while three (the United Arab Emirates, Saudi Arabia and Dominica) fell by more than five places.

Only one country (Japan) has risen into the top ten ranked economies; only one (Uruguay) has risen into the highest quartile; and only two (Mexico and Suriname) have moved into the upper half of the distribution. There has also been little change in the countries included in the lowest quartile (LCCs). Only one country (Côte d'Ivoire) moved out of this quartile, at the expense of Lesotho, which now tops the quartile, while the ten countries at the bottom of the rankings are the same as in 2016.

Of the 44 countries ranked as LCCs, 28 are in the Africa region, including all but one of the lowest-ranking decile, while 4 are in the Arab states region, 2 in the Americas region and 10 in the Asia and the Pacific region. The largest gains in rankings among these LCCs were made by Uganda and Afghanistan (up six places), and by Myanmar and Lao P.D.R. (up five places).

Overall distribution of IDI values

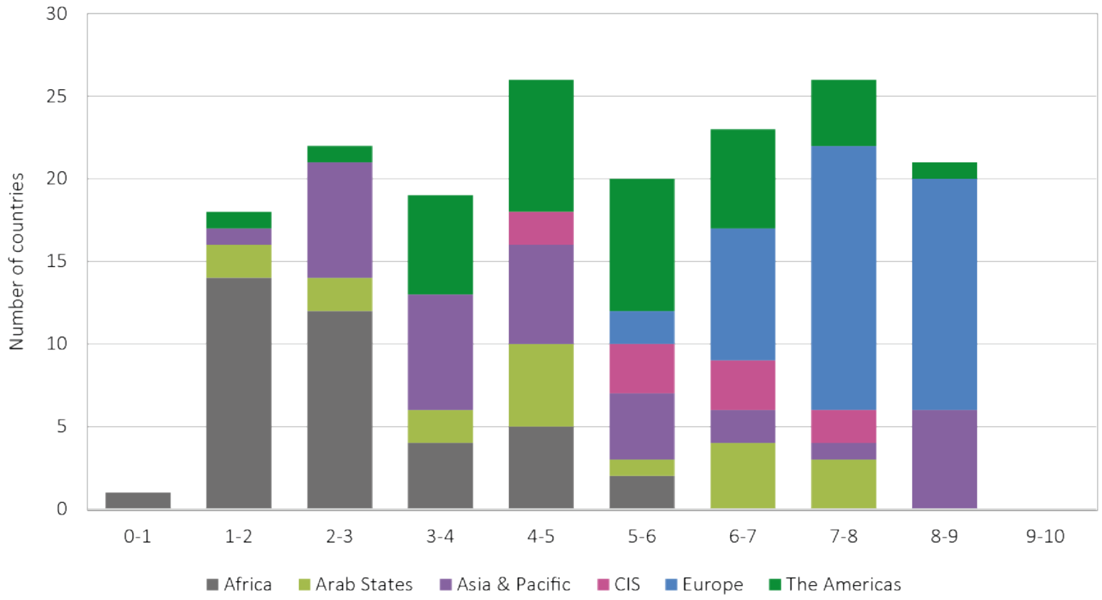
The relative stability of the Index year-on-year reflects steady progress towards higher IDI values in the large majority of countries. Only eight countries showed a decline in their overall IDI value – Estonia, Saudi Arabia, Azerbaijan, Dominica and Venezuela in the upper half of the distribution; and Sudan, Angola and Madagascar in the lower half. The reduction in value was below 0.10 points in all but one of these countries (Saudi Arabia, where there was a fall of 0.64 points in the use sub-index value).

The average improvement in IDI value across all economies was 0.18 points, from 4.93 points in IDI 2016 to 5.11 points in IDI 2017. The margin of improvement in overall values was highest in the middle of the distribution. The improvement in IDI values for the top ten countries was on average half the overall rate, at 0.09 points, reflecting the fact that markets in these high-performing countries are relatively saturated and approaching the maximum attainable figure within the current Index. Improvements in IDI values at the bottom of the distribution are constrained by the low levels of many indicators within the Index in LCCs, where significant improvements in the proportion of citizens with access do not necessarily translate into large increases in indicator levels.

The distribution between developed and developing countries, and the particular challenges faced by LDCs, are discussed in section 2.4 below. This distribution suggests that the gap in IDI values has continued to diminish between those countries at the top of the distribution – principally developed countries and developing countries with high levels of GNI per capita (such as the Republic of Korea; Hong Kong (China); and Singapore) and developing countries with lower levels of GNI per capita in the middle of the distribution. This is partly because higher gains have been made by middle-ranking developing countries in a number of indicators where developed countries had already attained high levels of performance.

However, developed countries and high-income, highly-connected developing countries now have access to much higher broadband speeds and more sophisticated digital services, which are not included in IDI 2017, and the gap between these higher-income countries and the majority of developing countries may be widening where

Chart 2.1: Distribution of IDI values between regions



Source: ITU.

these higher speeds and more sophisticated services are concerned. Adjustments to the Index that are to be introduced next year (see section 2.2) will address this question.

Section 2.4 also shows that there is a widening gap between the majority of developing countries on the one hand, and LDCs and LCCs on the other. This widening digital divide is a cause of particular concern in light of the role that ICTs are expected to play in efforts to achieve the Sustainable Development Goals.

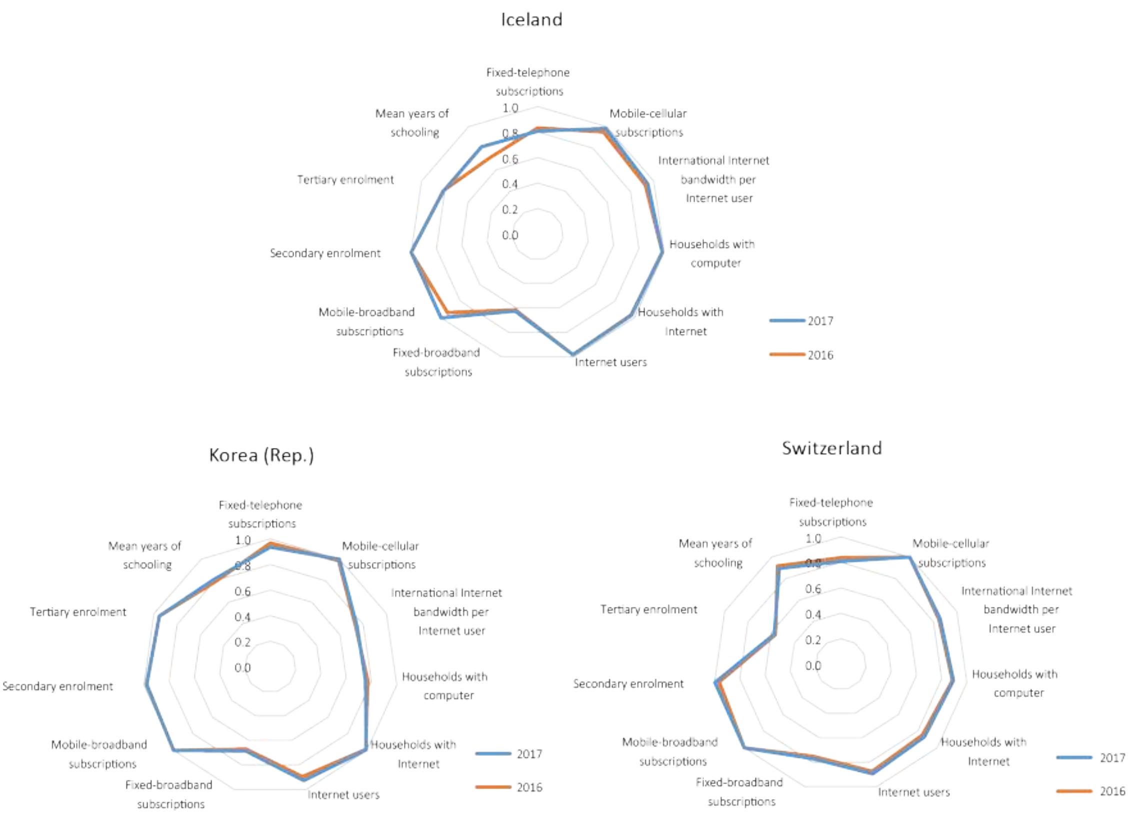
The distribution of IDI values between regions is illustrated in Chart 2.1. This shows the continuing dominance of countries in the Europe region among those performing highly in the Index, and of countries in the Africa region at the lower end of the distribution. Both these regions are economically relatively homogeneous. All but three countries in the Europe region are developed countries, while all of those in the Africa region are developing countries, and 25 of those included in the Index are LDCs. The CIS region, most of whose countries fall into the upper half of the distribution, is also relatively homogeneous, with almost all of its IDI rankings and values falling within the upper-middle and lower-middle quartiles. Other regions are more heterogeneous, including countries with both high and low levels of GNI per capita (and one or more LDCs), and both high and low levels of IDI performance. These regional characteristics are discussed in Chapter 3.

Top-performing countries

The top-performing economy in IDI 2017 is Iceland. The Republic of Korea, which was the top-performing country in IDI 2016, is in second place, followed by three more European countries – Switzerland, Denmark and the United Kingdom – and by another Asian economy, Hong Kong (China). Spider charts illustrating the IDI values of the top three economies are presented in Chart 2.2. As is to be expected of economies with very high IDI scores, these show high levels of attainment across the range of indicators in the Index. Individual country profiles can be found in Volume 2 of the present *Report*.

There has been relatively little change in most of the individual indicators for economies at the top of the IDI distribution. Each of these achieved very high values in some indicators, including mobile-cellular subscriptions and mobile-broadband subscriptions, some years ago, leaving little scope for further improvement where these particular indicators are concerned. However, there are some significant differences between the performances of these countries where other indicators are concerned.

Chart 2.2: IDI values for top-ranking countries, 2017 and 2016



Source: ITU.

Iceland has overtaken the Republic of Korea to rise to the top of the rankings, because of improvements in mobile-broadband subscriptions in the use sub-index and mean years of schooling in the skills sub-index. It scores particularly high in the proportion of households with a computer (for which it has the highest score of any economy in the Index, 98.5 per cent, compared with 75.3 per cent in the Republic of Korea) and in international bandwidth per Internet user (for which it has the fourth-highest score of any economy), but achieved lower scores than the Republic of Korea for all four subscription indicators (fixed-telephone, mobile-cellular, fixed-broadband and mobile-broadband).

The Republic of Korea's performance, in second place, is boosted by high values for fixed-telephone subscriptions and for tertiary enrolment, but its values for the percentage of households with a computer and for international Internet bandwidth per Internet user are notably lower than those in Iceland and Switzerland.

Switzerland's overall IDI value is affected by a low score, relative to other developed countries, for tertiary enrolment, in which it ranked 53rd worldwide. It scored more highly than either Iceland or the Republic of Korea on mobile-cellular and fixed-broadband subscriptions, and outranked the latter (but not the former) in international Internet bandwidth per Internet user.

Most dynamic countries

Movements in the position of countries within the IDI can be measured by changes in both/either their IDI ranking and their IDI value. Table 2.6 sets out the most dynamic improvements made by individual countries between IDI 2016 and IDI 2017 in terms of both ranking and value. As can be seen from the table, there are significant differences between the outcomes from these two approaches, and both should be taken into account when assessing improvements in performance.

Table 2.6: Most dynamic countries in IDI rankings and values, 2016–2017

Change in IDI ranking			Change in IDI value (absolute)		
IDI rank 2017	Country	IDI rank change	IDI rank 2017	Country	IDI value change
95	Uzbekistan	8	118	Namibia	0.57
159	Afghanistan	6	81	Iran (I.R.)	0.54
36	Croatia	6	114	Gabon	0.50
88	Suriname	6	139	Lao P.D.R.	0.47
152	Uganda	6	28	Cyprus	0.47
42	Uruguay	6	111	Indonesia	0.47
139	Lao P.D.R.	5	112	Bolivia	0.47
35	Latvia	5	122	Timor-Leste	0.46
135	Myanmar	5	67	Turkey	0.43
118	Namibia	5	80	China	0.42
122	Timor-Leste	5	135	Myanmar	0.42
67	Turkey	5	95	Uzbekistan	0.42
			130	Nicaragua	0.42

Source: ITU

The most dynamic country in terms of IDI ranking is Uzbekistan, which rose eight places overall between IDI 2016 and IDI 2017, from 103rd to 95th position, lifting its IDI value by 0.42 points, from 4.48 to 4.90. Uzbekistan made significant improvements in both access and use sub-indices. It rose three places in the access sub-index, from 98th to 95th, and improved its access sub-index value by 0.28 points, from 4.96 to 5.24. It rose even more substantially in the use sub-index, where it improved its ranking by ten positions (from 103rd to 93rd) and its sub-index value by 0.70 points, from 3.23 to 3.93. The most substantial contributions came from mobile-broadband subscriptions (use sub-index). The country's overall IDI performance was, however, adversely affected by a fall in its recorded secondary enrolment.

The most dynamic country in terms of IDI value, however, was Namibia, whose 0.57-point improvement from 3.33 to 3.89 points enabled a rise of five positions in the rankings. Namibia's improvement was even more concentrated than Uzbekistan's in the use sub-index, where it achieved the highest sub-index value increase, 1.20 points, from 2.16 to 3.36, which enabled a rise of nine places, from 118th to 109th, in the sub-index rankings. Although there was also a significant increase in the proportion of Internet users in the country, this improvement in the use sub-index was driven by a large increase in mobile-broadband subscriptions, which rose from 35.82 to 66.15 per 100 inhabitants over the year. Namibia also improved its value in the access sub-index by 0.16 points, from 4.23 to 4.39 points, and in the skills sub-index by 0.11 points, from 3.85 to 3.96 points.

Spider charts illustrating the IDI values of a number of these dynamic countries, ranging from high to low performers in the overall Index, are presented in Chart 2.3. These charts illustrate differences and similarities in the experience of dynamic countries at different levels in the overall distribution. More detailed analysis of the performance of individual countries is included in the regional analysis in Chapter 3 and in the country profiles in Volume 2.

Cyprus, which comes 28th in IDI 2017, is the highest-ranking country illustrated in Chart 2.3. Its spider chart has a shape broadly similar to those for countries at the top of the distribution, but is less rounded because its scores for several indicators are lower than those for top-performing countries. Cyprus' gain in IDI value between 2016 and 2017 is derived almost entirely from rapid growth in its score for mobile-broadband subscriptions per 100 population, which rose from 75.71 in IDI 2016 to 97.46 in IDI 2017, a rise of 28.7 per cent following aggressive marketing of mobile data packages in a competitive market.

Three other countries whose IDI outcomes are illustrated in Chart 2.3 fall within the upper half of the overall distribution (Turkey, China and Suriname). These are typical of countries at this ranking level in having both lower overall values

Chart 2.3: IDI values for most dynamic countries, 2017 and 2016

Source: ITU.

for the majority of indicators than countries towards the top of the distribution and especially lower values for fixed-telephone and fixed-broadband indicators. This makes their spider charts less rounded than those of countries that rank higher in the distribution. As with Cyprus, the most significant improvements in Turkey's and China's IDI scores have been in mobile-broadband subscriptions per 100 population. These countries also saw marked improvements in their scores for tertiary enrolment. The most significant improvement in Suriname, however, lay in international Internet bandwidth per Internet user.

The spider charts for the remaining countries in Chart 2.3 are typical of those for developing countries within the lower half of the overall distribution, though here too there are significant variations between individual countries. The most prominent gains in all five of these countries – Bolivia, Uzbekistan, Namibia, the Lao P.D.R. and Afghanistan – have been made on mobile-broadband subscriptions. Namibia had already achieved more than 100 mobile-cellular subscriptions per 100 inhabitants in IDI 2016, and Bolivia is now approaching this level, while Uzbekistan, the Lao P.D.R. and Afghanistan are still significantly below. All five countries score relatively high (compared with other indicators) on international Internet bandwidth per Internet user, though only Bolivia is above the global average where this is concerned, while Uzbekistan scores relatively high on households with Internet access. Among skills indicators, all five score much higher for secondary enrolment and mean years of schooling than they do for tertiary enrolment.

Changes in overall IDI values

As well as assessing economies' performance in terms of their overall IDI value, it is important to assess the progress that they are making in relation to their own previous performance. Table 2.7 lists economies in order of the improvement achieved in their overall IDI value between IDI 2016 and IDI 2017. Tables 2.9 and 2.11 do the same for the access and use sub-indices.

IDI values were very evenly balanced between the top and bottom halves of the distribution. Table 2.7 shows that, of the 176 economies in the IDI 2017, just under half (87) equalled or exceeded this average improvement, 17 doing so by more than twice the global average. Thirty-nine of the economies in IDI 2017 saw improvements in IDI value of less than half the average (i.e. less than 0.9 points), of which eight countries experienced a fall in their IDI value.

Changes in the IDI values for the four quartiles of economies in IDI 2017, for the overall IDI and its three sub-indices, are set out in Table 2.8.

As this indicates, the average improvement in IDI 2017 value was greater in the two middle-ranking quartiles than at either end of the distribution, suggesting that middle-ranking countries are catching up with highly-connected countries, at least so far as the indicators included in the Index are concerned, while LCCs may be falling further behind. Comparisons between improvements by development status and by region can be found in section 2.4 below and in Chapter 3 respectively.

The access, use and skills sub-indices

As in previous years, significant differences can be identified between the overall IDI rankings and values and the three sub-indices of which the Index is composed. As described in section 2.2, the access and use sub-indices each make up 40 per cent of IDI 2017, with the remaining 20 per cent derived from the skills sub-index. While the access and use sub-indices comprise ICT-specific indicators, the skills sub-index comprises proxy indicators, published by UIS which are primarily concerned with educational attainment. The skills sub-index is therefore less directly related to ICTs than the other two sub-indices are.

There is closer association between rankings in the overall Index and those in the access and use sub-indices, and greater disparity between the overall Index and the skills sub-index. These disparities are reflected also in the individual indicators from which the Index is compiled. For example, the proportion of individuals using the Internet ranges from less than 10 per cent of the population in some LDCs to nearly the entire population in some developed countries. Furthermore, the large range of values within the middle quartiles (quartiles 1 to 3) also suggests great variability across countries in the middle of the distribution.

Table 2.7: IDI value change, 2016–2017

Economy	IDI value change	IDI 2016	IDI 2017	Rank IDI 2017
Namibia	0.57	3.33	3.89	118
Iran (I.R.)	0.54	5.04	5.58	81
Gabon	0.50	3.62	4.11	114
Lao P.D.R.	0.47	2.43	2.91	139
Cyprus	0.47	7.30	7.77	28
Indonesia	0.47	3.85	4.33	111
Bolivia	0.47	3.84	4.31	112
Timor-Leste	0.46	3.11	3.57	122
Turkey	0.43	5.66	6.08	67
China	0.42	5.17	5.60	80
Myanmar	0.42	2.59	3.00	135
Uzbekistan	0.42	4.48	4.90	95
Nicaragua	0.42	2.85	3.27	130
Uruguay	0.41	6.75	7.16	42
Grenada	0.40	5.39	5.80	73
Suriname	0.38	4.77	5.15	88
India	0.38	2.65	3.03	134
Mauritius	0.36	5.51	5.88	72
Thailand	0.36	5.31	5.67	78
Samoa	0.35	2.95	3.30	127
Zambia	0.35	2.19	2.54	146
Algeria	0.34	4.32	4.67	102
Austria	0.32	7.70	8.02	21
Trinidad & Tobago	0.32	5.71	6.04	68
Ecuador	0.32	4.52	4.84	97
Kyrgyzstan	0.31	4.06	4.37	109
Ukraine	0.31	5.31	5.62	79
Côte d'Ivoire	0.30	2.84	3.14	131
Togo	0.29	1.86	2.15	156
Chile	0.29	6.28	6.57	56
Oman	0.29	6.14	6.43	62
Uganda	0.29	1.90	2.19	152
Maldives	0.29	4.97	5.25	85
Mexico	0.29	4.87	5.16	87
Croatia	0.28	6.96	7.24	36
Nepal	0.28	2.60	2.88	140
St. Vincent and the Grenadines	0.27	5.27	5.54	82
Belarus	0.26	7.29	7.55	32
Macao, China	0.26	7.55	7.80	26
Dominican Rep.	0.26	4.26	4.51	106
Romania	0.25	6.23	6.48	58
Portugal	0.25	6.88	7.13	44
Viet Nam	0.25	4.18	4.43	108
Moldova	0.25	6.21	6.45	59
Cambodia	0.24	3.04	3.28	128
Kenya	0.24	2.67	2.91	138
Peru	0.24	4.61	4.85	96
Albania	0.24	4.90	5.14	89
Brazil	0.23	5.89	6.12	66
Cameroon	0.23	2.14	2.38	149
Colombia	0.23	5.12	5.36	84
Afghanistan	0.23	1.71	1.95	159
Seychelles	0.23	4.80	5.03	90
Kuwait	0.23	5.75	5.98	71
Antigua & Barbuda	0.23	5.48	5.71	76
Ethiopia	0.23	1.42	1.65	170
Slovakia	0.22	6.84	7.06	46
Bahamas	0.22	6.29	6.51	57
Lithuania	0.22	6.97	7.19	41
Latvia	0.21	7.05	7.26	35
Jamaica	0.21	4.63	4.84	98
Malta	0.21	7.65	7.86	24
Chad	0.21	1.06	1.27	174
Pakistan	0.21	2.21	2.42	148
Armenia	0.21	5.56	5.76	75
Tonga	0.21	4.13	4.34	110
Georgia	0.20	5.59	5.79	74
Lebanon	0.20	6.09	6.30	64
Singapore	0.20	7.85	8.05	18
Iceland	0.20	8.78	8.98	1
Italy	0.20	6.84	7.04	47
El Salvador	0.20	3.62	3.82	119
Brunei Darussalam	0.20	6.56	6.75	53
Barbados	0.20	7.11	7.31	34
Bulgaria	0.20	6.66	6.86	50
Hungary	0.19	6.74	6.93	48
Germany	0.19	8.20	8.39	12
Morocco	0.19	4.57	4.77	100
France	0.19	8.05	8.24	15
Egypt	0.19	4.44	4.63	103
Slovenia	0.19	7.20	7.38	33
Djibouti	0.18	1.80	1.98	158
Libya	0.18	3.93	4.11	115
Mauritania	0.18	2.08	2.26	151
Spain	0.18	7.61	7.79	27
S. Tomé & Principe	0.18	2.91	3.09	132
Senegal	0.18	2.48	2.66	142
Israel	0.17	7.71	7.88	23
Nigeria	0.17	2.44	2.60	143
Australia	0.17	8.08	8.24	14
Paraguay	0.17	4.02	4.18	113
Gambia	0.17	2.43	2.59	144
Ghana	0.17	3.88	4.05	116
Poland	0.16	6.73	6.89	49
Belize	0.16	3.54	3.71	120
Burkina Faso	0.16	1.74	1.90	162
Russian Federation	0.16	6.91	7.07	45
Bangladesh	0.16	2.37	2.53	147
Malaysia	0.16	6.22	6.38	63
Fiji	0.16	4.34	4.49	107
Malawi	0.16	1.58	1.74	167
Bosnia and Herzegovina	0.16	5.23	5.39	83
Central African Rep.	0.16	0.89	1.04	175
Guatemala	0.16	3.19	3.35	125
Costa Rica	0.15	6.29	6.44	60
Greece	0.15	7.08	7.23	38
Hong Kong, China	0.15	8.47	8.61	6
Philippines	0.14	4.52	4.67	101
Sri Lanka	0.14	3.77	3.91	117
Honduras	0.14	3.14	3.28	129
Bahrain	0.14	7.46	7.60	31
Montenegro	0.13	6.30	6.44	61
Palestine	0.13	3.42	3.55	123
Canada	0.13	7.64	7.77	29
TFYR Macedonia	0.13	5.88	6.01	69
Kiribati	0.13	2.04	2.17	154
Andorra	0.13	7.58	7.71	30
Ireland	0.12	7.90	8.02	20
Tunisia	0.12	4.70	4.82	99
Cuba	0.12	2.80	2.91	137
Panama	0.12	4.80	4.91	94
Mali	0.11	2.05	2.16	155
Argentina	0.11	6.68	6.79	51
United Kingdom	0.11	8.53	8.65	5
Bhutan	0.11	3.58	3.69	121
Belgium	0.11	7.70	7.81	25
Japan	0.11	8.32	8.43	10
St. Lucia	0.10	4.53	4.63	104
New Zealand	0.10	8.23	8.33	13
Guinea-Bissau	0.10	1.38	1.48	173
Lesotho	0.10	2.94	3.04	133
Serbia	0.10	6.51	6.61	55
Burundi	0.10	1.39	1.48	172
Czech Republic	0.10	7.06	7.16	43
Netherlands	0.10	8.40	8.49	7
Haiti	0.09	1.63	1.72	168
Cape Verde	0.09	4.83	4.92	93
Mozambique	0.09	2.23	2.32	150
Qatar	0.08	7.12	7.21	39
Botswana	0.08	4.51	4.59	105
Tanzania	0.08	1.73	1.81	165
Solomon Islands	0.08	2.04	2.11	157
Rwanda	0.07	2.10	2.18	153
Switzerland	0.07	8.66	8.74	3
Congo (Dem. Rep.)	0.07	1.48	1.55	171
Zimbabwe	0.07	2.85	2.92	136
Guinea	0.07	1.71	1.78	166
Kazakhstan	0.06	6.72	6.79	52
Vanuatu	0.06	2.75	2.81	141
Luxembourg	0.06	8.40	8.47	9
St. Kitts and Nevis	0.06	7.18	7.24	37
Korea (Rep.)	0.06	8.80	8.85	2
South Africa	0.05	4.91	4.96	92
United States	0.05	8.13	8.18	16
Finland	0.05	7.83	7.88	22
Mongolia	0.04	4.91	4.96	91
Equatorial Guinea	0.04	1.82	1.86	163
Comoros	0.04	1.78	1.82	164
Denmark	0.03	8.68	8.71	4
Jordan	0.03	5.97	6.00	70
United Arab Emirates	0.02	7.18	7.21	40
Syria	0.02	3.32	3.34	126
Monaco	0.02	8.03	8.05	19
Norway	0.02	8.45	8.47	8
Benin	0.02	1.92	1.94	161
Guyana	0.00	3.44	3.44	124
Eritrea	0.00	0.96	0.96	176
Sweden	0.00	8.41	8.41	11
Sudan	-0.01	2.56	2.55	145
Estonia	-0.02	8.16	8.14	17
Madagascar	-0.02	1.70	1.68	169
Azerbaijan	-0.05	6.25	6.20	65
Venezuela	-0.06	5.22	5.17	86
Angola	-0.06	2.00	1.94	160
Dominica	-0.06	5.76	5.69	77
Saudi Arabia	-0.20	6.87	6.67	54

Note: Palestine is not an ITU member State; the status of Palestine in ITU is the subject of Resolution 99 (rev. Busan, 2014) of the ITU Plenipotentiary Conference.
Source: ITU.

Table 2.8: IDI values by IDI quartile, 2017 and 2016

	2016				2017				% change			
IDI Levels	Access	Use	Skills	IDI	Access	Use	Skills	IDI	Access	Use	Skills	IDI
High	8.15	7.25	8.09	7.78	8.21	7.52	8.15	7.92	0.7	3.7	0.8	1.9
Upper-middle	6.55	4.85	6.83	5.93	6.67	5.22	6.91	6.14	1.8	7.5	1.2	3.5
Lower-middle	4.59	2.78	5.30	4.01	4.70	3.11	5.39	4.20	2.6	12.1	1.7	5.0
Low	2.71	0.97	2.86	2.04	2.78	1.19	2.95	2.18	2.8	22.3	3.3	6.7

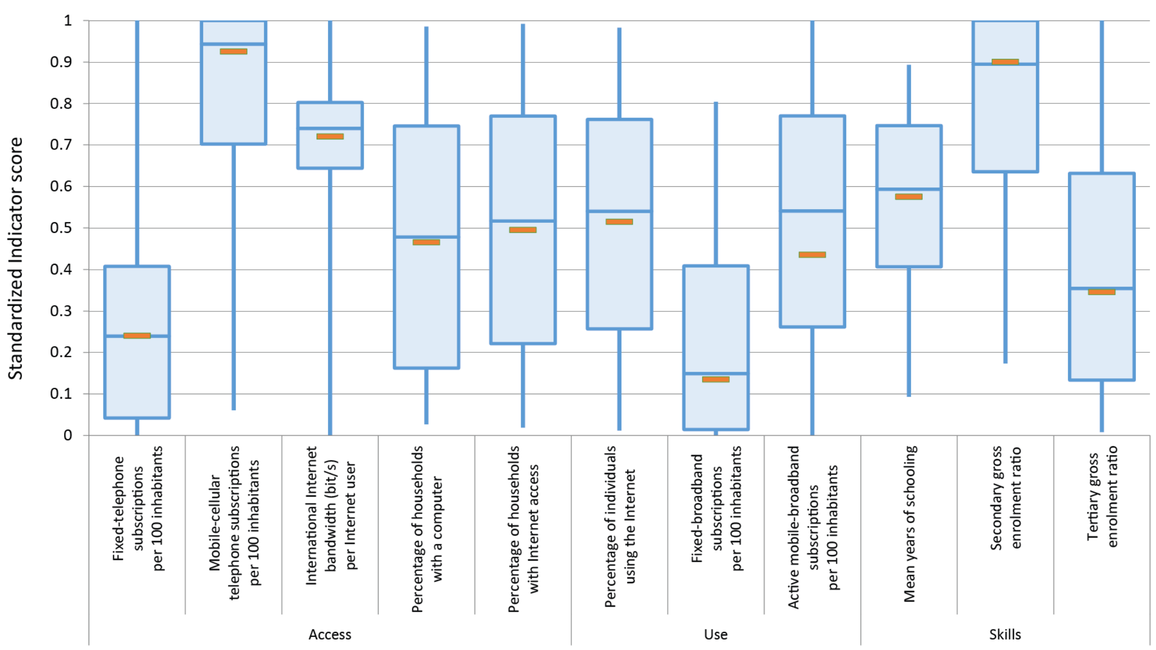
Source: ITU.

In contrast, some of the indicators in the access sub-index, such as the indicators on mobile-cellular subscriptions and international Internet bandwidth, show a narrower range. For example, considering that the number of mobile-cellular subscriptions per 100 inhabitants in many countries is close to, or exceeds, the reference value of 120, the potential for countries to improve their overall IDI ranks through this indicator is limited.

Chart 2.4 shows the range of values for all indicators in a box plot, with the box representing the middle quartiles (quartiles 1 to 3) and the line in the middle of the box representing the median. The top and bottom lines represent the maximum and minimum values. The blue area in this figure represents the distribution of values in the middle quartiles as in the IDI 2017, while the orange line shows the median value in the IDI 2016. While most indicators show an increase in the median value, the largest improvement was in active-mobile broadband subscriptions per 100 inhabitants.

All but two of the top ten economies in IDI 2017 also come within the top ten in the access sub-index, the exceptions – Denmark and Norway – being displaced in this sub-index by two other European countries, Malta and Germany. Norway ranks only 27th in the access sub-index, primarily because of its low value, compared with other developed countries, for fixed-telephone subscriptions. The highest-performing country in the sub-index, as in 2016, is Luxembourg, which occupies ninth place in the overall Index. Other countries with significantly higher performance towards the top of this sub-index include France,

Chart 2.4: Variability of scores across the IDI indicators



Source: ITU.

Austria, Singapore, Bahrain and Barbados. In some cases, among countries towards the top of the Index, it is possible that relatively low positions in the access sub-index result from low values for fixed-telephone subscriptions as a result of fixed-mobile substitution. Norway, for example, ranks 77th worldwide for this indicator, and Finland 104th.

The top 11 economies in IDI 2017 also comprise the top 11 in the use sub-index. Denmark is the highest-performing country in the use sub-index, as it was in 2016. Other economies that score particularly highly in the use sub-index, within the upper quartile, are Monaco (which has the highest score for fixed-broadband subscriptions among economies within the Index), Finland (which has an exceptionally low score for fixed-telephone subscriptions in the access sub-index, giving it a lower position in the IDI than would be expected from other indicators), Macao (China), Cyprus and three of the Gulf Cooperation Council (GCC) countries in the Arab States region – Bahrain, Qatar and the United Arab Emirates.

There is also strong consistency between IDI 2017 and its access and use sub-indices at the bottom of the distribution. Six of the ten countries at the bottom of the access sub-index are also in the bottom ten countries in the use sub-index. Only seven countries in the lowest quartile in the access sub-index are in a higher quartile for the use sub-index, of which one (Mozambique) exceeded its access ranking by more than 30 places, and Zambia, Myanmar and Zimbabwe by between 10 and 20 places. Uganda also had a ranking in the use sub-index that was 30 places above its access sub-index ranking, though it remained just within the lowest quartile of the use sub-index. The Gambia and Guatemala, by contrast, ranked 20 places higher in the access sub-index than in the use sub-index.

Fourteen countries within IDI 2017 have rankings for access that are 20 or more places higher than their rankings for usage, the greatest differences being those for Ukraine (45 places), Iran (37 places), Seychelles (32 places) and the Syria (30 places). The highest-ranking country to fall into this category is Malta (5th for access, 30th for use) and the lowest-ranking is Gambia (130th and 150th respectively). These imbalances in favour of the access sub-index suggest that there is scope for policy interventions to stimulate demand and usage in these countries.

Thirteen countries, meanwhile, have rankings in the use sub-index that are 20 or more places higher than their rankings for access, the largest differences being those for Finland (32 places) and Norway (24 places) near the top of the IDI; the Dominican Republic (34 places), Jordan (29 places) and Costa Rica (27 places) in the middle of the distribution; and Mozambique (36 places) and Uganda (30 places) towards the bottom. In both Finland and Norway, this is due to those countries' exceptionally low levels of fixed-telephone subscriptions, which may be a result of fixed-mobile substitution (i.e. of households choosing not to have both fixed and mobile connections). In other cases, policy interventions to stimulate investment in further infrastructure deployment may be desirable to match strong demand for services.

There is much more variation between IDI 2017 and the skills sub-index which, as noted above, is derived from non-ICT-specific indicators. Only three of the economies in the top ten rankings for IDI 2017 (the Republic of Korea, Denmark and Iceland) fall within the top ten countries in the skills sub-index. Four of the top ten performers in IDI 2017 are ranked between 30th and 33rd in the skills sub-index (Japan; Switzerland; Hong Kong (China); and the United Kingdom), while one (Luxembourg) ranks as low as 74th in the skills sub-index. Methodological and definitional differences may affect these sub-index values, as may demographic factors, including different age profiles within the populations of developed and developing countries.

The access sub-index

Rankings and values for the access sub-index for IDI 2017 and IDI 2016 are set out in Table 2.3. Table 2.9 presents the changes in access sub-index value for all economies in the Index during the year between 2016 and 2017. Table 2.10 identifies those countries which have seen the most significant rise in their access sub-index rankings and values in the year. It should be noted that, while some of these economies also feature among the most dynamic performers in IDI 2017 as a whole (Table 2.6), this is far from universally the case.

Table 2.9: Access sub-index value change, 2016–2017

Economy	IDI access value change	IDI access sub-index 2016	IDI access sub-index 2017	Rank IDI access sub-index 2017
Suriname	0.46	5.38	5.83	87
Iran (I.R.)	0.41	6.33	6.74	67
Myanmar	0.39	3.09	3.48	139
Nepal	0.38	3.24	3.62	136
Central African Rep.	0.36	1.20	1.57	175
India	0.36	3.24	3.60	137
Algeria	0.31	4.83	5.14	98
Lao P.D.R.	0.30	3.17	3.47	140
Bahamas	0.29	6.67	6.97	61
Cuba	0.28	2.12	2.40	166
Uzbekistan	0.28	4.96	5.24	95
Kiribati	0.27	2.05	2.32	169
Jamaica	0.27	5.02	5.29	93
Mauritius	0.26	6.78	7.04	58
Malaysia	0.25	6.67	6.93	62
Trinidad & Tobago	0.25	6.94	7.18	54
Mexico	0.24	5.04	5.28	94
Moldova	0.24	7.32	7.56	42
Malawi	0.23	1.95	2.18	171
Peru	0.22	4.68	4.90	102
Bahrain	0.22	7.92	8.14	22
Cape Verde	0.22	5.53	5.76	88
Libya	0.22	4.58	4.80	107
Brunei Darussalam	0.22	7.25	7.47	44
Lebanon	0.22	6.70	6.92	63
China	0.21	5.37	5.58	89
Tonga	0.21	4.43	4.64	112
Samoa	0.21	3.43	3.64	134
Côte d'Ivoire	0.20	3.72	3.92	128
Turkey	0.19	6.11	6.30	78
Lesotho	0.19	3.52	3.72	131
Belize	0.19	3.88	4.07	127
South Africa	0.19	5.29	5.48	90
Ethiopia	0.19	2.16	2.35	168
New Zealand	0.18	8.16	8.34	16
Belarus	0.18	7.69	7.87	34
Antigua & Barbuda	0.18	6.55	6.73	68
Romania	0.17	6.80	6.98	60
Indonesia	0.17	4.68	4.85	105
Maldives	0.17	6.04	6.22	81
Chad	0.17	1.84	2.01	173
Poland	0.17	7.41	7.58	40
Nicaragua	0.17	4.02	4.19	123
Egypt	0.17	5.23	5.40	92
Namibia	0.17	4.23	4.39	119
Ukraine	0.16	6.45	6.60	71
Ghana	0.16	4.20	4.36	120
Pakistan	0.16	3.18	3.34	143
Montenegro	0.16	6.87	7.03	59
Bolivia	0.16	4.26	4.42	117
Nigeria	0.15	3.01	3.16	145
Djibouti	0.15	2.48	2.63	156
Tunisia	0.15	4.96	5.11	99
Ecuador	0.15	4.78	4.93	100
Gabon	0.15	4.36	4.51	116
Uganda	0.15	2.31	2.46	164
Cambodia	0.14	4.01	4.16	124
Bhutan	0.14	3.95	4.09	125
Portugal	0.14	7.77	7.91	31
Croatia	0.14	7.46	7.60	39
Lithuania	0.14	6.97	7.11	57
Panama	0.14	5.81	5.95	84
Spain	0.14	7.84	7.98	29
Palestine	0.14	3.21	3.35	142
Guatemala	0.14	4.38	4.52	115
Colombia	0.14	5.74	5.88	85
Sri Lanka	0.13	4.52	4.66	111
Togo	0.13	2.58	2.71	154
Cameroon	0.12	2.72	2.84	150
Hungary	0.12	7.65	7.78	37
Grenada	0.12	6.20	6.32	76
Kyrgyzstan	0.12	4.43	4.54	114
Uruguay	0.11	7.17	7.28	49
Viet Nam	0.11	4.64	4.75	108
Seychelles	0.11	6.36	6.46	73
Russian Federation	0.11	7.12	7.23	50
Chile	0.11	6.69	6.79	66
Latvia	0.11	7.31	7.41	45
Timor-Leste	0.11	3.74	3.84	129
Albania	0.11	4.70	4.80	106
Paraguay	0.11	4.30	4.41	118
Burkina Faso	0.10	2.72	2.82	151
Australia	0.10	7.90	8.00	26
Macao, China	0.10	7.73	7.83	36
TFYR Macedonia	0.10	6.56	6.66	69
Italy	0.10	7.23	7.33	47
France	0.10	8.55	8.64	11
Bosnia and Herzegovina	0.10	5.74	5.84	86
Qatar	0.10	7.80	7.90	33
Burundi	0.10	2.04	2.14	172
Dominican Rep.	0.10	4.20	4.30	122
Senegal	0.09	3.48	3.57	138
Mali	0.09	3.07	3.16	146
Guyana	0.09	4.27	4.36	121
Zimbabwe	0.09	3.31	3.40	141
Rwanda	0.09	2.58	2.67	155
Zambia	0.09	2.77	2.85	149
Thailand	0.09	5.39	5.48	91
United States	0.08	8.18	8.27	17
Vanuatu	0.08	3.57	3.65	133
Solomon Islands	0.08	2.73	2.81	152
Cyprus	0.08	7.78	7.86	35
Afghanistan	0.08	2.48	2.56	160
S. Tomé & Principe	0.07	3.62	3.69	132
Japan	0.07	8.73	8.80	9
Austria	0.07	8.31	8.38	15
Morocco	0.07	5.99	6.06	82
El Salvador	0.07	4.68	4.75	109
Canada	0.07	7.86	7.93	30
Iceland	0.07	9.32	9.38	2
Kenya	0.06	3.56	3.63	135
Finland	0.06	7.28	7.35	46
Botswana	0.06	4.84	4.90	101
Kazakhstan	0.06	7.48	7.55	43
Brazil	0.06	6.19	6.25	80
Eritrea	0.06	1.32	1.38	176
Comoros	0.06	2.53	2.59	159
Malta	0.06	8.96	9.02	5
Philippines	0.06	4.81	4.87	104
Guinea	0.06	2.45	2.51	163
Singapore	0.06	8.56	8.61	12
Hong Kong, China	0.06	9.16	9.22	3
Armenia	0.05	6.46	6.52	72
Bangladesh	0.05	2.99	3.05	147
Bulgaria	0.05	6.78	6.83	65
Mauritania	0.05	2.91	2.96	148
Czech Republic	0.05	7.08	7.14	55
Georgia	0.05	6.21	6.26	79
Argentina	0.05	6.81	6.87	64
Costa Rica	0.05	6.35	6.40	74
Monaco	0.05	8.21	8.26	18
Serbia	0.04	7.16	7.20	53
Guinea-Bissau	0.04	2.39	2.43	165
Slovenia	0.04	7.87	7.91	32
Gambia	0.04	3.73	3.77	130
Denmark	0.04	8.35	8.39	14
Honduras	0.04	4.04	4.08	126
Slovakia	0.04	7.19	7.22	51
United Arab Emirates	0.04	8.07	8.11	24
Netherlands	0.03	8.62	8.65	10
Equatorial Guinea	0.03	2.68	2.71	153
Greece	0.03	7.73	7.76	38
United Kingdom	0.03	9.12	9.15	4
Oman	0.02	7.30	7.32	48
Switzerland	0.02	8.83	8.85	8
Saudi Arabia	0.01	7.20	7.21	52
Tanzania	0.01	2.51	2.52	162
Israel	0.01	8.16	8.17	19
Ireland	0.01	8.13	8.14	23
Madagascar	0.01	2.29	2.29	170
St. Lucia	0.00	5.16	5.17	96
Sudan	0.00	3.23	3.23	144
Luxembourg	0.00	9.54	9.54	1
Norway	-0.01	8.00	8.00	27
Belgium	-0.01	8.16	8.15	21
Barbados	-0.01	8.05	8.04	25
Estonia	-0.01	8.18	8.16	20
Fiji	-0.01	4.90	4.88	103
Andorra	-0.02	8.01	7.99	28
Germany	-0.04	8.97	8.93	6
Sweden	-0.04	8.58	8.55	13
St. Vincent and the Grenadines	-0.05	6.35	6.31	77
Jordan	-0.05	6.08	6.03	83
Korea (Rep.)	-0.05	8.90	8.85	7
Kuwait	-0.05	7.17	7.12	56
St. Kitts and Nevis	-0.06	7.63	7.57	41
Angola	-0.07	2.69	2.62	158
Azerbaijan	-0.07	6.69	6.62	70
Syria	-0.08	4.66	4.58	113
Benin	-0.10	2.73	2.63	157
Mozambique	-0.11	2.64	2.53	161
Congo (Dem. Rep.)	-0.11	1.79	1.68	174
Haiti	-0.12	2.49	2.37	167
Venezuela	-0.13	5.28	5.15	97
Dominica	-0.27	6.60	6.34	75
Mongolia	-0.29	5.03	4.74	110

Note: Palestine is not an ITU Member State; the status of Palestine in ITU is the subject of Resolution 99 (rev. Busan, 2014) of the ITU Plenipotentiary Conference.
Source: ITU.

Table 2.10: Access sub-index, most dynamic countries, 2016–2017

Change in access ranking			Change in access value		
Access rank 2017	Country	Access rank change	Access rank 2017	Country	Access value change
67	Iran (I.R.)	9	87	Suriname	0.46
156	Djibouti	7	67	Iran (I.R.)	0.41
139	Myanmar	5	139	Myanmar	0.39
102	Peru	5	136	Nepal	0.38
62	Malaysia	5	175	Central African Rep.	0.36
61	Bahamas	5	137	India	0.36
22	Bahrain	5	98	Algeria	0.31
154	Togo	4	140	Lao P.D.R.	0.30
107	Libya	4	61	Bahamas	0.29
100	Ecuador	4	166	Cuba	0.28
98	Algeria	4	95	Uzbekistan	0.28
93	Jamaica	4	169	Kiribati	0.27
50	Russian Federation	4	93	Jamaica	0.27

Source: ITU.

The average value of the access sub-index, at 5.59, is significantly higher than that for the use sub-index (4.26) and for the Index as a whole (5.11), but there has been less movement in the access sub-index than in the use sub-index between IDI 2016 and IDI 2017. The access sub-index has improved by an average of 0.10 points over the year compared with an improvement of 0.31 in the use sub-index and 0.18 in the Index as a whole.

The highest values achieved in the access sub-index are also significantly higher than those in the use sub-index. Luxembourg tops the rankings for the access sub-index for 2017 with a sub-index value of 9.54, the same as it scored in 2016, followed by Iceland (9.38); Hong Kong (China) (9.22); and the United Kingdom (9.15). At the other end of the distribution, 28 of the 30 lowest-ranking countries are LDCs. The three lowest-ranking countries in this sub-index which are not LDCs are Nigeria (145th), Cameroon (150th) and Cuba (166th).

A total of 29 economies improved their access sub-index value by twice or more than twice the average increase (by 0.20 points or more). All of these dynamic performers in the access sub-index were developing countries. The most substantial increases in sub-index values were achieved by Suriname (up 0.46 points), Iran (up 0.41 points) and Myanmar (up 0.39 points). In the case of Suriname, this was due to a substantial improvement in international Internet bandwidth per Internet user and to growth in mobile-cellular subscriptions. In Myanmar, growth in mobile-cellular subscriptions was the principal factor, backed by increases in households with computers and Internet access. Iran saw improvements in all access indicators.

At the same time, 23 economies experienced a fall in their access sub-index values between IDI 2016 and IDI 2017. The most substantial falls were experienced by Mongolia (down 0.29 points), Dominica (down 0.27 points) and Venezuela (down 0.13 points). In some cases, these reductions may be due in part or in whole to changes in methodologies for calculating indicators (for example, in accounting for non-active subscriptions). Data adjustments were made by one of the mobile-cellular providers in Dominica, for example. A reduction of 10.47 points in the indicator for mobile-cellular subscriptions in Botswana can be attributed at least in part to the introduction of a new methodology which reduced the number of non-active subscriptions in its response. As noted above, the substitution of mobile-cellular for fixed-telephone subscriptions may also have played a part in some countries.

The rankings of most economies in the access sub-index have changed little over the year, with Iran showing the highest gain (up 9 places) and Mongolia the greatest fall (down 14 places).

A number of countries have access sub-index rankings that are considerably higher than their rankings in IDI 2017 as a whole. These include Malta, the United Arab Emirates and Kuwait towards the top of the distribution; Seychelles, Morocco and Moldova in the middle of the distribution; and Gambia towards the lower end of the distribution. In these cases, the difference may indicate that greater efforts to increase usage of available infrastructure would have a positive impact on ICT development.

Two countries – Cuba and Finland – have IDI 2017 rankings that are more than 20 places higher than their access rankings. The overall IDI ranking for Cuba is elevated by the country's high performance in the skills sub-index, where it ranks 62nd, compared with 151st in use and 166th in access. In the case of Finland, its comparatively poor performance in the access sub-index is primarily due to its low penetration of fixed-telephone subscriptions (see above). Other economies whose access sub-index rankings are markedly lower than their overall IDI 2016 rankings include Norway and Lithuania towards the top of the overall distribution; the Dominican Republic, Albania, Mongolia and Palestine in the middle of the distribution; and Kiribati towards the bottom of the distribution. In some cases, the difference may indicate that infrastructure limitations are the principal constraint on ICT development.

There were significant improvements in average global performance on four of the five indicators in the access sub-index:

- The number of fixed-telephone subscriptions per 100 population has been falling since 2006, as new subscribers have increasingly chosen to rely solely on mobile connectivity, and has now fallen to a global average of 17.5. Only 46 of the 176 economies in IDI 2017 recorded an increase for fixed-telephone subscriptions between IDI 2016 and IDI 2017. While 9 economies recorded fixed-telephone penetration rates above 50 per 100 inhabitants in IDI 2017, 26 countries – all but two of which are LDCs – recorded scores below 1 per 100 inhabitants;

- The number of mobile-cellular subscriptions, by contrast, now exceeds 100 per 100 inhabitants, both globally and in 112 of the 176 economies in IDI 2017. The average figure recorded for mobile-cellular subscriptions per 100 inhabitants in IDI 2017 was 111.32, while the lowest figure recorded, for Eritrea, was 7.29 subscriptions per 100 inhabitants. There has been a slowdown in the rate of improvement in this indicator, as many economies approach market saturation. As many as 80 of the 176 economies in the Index recorded a fall in the number of mobile-cellular subscriptions between IDI 2016 and IDI 2017, and the average change for all 176 countries was much lower than in previous years;

- There was a 2.4 per cent increase between IDI 2016 and IDI 2017 in the average indicator value for Internet bandwidth per Internet user which, as noted in section 1.2, varies with both the total amount of international Internet bandwidth available and the number of Internet users. Thirty-two countries experienced a decline in this indicator during the year;

- There was a 2.8 per cent increase in the proportion of households with a computer (raising the global average from 45.6 per cent to 46.8 per cent), with a very wide range of values apparent between countries at the top and bottom of the distribution. Eight economies recorded figures above 90 per cent for this indicator, while 11 fell below the 5 per cent mark;

- There was a 5.3 per cent increase in the average figure for the proportion of households with Internet access (from a global average of 46.8 per cent to 49.3 per cent), with a similarly wide range of values. Fifteen economies recorded a proportion of households with Internet access above 90 per cent, while eight countries recorded figures below 5 per cent.

The use sub-index

Rankings and values for the use sub-index for IDI 2017 and IDI 2016 are set out in Table 2.4. Table 2.11 ranks countries according to the change in use sub-index value they have achieved during the course of the year. Table 2.12 identifies those countries which have seen the most significant rise in their use sub-index rankings and values in the period 2016–2017.

Table 2.11: Use sub-index value change, 2016–2017

Economy	IDI use value change 2016-2017	IDI use sub-index 2016	IDI use sub-index 2017	Rank IDI use sub-index 2017
Namibia	1.20	2.16	3.36	109
Gabon	1.07	2.77	3.85	97
Cyprus	0.98	6.63	7.61	21
Bolivia	0.98	2.40	3.38	107
Timor-Leste	0.98	2.02	3.00	117
Indonesia	0.97	2.22	3.19	115
Uruguay	0.83	6.20	7.03	34
Lao P.D.R.	0.80	1.11	1.90	132
Zambia	0.77	1.17	1.93	130
Iran (I.R.)	0.76	2.78	3.54	104
Turkey	0.75	4.18	4.92	73
Nicaragua	0.73	1.00	1.73	140
St.Vincent and the Grenadines	0.72	3.89	4.61	77
Samoa	0.71	1.23	1.94	129
Uzbekistan	0.70	3.23	3.93	93
Kyrgyzstan	0.67	2.25	2.91	118
Mauritius	0.66	3.78	4.44	82
Uganda	0.65	1.22	1.87	134
China	0.65	4.63	5.27	69
Austria	0.65	6.74	7.39	25
Ukraine	0.61	2.56	3.17	116
Oman	0.59	5.12	5.71	55
Myanmar	0.58	1.84	2.43	121
Armenia	0.58	3.85	4.42	83
Togo	0.58	0.49	1.06	156
Kuwait	0.57	4.42	4.99	72
Ecuador	0.57	3.34	3.92	94
Thailand	0.56	4.78	5.33	68
Dominican Rep.	0.56	3.49	4.04	88
Trinidad & Tobago	0.56	4.51	5.07	71
Albania	0.54	3.88	4.42	84
Chile	0.53	4.86	5.39	65
Slovakia	0.53	6.14	6.67	36
Kenya	0.52	1.23	1.76	139
Romania	0.51	5.08	5.59	61
Maldives	0.50	4.30	4.80	74
Belarus	0.49	6.05	6.54	40
Portugal	0.48	5.67	6.15	50
Viet Nam	0.47	3.18	3.65	102
Slovenia	0.47	5.69	6.16	49
Cambodia	0.47	2.09	2.56	119
Lithuania	0.46	6.18	6.63	38
Algeria	0.45	2.92	3.38	108
Malta	0.43	6.73	7.16	30
Germany	0.43	7.35	7.77	18
Hungary	0.43	5.28	5.71	56
Barbados	0.42	5.88	6.30	43
Moldova	0.42	4.71	5.12	70
Israel	0.41	6.92	7.34	26
Peru	0.40	3.55	3.96	90
Latvia	0.40	6.25	6.65	37
Lebanon	0.40	5.80	6.20	46
Côte d'Ivoire	0.40	2.10	2.50	120
Antigua & Barbuda	0.40	4.06	4.46	81
Croatia	0.40	6.05	6.45	41
El Salvador	0.39	1.86	2.25	124
Georgia	0.38	4.09	4.47	80
Mexico	0.38	4.27	4.65	76
Bulgaria	0.37	5.86	6.23	45
India	0.37	1.25	1.62	144
Suriname	0.37	4.18	4.55	78
Afghanistan	0.35	0.48	0.83	160
Greece	0.35	5.47	5.82	53
Haiti	0.34	0.41	0.75	165
Fiji	0.34	3.10	3.44	106
Mauritania	0.33	1.29	1.62	146
Andorra	0.33	6.74	7.07	33
Guatemala	0.33	1.45	1.78	135
Cameroon	0.33	0.84	1.16	154
Gambia	0.33	1.01	1.34	150
Costa Rica	0.33	5.85	6.18	47
France	0.32	7.61	7.93	17
Chad	0.32	0.17	0.49	171
Italy	0.32	6.03	6.35	42
Brunei Darussalam	0.31	5.98	6.30	44
Bosnia and Herzegovina	0.31	4.21	4.52	79
Jamaica	0.29	3.64	3.94	92
S. Tomé & Principe	0.29	1.49	1.77	137
St. Lucia	0.28	3.39	3.68	101
Pakistan	0.28	0.95	1.24	152
TFYR Macedonia	0.28	5.09	5.36	67
Morocco	0.28	3.40	3.68	100
Congo (Dem. Rep.)	0.27	0.41	0.68	167
Tonga	0.27	3.08	3.35	110
Honduras	0.27	1.63	1.89	133
Belgium	0.27	6.95	7.22	29
Hong Kong, China	0.26	7.95	8.21	10
Bahamas	0.26	5.33	5.59	60
Colombia	0.26	3.85	4.11	85
Ghana	0.26	3.29	3.55	103
Grenada	0.26	3.78	4.04	89
Spain	0.26	6.97	7.23	28
Russian Federation	0.26	5.87	6.13	51
Djibouti	0.26	0.73	0.99	158
Iceland	0.26	8.44	8.70	5
Mongolia	0.26	3.64	3.90	96
United Kingdom	0.26	8.13	8.38	7
Philippines	0.25	3.44	3.70	99
Canada	0.25	7.01	7.27	27
Burkina Faso	0.24	0.89	1.13	155
Libya	0.24	1.75	1.98	128
Poland	0.24	5.24	5.47	64
Bangladesh	0.24	1.17	1.41	149
Guinea-Bissau	0.24	0.12	0.36	173
Australia	0.23	7.74	7.97	16
Malaysia	0.23	5.94	6.17	48
Seychelles	0.22	3.24	3.47	105
St. Kitts and Nevis	0.22	6.53	6.76	35
Belize	0.22	2.07	2.29	123
Sri Lanka	0.22	1.69	1.91	131
Jordan	0.22	5.52	5.73	54
Ireland	0.22	7.38	7.59	22
Mali	0.21	0.97	1.19	153
Nepal	0.20	1.52	1.73	141
Paraguay	0.19	3.10	3.29	113
Netherlands	0.19	8.10	8.28	9
Macao, China	0.19	7.54	7.72	19
Ethiopia	0.18	0.54	0.72	166
Argentina	0.18	5.79	5.96	52
Czech Republic	0.18	6.44	6.62	39
Palestine	0.17	2.25	2.42	122
Mozambique	0.17	2.07	2.24	125
Vanuatu	0.17	1.47	1.63	142
Montenegro	0.16	5.21	5.38	66
Serbia	0.16	5.37	5.54	63
Korea (Rep.)	0.15	8.56	8.71	4
Egypt	0.15	3.20	3.35	111
Tunisia	0.15	3.96	4.11	86
Botswana	0.14	3.60	3.73	98
Switzerland	0.13	8.76	8.88	2
Luxembourg	0.13	8.17	8.30	8
Bhutan	0.12	3.08	3.21	114
Senegal	0.12	1.64	1.76	138
Brazil	0.12	5.58	5.69	57
Guyana	0.11	1.51	1.62	145
Tanzania	0.11	0.64	0.75	164
Syria	0.11	1.53	1.63	143
United States	0.11	7.56	7.67	20
Rwanda	0.10	1.47	1.58	148
Guinea	0.09	0.74	0.83	161
Malawi	0.09	0.85	0.94	159
Panama	0.09	3.24	3.32	112
Equatorial Guinea	0.08	0.74	0.82	162
Qatar	0.08	6.99	7.07	32
Solomon Islands	0.08	0.73	0.81	163
Benin	0.08	0.55	0.63	168
Japan	0.08	8.07	8.15	11
Nigeria	0.07	1.52	1.58	147
Kazakhstan	0.06	5.63	5.69	58
New Zealand	0.05	8.03	8.08	12
Norway	0.05	8.77	8.82	3
South Africa	0.05	3.86	3.91	95
Cuba	0.05	1.25	1.30	151
Bahrain	0.05	7.48	7.53	23
Dominica	0.05	4.73	4.78	75
Sweden	0.04	8.36	8.40	6
Kiribati	0.04	0.45	0.49	170
Denmark	0.04	8.90	8.94	1
Burundi	0.03	0.42	0.45	172
Central African Rep.	0.03	0.21	0.24	175
United Arab Emirates	0.03	7.07	7.09	31
Comoros	0.02	0.26	0.28	174
Estonia	0.02	7.95	7.97	15
Finland	0.02	7.97	7.99	14
Singapore	0.01	7.44	7.45	24
Cape Verde	0.01	4.10	4.11	87
Lesotho	0.00	2.15	2.15	126
Eritrea	0.00	0.04	0.04	176
Monaco	0.00	8.01	8.01	13
Venezuela	-0.01	3.95	3.94	91
Zimbabwe	-0.02	2.12	2.10	127
Angola	-0.06	1.10	1.03	157
Madagascar	-0.07	0.58	0.51	169
Sudan	-0.09	1.87	1.78	136
Azerbaijan	-0.14	5.70	5.55	62
Saudi Arabia	-0.64	6.32	5.68	59

Note: Palestine is not an ITU Member State; the status of Palestine in ITU is the subject of Resolution 99 (rev. Busan, 2014) of the ITU Plenipotentiary Conference.
Source: ITU.

Table 2.12: Use sub-index, most dynamic countries, 2016–2017

Change in use ranking			Change in use value		
Use rank 2017	Country	Use rank change	Use rank 2017	Country	Use value change
130	Zambia	18	109	Namibia	1.20
132	Lao P.D.R.	17	97	Gabon	1.07
129	Samoa	16	21	Cyprus	0.98
97	Gabon	15	107	Bolivia	0.98
21	Cyprus	12	117	Timor-Leste	0.98
140	Nicaragua	12	115	Indonesia	0.97
134	Uganda	12	34	Uruguay	0.83
93	Uzbekistan	10	132	Lao P.D.R.	0.80
156	Togo	10	130	Zambia	0.77
109	Namibia	9	104	Iran (I.R.)	0.76
55	Oman	9			

Source: ITU.

There is a closer correspondence between these high performers in the use sub-index and those in the IDI 2017 than there is between those in the access sub-index and IDI 2017.

The average value of the use sub-index, at 4.26, is significantly lower than that for the access sub-index (5.59) and for the Index as a whole (5.11). However, the use sub-index has seen a more substantial improvement in its average value between IDI 2016 and IDI 2017 than has the access sub-index. The average value for the use sub-index in IDI 2017, at 4.26, is 0.31 points above the figure of 3.95 in IDI 2016, compared with increases of just 0.10 points for both the access and skills sub-indices. As a result, the use sub-index has had more influence on rankings in the IDI between 2016 and 2017 than the other sub-indices.

Two countries – Namibia and Gabon – achieved increases of more than one whole point in this sub-index between IDI 2016 and IDI 2017, with another four countries (Cyprus, Bolivia, Timor-Leste and Indonesia) following close behind. All of these countries except Timor-Leste (which experienced a fractional decline in fixed-broadband subscriptions) increased their scores for all three indicators in the sub-index. In all cases, the overall improvement in this sub-index was strongly driven by growth in mobile-broadband subscriptions.

Seven countries experienced reductions in their value for this sub-index during the year. Saudi Arabia saw the largest decrease (0.64 points), resulting primarily from a substantial fall in the number of active mobile-broadband subscriptions. This followed the introduction of fingerprint registration and of legislation limiting the number of subscriptions per user, and the effect of the economic slowdown, which resulted in a reduction in the number of migrant workers.

The highest-ranking economies in the use sub-index closely resemble those in IDI 2017. With one exception – Sweden replacing Japan – the 10 highest-ranking countries are the same as those in IDI 2017, and there are only two differences in the top 20, Finland and Macao (China) taking the places of Singapore and Ireland. It is a similar story at the bottom of the distribution, where 19 of the 20 lowest-ranking countries in IDI 2017 appear among the 20 lowest in the use sub-index, the exception (Burkina Faso) being displaced by Kiribati.

As with the access sub-index, a number of countries perform significantly better in the use sub-index than they do in the Index as a whole. None of these is in the upper quartile of the sub-index distribution. High performers for this sub-index, relative to their overall IDI performance, include the Dominican Republic, Jordan and Lebanon in the middle of the distribution; and Gabon, Mozambique, Uganda and Zambia towards the bottom of the distribution. In these cases, where use is growing rapidly, limitations in the availability of infrastructure and devices could become constraints on ICT development, suggesting a need for greater policy focus on these areas.

Another group of countries performs less well in the use sub-index than in the access sub-index or in IDI 2016. These include Greece, Slovenia and Poland towards the top of the distribution; Grenada, Guyana, Iran, Panama, Ukraine and Syria in the middle of the distribution; and Cuba and Kiribati towards the bottom of the distribution. In these cases, demand-side policies to stimulate greater use of available infrastructure are more likely to raise the level of ICT development.

The use sub-index is made up of three indicators, which measure individuals using the Internet and fixed-broadband and mobile-broadband subscriptions:

- The average value recorded for the proportion of individuals using the Internet rose from 49.5 per 100 population in IDI 2016 to 52.0 in IDI 2017, a rise of 5.1 per cent. Fourteen economies recorded scores above 90 per cent, while 10 recorded scores under 10 per cent. The biggest proportional improvements year-on-year were made by countries starting from a low base in IDI 2016;

- The average value for fixed-broadband penetration rose by 4.45 per cent, from 12.81 to 13.39 subscriptions per 100 population. The highest values for this indicator, over 40 subscriptions per 100 inhabitants, were reported by six European countries and by the Republic of Korea, while 32 countries recorded (mostly minor) reductions. Most countries with very limited fixed-telephone penetration have very limited fixed-broadband penetration, with 45 countries recording figures below one subscription per 100 inhabitants, all but 8 of which are LDCs. However, the largest percentage increases were recorded by countries towards the bottom of the distribution, building from low starting points in IDI 2016;

- The indicator for mobile-broadband penetration was the most dynamic indicator in IDI 2016 and is the most dynamic once again in IDI 2017. Its average value rose by 12.9 per cent over the year, from 50.91 to 57.48 subscriptions per 100 population. Echoing the experience with mobile-cellular subscriptions, 22 economies in IDI 2017 now show penetration rates above 100 subscriptions per 100 inhabitants, while three countries report higher mobile-broadband than mobile-cellular penetration. At the bottom end of the distribution, 15 economies report mobile-broadband penetration rates below 10 subscribers per 100 population.

The skills sub-index

The skills sub-index is made up of three indicators that are concerned with educational outcomes, rather than with ICT-specific skills. Data for these indicators, which act as proxies for ICT-specific skills, are gathered and supplied by UIS.

Indicators in the skills sub-index carry less weight in calculating the overall IDI than do those in the access and use sub-indices (20 per cent of the total Index as against 40 per cent for each of the other two sub-indices). Nevertheless, the sub-index has a significant impact on overall IDI performance, since some countries perform particularly well or particularly poorly where skills indicators are concerned. The highest-performing country in the skills sub-index, for example, is Australia, which ranks only 14th on the overall Index (26th for access, 16th for use). Greece, which ranks fourth in the skills sub-index, is only 38th in the overall Index (38th in the access sub-index, 53rd in the use sub-index), while Belarus, fifth in the skills sub-index, ranks 32nd in the overall Index (34th and 40th for access and use respectively).

The largest positive differences between this sub-index and the overall Index, which have the effect of improving overall IDI 2017 performance, are those for Cuba (which ranks 62nd in the skills sub-index but 137th in the overall Index) and Ukraine (which ranks 15th in the skills sub-index but 79th overall). The largest negative differences, which impair overall IDI performance, are those for the United Arab Emirates (which ranks 108th in the skills sub-index but 40th in the overall Index) and Luxembourg (which ranks 74th in the skills sub-index but 9th in the overall Index and 1st in the access sub-index). It is possible that some of these differences may result from different definitions used for national data gathering.

2.4 The IDI and the digital divide

The term "digital divide" is used to describe differences in ICT development within and between countries, regions and socio-economic groupings. ITU and other United Nations agencies are committed to bridging such digital divides, to ensure that everyone is able to take advantage of the benefits of the emerging information society and that these benefits thereby contribute to sustainable development. The United Nations General Assembly reaffirmed this commitment in its ten- year review of the World Summit on the Information Society in December 2015.[5] The 2030 Agenda for Sustainable Development also states, "The spread of information and communications technology and global interconnectedness has great potential to accelerate human progress, to bridge the digital divide and to develop knowledge societies."[6]

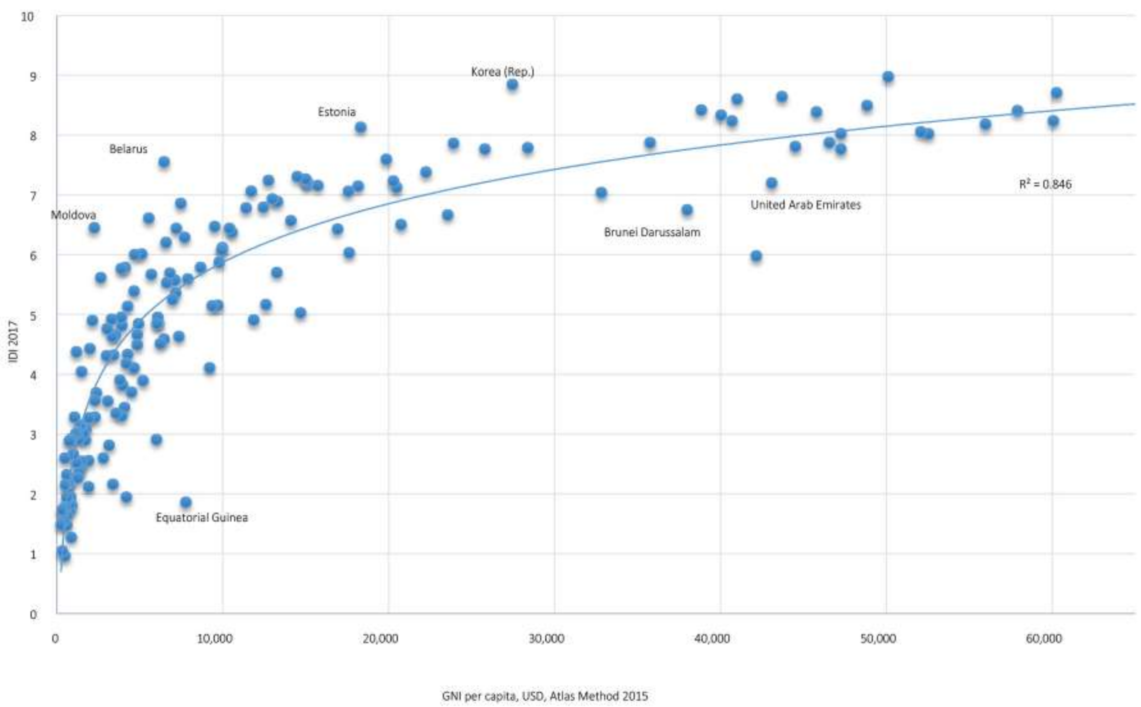
There has been growing concern that – while the digital divide in basic services between developed and developing countries has narrowed since the World Summit on the Information Society, as a result of the spread of mobile cellular uptake in almost all economies – digital divides in the availability of broadband networks and services have been growing. There is also concern that LDCs in particular may be falling further behind other countries. As a composite index, the IDI provides a useful tool for comparing differences between countries and regions which include countries with higher and lower levels of economic and ICT development.

The following paragraphs analyse the relationship between ICTs and development revealed by the IDI from four different perspectives: the relationship between the IDI and GNI per capita; the relationship between IDI and development status; the particular circumstances of LDCs; and the particular circumstances of LCCs which fall within the lowest quartile of the distribution.

The relationship between the IDI and GNI per capita

The starting point for an analysis of what the IDI reveals about the digital divide is the relationship between GNI per capita and IDI performance. GNI represents the total domestic and foreign output of an economy. Its per capita distribution, GNI per capita, is widely used as a proxy indicator for the overall level of economic development in a country.

Chart 2.5: IDI and GNI per capita, 2017



Source: ITU.

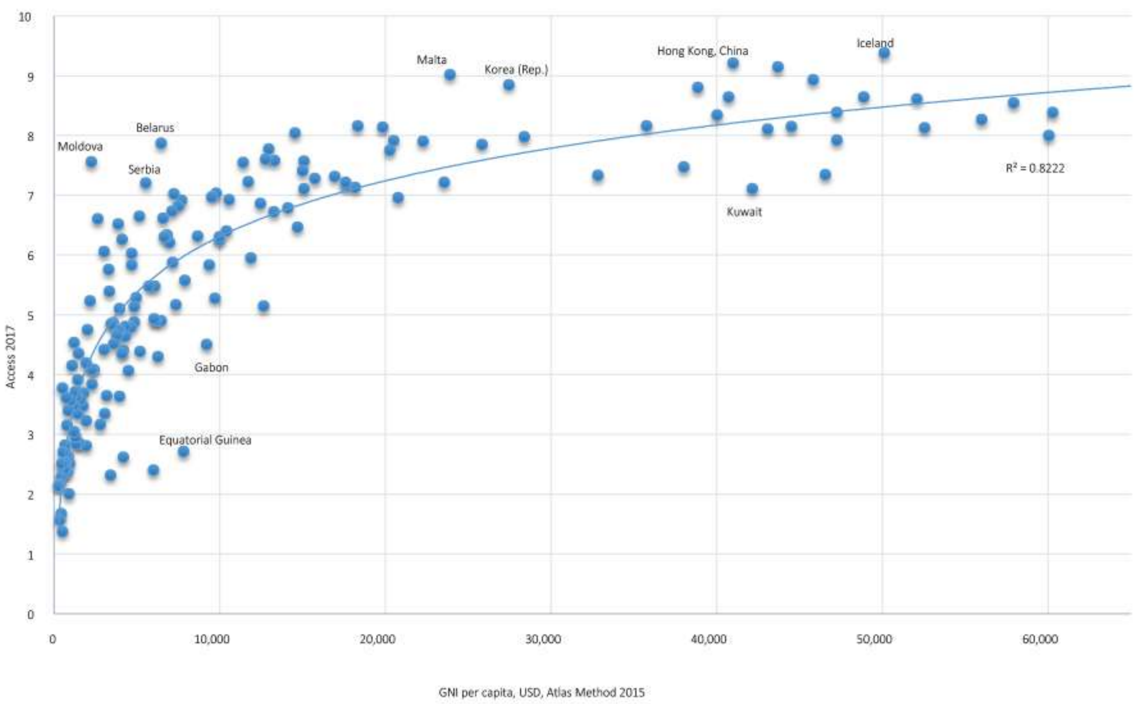
Chart 2.5 plots IDI 2017 values against GNI per capita data for 2015 (the latest year for which World Bank data are available). As in previous years, this shows a strong and significant correlation between the two measures, suggesting that the level of economic development has a significant bearing on ICT development. This is probably, at least to some degree, a self-sustaining phenomenon: it is likely that GNI per capita levels influence *both* the level of consumer demand to make use of ICTs *and* the level of infrastructure investment in access networks to meet that demand.

Outliers, which show significantly better or worse IDI performance than might be anticipated from GNI per capita, are worth considering further, as their experience may indicate that countries have made policy or investment choices which are more or less effective in leveraging ICT access and use. Not surprisingly, outliers that significantly outperform their GNI per capita level include countries at the top of the IDI 2017 distribution, such as Iceland, the Republic of Korea and Denmark. Overachieving countries at lower levels of economic performance include Estonia, Bulgaria, Belarus, Serbia, Ukraine and Moldova. Outliers that significantly underperform their GNI per capita level include Kuwait, the United Arab Emirates and Brunei Darussalam near the top of the distribution; Seychelles, Panama and Gabon towards the middle of the distribution; and Equatorial Guinea, Cuba and Angola towards the bottom of the distribution.

As noted above, there is a degree of difference between countries' performance against the access and use sub-indices, which is reflected in their values and relative rankings for those sub-indices. Similar differences can be mapped by comparing the access and use sub-indices against GNI per capita, as set out in Charts 2.6 and 2.7.

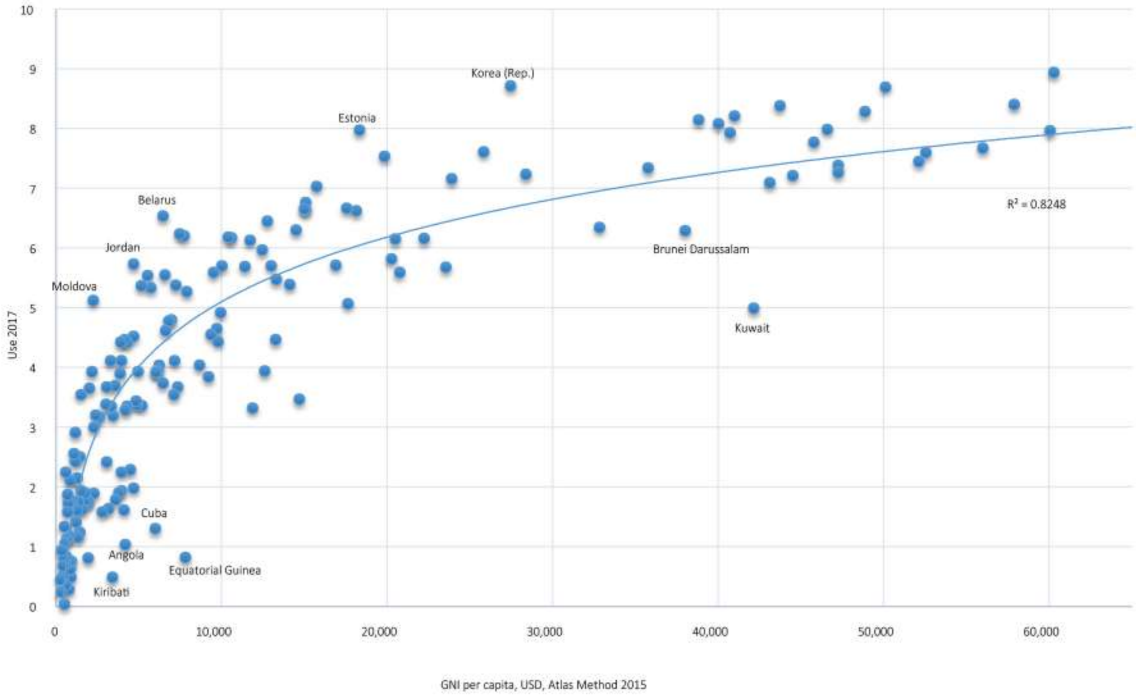
Economies which outperform GNI per capita expectations in the access sub-index include Iceland; Hong Kong (China); Malta; Belarus; and Moldova; while those that underperform expectations include Australia, Finland, Kuwait, Venezuela, Gabon, Equatorial Guinea and Cuba. Economies which outperform GNI per capita expectations in the use sub-index include Denmark, Iceland and the United Kingdom at the top of the distribution; Estonia, Belarus and Jordan in the middle of the distribution; and Moldova, Ghana and Kyrgyzstan at lower IDI levels. Those that underperform expectations in the use sub-

Chart 2.6: Access sub-index and GNI per capita, 2017



Source: ITU.

Chart 2.7: Use sub-index and GNI per capita, 2017



Source: ITU.

index include Kuwait, Brunei Darussalam, Italy, Seychelles, Panama, Equatorial Guinea, Angola, Cuba and Kiribati.

The relationship between IDI and development status

A second way to assess differences between economic groupings is to view IDI rankings and values in relation to the official development status of countries, in particular by differentiating between developed and developing countries, and considering the special circumstances of LDCs.

It is important to be clear about the composition of these development categories when interpreting data that distinguish between them. The developing-economies group, as defined in United Nations data sets, includes a number of economies with high GNI per capita, including several economies in East Asia as well as oil-exporting members of GCC. Some of these economies (notably the Republic of Korea; Hong Kong, China; and Singapore) have become ICT champions with very high rankings in the IDI. Five countries defined by the United Nations as developing countries – Chile, Israel, the Republic of Korea, Mexico and Turkey – are also member countries of the Organisation for Economic Co-operation and Development. All of these economies tend to have GNI per capita and IDI scores that are comparable with those of developed countries.

The developed country grouping, by contrast, includes relatively few countries with GNI per capita levels that are significantly lower than average, and only one country (Albania) that falls within the lower half of the IDI rankings. As a result, the upward effect exerted by outliers in the developing country grouping on the average IDI value tends to be greater than the downward effect of outliers in the developed country category on the IDI average for that category.

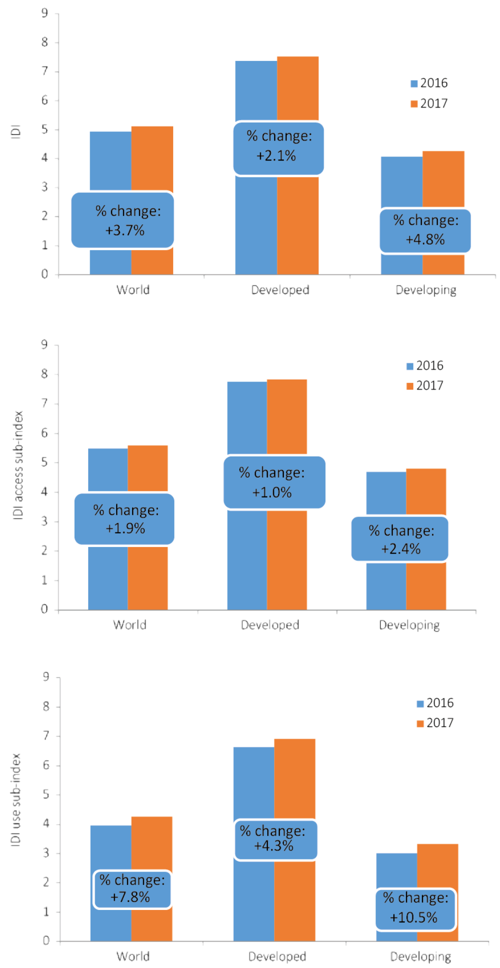
Data comparing IDI 2010 and IDI 2015, reported in the *Measuring the Information Society Report 2015* (ITU, 2015), showed that the average IDI values of developed and developing countries during that period had increased substantially, more or less in step with one another, leaving the digital divide between developed and developing countries largely unchanged. However, they also indicated that the gap between the majority of developing countries and LDCs had been growing in terms of overall IDI values.

Table 2.13: IDI by development status, 2017 and 2016

	IDI 2017						IDI 2016						Change in average value 2017-2016
	Average value*	Min.	Max.	Range	StDev	CV	Average value*	Min.	Max.	Range	StDev	CV	
World	5.11	0.96	8.98	8.02	2.22	43.52	4.94	0.89	8.80	7.91	2.23	45.20	0.17
Developed	7.52	5.14	8.98	3.84	0.92	12.22	7.37	4.90	8.78	3.88	0.96	13.05	0.15
Developing	4.26	0.96	8.85	7.89	1.90	44.65	4.06	0.89	8.80	7.91	1.89	46.44	0.19

Note: *Simple averages. StDev= Standard deviation, CV= Coefficient of variation
Source: ITU.

Chart 2.8: IDI values by development status, 2017 and 2016



Source: ITU.

IDI values for 2016 and 2017 by level of development are illustrated in Table 2.13 and Chart 2.8. These show that there has been a slight reduction in the gap between average IDI scores for developed and developing countries over the year, from 3.31 points in 2016 to 3.26 points in 2017. The average figure for developing countries improved by 0.19 points (an increase of 4.8 per cent) as against 0.15 points (an increase of 2.1 per cent) for developed countries. Developing countries as a group experienced slightly higher improvements than developing countries in average values for both access and use sub-indices (0.11 points as against 0.08 points, and 0.32 points as against 0.29 points respectively). These translate into more substantial differences in terms of rates of progress, with developing countries improving their average access and use sub-index values by 2.4 per cent and 10.5 per cent respectively, compared with improvements of 1.0 per cent and 4.3 per cent for developed countries.

ICT developments in Least Developed Countries[7]

Particular attention should be paid in this context to two groups of economies within the broader category of developing countries. These are Least Developed Countries (LDCs) and Least Connected Countries (LCCs).

LDCs are identified by the United Nations according to criteria concerned with GNI per capita, human assets and economic vulnerability.[8] LDC status is reviewed every three years. The United Nations identified 48 countries as LDCs during 2016, the year in which data for IDI 2017 were gathered,[9] 41 of which are represented in the IDI. Of these 41, 25 are in the Africa region, 11 in the Asia and the Pacific region, 4 in the Arab States region and one in the Americas. A number of these countries suffer from high levels of political instability or conflict, as well as low levels of development.

The bottom 27 countries in the IDI rankings are all LDCs, as are 37 of the 44 countries in the bottom (LCC) quartile, while a further 7 LDCs (including Niger, which ranked lowest in the 2016 *Report* (ITU, 2016b)) do not appear in the Index this year. Only four LDCs – Bhutan, Timor-Leste, Cambodia and Sao Tome & Principe – have rankings above

Table 2.14: IDI values for LDCs compared with global values and with other developing countries

Development status	IDI 2016				IDI 2017				% change			
	Access	Use	Skills	IDI	Access	Use	Skills	IDI	Access	Use	Skills	IDI
World	5.49	3.95	5.75	4.93	5.59	4.26	5.85	5.11	1.9	7.8	1.7	3.7
Developed	7.75	6.62	8.08	7.37	7.83	6.91	8.12	7.52	1.0	4.3	0.5	2.1
Developing	4.69	3.01	4.93	4.06	4.80	3.32	5.05	4.26	2.4	10.5	2.4	4.8
LDCs	2.72	1.03	2.73	2.05	2.82	1.27	2.82	2.20	3.7	23.1	3.3	7.5
Developing-LDCs	5.6	3.9	5.9	5.0	5.7	4.3	6.1	5.2	2.1	9.0	2.2	4.3

Source: ITU.

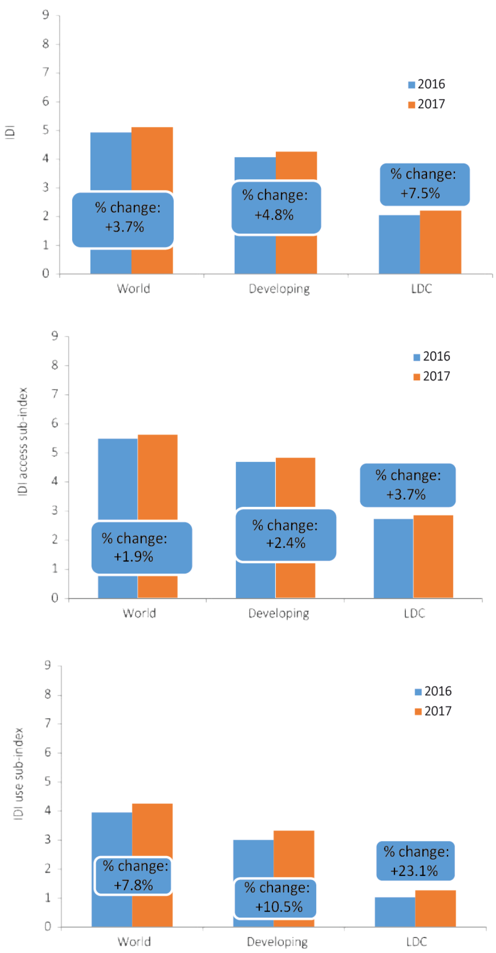
the bottom quartile, the highest of these (Bhutan) attaining 121st position in IDI 2017.

Table 2.14 and Chart 2.9 compare the IDI performance of LDCs between IDI 2016 and IDI 2017 with those of all developing countries, with non-LDC developing countries, and with the global average. The overall performance of LDCs has been lower, in terms of changes in actual IDI values, than that of other developing countries in recent years, though the average rate of improvement for LDCs, from a lower starting point, has been more rapid. This trend continued in the year under discussion. LDCs improved their average value for the overall IDI by 0.15 points between IDI 2016 and IDI 2017, below the world average improvement (0.18 points), the average improvement for all developing countries (0.19 points) and the average improvement for developing countries excluding LDCs (0.22 points).

The most significant improvements by LDCs within IDI 2017 as a whole were made by three countries in Asia and the Pacific – the Lao P.D.R. (up 0.47 points), Timor-Leste (up 0.46 points) and Myanmar (up 0.42 points). The most substantial improvement by an African LDC was that of Zambia (up 0.35 points). Four LDCs (Eritrea, Sudan, Madagascar and Angola) experienced no change or a slight fall in their overall IDI values.

The average improvement in LDC values in the access sub-index was almost the same as that for other developing countries (0.10 points compared with 0.11 points for all developing countries and 0.12 points for developing countries which are not LDCs), while that in the use sub-index was lower (0.24 points compared with 0.32 points for all developing countries and 0.35 points for developing countries which are not LDCs). LDCs also experienced little improvement in the skills sub-index by comparison with other developing countries.

Chart 2.9: IDI values for LDCs compared with global values and with all developing countries



Source: ITU.

These modest increases in IDI values suggest that LDCs may be falling further behind other developing countries in IDI performance. However, they can also be set alongside the rates of improvement which have been achieved by LDCs. LDCs improved their average performance for the overall IDI between IDI 2016 and IDI 2017 by 7.5 per cent year-on-year, compared with an improvement of 3.7 per cent for all economies in the Index and of 4.3 per cent for developing countries other than LDCs. They improved their performance in the access sub-index by 3.7 per cent (compared with 1.9 per cent for all economies and 2.1 per cent for developing countries which are not LDCs). Their performance on this criteria was strongest in the use sub-index, where LDCs' average value increased by 23.1 per cent, compared with 7.8 for all economies, 10.5 per cent for all developing countries and 9.0 per cent for developing countries which are not LDCs.

These findings suggest that, while LDCs are still falling behind other developing countries in absolute terms, many of them are making significant gains, particularly in the use sub-index, from previously low levels of performance. This should provide a better platform for further gains to be secured in future.

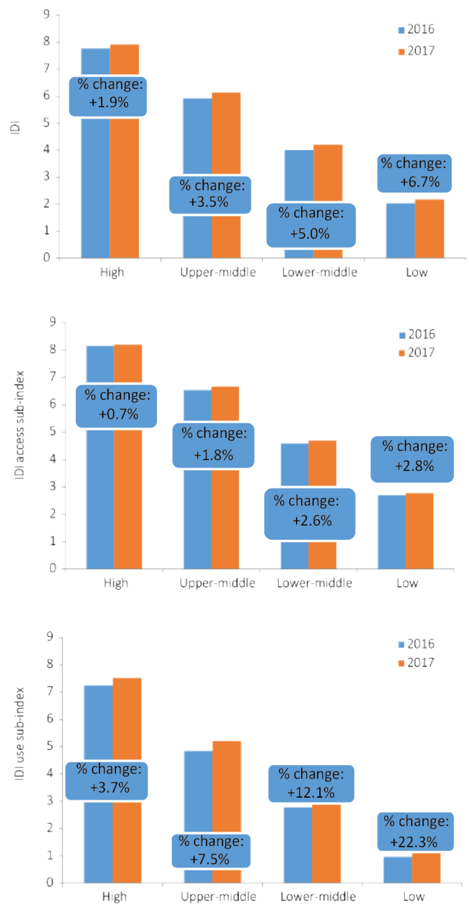
IDI performance quartiles and least connected countries (LCCs)

The final approach to analysing the digital divide which is considered in this chapter divides the Index into four quartiles, representing high, upper-middle, lower-middle and low IDI outcome values. The group forming the lowest of these quartiles is also referred to in this report as least connected countries (LCCs).

Changes in the IDI values for the four quartiles of economies in IDI 2017, for the overall IDI and its three sub-indices, are set out in Table 2.8 and illustrated in Chart 2.10.

The map in Figure 2.3 shows how IDI performance differs between geographic regions as well as levels of economic development. Most of the highest-performing economies in the IDI are developed countries and high-income developing countries in Western Europe, North America, East Asia and Oceania. Countries in the upper and medium quartiles in the Index are found mostly in Eastern Europe, Latin America and the Caribbean, Central Asia and the GCC region in the Arabian peninsula. The only country in the Africa region which is in the top half of the distribution is the Indian Ocean State of Mauritius. All but 5 of the 44 LCCs are located in the Africa region and in South Asia. The populations of these LCCs together

Chart 2.10: IDI values by IDI quartile, 2017 and 2016



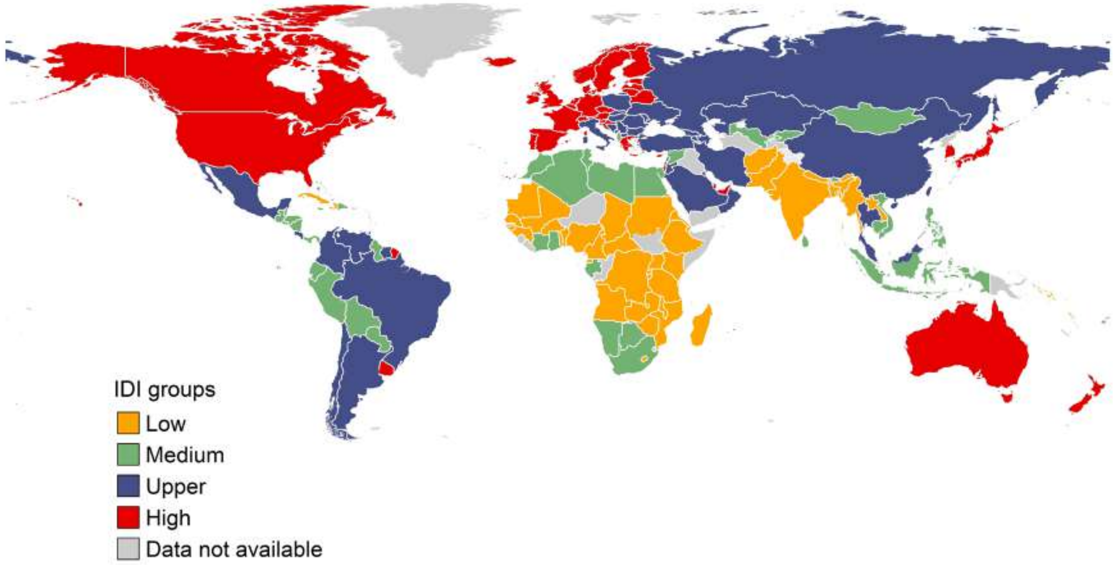
Source: ITU.

amount to 2.75 billion, some 35 per cent of the global population.

Chart 2.10 illustrates changing average IDI values for these four quartiles. The average improvement in IDI 2017 value was greater in the two middle-ranking quartiles of the distribution (0.21 points and 0.19 points, respectively, in the upper-middle and lower-middle quartiles) than it was in the high quartile or the LCC quartile (each of which saw an average improvement of 0.14 points). However, this represents a faster rate of improvement in the LCC quartile (6.7 per cent on average) than in the other quartiles (5.0 per cent in the lower-middle quartile, and less in other quartiles).

There is a close association between LDCs and LCCs. As noted in the previous section, 37 of the 44 LCCs in the lowest quartile are LDCs, while a further seven LDCs are not included in the Index

Figure 2.3: IDI quartiles by IDI value, 2017



The base map for this infographic is based on the UNmap database of the United Nations Cartographic Section.
UNCS Disclaimer: The designations employed and the presentation of material on this map do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.
Source: ITU.

and may well also have fallen into the LCC quartile had they done so. The non-LDCs in the LCC group are India, Zimbabwe, Cuba, Kenya, Nigeria, Pakistan and Cameroon.

Not surprisingly, in light of this correspondence between LDCs and LCCs, the IDI performance of the LCC group is similar to that of LDCs. They have grown their average IDI value by 0.14 points (compared with 0.14, 0.21 and 0.19 points for the high, upper-middle and lower-middle quartiles), their average access sub-index value by 0.07 points (compared with 0.06, 0.12 and 0.11 points for the other quartiles), and their average use sub-index value by 0.22 points (compared with 0.27, 0.37 and 0.33 points for the other quartiles). In each case, however, their rate of improvement – the percentage by which their performance has grown over the past year – has been higher than those of quartiles that are higher in the distribution (6.7 per cent for the Index as a whole compared with 1.9 per cent, 3.5 per cent and 5.0 per cent for the three higher quartiles; 2.8 per cent compared with 0.7 per cent, 1.8 per cent and 2.6 per cent for the access sub-index; and 22.3 per cent compared with 3.7 per cent, 7.5 per cent and 12.1 per cent for the use sub-index).

It is clear from these figures that LCCs, like LDCs, are still significantly behind other developing countries in terms of the values they achieve for the IDI and its access and use sub-indices. Although their rate of progress, from their low base values, exceeds those of other quartiles, this is not yet sufficient to reduce the overall gap in IDI values between them and more connected countries. However, it should become so as their performance levels improve. Much may depend on the particular circumstances of individual countries.

2.5 Summary and conclusion

Measuring progress towards the information society is a complex task which entails striking a balance between different dimensions of ICT experience in different countries. The IDI brings together 11 indicators concerned with ICT access, ICT use and ICT skills into a composite index that reflects the diversity and complexity of that experience. Reported annually in ITU's *Measuring the Information Society Report*, the IDI has made an important contribution to building understanding of the spread of ICTs and their impact on economies and societies.

Data for 176 economies are included in IDI 2017. As in previous years, this year's Index shows that there has been continued improvement in IDI performance by the large majority of countries, averaging 0.18 points overall. Europe is the region with the highest average IDI performance, while Africa's average is well below those of other regions.

As in 2016, improvements have been most significant among countries in the middle of the IDI rankings, many of which are middle-income developing countries. Some developed and higher-income developing economies towards the top of the rankings have attained very high levels of performance on many of the indicators included in the Index, which inhibits further improvement in their IDI values. Some LDCs towards the bottom of the distribution, by contrast, have very low levels of attainment on some indicators, and have achieved little improvement on low existing levels of performance.

Average IDI scores in the access sub-index are higher than those in the use sub-index. However, more progress was made during the year, on average, in the use sub-index, which rose by an average of 0.31 points, compared with 0.10 for both access and skills sub-indices.

The most significant increases in the access sub-index were for the proportion of households with computers and those with Internet access, particularly the latter, and in the volume of international Internet bandwidth per Internet user. Many countries have now attained or are approaching saturation in the market for mobile-cellular subscriptions, with the result that the contribution this indicator made to improvements in the sub-index was less significant than in recent years. There has been continued decline in the indicator for fixed-telephone subscriptions in many countries as fixed-mobile substitution becomes more prevalent.

The most significant increases in the use sub-index, and in IDI 2017 overall, came from the indicator for mobile-broadband subscriptions. This indicator rose globally by 12.90 per cent between IDI 2016 and IDI 2017, from 50.91 to 57.48 subscriptions per 100 population. Factors contributing to this improvement, as in 2016, include investment in new infrastructure, growing uptake of smartphones, and reductions in prices following increased competition or regulatory intervention. Fixed-broadband subscriptions also increased, though more slowly, during the year. Together, these increases in broadband penetration contributed towards increased access to and use of the Internet by both households and individuals.

Data included in IDI 2017 also demonstrate the continued digital divide between developed and developing countries, and between different regions, with IDI values ranging from 8.98 out of 10.00 in the top-ranking country, Iceland, to 0.96 in the lowest-ranking, Eritrea. There has been relatively little movement within the rankings over the past year, as most countries have made relatively consistent improvements in performance. A number of countries have, however, shown particularly dynamic improvements, including Namibia and Gabon in Africa, Iran, the Lao P.D.R., Indonesia and Timor-Leste in the Asia and the Pacific region, Cyprus in the Europe region, and Bolivia.

The relatively poor performance of LDCs continues to cause concern. There is a strong correlation between LDCs and LCCs in the bottom quartile of the IDI distribution. Of the 44 LCCs, 37 are also LDCs. On average, LDCs improved their IDI performance by an average of 0.15 points, significantly less than the 0.22 point improvement made by developing countries other than LDCs – though this reflects a higher rate of improvement by LDCs from their generally very low performance levels. Given that ICT development is considered important for enabling progress towards sustainable development, poor IDI performance points to the need for policy interventions by governments and other stakeholders in order to improve levels of ICT access and use.

Recent developments in ICT markets – including the very high subscription rates for mobile-cellular networks, which are now widespread; the trend towards fixed-mobile substitution; and increases in bandwidth, both available and required for new services – have led to proposals for changes to be made in the indicators included in the Index. A revised set of indicators will therefore be introduced starting from IDI 2018, which should add additional insights into the performance of individual countries and into the relative performance of countries at different development levels.

Endnotes

[1] Previous reports can be accessed online at www.itu.int/en/ITU-D/Statistics/Pages/publications/anapub.aspx.

[2] Data on the indicators included in the skills sub-index are sourced from the United Nations Educational, Scientific and Cultural Organization Institute for Statistics. See Annex 1 for more details on the definition of the indicators.

[3] For more information on the work of EGTI, see the EGTI online forum at http://www.itu.int/net4/ITU-D/ExpertGroup/default.asp.

[4] For more information on the work of EGH, see the EGH online forum at http://www.itu.int/net4/ITU-D/forum/expertgroupsonhouseholds/forum.

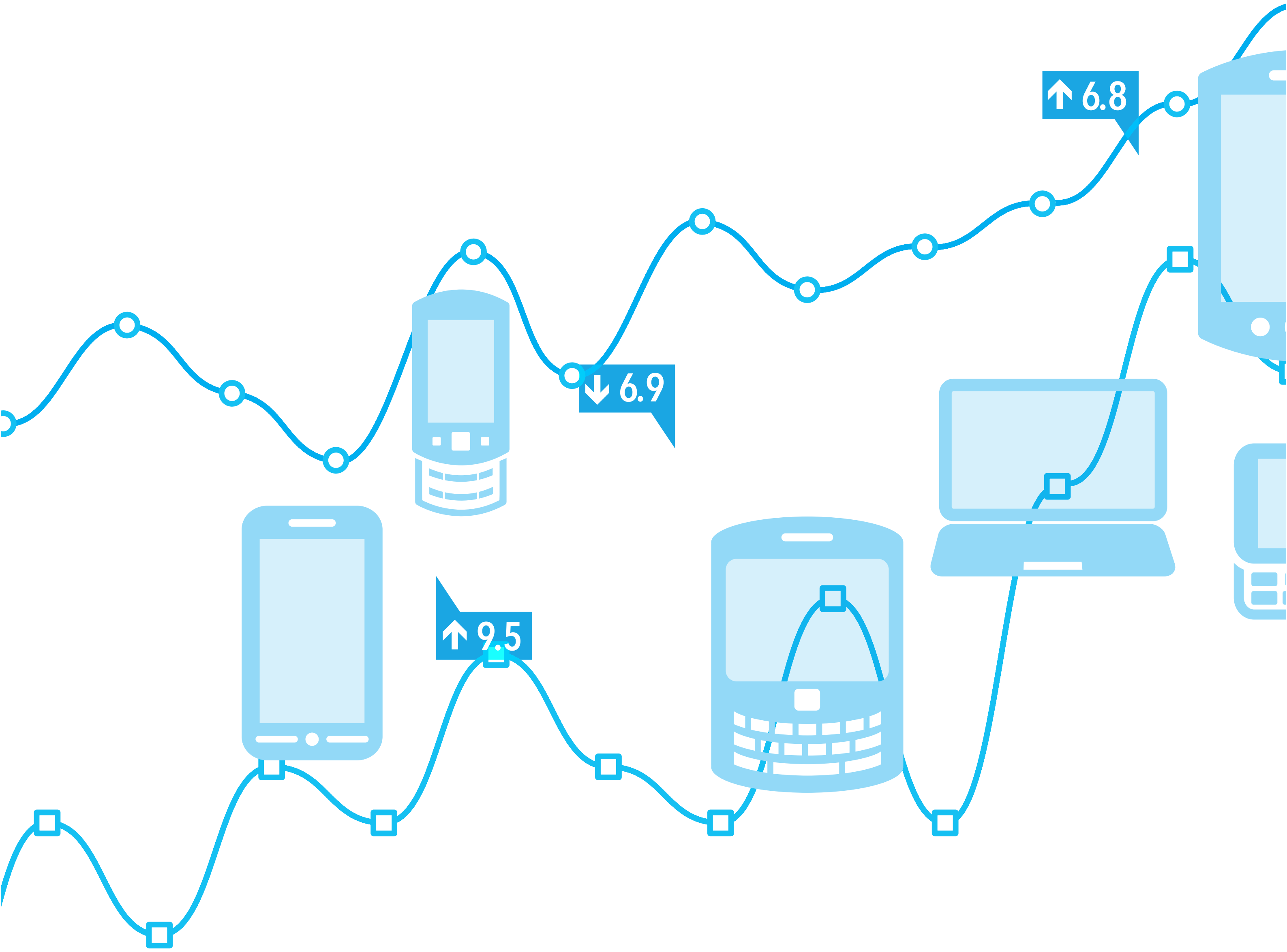
[5] General Assembly resolution 70/125, available at http://workspace.unpan.org/sites/Internet/Documents/UNPAN96078.pdf.

[6] General Assembly resolution 70/1, para. 15, available at http://www.un.org/ga/search/view_doc.asp?symbol=A/RES/70/1&Lang=E.

[7] The current list of LDCs can be found at www.un.org/development/desa/dpad/least-developed-country-category/ldcs-at-a-glance.html.

[8] Available from www.un.org/development/desa/dpad/least-developed-country-category/ldc-criteria.html.

[9] Equatorial Guinea graduated from this status in 2017, but is included as an LDC in IDI 2017 as the data concerned relate to a period when it held that status.



Chapter 3. The ICT Development Index – regional and country analysis

Key findings

There are considerable differences between geographical regions in the levels of ICT development as demonstrated by the IDI. There is also significant variation in the experience of individual countries within each region. The differences in the IDI between regions and individual countries are associated mainly with levels of economic development.

Europe continues to lead the way in ICT development. It has the highest average IDI value among world regions (7.50 points). This reflects the region's high levels of economic development, competitive communication markets, and high levels of ICT skills. Every country in the Europe region has an IDI value above the global average. As many as 28 of its 40 countries rank within the highest quartile, while only one, Albania, falls outside the top half of the distribution. The most substantial improvements in value were recorded by Cyprus and Turkey.

The United States and Canada top the IDI ranking in the Americas region. The majority of countries in the region fall within the two middle quartiles, with only two least connected counties (LCCs) in the bottom quartile (Cuba and Haiti). The most significant improvements in the Americas region were recorded by middle-ranking countries in South and Central America and the Caribbean.

The Commonwealth of Independent States (CIS) is the most homogeneous region in ICT development, reflecting its relative economic homogeneity**.** Only one country in the region, Belarus, is in the top quartile of the Index, but the region includes no LCCs. The most dynamic countries in terms of IDI value were those at the bottom of the regional rankings – Ukraine, Uzbekistan and Kyrgyzstan.

Asia and the Pacific is, by contrast, the most heterogeneous region in terms of ICT development. Seven economies in this region have IDI values above 7.50 points and rank within the highest quartile in the global IDI 2017, including the Republic of Korea, which is ranked second overall. However, ten countries in the region, including several with very large populations, are LCCs. Six countries improved their IDI values by more than 0.40 points, led by the second most dynamic country in IDI 2017, the Islamic Republic of Iran.

The Arab States region is also very diverse in terms of IDI performance. This region includes a number of oil-rich high-income economies, three of which are in the top quartile of the IDI, as well as a number of low-income countries, four of which are LCCs. The strongest improvements in this region were seen in middle-income countries, whose average value rose by more than twice that of countries at the top and bottom of the regional distribution.

Africa continues to be the region with the lowest IDI performance. The average value for this region in IDI 2017 is 2.64 points, little more than half the global average of 5.11. Only one country in the region, Mauritius, ranks in the upper half of the global IDI distribution, while 28 of the 38 African countries included in IDI 2017 fall into the lowest (LCC) quartile. This reflects the generally low level of economic development in the region. The region does, however, include two of the three countries which achieved the most dynamic improvements in their IDI value over the year – Namibia and Gabon.

Chapter 3. The ICT Development Index – regional and country analysis

3.1 Introduction

Chapter 2 described the ICT Development Index (IDI) and compared global findings for IDI 2016 and IDI 2017. The present chapter extends this analysis by investigating IDI findings at the regional level and comparing different regions. Information concerning individual countries can be found in volume 2 of this report.

3.2 Regional IDI analysis

ITU Member States are divided into six regions – Africa, the Americas, Arab States, Asia and the Pacific, the Commonwealth of Independent States (CIS) and Europe. The distribution of countries between regions differs in a number of respects from the regional distributions used in other United Nations data series, most notably where the Europe and Africa regions are concerned, and this should be borne in mind when undertaking comparative analysis with other data sets.[1]

The IDI 2017 data published in this volume are derived from 176 economies, of which 38 are in the Africa region, 35 in the Americas, 19 in the Arab States, 34 in Asia and the Pacific, 10 in CIS and 40 in Europe. Of the 20 ITU Member States for which data are not available, 6 are in the Africa region, 3 in the Arab States, 6 in Asia and the Pacific (including 5 from the United Nations Oceania region), 2 in CIS and 3 small States in Europe.

Table 3.1 sets out the results of IDI 2017 for each of the six ITU regions, and compares them with the results for IDI 2016. Chart 3.1 shows the distribution of average, minimum and maximum IDI values in these regions, compared with the global average.

As in previous years, Europe records the highest regional average IDI value, at 7.50, an increase of 0.16 points (just over 2.2 per cent) over 2016. No country in the region falls below the global average of 5.11, and only one country in Europe, Albania, falls outside the upper half of the distribution, ranking 89th, the position just below the halfway point. The range of IDI values (3.84 points, or 2.97 if the two bottom countries are excluded) is narrower than those of most other regions, reflecting the relative economic homogeneity of the region, which includes only three developing countries.

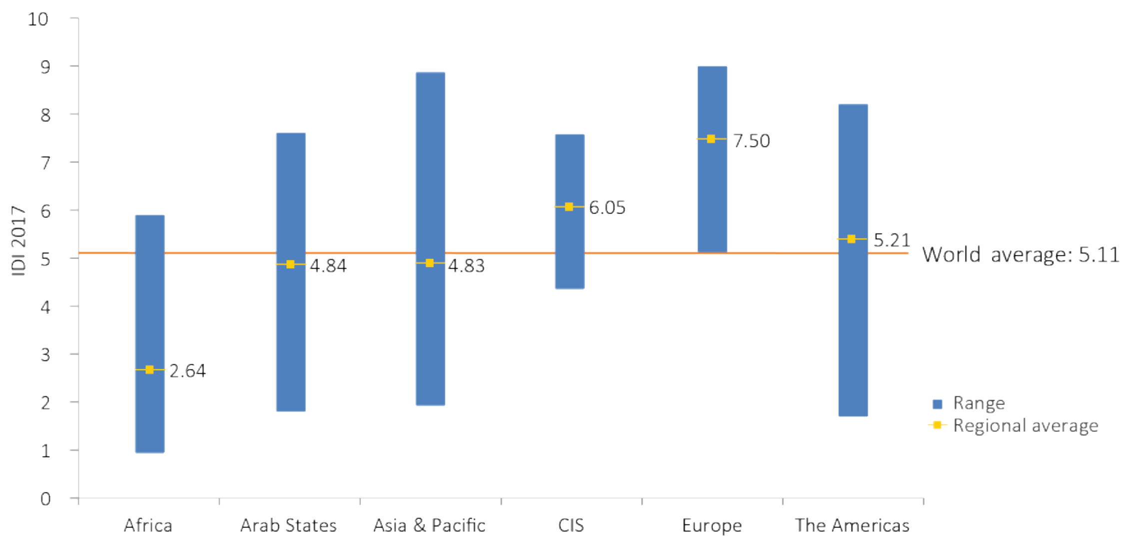
The regional average value for the CIS region rose more substantially than that in Europe – by 0.21 points, from 5.84 to 6.05 – and is also well above the global average (though it should be noted that two countries in this region are not included in the Index). As with Europe, the range of values within the CIS region is relatively small (3.18 points separate Belarus at the top of the regional distribution from Kyrgyzstan at the bottom), reflecting relative homogeneity in both economic and information and communication technology (ICT) development.

Table 3.1: IDI by region, 2017 and 2016

Region	Number of economies	IDI 2017						IDI 2016						Difference 2016-2017		
		Max.	Min.	Range	Average*	StDev	CV	Max.	Min.	Range	Average*	StDev	CV	Range	Average*	CV
Africa	38	5.88	0.96	4.92	2.64	1.23	46.37	5.51	0.89	4.63	2.48	1.18	47.64	0.29	0.16	-1.27
Arab States	19	7.60	1.82	5.78	4.84	1.87	38.71	7.46	1.78	5.68	4.71	1.88	39.95	0.10	0.13	-1.24
Asia & Pacific	34	8.85	1.95	6.91	4.83	2.17	44.99	8.80	1.71	7.08	4.60	2.21	48.02	-0.18	0.24	-3.03
CIS	10	7.55	4.37	3.18	6.05	0.97	16.04	7.29	4.06	3.23	5.84	1.04	17.83	-0.05	0.21	-1.79
Europe	40	8.98	5.14	3.84	7.50	0.92	12.22	8.78	4.90	3.88	7.34	0.96	13.09	-0.04	0.16	-0.87
The Americas	35	8.18	1.72	6.47	5.21	1.50	28.83	8.13	1.63	6.51	5.01	1.50	30.04	-0.04	0.20	-1.21

Note: *Simple averages. StDev = Standard deviation, CV = Coefficient of variation.
Source: ITU.

Chart 3.1: IDI by region compared with global average, 2017



Source: ITU.

The average IDI values in three of the remaining regions – the Americas, the Arab States, and Asia and the Pacific – is close to the global average. The average value for the Americas slightly exceeds the global average, at 5.21, while the average values for the Arab States and Asia and the Pacific – at 4.84 and 4.83 respectively – fall just below. Each of these regions includes countries with widely diverse levels of economic and ICT development. The average values for the Americas and Asia and the Pacific have increased more in the past year than has that for the Arab States (by 0.20 and 0.24 points, compared with 0.13 points), with a global increase of 0.18 points.

As in previous years, the Africa region records by far the lowest average IDI value, up 0.16 points on the year, from an IDI 2016 value of 2.48 to an IDI 2017 value of 2.64, not much more than half the global average. Only one country in this region (Mauritius) exceeds the global average value or ranks within the top half of the distribution, while 28 of the region's 38 countries fall within the least connected country (LCC) quartile at the bottom of the rankings. This concentration of IDI values towards the bottom of the distribution also means that Africa has a narrower range of values than other regions, including other regions that are primarily made up of developing countries, reflecting the consistency between levels of economic and ICT development, discussed in Chapter 2.

Table 3.2 further illustrates the differences in range and average values between regions by setting out IDI outcomes for the highest- and lowest-ranking economies within each region. The characteristics of the top- and bottom-ranking countries in each region are discussed alongside those of each region's most dynamic countries later in this chapter.

The factors contributing to high and low performance in IDI value, and to more or less dynamic movement in the rankings, vary between countries. Factors that are particularly important in the case of top-ranking countries globally are discussed in Chapter 2, while those that affect high- and low-performing countries in individual regions are considered in later sections of the present chapter.

Typically, countries towards the top of the global distribution score highly or relatively highly across the whole range of indicators, giving their spider diagrams – which represent the average scores achieved for each of the individual indicators that make up the Index – the characteristically rounded shape illustrated in Chart 2.2. There are, however, individual differences between countries that affect their overall rankings even at this level. Iceland, for example, at the top of the global distribution, scores significantly higher than does the Republic of Korea, which ranks second, in the proportion of households with a computer and in international Internet bandwidth per Internet user.

Table 3.2: Highest- and lowest-ranking economies by region, IDI 2017

Regional IDI rank	Economy	IDI	Global IDI rank
Europe			
1	Iceland	8.98	1
2	Switzerland	8.74	3
3	Denmark	8.71	4
4	United Kingdom	8.65	5
5	Netherlands	8.49	7
36	Montenegro	6.44	61
37	Turkey	6.08	67
38	TFYR Macedonia	6.01	69
39	Bosnia and Herzegovina	5.39	83
40	Albania	5.14	89
Asia and the Pacific			
1	Korea (Rep.)	8.85	2
2	Hong Kong, China	8.61	6
3	Japan	8.43	10
4	New Zealand	8.33	13
5	Australia	8.24	14
30	Bangladesh	2.53	147
31	Pakistan	2.42	148
32	Kiribati	2.17	154
33	Solomon Islands	2.11	157
34	Afghanistan	1.95	159
The Americas			
1	United States	8.18	16
2	Canada	7.77	29
3	Barbados	7.31	34
4	St. Kitts and Nevis	7.24	37
5	Uruguay	7.16	42
31	Guatemala	3.35	125
32	Honduras	3.28	129
33	Nicaragua	3.27	130
34	Cuba	2.91	137
35	Haiti	1.72	168

Regional IDI rank	Economy	IDI	Global IDI rank
Arab States			
1	Bahrain	7.60	31
2	Qatar	7.21	39
3	United Arab Emirates	7.21	40
4	Saudi Arabia	6.67	54
5	Oman	6.43	62
15	Syria	3.34	126
16	Sudan	2.55	145
17	Mauritania	2.26	151
18	Djibouti	1.98	158
19	Comoros	1.82	164
CIS			
1	Belarus	7.55	32
2	Russian Federation	7.07	45
3	Kazakhstan	6.79	52
4	Moldova	6.45	59
5	Azerbaijan	6.20	65
6	Georgia	5.79	74
7	Armenia	5.76	75
8	Ukraine	5.62	79
9	Uzbekistan	4.90	95
10	Kyrgyzstan	4.37	109
Africa			
1	Mauritius	5.88	72
2	Seychelles	5.03	90
3	South Africa	4.96	92
4	Cape Verde	4.92	93
5	Botswana	4.59	105
34	Burundi	1.48	172
35	Guinea-Bissau	1.48	173
36	Chad	1.27	174
37	Central African Rep.	1.04	175
38	Eritrea	0.96	176

Note: Georgia exited CIS on 18 August 2009, but is included in the ITU BDT administrative region for the CIS countries.
Source: ITU.

Lower down the distribution, at both global and regional levels, the spider charts representing indicator values for individual countries become more jagged and irregular. Countries at the bottom of the distribution tend to have low values for all indicators, though values for mobile-cellular subscriptions, international Internet bandwidth and secondary enrolment often contribute more positively than do other indicators.

Countries that have moved dynamically up in the rankings or dynamically increased their IDI values over the year have often done so because of sharp improvements in individual indicators. In many cases, between IDI 2016 and IDI 2017, active mobile-broadband subscriptions have contributed the most significant improvement in indicator scores, although some countries have seen dramatic improvements – and, in some cases, reductions – in scores for other indicators.

As highlighted in Chapter 2, caution must be exercised when comparing the improvements made in different indicators, which have different characteristics and dynamics. For instance, the value for mobile broadband can improve significantly between one year and the next if a 3G network is switched on in a country and customers are migrated from 2G to 3G. Fixed-broadband improvements, on the other hand, require costly and lengthy network roll-outs as well as longer-term commitment from each new customer subscribing to the service. However, each new fixed-broadband subscription may benefit not only an individual, but also a household or an organization. Education indicators also tend to change over a longer time period, because a change in the education system usually takes several years to have an impact on the enrolment indicators included in the IDI. Nevertheless, any progress in education may have a profound social and economic impact and thus, indirectly, support ICT development.

As a result of these different dynamics in the IDI indicators, the fact that mobile broadband has recorded the sharpest improvements does not imply that the more moderate progress achieved in the other indicators is not significant.

Regional variations

The similarities and differences between regions can be explored in more detail by comparing spider diagrams of the average scores achieved in the different regions for each sub-index and for each of the individual indicators making up the Index. Variations between the different sub-indices are presented in Table 3.3, while variations across the range of indicators are presented through spider diagrams in Chart 3.2, along with a diagram to enable comparison between regional and global averages. It should be remembered, when considering these, that they are concerned with average values and thus do not reflect the range of values within regions. Analysis of the range of values can be found in the subsequent discussion of spider diagrams from selected countries within each region.

Table 3.3 shows that improvements in the average value for the use sub-index were more substantial than those for the average value in the other two sub-indices – and therefore more influential on overall IDI outcomes – in all world regions between 2016 and 2017. The largest improvement in average value for the access sub-index was in Asia and the Pacific (up 0.15 points), less than the increase in the average value of the use sub-index in any region. The largest improvement for the use sub-index was in CIS region (0.40 points), followed by Asia and the Pacific and the Americas. Asia and the Pacific saw the largest improvement in the skills sub-index.

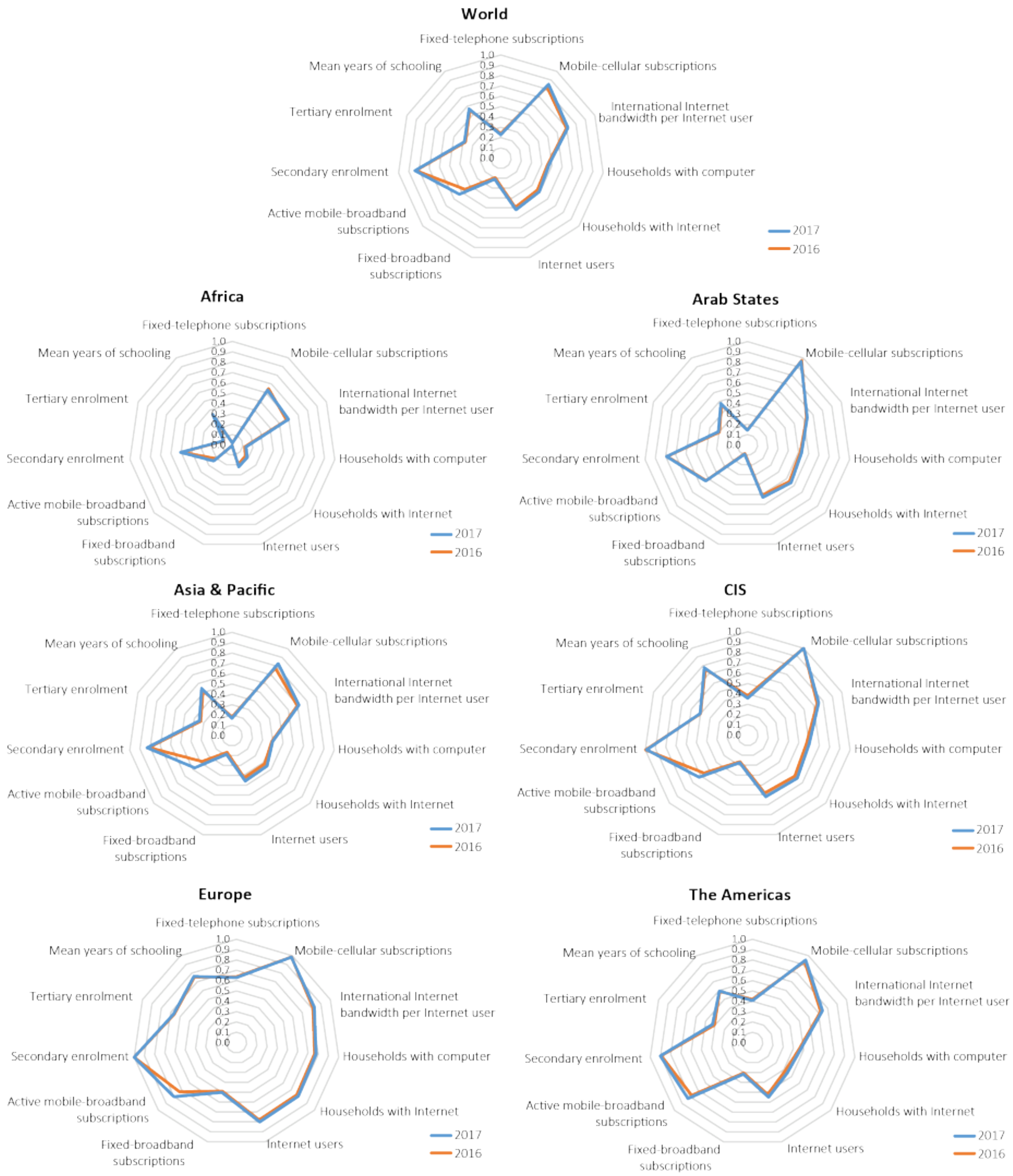
It is also worth considering the rate of improvement in each region, i.e. the improvement in average value as a proportion of IDI value in 2016. The average rate of improvement was much more substantial in the use sub-index (7.8 per cent) than in those for access and skills (1.9 per cent and 1.7 per cent respectively). The Africa region showed the highest proportional rate of improvement for the IDI as a whole, and for all three sub-indices, with an average improvement

Table 3.3: Average IDI and sub-index values, world and regions, IDI 2017 and IDI 2016

Region	Number of economies	IDI 2017				IDI2016				Value Change 2017-2016			
		Access	Use	Skills	IDI	Access	Use	Skills	IDI	Access	Use	Skills	IDI
Africa	38	3.28	1.74	3.16	2.64	3.18	1.48	3.07	2.48	0.10	0.26	0.10	0.16
Arab States	19	5.51	3.96	5.26	4.84	5.41	3.78	5.17	4.71	0.09	0.18	0.09	0.13
Asia and the Pacific	34	5.27	3.99	5.65	4.83	5.12	3.63	5.48	4.60	0.15	0.36	0.17	0.24
CIS	10	6.60	4.79	7.47	6.05	6.48	4.39	7.44	5.84	0.12	0.40	0.03	0.21
Europe	40	7.80	6.94	8.02	7.50	7.73	6.62	7.97	7.34	0.07	0.32	0.05	0.16
The Americas	35	5.64	4.21	6.34	5.21	5.54	3.86	6.24	5.01	0.11	0.34	0.11	0.20
World	176	5.59	4.26	5.85	5.11	5.49	3.95	5.75	4.93	0.10	0.31	0.10	0.18

Source: ITU.

Chart 3.2: Average IDI values for each indicator, world and regions, IDI 2017 and IDI 2016



Source: ITU.

of 6.6 per cent overall, and of 17.4 per cent for the use sub-index.

The spider diagrams in Chart 3.2 show there has been relatively little improvement in global average IDI performance for the majority of indicators in the Index during the year between IDI 2016 and IDI 2017. The most notable exception to this is the significant improvement at the global level in active mobile broadband subscriptions, which was the most prominent source of improvement in all regions between IDI 2016 and IDI 2017.

Most regions showed modest increases in other access and use indicators, with the exception of fixed-telephone subscriptions, which fell marginally in all regions. This reflects continuing year-on-year improvement in those indicators for most countries. Little change was recorded in any region for the indicators in the skills sub-index, though significant changes were recorded for some individual countries.

Regions with lower average IDI values tend to have more jagged distributions of indicator values. The smoothest distribution of results across the range of indicators – with relatively high performance across the board – is that within the Europe region. The distribution of indicator results becomes more irregular as overall IDI performance falls, the most significant factors accounting for greater variation being the level of fixed-telephone subscriptions in the access sub-index, the level of fixed-broadband subscriptions in the use sub-index, and tertiary enrolment in the skills sub-index.

The spider diagrams for the CIS and Americas regions reveal stronger performance overall than those for the Arab States and Asia and the Pacific, with a more balanced distribution of indicator values than in these latter regions. The most jagged spider diagram is that for Africa. This reflects particularly low indicator values in that region for fixed-telephone and fixed-broadband subscriptions, and for tertiary enrolment. The indicator contributing most strongly to overall IDI values in Africa is that for mobile-cellular subscriptions, while the most prominent improvement in the region during the past year came from the indicators for mobile-broadband subscriptions, households with Internet and Internet users. This suggests that the development of mobile broadband is helping to bring more people and households online in Africa.

The following sections describe the findings for each region in more detail, and explore the results achieved by a number of individual countries, including regional top performers and dynamic countries that have most significantly improved their positions in the rankings and/or IDI values.

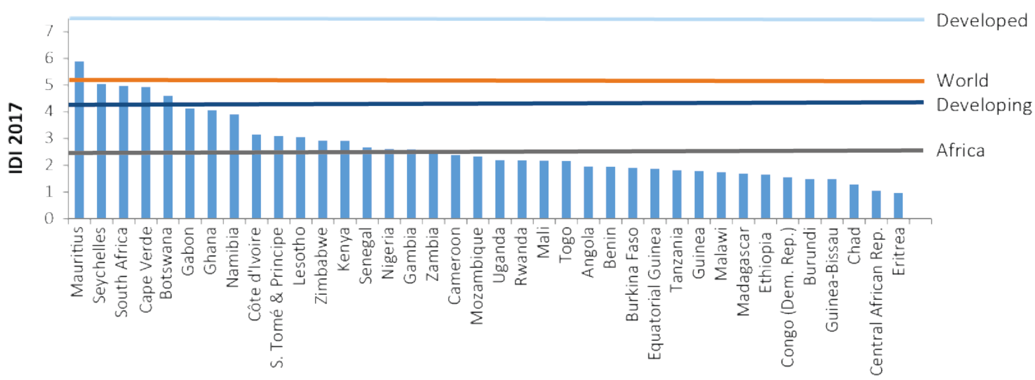
Africa

IDI values and rankings for the Africa region are set out in Chart 3.3 and Table 3.4, where they are compared with the global average and with averages for developed and developing countries.

Africa has by far the lowest average IDI performance of any region. Only one country in the region – Mauritius – falls into the top half of the IDI distribution or exceeds the global average value for IDI 2017, while only four more countries – Seychelles, South Africa, Cape Verde and Botswana – exceed the average value of 4.26 for developing countries.

By contrast, 28 of the 38 countries in the Africa region that are included in the Index rank as LCCs in the lowest quartile of the distribution, including 9 of the 10 countries at the bottom of the global rankings. The average improvement in IDI value for African least developed countries (LDCs), 0.12 points, was also significantly lower than that for non-LDCs within the region (0.23 points). A number of African LDCs are not included in the Index because of lack of data. However, it is likely

Chart 3.3: IDI values, Africa region, IDI 2017



Source: ITU.

Table 3.4: IDI rankings and values, Africa, IDI 2017 and IDI 2016

Economy	Regional rank 2017	Global rank 2017	IDI 2017	Regional rank 2016	Global rank 2016	IDI 2016	Global rank change 2017-2016	Regional rank change 2017-2016
Mauritius	1	72	5.88	1	75	5.51	3	0
Seychelles	2	90	5.03	4	92	4.80	2	2
South Africa	3	92	4.96	2	88	4.91	-4	-1
Cape Verde	4	93	4.92	3	91	4.83	-2	-1
Botswana	5	105	4.59	5	102	4.51	-3	0
Gabon	6	114	4.11	7	118	3.62	4	1
Ghana	7	116	4.05	6	113	3.88	-3	-1
Namibia	8	118	3.89	8	123	3.33	5	0
Côte d'Ivoire	9	131	3.14	12	134	2.84	3	3
S. Tomé & Principe	10	132	3.09	10	131	2.91	-1	0
Lesotho	11	133	3.04	9	130	2.94	-3	-2
Zimbabwe	12	136	2.92	11	133	2.85	-3	-1
Kenya	13	138	2.91	13	137	2.67	-1	0
Senegal	14	142	2.66	14	142	2.48	0	0
Nigeria	15	143	2.60	15	143	2.44	0	0
Gambia	16	144	2.59	16	145	2.43	1	0
Zambia	17	146	2.54	18	149	2.19	3	1
Cameroon	18	149	2.38	19	150	2.14	1	1
Mozambique	19	150	2.32	17	147	2.23	-3	-2
Uganda	20	152	2.19	24	158	1.90	6	4
Rwanda	21	153	2.18	20	151	2.10	-2	-1
Mali	22	155	2.16	21	153	2.05	-2	-1
Togo	23	156	2.15	25	159	1.86	3	2
Angola	24	160	1.94	22	156	2.00	-4	-2
Benin	25	161	1.94	23	157	1.92	-4	-2
Burkina Faso	26	162	1.90	27	163	1.74	1	1
Equatorial Guinea	27	163	1.86	26	160	1.82	-3	-1
Tanzania	28	165	1.81	28	164	1.73	-1	0
Guinea	29	166	1.78	29	166	1.71	0	0
Malawi	30	167	1.74	31	169	1.58	2	1
Madagascar	31	169	1.68	30	167	1.70	-2	-1
Ethiopia	32	170	1.65	33	171	1.42	1	1
Congo (Dem. Rep.)	33	171	1.55	32	170	1.48	-1	-1
Burundi	34	172	1.48	34	172	1.39	0	0
Guinea-Bissau	35	173	1.48	35	173	1.38	0	0
Chad	36	174	1.27	36	174	1.06	0	0
Central African Rep.	37	175	1.04	38	176	0.89	1	1
Eritrea	38	176	0.96	37	175	0.96	-1	-1
Average			**2.64**			**2.48**		

Source: ITU.

that at least some of these would also have IDI values within the lowest quartile if data were available. These findings illustrate the extent to which Africa continues to lag behind other regions in ICT development, as well as the importance of addressing the region's ongoing digital divide.

All but three countries in the region (Angola, Madagascar and Eritrea) showed some improvement in IDI value between 2016 and 2017, although in 11 countries this improvement was marginal (less than 0.10 points). The average improvement recorded was 0.16 points, less than

Table 3.5: Most dynamic countries by IDI ranking and IDI value, Africa, 2016–2017

Change in IDI ranking				Change in IDI value (absolute)			
IDI rank 2017	Rank region	Country	IDI rank change	IDI rank 2017	Rank region	Country	IDI value change
2	20	Uganda	6	118	8	Namibia	0.57
4	8	Namibia	5	114	6	Gabon	0.50
4	6	Gabon	4	72	1	Mauritius	0.36
6	1	Mauritius	3	146	17	Zambia	0.35
3	9	Côte d'Ivoire	3	131	9	Côte d'Ivoire	0.30
3	17	Zambia	3				
2	23	Togo	3				

Source: ITU.

the average improvement of 0.20 points for all developing countries.

The most dynamic countries in Africa, by IDI ranking and value, are identified in Table 3.5. The greatest improvements in the overall IDI were made by Namibia (up 0.57 points), Gabon (up 0.50 points) and Mauritius (up 0.36 points). The greatest improvements in the access sub-index were made by the Central African Republic, Mauritius and Malawi, and in the use sub-index by Namibia, Gabon and Zambia.

As in other regions, there was relatively little movement in regional rankings between IDI 2016 and IDI 2017. At the top of the distribution, Seychelles moved from fourth to second position, at the expense of South Africa and Cabo Verde, while Gabon moved above Ghana, from seventh to sixth. The biggest gain in the regional rankings was made by Uganda, which moved from 24th to 20th position.

The ten countries at the top of the African rankings achieved an average improvement in their IDI values of 0.25 points, well above the global average of 0.18, thanks to substantial improvements by the region’s three most dynamic countries (Namibia, Gabon and Mauritius), while the remaining countries in the region, all but one of which are in the LCC quartile, managed an average improvement of just 0.13 points.

Across the Africa region as a whole, the indicators that showed the greatest improvement in percentage terms between IDI 2016 and IDI 2017 were those for mobile-broadband penetration and households with Internet access, followed by those for Internet users, households with a computer and (from a generally low base) fixed-broadband penetration. This can be compared with the trend identified in *Measuring the Information Society Report 2016* (ITU, 2016b), which found that the greatest improvements in the region in the previous year occurred in mobile-cellular subscriptions and mobile-broadband subscriptions.

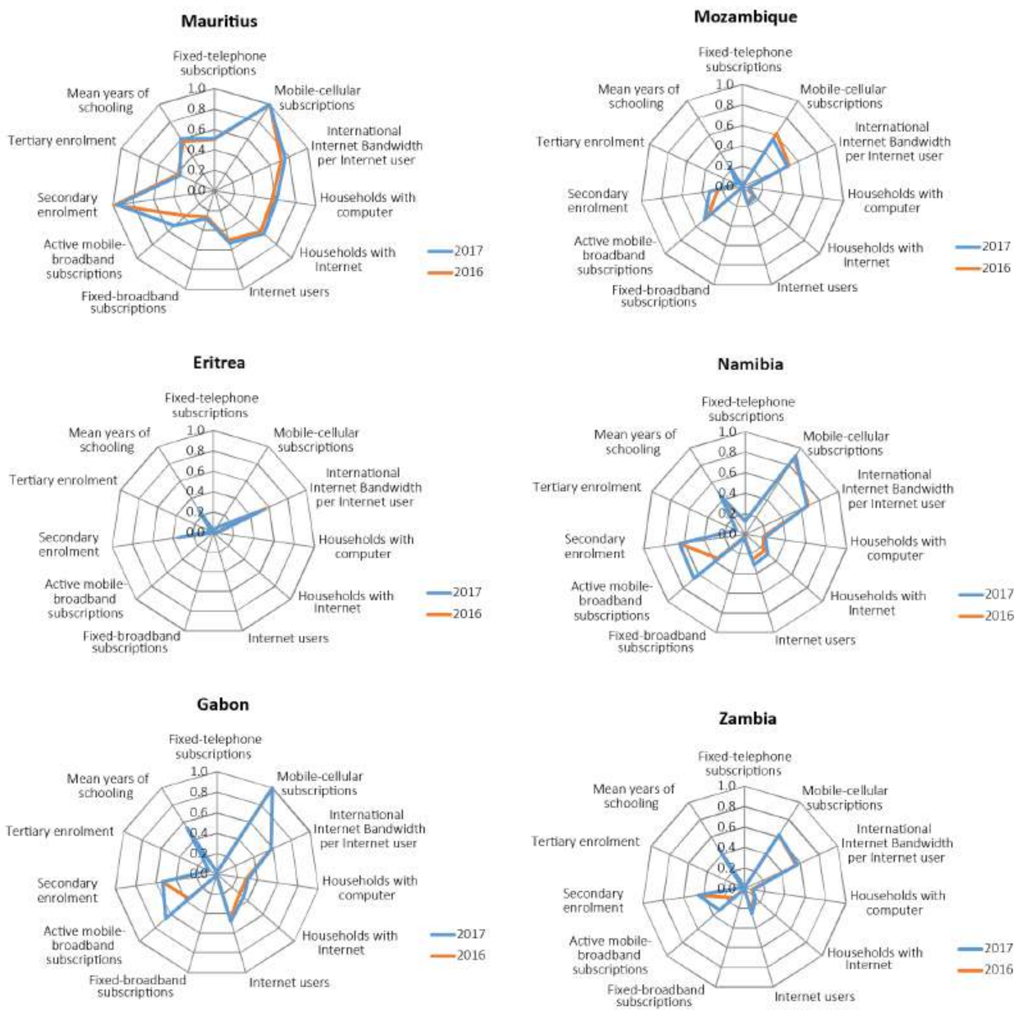
The steep increase in mobile-broadband penetration (from an average of 22.40 per 100 population in IDI 2016 to 27.78 in IDI 2017) was driven by exceptionally high growth rates (which exceed 100 per cent in Chad, Togo, Cameroon and Zambia), reflecting the impact of developments in licensing and infrastructure on very low starting points for this indicator in IDI 2016. For instance, a second operator started offering 3G services in Togo in 2016, thus breaking the monopoly that the Togolese incumbent had in the mobile-broadband market (see Togo profile available in volume 2). Seven more countries in the region recorded growth rates for this indicator of more than 50 per cent.

The highest growth rates for fixed-broadband penetration, from an even lower base, were recorded by Cameroon, Nigeria and Mali. Only half of the countries in the region recorded increases in mobile-cellular penetration between IDI 2016 and IDI 2017, while a majority recorded a decline in fixed-telephone subscriptions. All countries in the region recorded an increase in the proportion of Internet users, the highest growth rates being in the Democratic Republic of the Congo, Togo and Chad, while all but one recorded an increase in the proportion of households with Internet access.

Chart 3.4 presents spider diagrams that illustrate the performance of the countries at the top, midpoint and bottom of the regional distribution,

Chart 3.4: IDI values, selected countries, Africa region, IDI 2017 and IDI 2016

Fig3-4



Source: ITU.

in the upper row, and dynamic countries in the region by IDI value, in the lower.

The spider diagrams in Chart 3.4 illustrate the marked contrast between the performance of the region's highest-performing country (Mauritius) and the lowest-performing country in the IDI (Eritrea). The performance of Mauritius is typical of middle-ranking countries in the Index, with relatively high outturns for most indicators, but comparatively low scores for fixed-telephone and fixed-broadband subscriptions and for tertiary education. The position of Mauritius as first in the regional ranking reflects its historical role as a forerunner in ICT developments in the region: it was the first country in the southern hemisphere to launch commercial mobile services in 1989, the first African country to connect to an international undersea fibre-optic cable in 2002, and the first African country to launch 3G services in (see Mauritius profile available in volume 2).

Mozambique's performance, halfway down the regional rankings but within the LCC quartile, is much more typical of low-income developing countries, with low scores for most indicators, its highest performance being in mobile-cellular subscriptions and international Internet bandwidth per Internet user. The country connected to the SEACOM international submarine cable in 2009, and to the Eastern Africa Submarine System a year later, thus easing its historical lack of international connectivity. Its relatively strong performance on mobile-broadband subscriptions, which is explained by the boost in competition that the third operator brought into the Mozambican mobile-broadband market in 2012 (see Mozambique profile available in volume 2).

Namibia, Gabon, Zambia and Mauritius are the four most dynamic countries in the regional IDI in terms of IDI value. The first three of these have spider diagrams whose shape resembles those of Mozambique and other countries in the lower-middle quartile (Gabon and Namibia) and the upper reaches of the LCC quartile (Zambia). The most substantial improvements in indicator scores in all four countries were experienced in mobile-broadband subscriptions. The use sub-index value for Mauritius rose by 17 per cent, largely as a result of strong growth in mobile-broadband subscriptions, compared with a 4 per cent increase in its access sub-index value. It also recorded significant improvements in international Internet bandwidth, households with Internet access and Internet users. The use sub-index values for Namibia, Gabon and Zambia rose by 56 per cent, 39 per cent and 66 per cent respectively, driven predominantly by mobile-broadband subscriptions with the support of improved scores for the proportion of Internet users in the population. In Gabon, the incumbent's acquisition of the fourth mobile operator, Moov, granted access to the incumbent's 3G and long-term evolution (LTE) network to the data subscribers of Moov, who could previously only access 2G services.

Uganda was only the seventh most dynamic country in the region in terms of IDI value, rising by 0.29 points, but made the largest upward movement in the regional rankings because it improved significantly more than almost every other country in the third quartile of the regional distribution. It also saw its use sub-index value rise by more than 50 per cent, driven by mobile-broadband subscriptions, and it enjoyed significant improvements in the mobile-cellular subscriptions and the proportion of Internet users within the population.

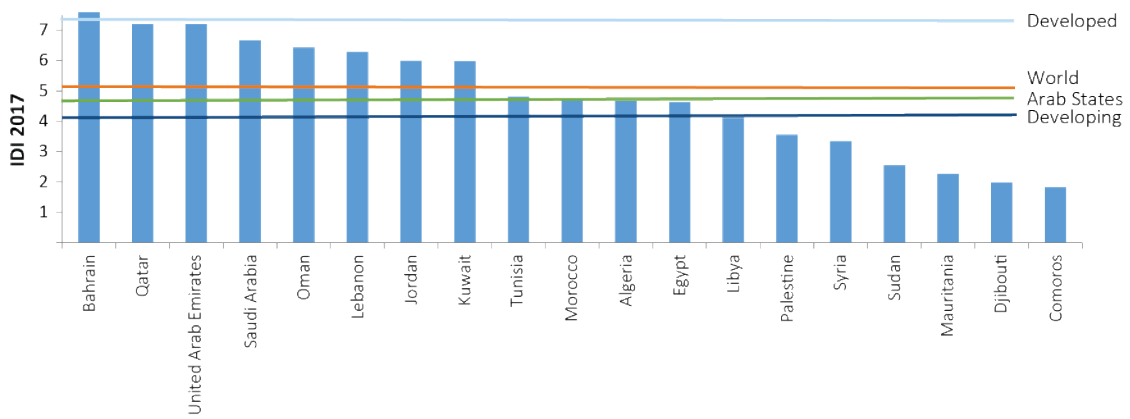
Arab States

IDI values and rankings for the Arab States region are set out in Chart 3.5 and Table 3.6, where they are compared with the global average and with averages for developed and developing countries.

There are marked differences in the economic and ICT characteristics of economies at different economic levels within these regional rankings. This partly explains why there were only two changes in position within the regional rankings between IDI 2016 and IDI 2017, with Qatar moving above the United Arab Emirates into 2nd position and Algeria above Egypt into 11th. However, the Arab States region saw the lowest average improvement in IDI values of any region in the Index. Consistent with this, 13 of its 19 economies dropped by one or more places in the global rankings.

Five of the six countries in the Gulf Cooperation Council sub-region occupy the top five regional positions, while the sixth, Kuwait, is in eighth position. These countries have high levels of gross national income (GNI) per capita, although, as indicated in Chapter 2, a number of them perform less well in the IDI rankings than developed

Chart 3.5: IDI values, Arab States region, IDI 2017



Note: Palestine is not an ITU Member State; the status of Palestine in ITU is the subject of Resolution 99 (Rev. Busan, 2014) of the ITU Plenipotentiary Conference.
Source: ITU.

Table 3.6: IDI rankings and values, Arab States, IDI 2017 and IDI 2016

Economy	Regional rank 2017	Global rank 2017	IDI 2017	Regional rank 2016	Global rank 2016	IDI 2016	Global rank change 2017-2016	Regional rank change 2017-2016
Bahrain	1	31	7.60	1	30	7.46	-1	0
Qatar	2	39	7.21	3	36	7.12	-3	1
United Arab Emirates	3	40	7.21	2	34	7.18	-6	-1
Saudi Arabia	4	54	6.67	4	45	6.87	-9	0
Oman	5	62	6.43	5	64	6.14	2	0
Lebanon	6	64	6.30	6	65	6.09	1	0
Jordan	7	70	6.00	7	66	5.97	-4	0
Kuwait	8	71	5.98	8	70	5.75	-1	0
Tunisia	9	99	4.82	9	95	4.70	-4	0
Morocco	10	100	4.77	10	98	4.57	-2	0
Algeria	11	102	4.67	12	106	4.32	4	1
Egypt	12	103	4.63	11	104	4.44	1	-1
Libya	13	115	4.11	13	112	3.93	-3	0
Palestine	14	123	3.55	14	122	3.42	-1	0
Syria	15	126	3.34	15	124	3.32	-2	0
Sudan	16	145	2.55	16	141	2.56	-4	0
Mauritania	17	151	2.26	17	152	2.08	1	0
Djibouti	18	158	1.98	18	161	1.80	3	0
Comoros	19	164	1.82	19	162	1.78	-2	0
Average			**4.84**			**4.71**		

Note: Palestine is not an ITU Member State; the status of Palestine in ITU is the subject of Resolution 99 (Rev. Busan, 2014) of the ITU Plenipotentiary Conference.
Source: ITU.

countries with comparable economic indicators. All six have IDI values well above the world average of 5.11, as do two middle-income countries in the region, Lebanon and Jordan.

These eight top-ranking countries have improved their IDI values by an average of 0.10 points between IDI 2016 and IDI 2017. They are followed in the rankings by four middle-income countries in North Africa (Tunisia, Morocco, Algeria and Egypt) which have improved their performance by an average of 0.21 points, suggesting that middle-income countries in the region may be gaining on countries in the Gulf Cooperation Council. Countries lower down the regional distribution also improved their average IDI value by 0.10 points.

The most dynamic countries in the region, by IDI ranking and value, are identified in Table 3.7. The most substantial improvements in IDI value were made by Algeria (up 0.34 points), Oman (up 0.29 points) and Kuwait (up 0.23 points). The greatest improvements in the access sub-index were made by Algeria, Bahrain, Lebanon and Libya, while the greatest improvements in the use sub-index were made by Oman, Kuwait, Algeria and Lebanon.

In Algeria, the expansion of 3G coverage and the launch of LTE services led to a significant increase in mobile-cellular subscriptions and, to a lesser extent, in mobile-broadband subscriptions.
In Oman, the rising popularity of social media applications and the successful commercial strategy undertaken by the second operator, Ooredoo, have led to a remarkable increase in Ooredoo's data subscriptions. The operator has benefitted from the Telecommunications Regulatory Authority's permission to use the 900 MHz band for 3G services. The Authority's Information Memorandum detailing the process for the award of the country's third mobile network operator (MNO) license may also have contributed to the developments in the mobile market. Indeed, the international experience shows that disruptive effects of adding a new player in a mobile market with limited competition (a duopoly in the case of Oman) may start from the announcement of the regulatory decision.[2]

Table 3.7: Most dynamic countries by IDI ranking and IDI value, Arab States, 2016–2017

Change in IDI ranking				Change in IDI value (absolute)			
IDI rank 2017	Rank region	Country	IDI rank change	IDI rank 2017	Rank region	Country	IDI value change
102	11	Algeria	4	102	11	Algeria	0.34
158	18	Djibouti	3	62	5	Oman	0.29
62	5	Oman	2	71	8	Kuwait	0.23
64	6	Lebanon	1	64	6	Lebanon	0.20
103	12	Egypt	1	100	10	Morocco	0.19
151	17	Mauritania	1				

Source: ITU.

Saudi Arabia saw a marked fall in both access and use sub-indices, caused in particular by falls in recorded mobile-cellular and mobile-broadband subscriptions, which were the result of new fingerprint requirements for registration of SIM cards, new legislation limiting the number of subscriptions per user and an economic slowdown that resulted in the departure of many foreign workers. The decrease in mobile-broadband subscriptions, in combination with the halt on unlimited broadband packages, also resulted in less Internet traffic and thus a reduction in the used international Internet bandwidth per Internet user.

At the bottom end of the rankings, the region includes four LDCs which fall into the low (LCC) quartile of the IDI distribution. While two of these countries – Mauritania and Djibouti – have improved their IDI values by 0.18 points, Comoros has achieved only weak growth and Sudan has seen a marginal decline in IDI value.

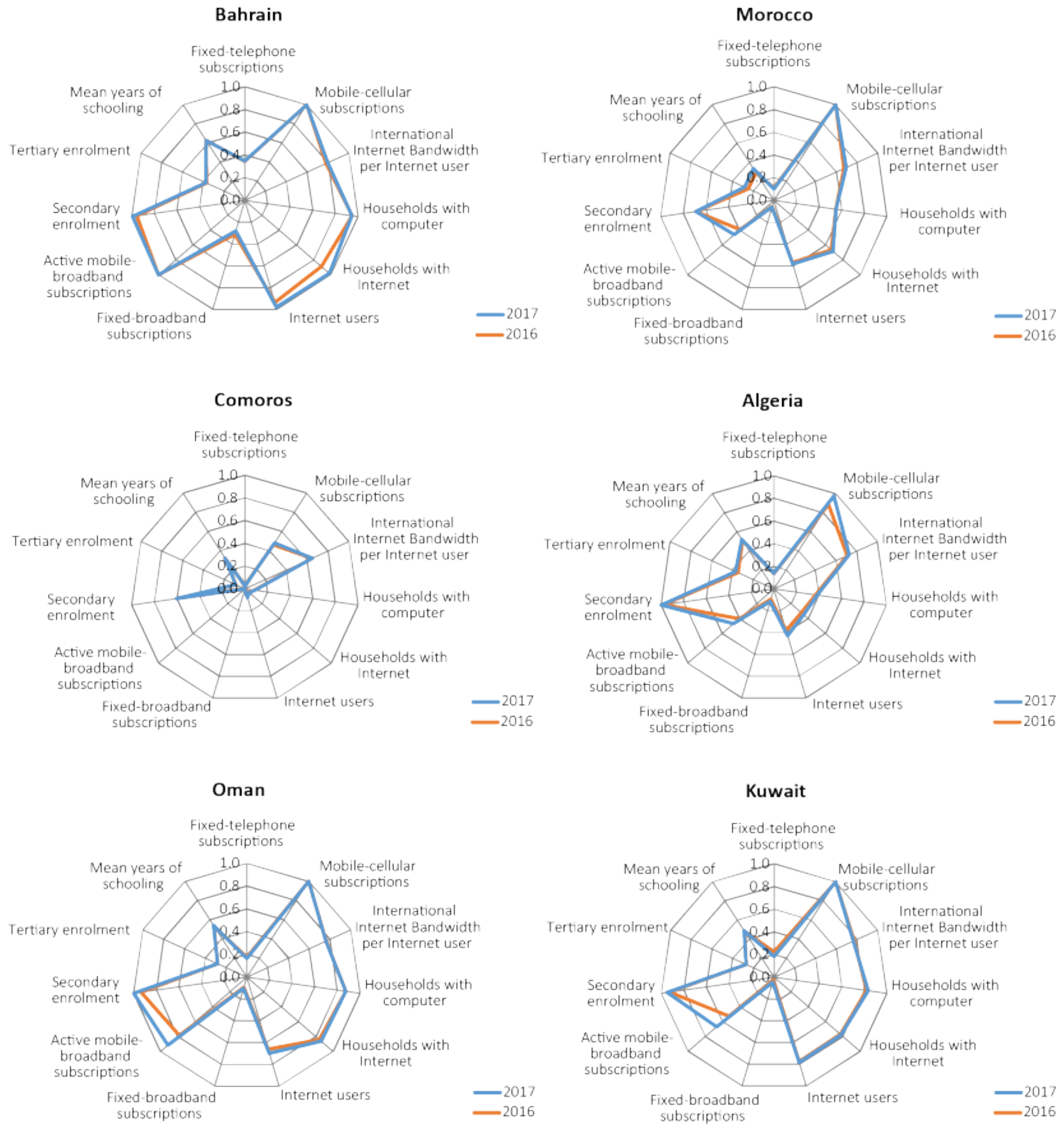
The most significant rates of improvement across the Arab States region were made in international Internet bandwidth and fixed- and mobile-broadband subscriptions. Each of those rose by more than 15 per cent on average during the year. The average growth rate for fixed-broadband subscriptions was boosted by an exceptionally high rate of growth in one country, Libya, explained by an expansion of the capacity of the fixed wireless network. Despite the remarkable improvement, the starting base was very low and therefore fixed-broadband penetration only reached 3 per cent in Libya. Other particularly strong performances in the fixed-broadband arena were recorded in Kuwait, Jordan and Comoros.

Djibouti showed a very high rate of improvement in mobile-broadband subscriptions coinciding with the incumbent's accelerated investment in the mobile network and the expansion of 3G coverage in the country. Nevertheless, mobile-broadband penetration in Djibouti remains low in comparison with other countries in the region, at 12 per cent, and the country is the only Arab State to maintain a monopoly in the mobile market. Other countries that stand out for their high growth rates in mobile-broadband subscriptions include Mauritania, Kuwait and Bahrain, whereas Saudi Arabia and Sudan registered significant declines. The indicator for international Internet bandwidth per Internet user is affected by changes in both bandwidth availability and numbers of Internet users. It grew markedly in the Syrian Arab Republic, Egypt and Djibouti. These countries share a remarkable increase in international connectivity in 2016 and a more modest increase in Internet users. In the case of Egypt, data show that these trends are explained by an increase in the data consumption per Internet user. Indeed, data consumption per subscription grew by 75 per cent and 31 per cent for mobile broadband and fixed broadband, respectively, in 2016. The highest growth rates for both Internet users and households with Internet access were recorded, from low base levels, in Mauritania.

Chart 3.6 presents spider diagrams that compare the performance of the countries at the top, midpoint and bottom of the regional distribution in the upper row, and the most dynamic countries in the region by IDI value in the lower row.

The upper row of these spider diagrams illustrates the differences between high-performing and low-performing countries in the region. As in other regions, high-performing countries such as Bahrain, which ranks 31st in the global distribution, exhibit relatively high scores across the majority of indicators, particularly those for mobile-cellular

Chart 3.6: IDI values, selected countries, Arab States region, IDI 2017 and IDI 2016



Source: ITU.

and mobile-broadband penetration. Bahrain's higher scores for mobile-broadband subscriptions, fixed-telephone subscriptions, Internet-related access and use indicators account for its lead over Oman and Kuwait, which rank 62nd and 71st respectively in the global distribution.

Bahrain already had a mobile-broadband penetration rate above 100 subscriptions per 100 population in IDI 2016, and therefore less scope for growth in this indicator. Its most significant improvements were made in the proportions of Internet users and households with Internet access. The early launch of LTE services in 2013 by all three MNOs has contributed to achieving almost universal Internet use in Bahrain.

Moreover, the success of LTE services in the country has led to the migration of Worldwide Interoperability for Microwave Access (WiMAX) customers to LTE services, resulting in a sustained decrease in fixed-broadband subscriptions since 2013.[3] The chart for Comoros, an LDC, is more typical of countries in the LCC quartile.

The most dynamic countries in the region – Algeria, Kuwait and Oman – improved their values for the use sub-index by 16, 13 and 12 per cent respectively. In Kuwait and Oman, this was driven overwhelmingly by increases in the proportion of mobile-broadband subscriptions, but in Algeria, improvement in the proportion of Internet users was also of substantial importance. While Algeria also improved its access sub-index value, as a result of a substantial increase in mobile-cellular subscriptions, Oman's value for the access sub-index was stagnant and Kuwait's fell marginally as the result of a substantial fall in mobile-cellular subscriptions. Djibouti enjoyed the greatest improvement in its IDI ranking in the region, up three positions, because its performance in both access and use sub-indices was better than that of other countries with similar performance ratings in IDI 2016.

Asia and the Pacific

IDI values and rankings for the Asia and the Pacific region are set out in Chart 3.7 and Table 3.8, where they are compared with the global average and with averages for developed and developing countries.

Asia and the Pacific has the widest range of IDI values of any region in the Index (6.91 points between its highest and lowest ranking countries, compared with 6.47 points in the Americas and just 3.18 in the CIS region). As in the Arab States and the Americas, this results from major differences in the economic characteristics of different economies within the region.

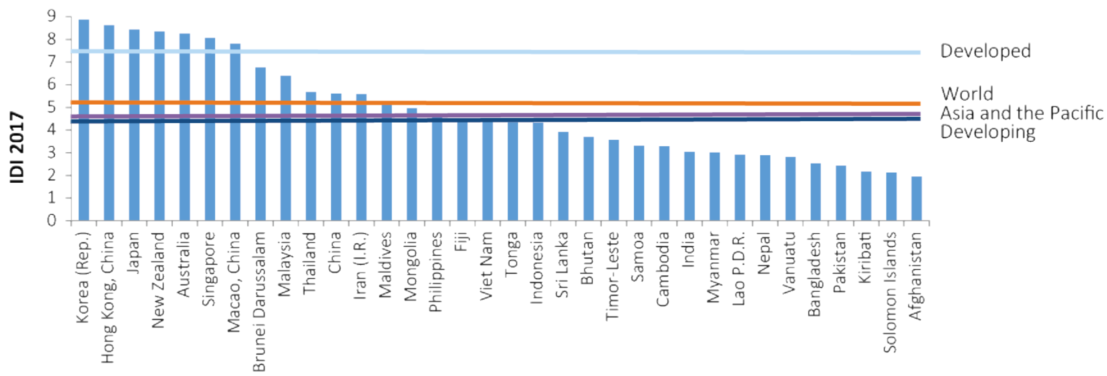
There were very few changes in position within the regional rankings between 2016 and 2017, the most significant being made by the Lao P.D.R., which rose from 144th to 139th in the global rankings and from 29th to 27th in the regional rankings.

The most dynamic countries in the region, by IDI ranking and value, are listed in Table 3.9. The biggest gains were made by Iran (up 0.54 points), the Lao P.D.R. and Indonesia (both up 0.47 points) and Timor-Leste (up 0.46 points). The most substantial improvements in value for the access sub-index were made by Iran, Myanmar, Nepal and India, while the most substantial improvements in the use sub-index were made by Timor-Leste, Indonesia, the Lao P.D.R., Iran and Samoa.

The top six positions in the region, which fall within the top 20 in the global rankings, are held by high-income economies. Four of these (the Republic of Korea, Japan, New Zealand and Australia) are members of the Organisation for Economic Co-operation and Development. Singapore and Hong Kong (China) also enjoy a very high level of GNI per capita. These six economies, together with Macao (China), which ranks seventh in the region, have IDI values above 7.75, compared with the global average of 5.11. This group of economies increased its average IDI value by 0.15 points between IDI 2016 and IDI 2017.

Seventeen countries in the region fall within the two middle quartiles of the IDI distribution. All but six of these have improved their IDI performance by more than the global average during the year, with an average improvement of 0.27 points. The most substantial improvements were made by three of the four most dynamic countries in the region – Iran, Indonesia and Timor-Leste. In Iran, the entry of the second and third MNOs into the mobile-broadband market in 2014 is bearing its fruits: mobile-broadband penetration has tripled in two years, while mobile-cellular penetration has continued its strong growth and reached the

Chart 3.7: IDI values, Asia and the Pacific, IDI 2017



Source: ITU.

Table 3.8: IDI rankings and values, Asia and the Pacific, IDI 2017 and IDI 2016

Economy	Regional rank 2017	Global rank 2017	IDI 2017	Regional rank 2016	Global rank 2016	IDI 2016	Global rank change 2017-2016	Regional rank change 2017-2016
Korea (Rep.)	1	2	8.85	1	1	8.80	-1	0
Hong Kong, China	2	6	8.61	2	6	8.47	0	0
Japan	3	10	8.43	3	11	8.32	1	0
New Zealand	4	13	8.33	4	12	8.23	-1	0
Australia	5	14	8.24	5	16	8.08	2	0
Singapore	6	18	8.05	6	20	7.85	2	0
Macao, China	7	26	7.80	7	29	7.55	3	0
Brunei Darussalam	8	53	6.75	8	54	6.56	1	0
Malaysia	9	63	6.38	9	62	6.22	-1	0
Thailand	10	78	5.67	10	79	5.31	1	0
China	11	80	5.60	11	83	5.17	3	0
Iran (I.R.)	12	81	5.58	12	85	5.04	4	0
Maldives	13	85	5.25	13	86	4.97	1	0
Mongolia	14	91	4.96	14	87	4.91	-4	0
Philippines	15	101	4.67	15	100	4.52	-1	0
Fiji	16	107	4.49	16	105	4.34	-2	0
Viet Nam	17	108	4.43	17	108	4.18	0	0
Tonga	18	110	4.34	18	109	4.13	-1	0
Indonesia	19	111	4.33	19	114	3.85	3	0
Sri Lanka	20	117	3.91	20	116	3.77	-1	0
Bhutan	21	121	3.69	21	119	3.58	-2	0
Timor-Leste	22	122	3.57	22	127	3.11	5	0
Samoa	23	127	3.30	24	129	2.95	2	1
Cambodia	24	128	3.28	23	128	3.04	0	-1
India	25	134	3.03	26	138	2.65	4	1
Myanmar	26	135	3.00	28	140	2.59	5	2
Lao P.D.R.	27	139	2.91	29	144	2.43	5	2
Nepal	28	140	2.88	27	139	2.60	-1	-1
Vanuatu	29	141	2.81	25	136	2.75	-5	-4
Bangladesh	30	147	2.53	30	146	2.37	-1	0
Pakistan	31	148	2.42	31	148	2.21	0	0
Kiribati	32	154	2.17	33	155	2.04	1	1
Solomon Islands	33	157	2.11	32	154	2.04	-3	-1
Afghanistan	34	159	1.95	34	165	1.71	6	0
Average			**4.83**			**4.60**		

Source: ITU.

threshold of 100 subscriptions per 100 inhabitants in 2016. Only one country in this group of middle-ranking countries improved its IDI value by less than 0.10 points (Mongolia).

Ten countries in the region fall within the LCC quartile. Six of these also experienced substantial improvements in their IDI values during the year – including the Lao P.D.R. (up 0.47 points), Myanmar (up 0.42 points) and India (up 0.38 points), as well as Pakistan, Nepal and the region's lowest-ranking country, Afghanistan, all of which improved their IDI values by more than 0.20 points. In Myanmar, the opening of the mobile market to competition in 2014 has driven investment into the sector: 3G coverage grew from 50 per cent to almost the entire population in the period 2014–2016, and LTE services were launched in 2016. As a result, mobile-cellular and mobile-broadband subscription growth are leading ICT development in the country. India has seen an acceleration of subscription growth in the mobile market, both in

Table 3.9: Most dynamic countries by IDI ranking and IDI value, Asia and the Pacific region, 2016–2017

Change in IDI ranking				Change in IDI value (absolute)			
IDI rank 2017	Rank region	Country	IDI rank change	IDI rank 2017	Rank region	Country	IDI value change
159	34	Afghanistan	6	81	12	Iran (I.R.)	0.54
122	22	Timor-Leste	5	139	27	Lao P.D.R.	0.47
135	26	Myanmar	5	111	19	Indonesia	0.47
139	27	Lao P.D.R.	5	122	22	Timor-Leste	0.46
81	12	Iran (I.R.)	4	80	11	China	0.422
134	25	India	4	135	26	Myanmar	0.419

Source: ITU.

terms of mobile-cellular and mobile-broadband subscriptions. This follows the consolidation of the operations of some mobile operators, five of which now have a countrywide presence.

The most substantial average rate of improvement for any indicator in Asia and the Pacific was for mobile-broadband subscriptions. This indicator rose by an average 36.2 per cent between IDI 2016 and IDI 2017, with increases over 100 per cent, from very low baselines, in four countries (Samoa, Kiribati, the Lao P.D.R. and Afghanistan). The second most substantial average rate of improvement (12.4 per cent) was for the proportion of households with Internet access, the highest improvements for which came from three LDCs (Bangladesh, the Lao P.D.R. and the Solomon Islands). All but one country in the region (Mongolia) recorded an improvement in this indicator.

Only seven countries in the region recorded increases in the number of fixed-telephone subscribers per 100 population. Two of these (the Lao P.D.R. and the Philippines) recorded significant increases. Twenty-three of the region's 34 economies, however, recorded increases in the number of fixed-broadband subscriptions per 100 population.

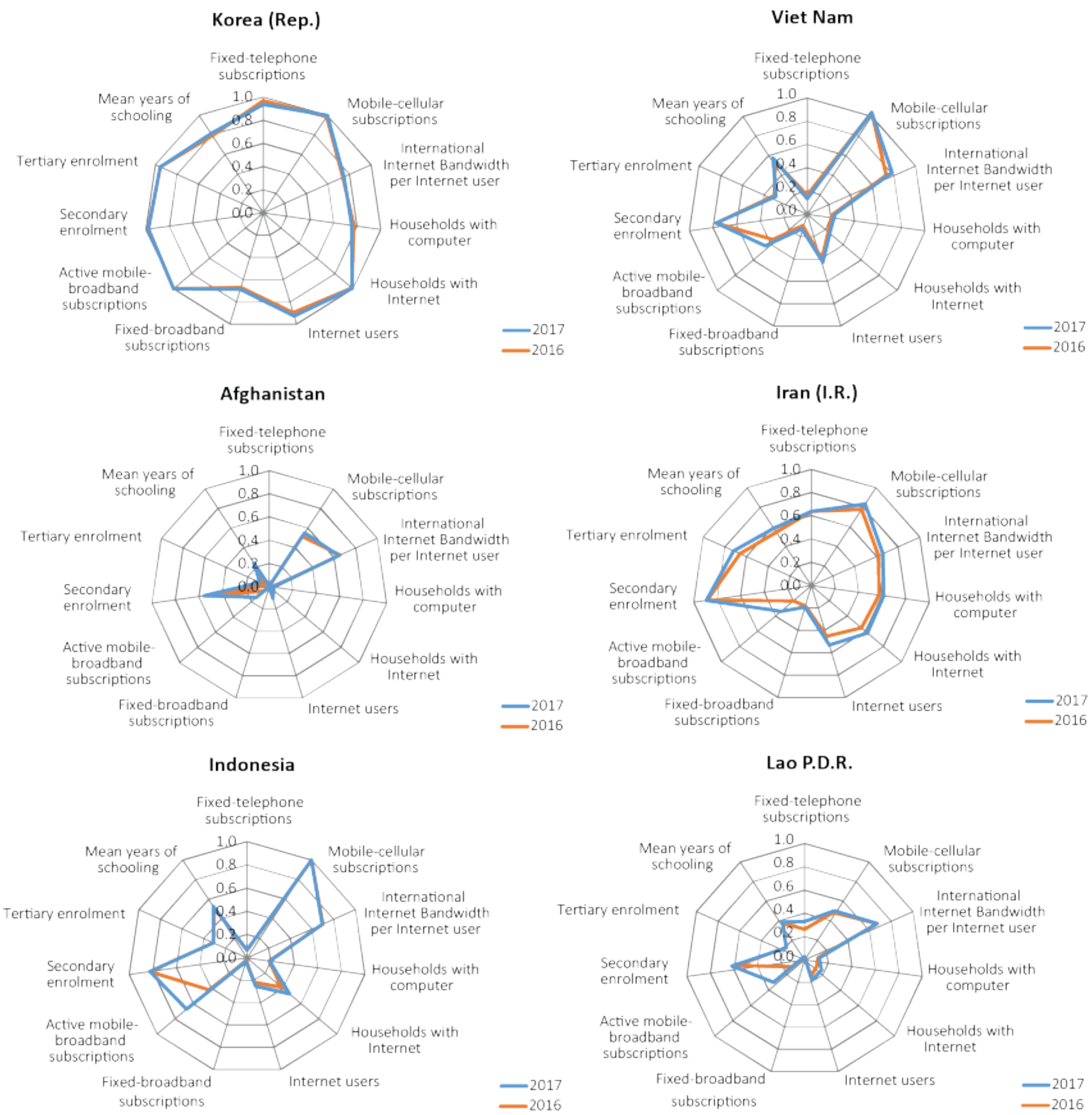
Chart 3.8 presents spider diagrams that illustrate the performance of the countries at the top, midpoint and bottom of the regional distribution in the upper line, and the most dynamic countries in the region by IDI value in the lower.

As in other regions, there are marked differences in the shape of these spider diagrams between countries at different levels of the IDI distribution. The Republic of Korea's chart is well-rounded, with high scores for all the indicators in the Index. The diagrams for Viet Nam and Afghanistan, by contrast, are typical of those for countries around the middle of the distribution and in the LCC quartile respectively.

Iran, which was the region's most dynamic country in terms of IDI value, showed improvements in every indicator in the Index, with a particularly high rate of improvement (68.7 per cent) in the number of mobile-broadband subscriptions per 100 population, as well as notable improvements in Internet users and households with Internet access. By far the most substantial improvements for the other two dynamic countries illustrated – Indonesia and the Lao P.D.R. – were in the number of mobile-broadband subscriptions per 100 population. Both of these countries also saw significant growth in the proportion of households with Internet access, while the Lao P.D.R. also significantly improved its value for fixed-telephone subscriptions. The improvement in Timor-Leste's IDI value derived almost entirely from mobile-broadband and mobile-cellular subscriptions. China saw improvements in all indicators other than fixed-telephone subscriptions, but its highest percentage increase in any indicator came from tertiary enrolment.

Afghanistan improved its IDI value over the year by 0.23 points, which was only the 15th highest increase in the region (out of 34 economies), but this enabled it to jump six places in the IDI rankings because it was the highest improvement in value among the 20 countries at the bottom of the distribution. The most significant improvements in Afghanistan's access and use indicators were for mobile-broadband and mobile-cellular subscriptions, followed by the proportion of Internet users. Despite the country's challenging geographic and security environment, Afghanistan maintains a competitive mobile market, with five

Chart 3.8: IDI values, selected countries, Asia and the Pacific region, IDI 2017 and IDI 2016



Source: ITU.

operators offering services. The latest entrant, the State-owned fixed incumbent in 2014, has contributed to keeping the steady growth in mobile-cellular subscriptions and boosting mobile-broadband subscriptions. The latter more than doubled in 2016, reaching a rate of 14 mobile-broadband subscriptions per 100 inhabitants. This is a remarkable achievement given that only 40 per cent of the Afghan population is covered by a 3G signal.

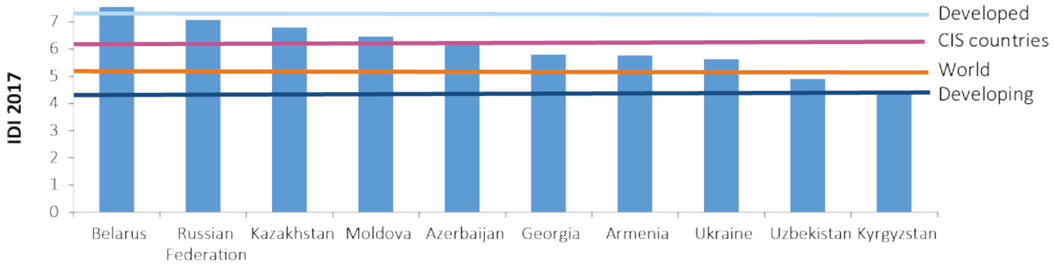
Commonwealth of Independent States

IDI values and rankings for the CIS region are set out in Chart 3.9 and Table 3.10, where they are compared with the global average and with averages for developed and developing countries.

Ten of the 12 countries within the CIS region supply data for the IDI, the exceptions being Tajikistan and Turkmenistan. Four countries in the region (Belarus, Moldova, the Russian Federation and Ukraine) are categorized as developed countries, while the remainder are categorized as developing countries.

The CIS region includes fewer countries than other regions. It is also economically relatively homogeneous. Reflecting this relative homogeneity, it has the narrowest range of IDI values of any region (3.18 points between its

Chart 3.9: IDI values, CIS region, IDI 2017



Note: Georgia exited CIS on 18 August 2009 but is included in the ITU BDT administrative region for the CIS countries.
Source: ITU.

Table 3.10: IDI rankings and values, CIS region, IDI 2017 and IDI 2016

Economy	Regional rank 2017	Global rank 2017	IDI 2017	Regional rank 2016	Global rank 2016	IDI 2016	Global rank change 2017-2016	Regional rank change 2017-2016
Belarus	1	32	7.55	1	32	7.29	0	0
Russian Federation	2	45	7.07	2	43	6.91	-2	0
Kazakhstan	3	52	6.79	3	51	6.72	-1	0
Moldova	4	59	6.45	5	63	6.21	4	1
Azerbaijan	5	65	6.20	4	60	6.25	-5	-1
Georgia	6	74	5.79	6	73	5.59	-1	0
Armenia	7	75	5.76	7	74	5.56	-1	0
Ukraine	8	79	5.62	8	78	5.31	-1	0
Uzbekistan	9	95	4.90	9	103	4.48	8	0
Kyrgyzstan	10	109	4.37	10	110	4.06	1	0
Average			**6.05**			**5.84**		

Note: Georgia exited CIS on 18 August 2009 but is included in the ITU BDT administrative region for the CIS countries.
Source: ITU.

highest and lowest ranking countries). Only one country in the region, Belarus, falls within the high quartile of the IDI for 2017, while a second, the Russian Federation, has slipped from this quartile into top position in the upper-middle quartile, joining six other countries in the region. Two countries (Uzbekistan and Kyrgyzstan) fall into the lower-middle quartile, but the region includes no LCCs.

All but three countries in the region enjoyed improvements in their IDI values over the year that were above the global average of 0.18 points. The most dynamic countries in the region, by IDI ranking and value, are identified in Table 3.11. The biggest improvements were made by Uzbekistan (up 0.42 points), Kyrgyzstan and Ukraine (both up 0.31 points). Azerbaijan, which experienced a fall of 0.05 points, was the only country to drop a position in the regional rankings, being overtaken by Moldova. The biggest improvements in the access sub-index were made by Uzbekistan and Moldova, and in the use sub-index by Uzbekistan and Kyrgyzstan.

As in most other regions, the most substantial rate of improvement for any individual indicator in the CIS region was that for mobile-broadband subscriptions, which rose by an average of 31.9 per cent over the year. This indicator rose most substantially – by over 175 per cent – in Ukraine, and also by substantial levels in Kyrgyzstan and Armenia. In Uzbekistan, there was also significant growth in the indicators for fixed-broadband and mobile-cellular subscriptions, and for international Internet bandwidth per Internet user.

Chart 3.10 presents spider diagrams that illustrate the performance of the countries at the top, midpoint and bottom of the regional distribution in the upper row, and the most dynamic countries in the region by IDI value in the lower.

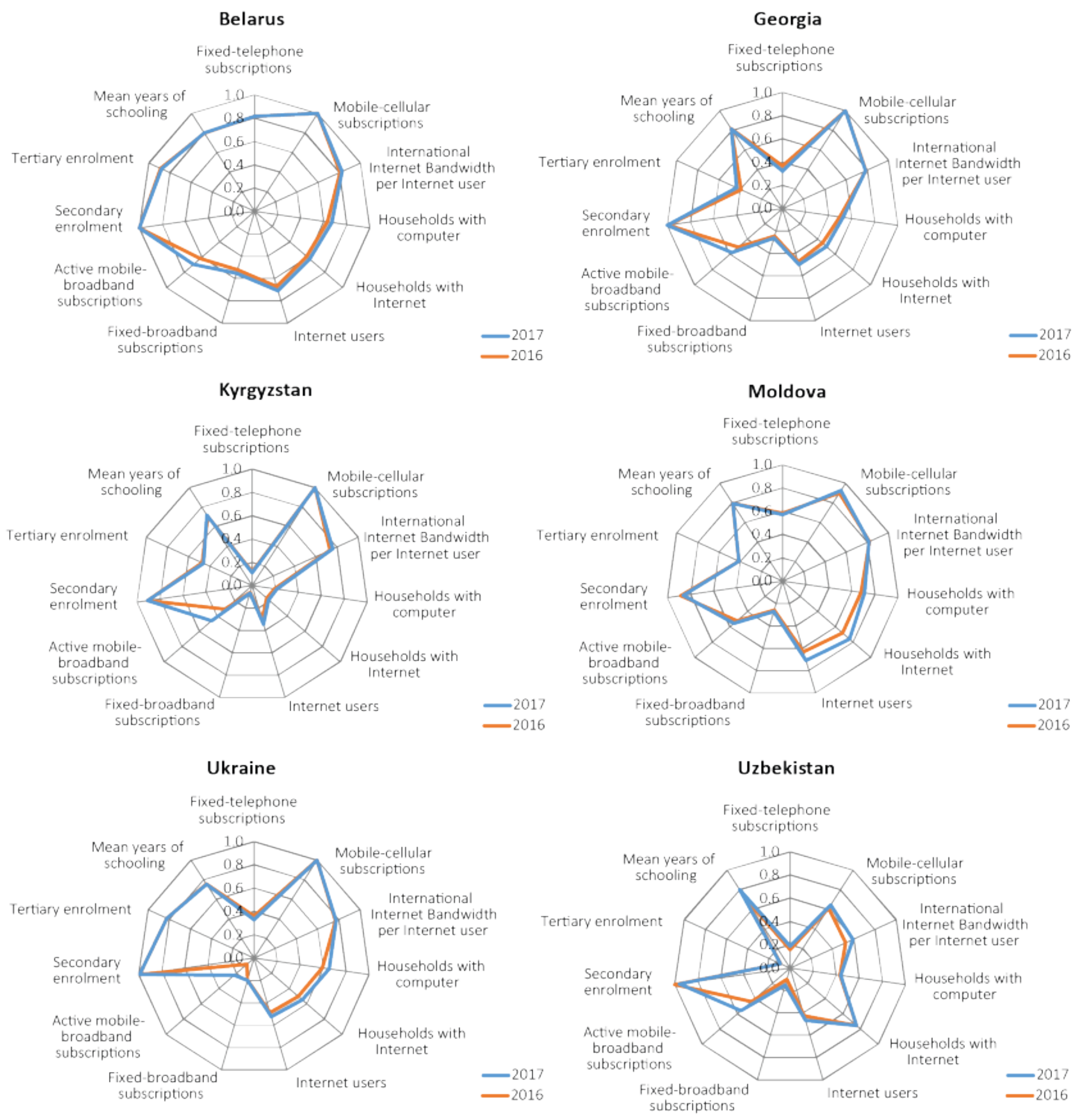
Table 3.11: Most dynamic countries by IDI ranking and IDI value, CIS region, 2016–2017

Change in IDI ranking				Change in IDI value (absolute)			
IDI rank 2017	Rank region	Country	IDI rank change	IDI rank 2017	Rank region	Country	IDI value change
95	9	Uzbekistan	8	95	9	Uzbekistan	0.42
59	4	Moldova	4	109	10	Kyrgyzstan	0.31
109	10	Kyrgyzstan	1	79	8	Ukraine	0.31
32	1	Belarus	0	32	1	Belarus	0.26
				59	4	Moldova	0.25

Source: ITU.

The spider diagrams in Chart 3.10 illustrate the relative homogeneity of IDI performance in the CIS region. Belarus is the only country illustrated which shows the characteristically rounded form of countries near the top of the overall distribution, which score relatively highly on all

Chart 3.10: IDI values, selected countries, CIS region, IDI 2017 and IDI 2016



Note: Georgia exited CIS on 18 August 2009 but is included in the ITU BDT administrative region for the CIS countries.
Source: ITU.

indicators, though its indicator values are notably lower than those of the top-ranking countries in the Asia and the Pacific and Europe regions. Belarus has by far the largest fixed-broadband uptake in the region, at 33 subscriptions per 100 inhabitants. The fixed-broadband market in Belarus is highly concentrated, with over 75 per cent of the subscriptions belonging to the publicly-owned incumbent Beltelecom (see Belarus profile available in volume 2). Belarus also stands out for the high fixed-telephone penetration (49 subscriptions per 100 inhabitants), which has been stable in recent years.

Moldova, which is near the top of the upper-middle quartile, shows some of the same characteristics but notably lower values in fixed-telephone and fixed-broadband subscriptions, and in tertiary enrolment. Its weaker performance in terms of fixed connections is also demonstrated by the charts for Georgia[4] and Ukraine, which rank further down the upper-middle quartile, and particularly by Uzbekistan and Kyrgyzstan, which are in the lower-middle quartile. However, these two countries demonstrate much higher IDI values than do countries in the LCC quartile.

Among these countries, Belarus shows noticeably improved performance for all of the access and use indicators other than fixed-telephone subscriptions, where it showed a marginal fall, and mobile-cellular subscriptions, where it showed a small increase. The biggest improvements in Moldova came from the indicators for Internet users and households with Internet access. In the other four countries illustrated, mobile-broadband subscriptions have led the way, though with contributions from other indicators.

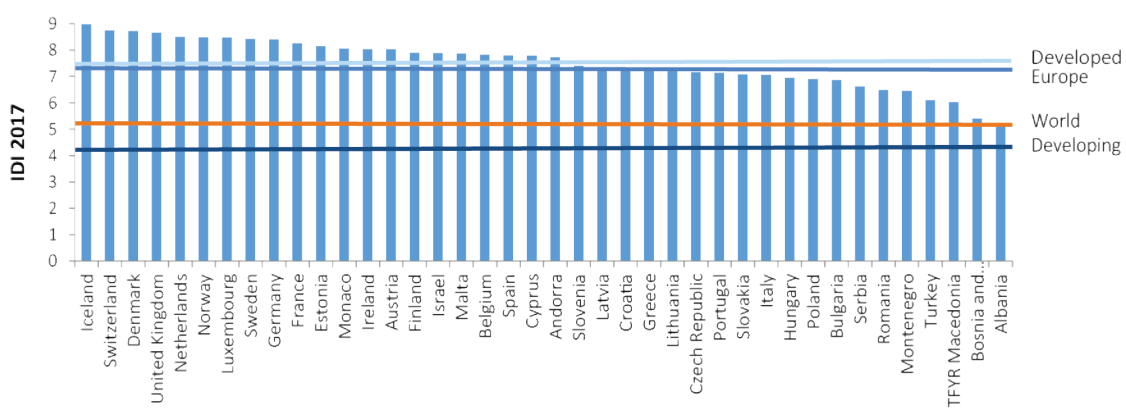
Uzbekistan was the most dynamic country in the region in terms of both IDI value and ranking. Like most dynamic countries in other regions, it increased its performance in the use sub-index (up 22 per cent) more significantly than its performance in the access sub-index. These improvements were driven, in turn, by significant improvements in mobile-broadband and mobile-cellular subscriptions, but the country also enjoyed significant improvements in fixed-broadband and fixed-telephone subscriptions, and in the proportion of Internet users. Five MNOs compete in Uzbekistan's mobile market and their focus is progressively shifting from regular mobile service to mobile broadband. Indeed, the five MNOs have launched LTE services and they are expanding 3G and LTE coverage in the country, which reached 45 and 17 per cent of the population respectively. The reallocation of the 900/1800 MHz radio frequency bands in the first half of 2017 is expected further to boost LTE deployment (see Uzbekistan profile available in volume 2).

Europe

IDI values and rankings for the Europe region are set out in Chart 3.11 and Table 3.12, where they are compared with the global average and with averages for developed and developing countries.

Europe is the region with the highest average value in IDI 2017, 7.50 points, an improvement of 0.16 points on IDI 2016. This is just below the average value of 7.52 for developed countries. Every country in the region has an IDI value above the global average, while only one (Albania) is (just) within the lower half of the global distribution. As

Chart 3.11: IDI values, Europe region, IDI 2017



Source: ITU.

Table 3.12: IDI rankings and values, Europe region, IDI 2017 and IDI 2016

Economy	Regional rank 2017	Global rank 2017	IDI 2017	Regional rank 2016	Global rank 2016	IDI 2016	Global rank change 2017-2016	Regional rank change 2017-2016
Iceland	1	1	8.98	1	2	8.78	1	0
Switzerland	2	3	8.74	3	4	8.66	1	1
Denmark	3	4	8.71	2	3	8.68	-1	-1
United Kingdom	4	5	8.65	4	5	8.53	0	0
Netherlands	5	7	8.49	8	10	8.40	3	3
Norway	6	8	8.47	5	7	8.45	-1	-1
Luxembourg	7	9	8.47	7	9	8.40	0	0
Sweden	8	11	8.41	6	8	8.41	-3	-2
Germany	9	12	8.39	9	13	8.20	1	0
France	10	15	8.24	11	17	8.05	2	1
Estonia	11	17	8.14	10	14	8.16	-3	-1
Monaco	12	19	8.05	12	18	8.03	-1	0
Ireland	13	20	8.02	13	19	7.90	-1	0
Austria	14	21	8.02	17	24	7.70	3	3
Finland	15	22	7.88	14	21	7.83	-1	-1
Israel	16	23	7.88	15	22	7.71	-1	-1
Malta	17	24	7.86	18	25	7.65	1	1
Belgium	18	25	7.81	16	23	7.70	-2	-2
Spain	19	27	7.79	19	27	7.61	0	0
Cyprus	20	28	7.77	21	31	7.30	3	1
Andorra	21	30	7.71	20	28	7.58	-2	-1
Slovenia	22	33	7.38	22	33	7.20	0	0
Latvia	23	35	7.26	25	40	7.05	5	2
Croatia	24	36	7.24	27	42	6.96	6	3
Greece	25	38	7.23	23	38	7.08	0	-2
Lithuania	26	41	7.19	26	41	6.97	0	0
Czech Republic	27	43	7.16	24	39	7.06	-4	-3
Portugal	28	44	7.13	28	44	6.88	0	0
Slovakia	29	46	7.06	30	47	6.84	1	1
Italy	30	47	7.04	29	46	6.84	-1	-1
Hungary	31	48	6.93	31	49	6.74	1	0
Poland	32	49	6.89	32	50	6.73	1	0
Bulgaria	33	50	6.86	33	53	6.66	3	0
Serbia	34	55	6.61	34	55	6.51	0	0
Romania	35	58	6.48	36	61	6.23	3	1
Montenegro	36	61	6.44	35	56	6.30	-5	-1
Turkey	37	67	6.08	38	72	5.66	5	1
TFYR Macedonia	38	69	6.01	37	68	5.88	-1	-1
Bosnia and Herzegovina	39	83	5.39	39	81	5.23	-2	0
Albania	40	89	5.14	40	89	4.90	0	0
Average			**7.50**			**7.34**		

Source: ITU.

many as 28 of the region's 40 countries fall into the highest quartile, while the region takes up 7 of the top 10 – and 9 of the top 12 – positions in the global rankings. One of these countries, Iceland, has moved above the Republic of Korea to the top of the global rankings.

As in previous years, most of the highest positions in the regional rankings are occupied by countries in Northern and Western Europe, with the five Nordic countries – Denmark, Finland, Iceland, Norway and Sweden – ranked particularly highly. All but one of the positions in the lower half of the regional distribution are occupied by countries on the Mediterranean and in Eastern Europe.

Although all but one country in the region (Estonia) has improved its IDI value over the year, there have been some significant movements in the regional rankings as a result of differences in performance. Switzerland has moved above Denmark to second place within the region, while the Netherlands has moved up three places, from eighth to fifth. France has moved above Estonia to tenth position in the region. Other significant gains in ranking were made by Austria (up three places to 14th) and Croatia (up three places to 24th).

The most dynamic countries in the region, by IDI ranking and value, are identified in Table 3.13.

The average improvement over the year in the Europe region was just below the global average improvement (0.16 versus 0.18 points), but there were significant variations between countries. The average increase in the use sub-index in Europe was much more substantial (an average of 0.32 points) than the increase in the access or skills sub-indices (0.07 and 0.05 points respectively), reflecting the fact that many countries in the region already have very high values for some access and skills indicators. At least partly for the same reason, the average improvement was higher in the lower half of the regional distribution (0.20 points) than in the upper half (0.13).

The most substantial improvements in IDI value were therefore, not surprisingly, mostly recorded by countries in the lower half of the regional distribution, headed by two of the region's three developing countries: Cyprus, which improved its IDI value by 0.47 points; and Turkey, which improved that value by 0.43 points. Cyprus' improvement was almost entirely attributable to a 15 per cent increase in its value for the use sub-index, led by the indicator for mobile-broadband but supplemented by improvements in those for fixed-broadband and Internet users.

Turkey's 18 per cent rise in use sub-index value was similarly driven, but it had a notable improvement also in the proportion of households with Internet access in the access sub-index.

The most substantial improvement in the access sub-index was recorded by Turkey, at 0.19 points, followed by Romania, Poland and Montenegro. Cyprus and Turkey recorded the biggest increases in the use sub-index, at 0.98 points and 0.75 points respectively, followed by Austria, Albania, Slovakia and Romania.

Average rates of improvement for individual indicators tend to be lower in Europe than in other regions because of the high starting point for each indicator in countries close to the top of the overall distribution. It should be noted, however, that highly developed countries in Europe are experiencing other improvements in ICT access and usage, such as the introduction of very high fixed-broadband speeds and the widespread use of cloud computing driving higher data volumes, which are not included in the current IDI but are also affecting their overall ICT performance. These advanced capabilities may tend to exacerbate

Table 3.13: Most dynamic countries by IDI ranking and IDI value, Europe region, 2016–2017

Change in IDI ranking				Change in IDI value (absolute)			
IDI rank 2017	**Rank region**	**Country**	**IDI rank change**	**IDI rank 2017**	**Rank region**	**Country**	**IDI value change**
36	24	Croatia	6	28	20	Cyprus	0.47
35	23	Latvia	5	67	37	Turkey	0.43
67	37	Turkey	5	21	14	Austria	0.32
7	5	Netherlands	3	36	24	Croatia	0.28
21	14	Austria	3	58	35	Romania	0.250
28	20	Cyprus	3	44	28	Portugal	0.247
50	33	Bulgaria	3				
58	35	Romania	3				

Source: ITU.

gaps in performance between more- and less-connected countries.

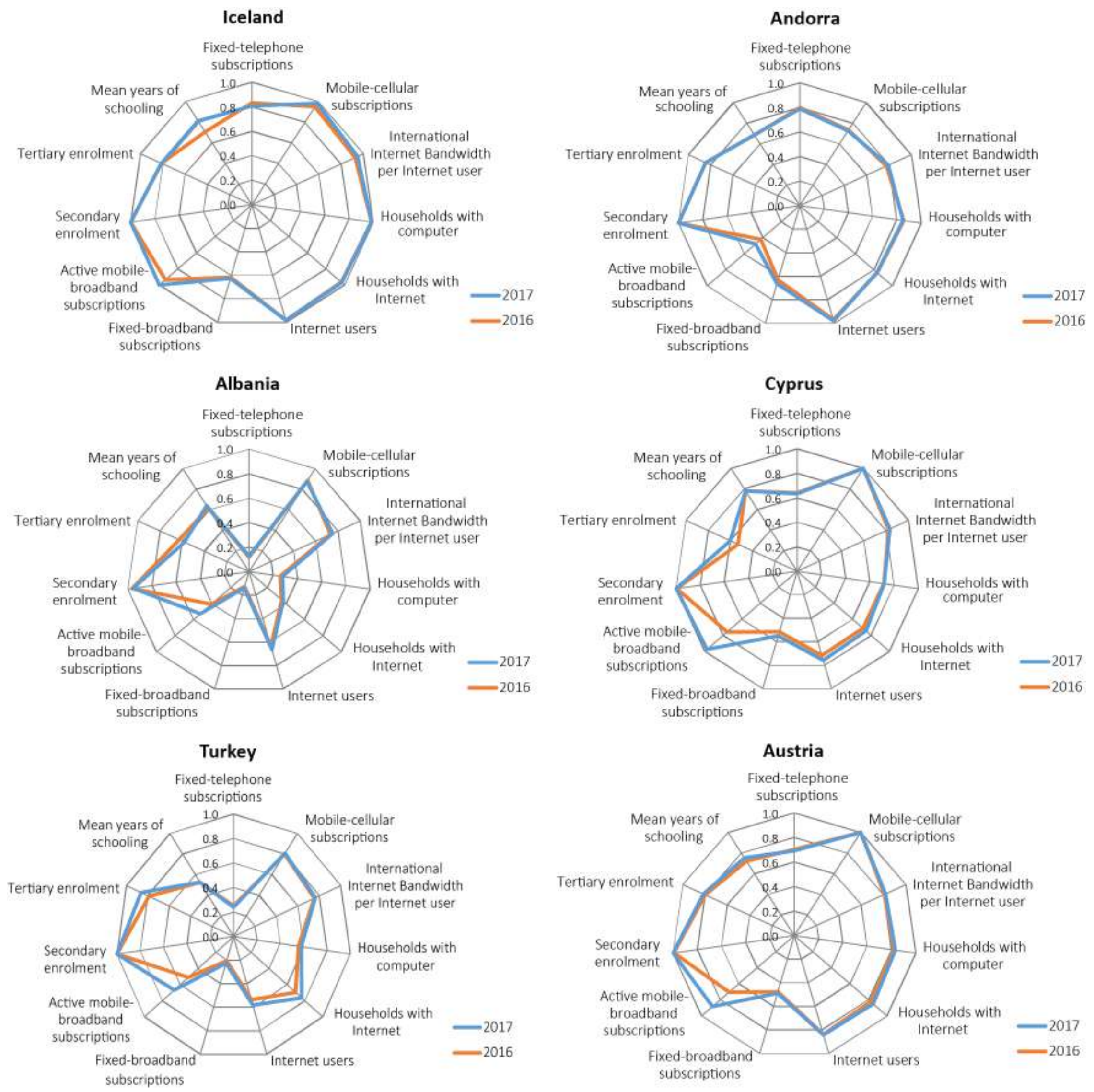
As elsewhere, the highest rate of improvement occurred with the mobile-broadband indicator. The highest improvement rates in mobile-broadband subscriptions occurred in Turkey, Albania, Austria and Cyprus, driving those countries' more dynamic performance overall. At the top end of the distribution, six countries in the region recorded mobile-broadband subscription rates of more than 100 per 100 population (Finland, Sweden, Denmark, Estonia, Switzerland and Norway). Only 8 of the 40 countries in the region recorded increases in fixed-telephone subscriptions, though all but one recorded increases in fixed-broadband subscriptions.

Levels of Internet access and use are particularly high in some European countries. More than 90 per cent of households were reported to have computers and Internet access in Denmark, Germany, Iceland, Luxembourg and Norway, with Iceland recording figures above 95 per cent for both these indicators and for the proportion of Internet users in the population.

Chart 3.12 presents spider diagrams that illustrate the performance of the countries at the top, midpoint and bottom of the regional distribution in the upper row, and the most dynamic countries in the region by IDI value in the lower.

Chart 3.12 illustrates the generally high levels of IDI performance that are prevalent in Europe.

Chart 3.12: IDI values, selected countries, Europe region, IDI 2017 and IDI 2016



Source: ITU

Iceland, which heads the global rankings, has high performance levels across the board, though it falls significantly behind the Republic of Korea, which is second in the global rankings, in the skills sub-index. Iceland's scope for future improvements within the current set of indicators lies with fixed-broadband subscriptions, where it ranks only 12th in Europe. The chart for the small mountain country of Andorra, which ranks at the midpoint in Europe, shows a pattern broadly similar to that for Iceland but with lower outcome scores, particularly for active mobile-broadband subscriptions. The chart for the lowest-ranking country in the region, Albania, is marked by low scores (in regional terms) for fixed-telephone and fixed-broadband subscriptions, and for households with a computer (where its outcome figures are less than half those of any other country in the region), but is still much stronger than that for the lowest-ranking countries in other regions.

The three dynamic countries illustrated in Chart 3.12 include two of the region's three developing countries, Cyprus and Turkey, as well as Austria. All three of these countries have experienced their highest rates of improvement during the year in mobile-broadband subscriptions. Developments in Cyprus' mobile market were fuelled by the entry of the third MNO in 2016, which has led to aggressive promotions and an overall shift towards mobile data packages and post-paid contracts. In parallel, 3G and LTE network coverage was significantly extended in 2016, reaching 100 per cent and 73 per cent respectively of the population.

In Turkey, the launch of LTE-Advanced services in 2016 has prompted operators to capitalize the new technology by attracting customers to mobile-broadband plans with convenient data offers and handset subsidies. As a result, not only has the number of mobile-broadband subscriptions increased by 32 per cent, but also the mobile data traffic per subscriptions has grown by 50 per cent. Turkey's comparatively low scores for fixed-telephone and fixed-broadband subscriptions result in a less-consistent overall performance than those in the other countries in Chart 3.12, other than Albania, but Turkey has shared the improvement seen in Internet users and households with Internet access that is evident in many other middle-income developing countries.

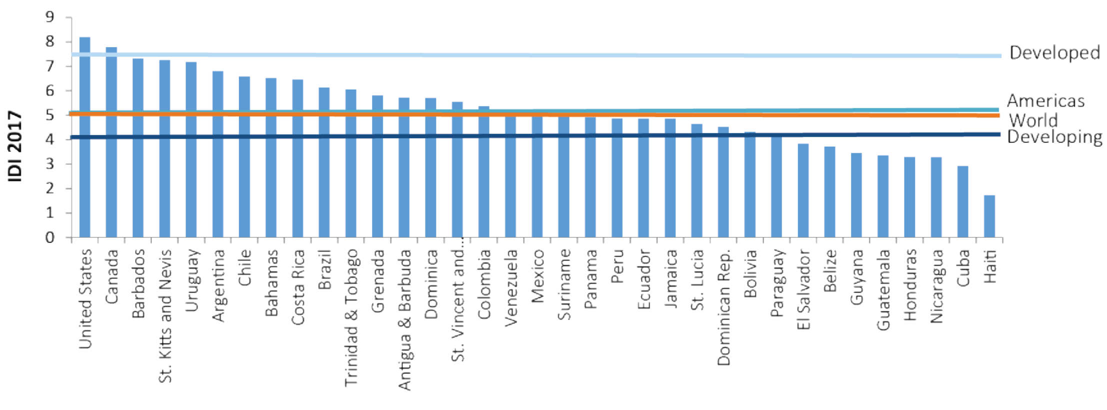
The Americas

IDI values and rankings for the Americas region are set out in Chart 3.13 and Table 3.14, where they are compared with the global average and with averages for developed and developing countries.

The Americas region, like Asia and the Pacific, is highly diverse, including two high-income developed countries in North America, large middle-income developing countries in Mexico and South America, and smaller developing countries and small island States in Central America and the Caribbean. The average improvement in IDI value in this region during the year, 0.20 points, was slightly above the global average. No country moved up or down the regional rankings by more than three positions.

At the top of the rankings are the region's two large developed countries, the United States and Canada. These both rank within the

Chart 3.13: IDI values, Americas region, IDI 2017



Source: ITU.

Table 3.14: IDI rankings and values, Americas region, IDI 2017 and IDI 2016

Economy	Regional rank 2017	Global rank 2017	IDI 2017	Regional rank 2016	Global rank 2016	IDI 2016	Global rank change 2017-2016	Regional rank change 2017-2016
United States	1	16	8.18	1	15	8.13	-1	0
Canada	2	29	7.77	2	26	7.64	-3	0
Barbados	3	34	7.31	4	37	7.11	3	1
St. Kitts and Nevis	4	37	7.24	3	35	7.18	-2	-1
Uruguay	5	42	7.16	5	48	6.75	6	0
Argentina	6	51	6.79	6	52	6.68	1	0
Chile	7	56	6.57	9	59	6.28	3	2
Bahamas	8	57	6.51	8	58	6.29	1	0
Costa Rica	9	60	6.44	7	57	6.29	-3	-2
Brazil	10	66	6.12	10	67	5.89	1	0
Trinidad & Tobago	11	68	6.04	12	71	5.71	3	1
Grenada	12	73	5.80	14	77	5.39	4	2
Antigua & Barbuda	13	76	5.71	13	76	5.48	0	0
Dominica	14	77	5.69	11	69	5.76	-8	-3
St. Vincent and the Grenadines	15	82	5.54	15	80	5.27	-2	0
Colombia	16	84	5.36	17	84	5.12	0	1
Venezuela	17	86	5.17	16	82	5.22	-4	-1
Mexico	18	87	5.16	18	90	4.87	3	0
Suriname	19	88	5.15	20	94	4.77	6	1
Panama	20	94	4.91	19	93	4.80	-1	-1
Peru	21	96	4.85	22	97	4.61	1	1
Ecuador	22	97	4.84	24	101	4.52	4	2
Jamaica	23	98	4.84	21	96	4.63	-2	-2
St. Lucia	24	104	4.63	23	99	4.53	-5	-1
Dominican Rep.	25	106	4.51	25	107	4.26	1	0
Bolivia	26	112	4.31	27	115	3.84	3	1
Paraguay	27	113	4.18	26	111	4.02	-2	-1
El Salvador	28	119	3.82	28	117	3.62	-2	0
Belize	29	120	3.71	29	120	3.54	0	0
Guyana	30	124	3.44	30	121	3.44	-3	0
Guatemala	31	125	3.35	31	125	3.19	0	0
Honduras	32	129	3.28	32	126	3.14	-3	0
Nicaragua	33	130	3.27	33	132	2.85	2	0
Cuba	34	137	2.91	34	135	2.80	-2	0
Haiti	35	168	1.72	35	168	1.63	0	0
Average			**5.21**			**5.01**		

Source: ITU.

top 30 countries worldwide, but fall behind developed countries in Europe and Asia, which have comparably high GNI per capita, primarily because of lower values for international Internet bandwidth per Internet user, household computer and Internet access, the proportion of Internet users in the population and lower fixed-broadband connectivity. The improvement in their IDI values during the year also fell below the global average.

Three other countries in the region fall within the high quartile of the global rankings – the Caribbean island States of Barbados and St. Kitts and Nevis, and Uruguay in South America, which has risen six places in the global rankings, from 48th to 42nd, after improving its IDI value by 0.41 points.

All but two of the remaining 30 countries in the region fall within the two middle quartiles of the global rankings. All but two of these (Dominica and Venezuela) improved their IDI value, with the most substantial gains being made by the Bolivia (up 0.47 points), Grenada (up 0.40 points), Suriname (up 0.38 points) and, near the bottom of the regional distribution, Nicaragua (up 0.42 points).

The two countries in this region that fall into the LCC quartile are Cuba (which ranks 137th in the global rankings) and the region's only LDC, Haiti (which ranks 168th). Cuba exhibits an unusual IDI profile, scoring relatively highly in the skills sub-index but registering the region's lowest scores for mobile-cellular subscriptions and international bandwidth in the access sub-index and for fixed-broadband subscriptions in the use sub-index (0.13 per 100 citizens against a regional average of 13.24 per cent). It also has a very low score for households with Internet access (7.5 per cent against a regional average of 44.62 per cent), and a score of zero for mobile-broadband access. However, Cuba showed significant improvements between IDI 2016 and IDI 2017, from these low levels, for all access and use sub-indicators.

The greatest improvements in value between IDI 2016 and IDI 2017 were made by the Bolivia, Nicaragua, Uruguay and Grenada. The greatest improvements in the access sub-index were made by smaller countries – Suriname, Bahamas, Cuba and Jamaica. The highest improvements in the use sub-index were made by the Bolivia and Uruguay in South America, Nicaragua in Central America and the Caribbean island State of St. Vincent and the Grenadines. Grenada's IDI improvement was driven by improvement in the skills sub-index.

The most dynamic countries in the region by IDI ranking and value are identified in Table 3.15.

As in most regions, the most dynamic growth of any indicator in the Americas occurred with the indicator for mobile-broadband subscriptions. The average for this indicator was distorted by the effective introduction of services in Haiti, whose score rose from 0.10 subscriptions per 100 population in IDI 2016 to 10.29 subscriptions in IDI 2017. Nicaragua also experienced a high rate of growth from a low starting point for this indicator, and there were high growth rates in the Bolivia, Trinidad and Tobago, and El Salvador. The highest growth rates for fixed-broadband subscriptions, in Cuba, Nicaragua and the Bolivia, likewise came from very low starting points in IDI 2016.

Chart 3.14 presents spider diagrams that illustrate the performance of the countries at the top, midpoint and bottom of the regional distribution in the upper row, and the most dynamic countries in the region by IDI value in the lower.

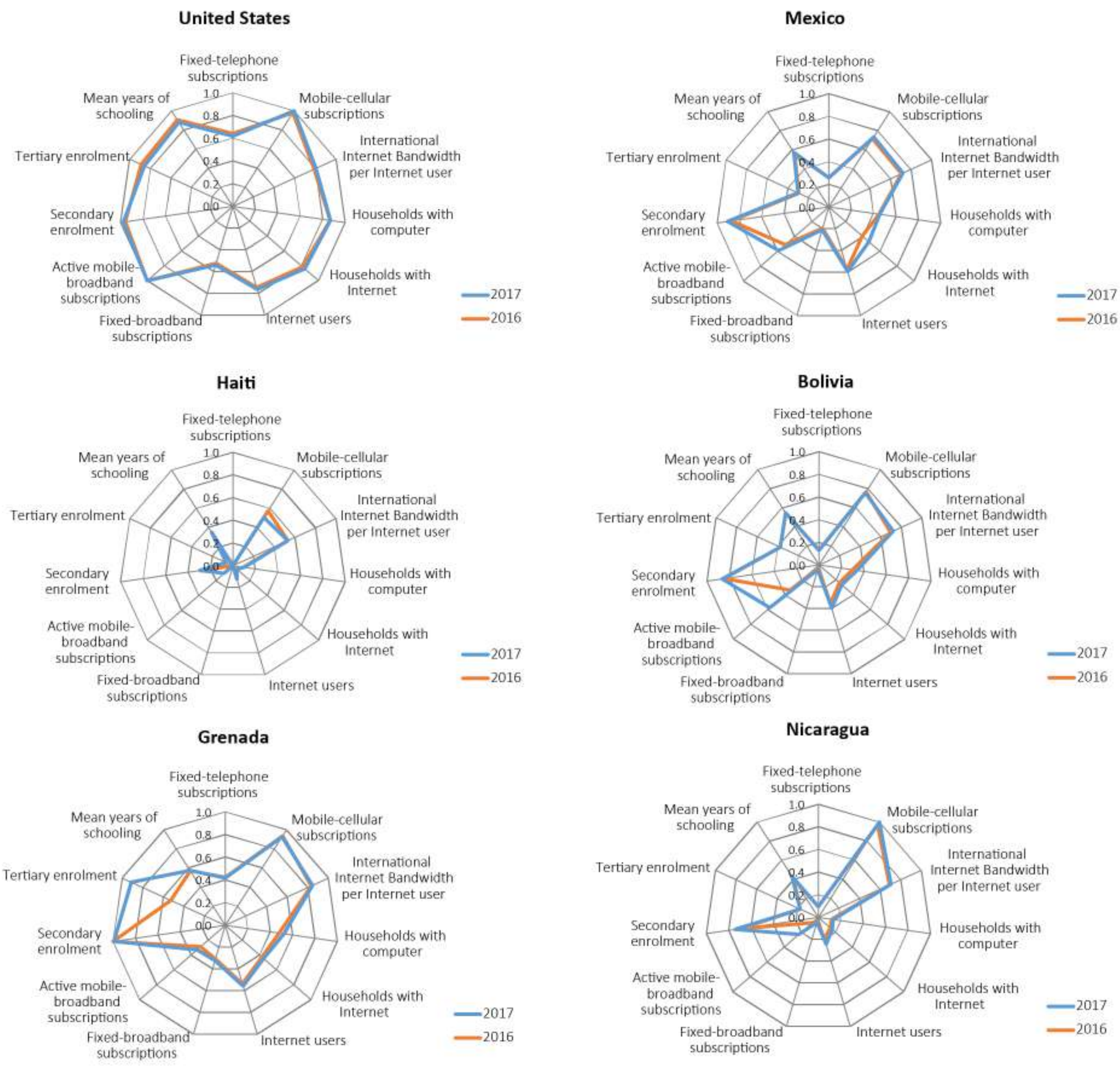
As Chart 3.14 shows, the range of IDI performance in the Americas is much wider than that in Europe, though only two countries in the region, Cuba and Haiti, fall into the LCC quartile. The chart for the United States shows the characteristic rounded shape for most developed countries, which have relatively high scores for all 11 indicators, though the country's performance is generally below that of leading European countries and the most connected countries in East Asia. Mexico's spider diagram is typical of many middle-income developing countries, with noticeably lower scores than developed countries for fixed-telephone and fixed-broadband penetration, and for tertiary

Table 3.15: Most dynamic countries by IDI ranking and IDI value, Americas region, 2016–2017

Change in IDI ranking				Change in IDI value (absolute)			
IDI rank 2017	Rank region	Country	IDI rank change	IDI rank 2017	Rank region	Country	IDI value change
42	5	Uruguay	6	112	26	Bolivia	0.47
88	19	Suriname	6	130	33	Nicaragua	0.42
73	12	Grenada	4	42	5	Uruguay	0.41
97	22	Ecuador	4	73	12	Grenada	0.40
34	3	Barbados	3	88	19	Suriname	0.38
56	7	Chile	3				
68	11	Trinidad & Tobago	3				
87	18	Mexico	3				
112	26	Bolivia	3				

Source: ITU.

Chart 3.14: IDI values, selected countries, Americas region, IDI 2017 and IDI 2016



Source: ITU.

enrolment. Haiti shows the typical characteristics of LDCs within the LCC quartile, scoring most strongly on the indicators for mobile-cellular penetration and international Internet bandwidth per Internet user, but very weakly on indicators for fixed connections, Internet use and skills.

There is some variation in the changes in performance of the three dynamic countries illustrated in the lower row of this chart. The shape of the diagrams for the Bolivia and Nicaragua is broadly similar, with relatively high performance in mobile-cellular subscriptions, international Internet bandwidth and secondary enrolment. Both countries saw substantial growth in their use sub-index values, by 41 per cent in the case of Bolivia and 73 per cent in that of Nicaragua. In both cases, as in many other dynamic countries, this was led by substantial growth in the number of mobile-broadband subscriptions per 100 citizens during the year. In Bolivia, operators are migrating customers from 2G to 3G networks, following an increase in investment and remarkable progress in the coverage of 3G and LTE networks, which now reach 74 and 61 per cent of the population respectively. In Nicaragua, the commercial launch of a third mobile operator in 2016 has boosted competition and contributed to the expansion of mobile-broadband coverage. Indeed, the licence granted to the new entrant included coverage obligations concerning remote areas in the country. In parallel, the two other MNOs launched

LTE services in 2015 and are in the process of rolling out LTE networks. As a result of the coverage and competition developments, mobile-broadband uptake increased from 7 to 26 mobile-broadband subscriptions per 100 inhabitants in Nicaragua in 2016.

Mobile-broadband developments in Bolivia and Nicaragua have driven growth in the proportion of Internet users. In addition, Bolivia also improved significantly in households with a computer, and Nicaragua improved on mobile-cellular subscriptions.

3.3 Summary and conclusion

The IDI illustrates continued and persistent differences in ICT experience between different world regions. As discussed in Chapter 2, there is a strong correlation between economic development and IDI performance. The Europe region, which is economically more homogeneous than other regions, and largely composed of developed countries, has a much higher average IDI performance than the Asia and the Pacific, Arab States and Americas regions, which are more economically heterogeneous, including low- as well as high-income countries. The Africa region, which is also economically more homogeneous but composed largely of LDCs and other lower-income countries, has a much lower average performance than these other regions. From this low base, however, Africa also showed the highest proportional rate of improvement for the IDI as a whole and for all three sub-indices.

Each economy within the IDI faces different challenges, related to its geography, infrastructure requirements and social and economic structure, as well as the resources available to it. Policy interventions aimed at improving the ICT environment need to be tailored to those particular characteristics. Although there is a strong correlation between economic and IDI performance, as Chart 2.5 illustrates, the ICT sectors in some countries have been able to outperform expectations derived from their level of economic development.

This chapter has also identified countries which have achieved dynamic improvements in IDI values during the year between IDI 2016 and IDI 2017. The mobile-broadband market is driving most of these developments, which are in many cases triggered by regulatory and policy interventions. Indeed, the transition from 2G to 3G mobile services in some countries, as well as the transition from 3G to LTE or LTE-Advanced services in some other countries, is providing a window of opportunity for policy-makers to shake up the mobile market. For instance, the granting of licences to new operators and the redistribution of the 3G and LTE spectrum have had a disruptive effect in several countries highlighted as dynamic in this chapter and have led to more competition and higher mobile-broadband uptake. Moreover, coverage obligations attached to the new licences have proved to be an efficient way to extend 3G and LTE network coverage to rural areas, particularly in those countries where market forces by themselves had not previously reached universal mobile-broadband coverage.

Operators have also played an important role in driving the impetus underpinning the developments seen in the mobile-broadband market. Some examples of successful operator-led initiatives observed in the dynamic countries include the aggressive promotions launched by some new entrants, most of them centred on data plans, and the large migration of customers from 2G to 3G services undertaken by some incumbents. Furthermore, high growth in mobile-broadband subscriptions in some countries with moderate penetration rates has acted as a stimulus for operator investment in the sector, thus creating a virtuous circle and driving further mobile-broadband subscription growth.

The successful experiences of the countries that have achieved higher rates of ICT development can help policy-makers and businesses elsewhere as they pursue better ICT performance which can, in turn, contribute towards sustainable economic and social development within their countries.

Endnotes

1 The countries included in each regional grouping of the ITU Telecommunication Development Bureau (BDT) are listed at http://www.itu.int/en/ITU-D/Statistics/Pages/definitions/regions.aspx . Palestine is not an ITU Member State; the status of Palestine in ITU is the subject of Resolution 99 (Rev. Busan, 2014) of the ITU Plenipotentiary Conference.

2 For an example of how the entry of new players may affect mobile uptake, see the case of Costa Rica discussed in Box 2.5 of Measuring the Information Society Report 2013 (ITU, 2013).

3 In Bahrain, fixed-broadband subscriptions decreased from 22.5 to 16.8 per 100 inhabitants in the period 2013–2016. This equates to a compound annual growth rate of minus 9.3 per cent.

4 Georgia exited CIS on 18 August 2009 but is included in the ITU BDT administrative region for the CIS countries.

Chapter 4. Emerging ICT trends

Key findings

Concurrent advances in the Internet of Things (IoT), big data analytics, cloud computing and artificial intelligence (AI) will enable tremendous innovations and fundamentally transform business, government, and society. This revolution will unfold over the coming decades with opportunities, challenges, and implications that are not yet fully known. To harness these benefits, countries will need to create conditions supportive to the deployment of next-generation network and service infrastructures. They will also have to adopt policies that are conducive to experimentation and innovation, while mitigating potential risks to information security, privacy, and employment. Equally important, internationally comparable indicators are needed to track the growth and impact of these emerging ICT trends.

The Internet of Things will greatly expand the digital footprint. In addition to people, organizations and information resources, it will connect objects equipped with digital information sensing, processing, and communication capabilities. This ubiquitous infrastructure will generate abundant data that can be used to achieve efficiency gains in the production and distribution of goods and services, and improve human life in innovative ways.

Big data analytics will extract useful knowledge from digital information flows. It will enable us to better describe, understand and predict developments and to improve management and policy decisions. Making sense of proliferating information requires a workforce with appropriate analytical, computational and methodological skills, as well as a high-capacity ICT infrastructure.

Cloud and other architectures will lower the entry barriers to scalable computing resources. They are starting to deliver flexible and on-demand computational services over the Internet, lowering the fixed costs of ICT infrastructure, to the benefit of small and medium-sized organizations. Realizing their full potential will depend on the availability of reliable fixed and mobile broadband connectivity.

Artificial intelligence will help human beings to make better decisions. In order to achieve this objective, every algorithm needs to be tailored carefully to existing data and the objectives pursued. This requires considerable human expertise in machine learning and large datasets to train algorithms.

Advanced ICTs, such as IoT, big data analytics, cloud computing and AI, contribute to realizing the Sustainable Development Goals (SDGs). Promising applications exist in areas such as manufacturing, precision agriculture, government, education, health care, smart cities, and smart transportation. As part of broader initiatives, ICTs can contribute to achieving each of the 17 SDGs.

Harnessing the benefits of advanced ICTs requires appropriate infrastructures, services, and skills. Networks will have to support diverse quality-of-service demands from applications and users while delivering robust and ubiquitous connectivity. This will require roll-out of wireless IoT platforms, reliance on network virtualization and improved fibre connectivity. Moreover, it will require the development of advanced ICT skills among users.

Advanced ICTs raise concerns over next-generation digital divides. Network operators and users will have to adapt their business models to take advantage of the opportunities of the digital transformation. Policy-makers and regulators are called upon to create conditions facilitating entrepreneurial experiments and innovation. Policy will also have to mitigate challenges in the areas of information security, privacy, employment and income inequality.

Advanced ICTs can be adapted to specific local and national needs. Low entry barriers to many parts of the digital economy empower local entrepreneurs to develop innovative business models adapted to local conditions. It will be important to facilitate the development of culturally sensitive human-centred algorithms and applications.

Reliable and meaningful measurements of the deployment and use of advanced ICTs are critical. Fully harnessing the potential benefits of advanced ICTs requires reliable and meaningful metrics that go beyond existing data. This will require collaboration among various stakeholders and novel approaches to harvesting information from digital infrastructures and applications directly.

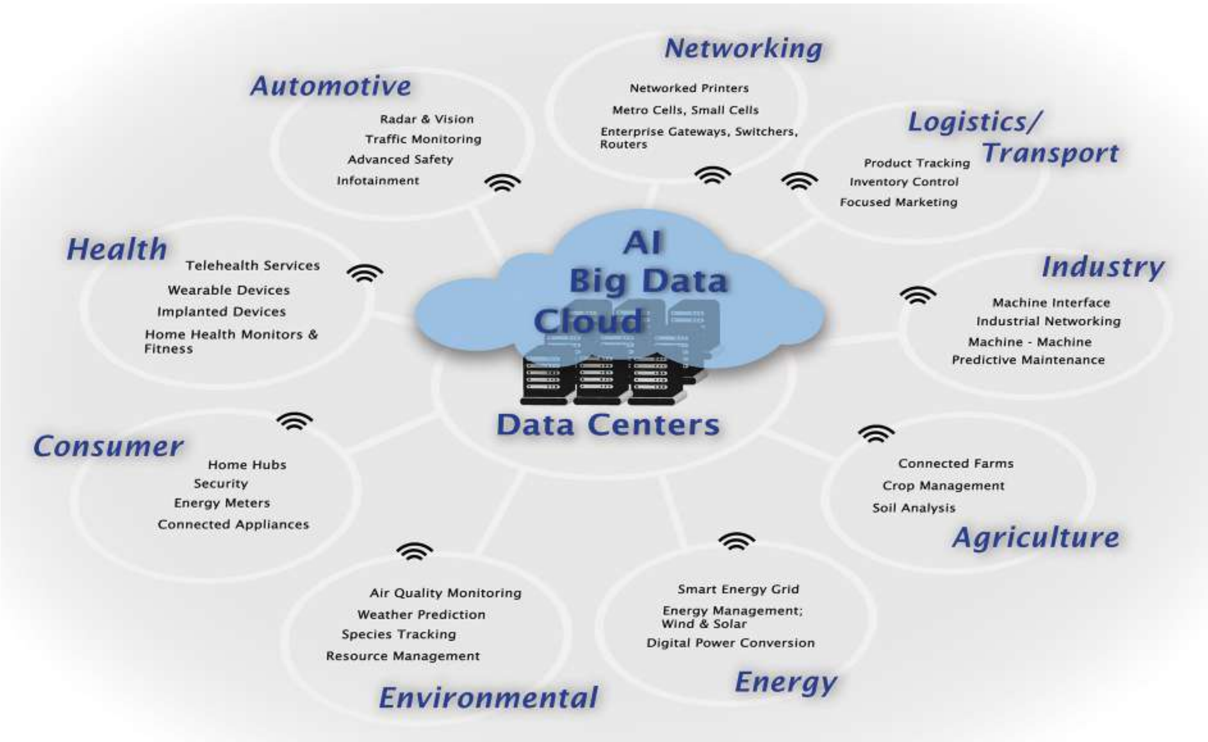
Chapter 4. Emerging ICT trends

4.1 Introduction

The world is at the cusp of another digital revolution that will accelerate changes to business, government and society. This transformation will unfold over the coming decades with opportunities, challenges and implications that are not yet fully known. Four key developments — the Internet of Things (IoT), cloud computing, big data analytics and artificial intelligence — together with advances in information and communication technologies (ICTs), are at the heart of these developments. As illustrated in Figure 4.1, when these technologies are appropriately deployed and used, they enable a plethora of fundamental innovations that serve as the basis for new products and services, with tremendous benefits for individuals and society. At the same time, they will deeply alter the process and organization of production and distribution of goods and services. Often referred to as the "Second Machine Age" (Brynjolfsson and McAfee, 2014) or the "Fourth Industrial Revolution" (Schwab, 2016), ICTs not only enhance technological capabilities, they also change the way humans, technology, businesses and society interact.[1] If their potential is realized, they will allow productivity increases that go beyond the contributions of ICTs during the past decades (Cardona et al., 2013; Corrado and Van Ark, 2016; Gordon, 2016). Because the four developments are closely intertwined and complement each other, their benefits can be more fully harnessed if they are used jointly.

As part of broader policy initiatives, these technologies will be instrumental in advancing the Sustainable Development Goals (SDGs) adopted in September 2015 by the United Nations as part of the 2030 Agenda for Sustainable Development (Earth Institute and Ericsson, 2016; Hilbert, 2016; Hilbert et al., 2016; United Nations, 2015). Taking advantage of these tremendous opportunities requires not only access to infrastructure, devices and software, it is also contingent on the availability of complementary skills and institutional arrangements (World Bank, 2016).

Figure 4.1: IoT, cloud computing, big data and artificial intelligence – the new drivers of the ICT ecosystem



Source: ITU.

At the same time, the all-encompassing nature and ubiquitous use of advanced ICTs create new concerns for individuals and society, ranging from threats to information security and violations of privacy to surveillance and control by private and public organizations. Consequently, stakeholders worldwide are re-evaluating their approaches to information and communication policy, and integrating them in new ways with broader initiatives toward the digital economy (ITU, 2016c).

This chapter begins with a brief overview of the four technological developments, their economic and societal repercussions, and their potential contribution to advancing the SDGs. It proceeds with a more detailed exposition of the main drivers of IoT, cloud computing, big data analytics and artificial intelligence. The third section reviews the state of adoption of these technologies, their use, and major ongoing developments on a global scale and in Telecommunication Development Bureau (BDT) regions. The fourth section focuses on the policy challenges, and sketches policy lessons that can be drawn from the experience with advanced ICTs and best practices. The fifth section discusses a framework for collection and curation of metrics documenting the current changes, with the goal of providing a better evidentiary basis for decision-makers. The chapter concludes with a summary of the main points.

4.1.1 An overview of key technological trends

Four interrelated technological developments are further transforming the information society: the emergence of IoT, cloud computing, big data analytics and artificial intelligence (ITU, 2014, 2015; OECD, 2016). Research on and early development of these technologies dates back decades but they have now reached a level of maturity that allows their wide deployment and use (ITU, 2005; McAfee and Brynjolfsson, 2017). IoT will expand digital connectivity beyond people, organizations and information resources to objects equipped with digital information sensing, processing and communication capabilities. Connected objects could include household appliances (e.g. refrigerators, washing machines and thermostats), wearable devices (e.g. fitness monitors and health monitoring devices), machines (e.g. jet engines, cars and automated production plants) and devices to monitor the environment (e.g. agricultural, traffic, environmental and weather monitoring sensors). These devices will generate large quantities of data that can be utilized in new ways to effectuate efficiency gains in the production and distribution of goods and services, and spawn innovative new services.

A second key technological development, closely related to IoT, is the emergence of and stronger reliance on new distributed computing architectures, cloud computing being the fastest growing among these. Cloud computing delivers on-demand computing resources — including applications, platforms and infrastructure — flexibly and on a pay-for-use base over the Internet. Other concepts, such as fog and mist computing, are under discussion and may contribute to a further restructuring of the locus of computing. In combination with smart devices, computing resources are increasingly available and ubiquitously diffused, complementing the opportunities provided by IoT and big data analytics.

Data are often seen as one of the most valuable resources of the twenty-first century. Communications and information flows in digital networks leave detailed traces that can be analysed to better understand users, better manage the communications infrastructure and resources, and improve service quality. The deployment of sensors in the natural and human-made environment, and in machines and objects, creates additional detailed data that can be harvested and analysed. Human and machine-generated data are often unstructured, voluminous and dynamic. They do not speak on their own but need appropriate theoretical and methodological approaches to unlock the insights embedded in the data streams. Thus, big data analytics are a necessary complement to and precondition for IoT.

The proliferation and wide adoption of digital technology, and the emergence of the open Internet as a general connectivity platform, have greatly benefited content production and accelerated the amounts of information generated. In part, this is an artefact of different types of information representation – such as audio, video and images with much higher quality – but much is new information generated by individuals and organizations. The massive amounts of information available often exceed the capacity of traditional models and software packages to make sense of the ongoing processes and to make good decisions. Artificial intelligence and machine learning offer a solution to this dilemma of information overload by creating valuable insights from the torrents of data generated by people and objects. Advanced machine learning develops algorithms that enable computers to "learn without being explicitly programmed" (Samuel, 1959). This allows the design of machines that can replicate and often exceed the capabilities of humans. Such devices may act as intelligent agents that perceive their environment, learn from it to make decisions and take actions to maximize the likelihood of achieving desired outcomes (Marsland, 2015; McAfee and Brynjolfsson, 2017).[2]

4.1.2 The new ICT ecosystem

These technological developments are an integral part of a broader reorganization of the ICT ecosystem that has unfolded since the 1970s. Technology, business models, uses of ICTs, and public policy develop interdependently. Whether the benefits of ICTs, in general and regarding the SDGs, can be harvested fully depends on how well these drivers are aligned to evolve in a virtuous, mutually enforcing cycle. The heart of the digital revolution continues to be major technological advances in components, networking, devices and software. Exponential growth in the performance of semiconductors (as reflected, for example, in Moore's Law[3]) and similar performance increases in networking (as reflected in Cooper's Law of Spectral Efficiency[4]) have resulted in greatly decreased costs per unit of information processing and transportation.

The dramatic performance improvements expand the capabilities of ICTs and are reshaping value generation in the digital economy. They put new demands on providers of telecommunication services and content providers. Originally deployed on the Internet, Internet Protocol networking principles have been adopted for next-generation networks (NGNs). Wireless and wireline, fixed and mobile communications are increasingly integrated in a seamless, converged communication infrastructure. In contrast to the specialized networks of the past (e.g. voice, data, audio and video), the Internet and NGNs are designed as general-purpose technology, suited to support a wide range of services and applications (Bresnahan and Trajtenberg, 1995). Much of the intelligence on the Internet is located on the logical edges of the network rather than in its core. This unique network architecture, epitomized in the end-to-end principle and the modular design, greatly facilitates innovation within the modules and on the edges of the network (Greenstein, 2015; Van Schewick, 2010; Yoo, 2012). In the emerging ICT ecosystem, this arrangement may change again in a process of integration and differentiation, in which the locations of resources and functions are distributed in new ways, dependent on costs, functions, services and user needs.

Exponential performance increases have greatly expanded the diversity of networked devices, ranging from simple handsets to tablets, wearable devices and many types of sensors and actuators. Rapid cost decreases have allowed the development and production of affordable end-user devices. Consequently, smart handsets are increasingly available in low- and middle-income countries and for groups of the population with tighter budget constraints. The widespread adoption of more capable devices and networks has enabled new services and applications. Lower costs and a broader range of applications and services have stimulated increasing uses. In turn, higher user demand and efficiency gains support new business models based on innovative pricing and revenue models, which have further expanded the number of subscribers of mobile and fixed communication services. This virtuous cycle was further accelerated by the abundance of computing infrastructure that was brought online as part of the rapid dot.com growth during the 1990s, thus paving the way for cloud computing. It also made available ample, cheap online storage resources for online content and applications.[5]

A third factor transforming the ICT ecosystem, related to and enabled by the other two, is the proliferation and rapid growth of content and applications on the Internet. Much of that content is user-generated, but much is also commercially produced. Global social media platforms such as Facebook, Twitter, Instagram, WhatsApp, Tencent's WeChat, as well as services with a more limited footprint, have built online platforms that allow users to share stories, images and videos. Each platform hosts massive amounts of commercial and user-uploaded videos.[6] Traditional media players, including television and radio stations, regularly stream their signals online in addition to making them available over the air or via satellite. New digital media players – such as Netflix, iTunes, Spotify, Deezer and numerous others – produce content specifically for online streaming, taking advantage of the flexibility of digital technology to design innovative business models. A new wave of entrepreneurs is experimenting with "communitainment", new forms of streamed media production, further expanding the amount and diversity of online content. As many of these services include a free tier and possibly zero-rated access, digital content is in high demand. Consequently, the traffic load of digital networks is increasingly dominated by video and real-time entertainment, although there are wide differences across regions.[7]

4.1.3 Implications for the ICT industry and public policy

These changes have accelerated the transformation of value generation in the digital economy. Much of the value is related to content and applications and is thus generated at the higher layers of the ICT ecosystem. Network infrastructure and connectivity are necessary to realize the benefits of these services, but many market segments have become increasingly commoditized. This has generated considerable challenges for all players to find sustainable business models. Network operators, both traditional telecommunication network providers and new players offering Internet access services, face high costs of network expansion and upgrades to NGNs. Funding models for the infrastructure investments and upgrades needed for IoT are in the early stages of development and many uncertainties remain. While there are examples of players who have created successful applications with relatively limited resources, and digital technology has significantly reduced entry barriers for entrepreneurs, others face high initial and operating costs. Sustainable business models typically require combinations of multiple direct and indirect revenue streams.

Advanced ICTs need data communication support that is more heterogeneous than earlier communication flows. Until recently, specialized communications were provided in separate networks. With the migration to all-Internet Protocol networks, heterogeneous traffic will have to be supported by a network infrastructure that allows better quality-of-service differentiation than the traditional best-effort Internet. Some IoT services, such as smart metering and other smart city applications, require relatively little bandwidth and are not sensitive to delay and jitter, and can thus be delivered via best-effort networks. Others, such as time-critical health applications, microgrids and videoconferencing, will require deterministic service quality. This creates considerable new challenges for network operators. While IPv4 and IPv6 both provide frameworks for better quality of service management, these tools have not been widely implemented on the public Internet. Yet other forms of emerging applications, such as connected vehicles and other verticals, will require highly secure communications. Most likely, these will at least initially be provided via separate network platforms and in a decentralized local environment.

Network operators and other firms in the digital economy have three principal strategies to overcome these challenges: vertical integration into complementary layers; mergers and acquisitions to increase market power; and differentiation of services and prices. Many of these options have repercussions for competition in the digital economy and may have detrimental effects on users. All these strategies are currently playing out in the marketplace. Consequently, the digital economy, both nationally and internationally, is more highly concentrated than the industrial economy. For example, digital storage resources are more highly concentrated on a global level than earlier forms of information preservation (Hilbert, 2016, p. 152). One challenge for public policy is to safeguard competition while not impeding the innovative energy of the digital economy. Traditional regulation is not designed to address these issues well, and antitrust policy does not yet have the tools needed to assess the effects of market concentration in virtual and big data markets (Ezrachi and Stucke, 2016; Stucke and Grunes, 2016).

In addition to these supply and demand-side challenges, public policy has an important role to play in helping to create the complementary knowledge and skills required to take advantage of the potential benefits of IoT, big data and cloud computing. The most effective measures to harness the potential benefits of these technologies will depend on the technological and institutional assets of a country, as well as complementary human skills. Some steps in this direction will be relatively easy to achieve. For example, local and national governments can adopt open data policies; they can allow access to public infrastructures, such as street light poles, to facilitate the deployment of sensors and actuators; and they may grant rights of way along other public infrastructures. Other prerequisites will be more difficult to provide. Making the most efficient use of IoT and big data analytics requires computational resources and a workforce trained in data science techniques. In many countries and regions, there is a skills gap that may constrain the speed with which the potential benefits of the digital economy can be realized. In addition, moving beyond established routines to the new business and organizational models that can take full advantage of advanced ICTs will be challenging.

4.2 Description of key trends

4.2.1 Internet of Things

IoT constitutes a next phase of the development of the Internet. Like big data analytics and artificial intelligence, it is enabled by rapid performance increases in ICTs that have dramatically reduced the cost of information collection, processing and storage, and made possible the deployment of ubiquitous computing capabilities. No single, universally accepted definition of IoT exists, and many of the specifics are still unfolding, propelled by innovators, entrepreneurs and policy-makers.[8] Several terms are used in parallel, emphasizing certain aspects of the broader IoT. They include ambient intelligence (often referring to home environments), the industrial Internet or Industry 4.0 (focusing on applications in the manufacturing sectors), Agriculture 4.0 (focusing on applications in agricultural production), and various concepts of "smart" technologically enhanced environments (e.g. smart cities, smart power grids, and smart transportation) (Greengard, 2015; McKinsey and Company, 2015).

Despite this diversity of approaches, key elements are common to all scenarios. People, objects, organizations and their environment will be linked in new ways by ubiquitous digital connectivity and computing power. Environmentally aware sensors, objects and actuators will allow for managing and controlling objects and processes to increase efficiency and optimize outcomes. This is done in a continuous feedback loop as the connected objects create information flows that can be integrated into the broader ICT ecosystem of computing and control resources. This will allow, for example, the fine-grained monitoring of air quality, traffic flows, road conditions, vital health signals, production processes, agricultural conditions and many others. Together with big data analytics, artificial intelligence, flexible forms of cloud computing and smart devices, these information streams can be utilized to reduce waste, achieve efficiency gains, develop monitoring and early warning systems, and design new and innovative services. A range of forecasts exists but all anticipate the deployment of billions of connected objects by 2020.[9] It is possible that, eventually, trillions of sensors and objects will be integrated into IoT (Diamandis and Kotler, 2012). McKinsey Global Institute estimates that IoT may contribute between USD 3.9 trillion and USD 11.1 trillion (in constant 2015 terms) to global gross domestic product (GDP) by 2025 (McKinsey and Company, 2015, pp. 1–14). This would correspond to about 4.5 to 11 per cent of the forecast global GDP.

Four main components make up IoT and allow for connecting physical objects and people in novel ways: a sensing layer; a network layer; a services layer; and an interface layer (Li et al., 2015). Since the late 1990s, when the notion of an IoT was first articulated, these components evolved in several stages. In this dynamic process, the sensing capabilities of things developed faster than the services built around these devices. The first stage was the development of RFID (radio frequency identification device) technology. These passive devices are widely used in manufacturing and retail logistics, greatly enhancing the trackability of parts and merchandise. The capabilities of RFID technology were enhanced by wireless sensor networks, the emergence of low-energy communications and cloud computing. Mobile computing and cooperation among connected objects further enhanced the capabilities. The current developments of advanced sensors, faster wireless connectivity and predictive analytic capability mark the next stages of IoT (*ibid.*, p. 244).

It is critical for the further development of IoT that these functions are designed and integrated in ways that enable them to adapt and evolve in

Box 4.1: Examples of IoT devices and apps

Home, convenience: Smart door locks, smart bike locks, smart appliances, smart grocery ordering, smart trash bins, smart silverware, smart pots and pans, smart faucets, digital assistants, integrated apps for smart homes.

Health: Fitness tracking devices, wearable health monitoring devices, wearable healthcare devices (e.g. insulin pumps), internal healthcare devices (e.g. embedded sensors), stationary devices (e.g. home monitoring devices and foetal monitors), disease outbreak warnings and monitoring.

Energy management: Smart outlets; home energy monitors; smart vents; heating, ventilation and air conditioning control devices and systems; smart lighting.

Precision agriculture: Remote monitoring of soil conditions, crops, livestock feed levels; precision agriculture analysis software and apps; irrigation optimization systems; crop disease detection.

Environment: Air quality monitoring, weather monitoring, severe weather alerts, water quality monitoring, foliage monitoring, forest fire prevention, earthquake warnings, tsunami warning systems, landslide warnings, noise monitoring and mapping, electromagnetic field measurement.

Transportation: Traffic congestion monitoring, transportation planning, smart streets, parking space management.

Security and emergency: Hazardous materials monitoring, radiation, perimeter access control.

Sources: https://www.postscapes.com; author's research.

response to technologies and needs. In each of the four layers, multiple technologies and protocols are available. For example, fixed and wireless communications coexist in the network layer. Wireless connectivity may be achieved in licensed and unlicensed spectrum and using different protocols (e.g. NB-IoT, LTE-M, LPWAN and ZigBee). Apart from their different regulatory treatment, these technologies have different cost and propagation characteristics and therefore allow configuring IoT solutions that are best suited for specific local contexts and conditions. Because of this diversity of possible solutions, standardization and interoperability are important prerequisites for IoT to develop its full potential. Moreover, given the large number of potential stakeholders and contributors, it will be important to develop overarching conventions for service architectures. With these elements in place, numerous potential applications in health care, personal services, early warning systems and smart infrastructures are possible, in addition to the existing applications of IoT in the production and transportation of goods and services.

Many of the devices linked to IoT are enterprise grade objects supporting the provision of more efficient services (e.g. automated production lines and supply chain management). The diffusion of IoT and of cloud computing is also accelerated by the rapidly growing number of smart devices that are available for the consumer market. Like other advances in ICTs, these devices and the apps that help take full advantage of their capabilities are made possible by the exponential performance improvement and the concomitant cost decreases that drive the four major ICT trends. These devices can easily be configured and networked to centralized computing resources using personal, local or wide area mobile connectivity.

Box 4.1 provides selected examples of devices, services and apps in IoT. They range from a variety of objects in connected homes (e.g. appliances such as refrigerators, washers, dryers; kitchen and cooking tools; and applications that manage home security) to devices supporting better energy management, heating and cooling, health monitoring devices and lifestyle devices. All these devices are useful, but networking them and using them to collect data that can be mined and analysed allows the creation of additional value. Consumers can make better decisions by having more accurate and detailed information

Box 4.2: Focus areas of big data application development

- IoT
- Professional, scientific and technical services (non-computer related)
- Telecommunications
- Manufacturing (non-computer related)
- Finance and insurance
- Arts, entertainment and recreation
- Medical and health care
- Retail/wholesale
- Education/academic
- Government (non-military)
- Transportation (other than automotive)
- Utilities/energy
- Automotive
- Robotics
- Construction/heavy industrial
- Military/aerospace
- Others

Source: Forbes (n.d.).

available on energy use, water use, nutritional habits and exercise. Energy consumption can be reduced by allowing remote control of devices. Moreover, peer effects may be utilized by sharing consumption patterns in buildings and neighbourhoods (Ayres et al., 2013). With the power and increasing capabilities of these devices come growing concerns about information security and privacy, especially in the health domain.

4.2.2 Big data analytics

Big data, broadly speaking, refers to the ability to generate useful knowledge from the vast amounts of data available in digital communication environments, where every action and every bit of information leaves a trail.[10] There is no single agreed definition of "big data", but there is wide consensus that volume, variety, velocity and veracity are key characteristics, although each of them is a moving target (Feijóo et al., 2016; ITU, 2014; Kshetri, 2014). While large volumes of data that exceed the capacity of off-the shelf software are often invoked, useful data do not necessarily have to be voluminous and the capabilities of standard software are increasing rapidly. Variety refers to the fact that data are harvested from a range of sources that will typically include structured and unstructured information. Some of this information is created as a by-product of the communication process. Much more is either voluntarily divulged by users or is intentionally collected via sensing and other smart devices. High velocity refers to the dynamic, fast-paced processes in which information is generated. The notion of veracity or validity was introduced to highlight that big data analytics go beyond traditional forms of statistical inference. However, more recent experience suggests that traditional statistical concepts such as sampling and inference complement big data analytics.

The proliferation of data creates an enormous opportunity to extract useful knowledge from the rich and highly granular information that is generated, even though it also raises considerable concerns about potential abuses. The uses of big data analytics span a wide spectrum, including better understanding of complex phenomena, early warning about impending developments, and predictive analytics (see Box 4.2). Early enthusiasm about the tremendous potential of big data uncritically assumed that such knowledge would emerge directly from data. However, making sense of proliferating information requires considerable analytical and methodological savvy to ensure that detected patterns are not spurious or of little value. The initial focus of big data analytics was on prediction, although this is only one of four important uses. Big data methods have important applications in descriptive, explanatory, predictive and prescriptive models. All four of these are relevant in the context of pursuing SDGs.

Much of the early interest in big data has focused on predictive uses. To this end, it is often sufficient to establish strong correlations between predictors and outcomes. Big data have facilitated finding better predictors and creating higher-dimensional predictive models. Such knowledge can be extremely useful and greatly improve individual lives, the efficiency of business and markets, and the pursuit of broader societal goals such as environmental stewardship. This approach is contingent on the existence of stable processes driving a phenomenon. If that assumption is not met, models based on past data will increasingly fail to predict accurately.[11] Another risk of that approach is that big data are predicated on existing social, legal and regulatory structures. If the *status quo ante* is undesirable, predictive big data analysis will be of limited help in understanding alternative futures. To that end, explanatory models that can also be used to simulate interventions and their potential effects will be necessary. Moreover, complementary qualitative and quantitative models may be necessary to create better foresight (Hilbert et al., 2016).[12]

While big data analytics alone are not sufficient to achieve any of the 17 SDGs, they can greatly contribute to their pursuit, especially if they are used beyond simple prediction. One important role is to help create accurate and reliable information about underlying causes and developments. Their biggest impact will perhaps be in the identification of problems, in the monitoring of effects of interventions, and in the calibration and adaptation of such measures. For example, big data analytical models will make it possible to reduce waste in the production and distribution of food. World food production currently exceeds nutritional needs, but inequities and waste in distribution continue to create significant hunger in the world. Big data can help detect, quantify and alleviate these connections. They can also contribute to more efficient energy production and distribution. As in food production, energy supply systems suffer from enormous losses. Moreover, the efficiency of energy use can be increased. In both areas, big data promise significant contributions. Pilot examples of such uses exist around the world, including projects to improve water management, waste management, precision agriculture, education and empowerment (see section 4.2.6 for additional details).[13]

4.2.3 Cloud computing

Cloud computing is complementary to big data, IoT and artificial intelligence. Narrowly construed, it is a technical solution to deploy computing resources such as data processing, storage and analysis in a flexible way that is accessible from any device and any location. Cloud resources can be scaled according to user needs, are typically priced on the basis of actual usage, and are regularly upgraded. Neither big data nor IoT would be fully realized without cloud computing. Because cloud computing requires good levels of always-on connectivity, network infrastructure constraints may significantly impede the usability of cloud solutions. In turn, this may also limit the ability of places to take advantage of big data, IoT and artificial intelligence.

In a broader perspective, cloud computing is the latest stage in a continuous evolution of computing concepts. Since the early days of digital information processing, computing resources have been deployed in response to the available technology and its costs. How and where resources were located – centrally in the network or on the edges – is driven by cost and engineering considerations. However, such architectural choices also influence the type and range of uses that are supported. The importance of centralized mainframe computers was reduced by personal computers and both are now superseded by decentralized ubiquitous computing solutions, in which resources are flexibly allocated and tasks will be handled locally and/or centrally.

Key components of cloud computing are Infrastructure as a Service (IaaS), Platforms as a Service (PaaS) and Software as a Service (SaaS). More recently, Security as a Service and Backend as a Service have also become available in the marketplace. Because clients pay only for the services they use, cloud solutions replace capital and maintenance costs with variable expenses. If economies of scale and scope are very large, cloud solutions may allow the reduction of unit costs below those that could be achieved in an enterprise data centre. Moreover, because capacity can be scaled relatively easily in the light of requirements, the cost of holding spare capacity can be minimized, if the resources are efficiently deployed.[14] Cloud services allow users to take advantage of the most recent software functionality. As major providers of IaaS, including Amazon Web Services, IBM, Google, AT&T, NTT and Fujitsu, as well as providers of PaaS and SaaS, operate on a global basis, clients can scale and extend services quickly beyond national and regional boundaries. With all these advantages, however, comes an increasing dependence on ubiquitous and always-available connectivity.

Private clouds are operated for single organizations. They can be managed internally or by third party service providers. Public cloud services are typically provided via public Internet connections, although the cloud infrastructure is located within the data centres of the major suppliers such as Amazon Web Services. The advantages of different deployment models can be combined in hybrid clouds, typically combinations of private, public, community and other cloud solutions. Emerging concepts such as fog and mist computing move computational resources closer to the edge of the system of connected devices (Bonomi et al., 2014; Stojmenovic and Wen, 2014). For example, computational power may be located at switches or routers, or it may even be embedded in devices. This allows offloading traffic from communication channels and taking care of computing tasks that can be handled locally in a decentralized fashion.

4.2.4 Artificial intelligence

Artificial intelligence builds on insights that were developed by pioneers in computer science and other disciplines over the past 70 years. It has many different aspects, but at a generic level it refers to the reliance on machines to make routine decisions or to augment human capability for making difficult decisions. Many of the early challenges, such as optical character recognition and face recognition, have been solved and in many other areas, such as voice recognition, great progress has been made. These advances allow devices to better sense their environment (computer vision, audio processing), comprehend interactions with humans and other devices (natural language processing, knowledge representation), and make decisions and interact with the physical world (machine learning, expert systems) (Purdy and Daugherty, 2016).

Nonetheless, many aspects of human intelligence, especially general tasks, remain beyond the capability of machines for the time being. Because of the lack of a general-purpose artificial intelligence, each algorithm needs to be tailored carefully to existing data and to the specific objectives pursued. This requires considerable human expertise in machine learning and large datasets to train algorithms. Advanced types of artificial intelligence are designed to support endogenous, evolutionary learning so that decisions will improve over time. Artificial intelligence has enabled great advances in robotics so that machines can take on an increasing number of routine and even non-routine tasks that only humans could do well until recently, such as harvesting, preparing food to order, and cleanup tasks. While artificial intelligence and robotics are likely to replace a range of existing jobs, in many other areas artificial intelligence will complement human labour and capital to enhance their productivity. Looking at artificial intelligence as a new factor of production, Accenture and Frontier Economics estimate that it could boost labour productivity by 2035 by up to 40 per cent in 12 high-income countries examined (*ibid.*).[15]

Advances in artificial intelligence are closely related to access to ubiquitous computing power and the availability of increasing amounts of data. There is a close complementarity between big data and artificial intelligence, as both rely on algorithms and machine learning to generate useful and executable knowledge. In principle, artificial intelligence can augment the power of big data and help put insights derived from big data analytical models into practice. However, the development of powerful and reliable artificial intelligence algorithms is highly dependent on the availability of sufficiently large data sets that can be used to train them ("supervised learning"). Many alternative learning models (e.g. regression analysis, logistical regression, decision trees, neural networks) are available, and their performance will vary with the type of problem. The amount of data needed to train an algorithm increases with the complexity of the problem, so that the lack of sufficient training data may be a serious barrier to reliance on artificial intelligence.

Box 4.3: Cases of use of artificial intelligence

- Image recognition, classification and tagging
- Improvement of algorithmic trading strategies
- Health care – patient data processing
- Predictive maintenance
- Object identification, detection, classification and tracking from geospatial images
- Text query of images
- Automated geophysical feature detection
- Content distribution on social media
- Object detection and classification – avoidance, navigation
- Cybersecurity threat prevention
- Contract analysis
- Text-based automated bots
- Sensor data analysis (IoT) and fusion
- Human emotion analysis

Source: Kaul and Wheelcock (2016), p. 8; author's research.

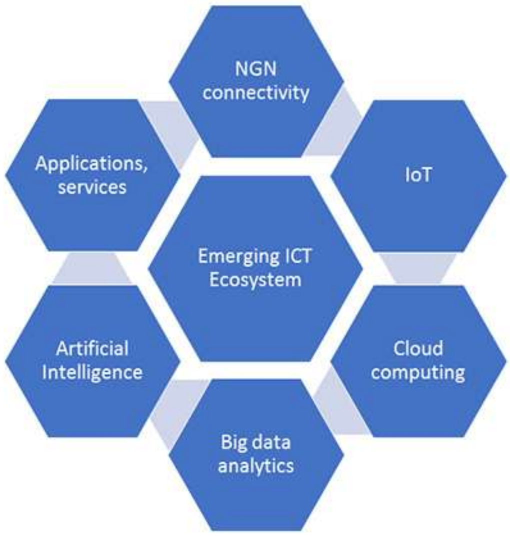
Applications range from the simple control of energy use (e.g. use of appliances only during off-peak periods), to systems that manage the energy consumption of office buildings, to highly complex systems governing traffic flows in smart cities that reroute traffic around congested areas or control traffic lights to optimize traffic flows. Examples include reliance on smart traffic management in Hangzhou provided by Alibaba Cloud, and traffic management systems in Los Angeles and Pittsburgh in the United States (see Kwong, 2016; and Patel, 2016). These technologies also have great potential in developing contexts, as shown by projects in Jakarta and Colombo, where mobile data have been mined in order to improve public transportation. Artificial intelligence also has numerous applications in health care, energy management and agriculture, as well as in logistics and supply chain management, with great potential to achieve considerable efficiency improvements (see Box 4.3). Moreover, big data and artificial intelligence can be deployed to significantly improve customer relations and redesign digital business models, allowing increases in customer satisfaction and consumer welfare (Rogers, 2016).

4.2.5 Convergence and innovation opportunities

While IoT, cloud computing, big data analytics and artificial intelligence all have useful applications on a standalone basis, potentially much higher benefits can be realized if they are used jointly to mutually enhance their capabilities. These four technologies form a highly complementary innovation system. As shown in Figure 4.2, these technologies, together with next-generation networks and new applications or services, comprise an emerging ICT ecosystem. IoT can unfold its true potential when combined with data analytical capability. Given the rapidly increasing amounts of information, their velocity and complexity, artificial intelligence can greatly help to make sense of the information and create semi-autonomous and autonomous cyber–physical systems (such as autonomous vehicles, smart homes, smart grids and smart transportation).

Sensors, actuators and networks form the physical backbone of IoT in a narrow sense. Cloud and other new computing architectures provide a complementary layer of data processing and storage capabilities that enables ubiquitously available services. Big data analysis helps to make descriptive, explanatory, predictive and prescriptive sense of the detailed data. Artificial intelligence enhances all these capabilities (e.g. computer vision allows new forms of sensing) but also, most importantly, adds another layer of analytical power. Most of the value in this new technology stack is in the applications and services that can be created by using IoT, cloud computing, big data analytics and artificial intelligence (Hunke et al., 2017) in a wide range of verticals (e.g. energy, transportation and health care) and across sectors.

Figure 4.2: Complementary innovation in advanced ICTs



Source: ITU.

4.2.6 Advanced ICTs and SDGs

ICTs are important instruments in efforts to achieve the 17 SDGs. Table 4.1 provides selected examples as to how ICTs in general, and IoT, big data analytics and artificial intelligence in particular, may be used to advance SDGs. Cloud computing, as a critical component of ubiquitous computing resources, will also be an important contributor.

There are an increasing number of proofs of concept, pilot projects and limited-scale examples that illustrate the potential contribution of ICTs. For example, several mobile money projects, such as m-Pesa (Kenya), EcoCash (Zimbabwe), Modelo Perú (Peru), and EasyPaisa (Pakistan) have shown the positive effects of mobile money (contributing directly to SDGs 1, 5, 8 and 9). Technologies such as Blockchain hold great promise to increase security of and trust in transactions, to reduce transaction costs, and to mitigate corruption (contributing to SDGs 1, 10 and 16).

Cities such as Colombo and Jakarta have successfully utilized data from mobile network operators to better understand commuter flows and improve urban transportation systems in response. Others, such as Sao Paolo, Brazil, have made municipal data openly available to developers. These and other initiatives contribute to SDGs 9 and 11. Mobile phone data have also been used to develop better responses to the 2010 cholera outbreak in Haiti, the Ebola crisis in Africa, and in disaster responses after earthquakes (contributing to SDG 3).

Many of the benefits of such initiatives can be reaped at the decentralized, local level. However, in other cases, such as creating national databases with medical information that can be accessed by remote healthcare workers, scaling up initial experiments will be critical. To be most effective, advances in ICTs are necessary but not sufficient to accomplish the SDGs. In other words, they will need to be used in conjunction with other policy initiatives and measures.

4.3 Global and regional developments

The extent to which a community or a nation can fully realize the benefits of the new ICT ecosystem is dependent on four complementary factors: (a) the availability of appropriate physical infrastructures, including networks, data processing and storage facilities, and devices; (b) basic services such as connectivity, computational services and information transportation channels; (c) user-side knowledge and skills; and (d) a

Table 4.1: Utilizing advanced ICTs to pursue SDGs

SDG	Ways in which advanced ICTs contribute to achieving SDG
Goal 1: End poverty in all its forms everywhere	ICTs help businesses to become part of the formal market economy; provision of better price information helps increase revenues and profits; mobile banking provides access to loans and microcredit; mobile payment systems reduce transaction costs; computer modelling and simulation can help develop better policies
Goal 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture	Smart agriculture solutions to monitor soil and weather conditions allow increasing crop yield; better coordination of food supply chains reduce waste; better crop management can restore soil conditions and create more sustainable agriculture
Goal 3: Ensure healthy lives and promote well-being for all at all ages	IoT allows innovative forms of low-cost health monitoring and diagnostics; ICTs can connect remote health workers with specialized diagnostic services; big data analytics allow forecasting of disease outbreaks
Goal 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all	ICTs allow access to online educational resources and learning communities; big data analytics help identify learning challenges and create more effective instruction, and allow continuing education and specialized training
Goal 5: Achieve gender equality and empower all women and girls	ICTs can provide women access to empowering information and education, and access to microcredit and secure payment systems
Goal 6: Ensure availability and sustainable management of water and sanitation for all	Smart water management reduces losses; water quality monitoring enhances water safety; smart waste management reduces risks of contamination
Goal 7: Ensure access to affordable, reliable, sustainable and modern energy for all	Smart metering and smart appliances allow better energy use management; microgrids and smart grids allow for building more sustainable energy supply while lowering the carbon footprint; green buildings reduce energy consumption
Goal 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	IoT and artificial intelligence have significant potential to increase productivity and economic growth while reducing the resource intensity and carbon footprint of production; additive manufacturing provides new opportunities for smaller scale, custom manufacturing
Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation	ICT, IoT, big data and artificial intelligence contribute to smarter infrastructures; preventative maintenance and continuous monitoring increase resilience; the plasticity of advanced ICTs allows accelerated learning, rapid prototyping and continuous innovation
Goal 10: Reduce inequality within and among countries	Advanced ICTs will allow further decentralized and localized production with the potential to reduce income inequality among countries; by improving education, they can contribute to reducing interpersonal inequality within countries
Goal 11: Make cities and human settlements inclusive, safe, resilient and sustainable	IoT applications allow creating smart and energy-efficient cities; big data analytics and artificial intelligence can help in creating better urban transport systems, safer neighbourhoods and more accountable city government
Goal 12: Ensure sustainable consumption and production patterns	ICTs in combination with IoT and big data analytics can improve coordination between consumers and producers; additive manufacturing and just-in-time production will increase efficiency and sustainability
Goal 13: Take urgent action to combat climate change and its impacts	Big data analytics and artificial intelligence can help reduce the carbon footprint of production and consumption; information sharing and learning communities can develop and replicate better practices
Goal 14: Conserve and sustainably use the oceans, seas and marine resources for sustainable development	New sensing and monitoring technologies can help track oceanic resources; big data and artificial intelligence will facilitate better resource management practices and will allow early warning systems
Goal 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss	Monitoring of the use of land resources, deforestation, and soil conditions can contribute to the preservation of resources
Goal 16: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels	Big data analytics combined with open data policies can empower citizens; monitors and big data analytics may help in increasing government transparency; direct trade relations may increase global tolerance and understanding
Goal 17: Strengthen the means of implementation and revitalize the global partnership for sustainable development	ICTs enable the formation of new communities of engaged citizens; big data analytics and artificial intelligence will allow advanced modelling of developments that can be shared rapidly and widely

Source: ITU.

policy environment conducive to the types of experiments needed to develop sustainable and scalable solutions. The absence of any one of these complementary factors will impede efforts to harness the potential benefits of the digital transformation, although it will not necessarily completely jeopardize them. As is well documented in detailed research and policy studies on digital divides, all four prerequisites are unevenly available across countries, regions and socio-demographic groups (Bagchi, 2005; Baller et al., 2016; ITU, 2016b; Pick and Azari, 2008; Van Deursen et al., 2017; Van Dijk, 2005). The well-known policy challenges of overcoming first (access) and second (skills) digital divides are compounded in the digital economy by the need to have access to even more advanced technology and user skills. Thus, while they offer considerable new opportunities for inclusion and empowerment, the four trends create new forms of digital exclusion that require additional policy initiatives to mitigate.

Many of the benefits of these four key technologies materialize in a broadly diffused way that may be difficult to measure empirically. Because they are general-purpose technologies and other factors are in play, it is challenging to isolate the specific contributions of big data or artificial intelligence to improved efficiency. For example, their application helps reduce inefficiencies and losses across all stages of the production and distribution process in verticals such as food production. Customization of products and services as well as location-based services may greatly enhance consumer surplus but are not always fully captured in measures of economic activity such as GDP (Moulton, 2000). Until reliable data on the effects of these technologies on outcomes are available, one is often forced to consider inputs such as spending for big data as proxies for national, regional and global adoption. Even with this caveat, empirical data documenting the four key developments are incomplete and suffer from numerous gaps and inconsistencies. The following sections will discuss developments at the global and regional levels, with a separate look at the situation in the least developed countries (LDCs).

4.3.1 Global overview

Because IoT, cloud computing, big data and artificial intelligence are complementary and to some degree overlapping technologies, some authors refer to IoT as the overarching concept, while others refer instead to artificial intelligence. Depending on how they are delineated, this results in empirical information as to their global size and growth that varies very widely, sometimes by more than an order of magnitude. Table 4.2 summarizes estimated global revenues using numbers that are supported by multiple sources. Based on these forecasts, IoT (both services and devices) and public cloud services generate the highest revenues. While all activities are growing fast, public cloud services, and especially artificial intelligence, is forecasted to experience much higher growth.

The pervasive adoption of ICT across all aspects of the economy and society is generating an exponentially increasing amount of data. Industry forecasts anticipate that the volume of data generated globally will increase from 145 zettabytes (ZB)[16] in 2015 to 600 ZB by 2020 (Cisco, 2016, p. 3). Much of this information is ephemeral or local and may not be transmitted or stored for extended periods. For example, a connected factory may generate 50 petabytes (PB) of data per day but only 0.2 per cent is transmitted. A connected plane generates 40 terabytes (TB) per day (of which 0.1 per cent is transmitted) and a connected car 70 gigabytes (GB) per day (0.1 per cent transmitted). In total, a smart city with a

Table 4.2: Estimated global market sizes for selected advanced ICTs (USD millions)

	Estimated global revenues		
	2015	2020[a]	2025[a]
IoT[b]	193 500	267 000	640 000[c]
Big data[d]	27 300	57 300	88 500
Public cloud[e]	75 300	278 200	489 800
Artificial Intelligence[f]	644[g]	6 076	36 818

[a] Forecast. [b] Statista (2017b); Hunke et al. (2017). [c] Estimate based on expected compound annual growth rate. [d] Statista (2016, p. 22). [e] Statista (2017a, p. 13). [f] Kaul and Wheelcock (2016). [g] Information for 2016.
Sources: Statista (2016, 2017a, 2017b), Hunke et al. (2017), Kaul and Wheelcock (2016).

population of 1 million will generate approximately 200 PB of data per day (Cisco, 2016, p. 14). The amount of data stored in data centres is expected to grow at a compound annual growth rate of 40 per cent, from 171 exabytes (EB) in 2015 to 915 EB by 2020. By 2020, 247 EB of the data stored in data centres – about 27 per cent – will be related to big data analytics. This is a ten-fold increase from 2015, when this amount was about 25 EB. These numbers suggest that less than half of the data generated by IoT will be stored. In addition, as much as 5.3 ZB – five times the total amount stored in data centres – will be stored on devices.

This rich pool of data can be utilized to improve the efficiency of the production and distribution of goods and services, design products and services to improve welfare and well-being, and support a more open and inclusive society. Part of it can be mined, analysed and put to productive use locally. For example, information captured by smart traffic lights used to optimize traffic flows might be deleted after a short period. Selected information may be communicated to an aggregation point that collects data for a larger geographic area. Some applications, such as remote metering, monitoring of air quality, and monitoring of soil conditions, involve a massive number of devices, but require very limited bandwidth and network resources.[17] Others, such as vehicle-to-vehicle communications, are critical applications that require a higher quality of service and possibly higher bandwidth to support reliable real-time communications.

In the recent past, many of these applications were running over separate specialized networks on the edges of the Internet. The deployment of NGNs has supported a convergence into integrated networks that need to support differentiated communication needs. The availability of diverse, appropriately configured NGNs and services is therefore an important precondition to support decentralized storage, processing and analytics in online cloud spaces. It allows for making insights available everywhere in support of new and innovative services and applications. Network upload and download speeds, latency and other quality indicators, are all important parameters that will influence how widely the benefits of the digital economy can be realized in a given place.

Driven by steady cost decreases and policies in many countries that support private and public investment, coverage with networks that support advanced digital transformation and adoption of generic services has increased considerably during the past decades. Nonetheless, substantial gaps remain between regions, between urban and rural access within countries, and between different access platforms. According to ITU data, by end-2016, approximately 85 per cent of the global population had access to 3G mobile phone services, and 66 per cent of the global population had coverage with long-term evolution (LTE) service. An estimated 48 per cent of the global population used the Internet in 2017 (ITU, 2017). There is great variation among regions, with Internet use ranging from 79.6 per cent of individuals in the European region, 67.7 per cent in the Commonwealth of Independent States (CIS) countries, 65.9 per cent in the Americas, 43.9 per cent in Asia and the Pacific, 43.7 per cent in the Arab States, to 21.8 per cent in Africa. In the 48 LDCs, 17.5 per cent of the population used the Internet (*ibid.*). Availability and use of fixed-broadband is much lower across all regions, which adds an additional challenge to taking advantage of the potential benefits from the new digital economy. A global survey by the Pew Research Center found that in 2015 the global median of smartphone ownership was 43 per cent. It was 68 per cent in advanced economies and 37 per cent in developing and emerging economies. While price declines have contributed to double-digit growth in many countries,[18] similar divides exist regarding smartphone ownership and use.

Similarly, while each region has made significant progress in improving the quality of digital networks and services, considerable differences in download and upload speeds and in quality of service (QoS) attributes prevail between regions. Speed measurements are afflicted with many potential problems and need to be used with caution (Bauer et al., 2010). Available data (e.g. from Ookla, Akamai, or M-Lab) are based on different measurement methods and often deviate from each other, although the data generally show similar patterns. Additional complications arise if data are averaged across regions.

With these caveats, in 2016 Asia could boast the highest fixed average download speeds, followed closely by North America and Europe (see Table 4.3). The highest average upload speeds were measured in Central and Eastern European countries, closely followed by Asia and the Pacific.

Table 4.3: Mean upload and download speeds by region (Mbps, 2016)

	Fixed networks		Mobile networks	
Regions[a]	Download	Upload	Download	Upload
Middle East and Africa	7.8	3.9	6.6	3.9
Asia and the Pacific	33.9	19.0	18.5	8.9
Central and Eastern Europe	29.1	19.3	11.0	6.8
Western Europe	30.2	11.0	18.2	7.9
North America	32.9	11.6	17.7	9.9
Latin America	9.3	3.3	8.4	4.1

[a] Owing to data availability regions differ from the ITU classification.
Source: Cisco (2016).

North America and Western Europe were third and fourth, at a distance, with Latin America and Africa even slower. On mobile platforms, Asia and the Pacific, Western Europe and North America had the highest mean download speeds; North America, Asia and the Pacific, and Western Europe had the highest upload speeds.

Fixed and mobile network latency improved globally and in all regions. In 2016, fixed and mobile networks in the Middle East and Africa had the highest latency (see Table 4.4). Fixed networks in Asia and the Pacific and mobile networks in Western Europe exhibited the lowest latency. Differences in latency between regional fixed networks increased slightly between 2014 and 2016, but they declined for mobile networks, for which variation in latency was lower in 2016 than in 2014. Speed and latency are not the only QoS dimensions of importance. Some applications in IoT, such as some communication from autonomous vehicles, also require jitter to be within certain boundaries. Thus, provisioning the necessary quality of service will be important in harnessing some benefits of IoT.

4.3.2 Regional analysis

Emergent technologies require considerable experimentation to find sustainable applications and business models. Much innovation is a process of trial and error in which only a small number of initiatives will succeed. IoT, cloud computing, big data and artificial intelligence all have shown their tremendous potential but continue to be in fairly early stages of experimentation. In every region, numerous innovative projects are under way. Given differences in available infrastructure, basic services and skills, some regions and countries are further along in this process than others.

4.3.2.1 Africa

The four ICT trends and related technological capabilities hold great promise for Africa. Potential applications with significant positive impacts range from precision agriculture to increased efficiency and yield, to programmes providing education on best agricultural practices, to remote provision of health and new models of education. Because digital applications can be customized to local and regional conditions, there are considerable opportunities for local entrepreneurs and start-ups to develop unique solutions. However, the

Table 4.4: Network latency by region (milliseconds, 2014–2016)

	Average fixed latency			Average mobile latency[b]		
Regions[a]	2014	2015	2016	2014	2015	2016
Middle East and Africa	87	77	62	328	156	118
Asia and the Pacific	40	35	26	182	82	65
Central and Eastern Europe	47	33	30	150	76	75
Western Europe	46	44	38	114	70	46
North America	49	42	38	100	90	85
Latin America	69	64	54	218	118	100

[a] Due to data availability, regions differ from the ITU classification. [b] Estimated.
Source: Cisco (2016, p. 23).

Table 4.5: M2M subscriptions by region (millions, 2013–2016)

	M2M subscriptions			
Regions[a]	2013	2014	2015	2016
Middle East and Africa	8.6	10.9	14.0	17.9
Asia and the Pacific	67.5	85.4	106.3	128.5
Europe	50.4	59.4	71.9	91.8
North America	35.4	42.3	52.5	65.0
Latin America	14.5	17.1	25.0	25.2

[a] Due to data availability, regions differ from the ITU classification.
Source: Berg Insight (2016, p. 116).

region faces numerous obstacles that need to be overcome to take full advantage of these developments. A first challenge is the state of ICT infrastructure in general. Despite major advances in mobile connectivity and Internet access, many African nations continue to lag behind other regions of the world in mobile connectivity. This gap is more pressing in the technologies that are critical for IoT, big data, artificial intelligence and cloud computing. Large-scale deployments of big data analytics, cloud computing and artificial intelligence will require fixed broadband infrastructure. The underdevelopment of fixed connectivity therefore constitutes a major challenge and obstacle to fully benefitting from advanced ICTs. Similar gaps will need to be overcome in enabling connectivity via advanced devices. In 2016, about 11.7 per cent of all smartphones, 165.5 million units, were sold in the Middle East and in Africa.[19] Smartphone ownership varies widely within the region. In 2015, South Africa had the highest rate of smartphone ownership, 37 per cent; Ethiopia and Uganda were among the lowest, at 4 per cent. The median of smartphone ownership across Africa was 19 per cent, compared with 37 per cent in Asia and the Pacific, 43 per cent in Latin America and 57 per cent in the Middle East (Poushter, 2016, pp. 16–18).

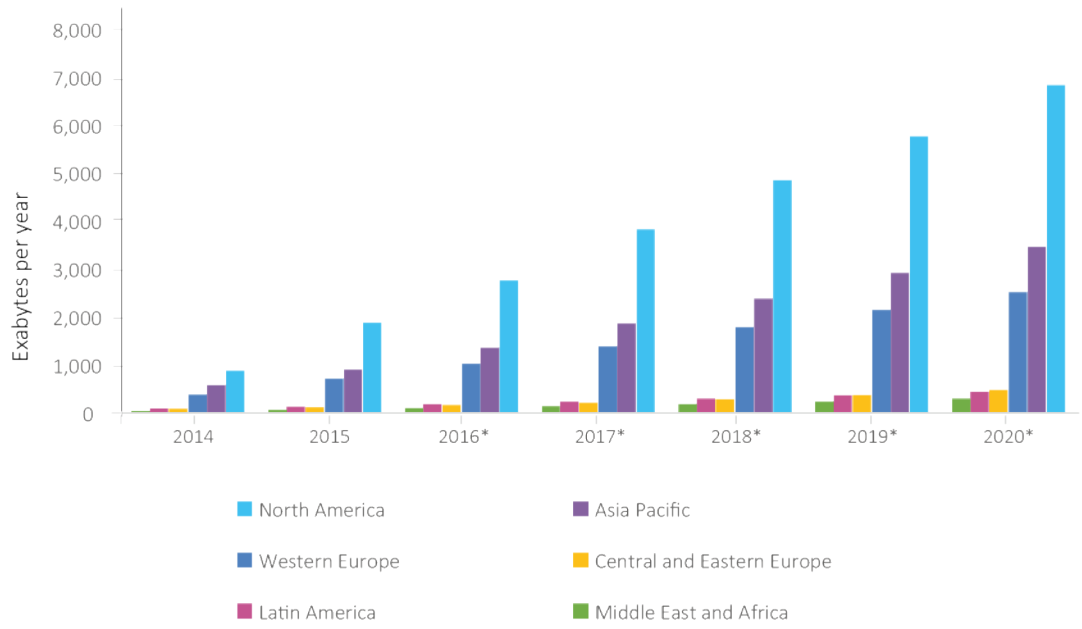
In 2016, there were about 17.9 million machine-to-machine (M2M) subscribers in the Middle East and in Africa (see Table 4.5).[20] Ericsson (2016b) estimates that between 2016 and 2022, cellular IoT devices will grow at a compound annual rate of 38 per cent, to about 80 million. Although cloud traffic will more than double, from 145 EB in 2017 to a forecast 304 EB in 2020, the Africa and Middle East region ranks last in terms of global cloud traffic generated (see Figure 4.3). The number of individuals who store data in the cloud or who use cloud-based software is also at the bottom end of the global regions.[21] Market research suggests that Africa and the Middle East will capture about 4.5 per cent of the global big data market of USD 57.3 billion by 2020.[22]

4.3.2.2 Arab States

Countries in the Arab States region have great potential to reap the benefits of the digital economy. A large percentage of young people in the age pyramid are social media- and technology-savvy. Qatar, the United Arab Emirates and Bahrain have the highest smartphone ownership rates in the world and among the highest rates of social media use. Citizens across the region have organized using social media. Several smart city initiatives – including initiatives in Dubai (United Arab Emirates) and in Bahrain – promise to demonstrate the potential of the concept in the region. Other projects, such as the participatory water management project in Tunisia using advanced ICTs to raise awareness and understanding, also demonstrate the potential contribution. Despite this potential, the region needs to overcome several challenges. A culture of digital entrepreneurship and empowerment is only slowly emerging. Businesses lag behind in terms of digitization, and government initiatives are limited. Moreover, venture capital funding is lower than in peer regions. McKinsey Global Institute estimates that only 1 per cent of the top 1,000 ICT companies globally by revenue are located in the region (Elmasry et al., 2016).

Infrastructure availability and important network quality indicators lag behind other regions. Even in the leading countries in the region, connectivity is provided at less than half the speeds available in Asia and the Pacific, North America or Europe, and the poorest performers lag significantly behind the lower performers of these regions. Average network latency in the region could also

Figure 4.3: Cloud traffic worldwide 2014–2020, by region (exabytes per year)



Notes: Regions differ from the ITU classification. * denotes a forecast.
Source: Cisco (2016).

be improved. Cloud traffic and use are low and the number of users who use cloud-based resources is only one-quarter of the comparable share in Asia and the Pacific. All this calls for concerted efforts to implement initiatives in government and business, and in the education sector, that will allow users to take better advantage of the digital opportunities.

4.3.2.3 Asia and the Pacific

Several countries and companies in the Asia and the Pacific region have grown into global leaders in the ICT sector, thus propelling the digital economy in the region. While countries vary greatly in their readiness to take advantage of the benefits of IoT, big data, cloud computing and artificial intelligence, a pattern is recurring in the leading countries. The strong performance of Asian nations is an outcome of a pragmatic series of policy reforms that have balanced private sector competition with government planning and the setting of overarching objectives. A project such as Songdo City in the Republic of Korea, a high-tech city taking full advantage of advanced ICTs, is an example of a successful, ambitious strategy. Similarly, Singapore has adopted several generations of plans to develop into a leading example of a smart city of the future. Japan, likewise, has supported its high-tech industries for decades and invested strategically in emerging fundamental technologies such as quantum computing. Combined with a very tech-savvy population, education programmes, and a highly competitive work culture, several Asian nations score very well in national rankings of the readiness to take advantage of the digital economy (Baller et al., 2016) or related indicators such as network quality of service and uptake (OECD, 2017).[23]

Within Asia and the Pacific, there are considerable differences and gaps. The region encompasses both global top performers as well as countries that lag significantly behind others. Home to several of the most populous countries, the region has considerable potential. Considering average key performance metrics, it leads the world in ICT adoption, broadband speeds, mobile connectivity and network latency. The figure of 128.5 million M2M subscriptions in 2016 corresponds to an average rate of 3.8 per 100 inhabitants. The technological progress of the region is clearly shown in the position of major vendors of telecommunication equipment and their patent activity. Examining patent applications between 2000 and 2012, Ardito et al. (2017) demonstrate a strong standing of the region. In all categories studied, United States companies have registered the highest number of patents. In IoT-related patents, China is second, followed by Japan and the Republic of Korea. Four players from Europe follow (Sweden, Finland, France and Germany).[24] Individual players, such as Huawei and Samsung, have taken advantage of the strong overall market dynamics and developed ambitious innovation programmes that have bolstered their global market share.

Given the rapid development of the ICT sector and of the country in general, IoT promises high incremental benefits in China (Kshetri, 2017). In this context, there are numerous applications. Given the high skill level of part of the workforce, China is in a good position to take advantage of these opportunities. This is further advanced by concerted government efforts to diffuse advanced production technologies across all sectors of the economy (OECD, 2017). Likewise, India is poised to take advantage of the enormous efficiency potential that can be unlocked with advanced ICT use. Internet access and smartphone use are growing rapidly and the cost of data communications is declining. Key sectors that will benefit from the wide application of IoT, big data, cloud computing and artificial intelligence (e.g. finance, manufacturing, agriculture, transportation and logistics) are ripe to apply these technologies. The Government has started several initiatives to accelerate adoption, including Digital India, Startup India, and training for entrepreneurship.[25]

4.3.2.4 Commonwealth of Independent States

Regarding the state of the ICT infrastructure, the nine Member States and two associate States of CIS are positioned between the leading regions (Asia and the Pacific, North America and Europe) and the Arab States, Latin America and Africa. Use of advanced network services and smartphones is, likewise, in between the values of these regions. With an average download connection speed of 7.4 megabits per second (Mbps) (Akamai, 2017), there is a clear gap with the leading nations. At the same time, the region benefits from a large pool of highly educated engineers and computer scientists and a wage level that is below that of high-income countries. Armenia is sometimes referred to as the Silicon Valley of the region, and leading high-tech companies, including Microsoft and Cloudflare, a cloud service provider, have established offices and data centres in Yerevan.[26]

Among the major obstacles to benefitting from advanced ICTs are a low level of trust and limited venture capital funding. Successful digital entrepreneurs, after an initial start-up phase, often seek to migrate their businesses to the United States or Europe. Several policy initiatives, including the creation of Free Enterprise Zones with reduced or no taxes, are intended to support a culture of entrepreneurship. Given the potential of IoT solutions to contribute to institution-building, as well as to entrepreneurship and innovation, the region is well positioned to harvest considerable benefits of advanced ICTs.

4.3.2.5 Europe

Several European countries are among the world leaders in Internet connectivity. The Nordic countries have historically had outstanding access infrastructures and they have been able to adapt their policy responses to support digital connectivity. Moreover, with Ericsson, the region has one of the world's leading network infrastructure technology companies. The European integration project has led to harmonization in important areas and, overall, helped boost connectivity across the region (Lemstra and Melody, 2015). Europe has dedicated several major research initiatives to technologies related to IoT, and numerous business and government activities across the region are pursuing promising innovation projects. Connectivity and participation in the digital economy across Europe continues to be heterogeneous. The composite Digital Economy and Society Index, published by the European Commission, shows much stronger performance in the North than in the South and the East of the Union.[27]

On average, network performance across Europe is high. Fixed network download and upload speeds are slightly below the Asia and the Pacific and North American average. Mobile upload and download speeds were also below the Asia and the Pacific region and mobile uploads were also below those of North America. Overall, however, the three regions exhibit, on average, quite comparable performance metrics. As in other regions, there is considerable variation within the region, with the highest download and upload speeds in the Nordic countries, Switzerland and, interestingly, countries such as Romania, which could leapfrog generations of networking technology and roll out fibre networks that support high speeds. Cisco (2016) estimates that Europe will generate about 3 000 EB of cloud traffic per year in 2020, ranking third behind North America and Asia and the Pacific. With an estimated 91.8 million M2M subscriptions in 2016, the rate is about 12.4 per cent of the population. In 2015, Pew found that 60 per cent of Europeans owned smartphones. IDATE Digiworld (2016) estimates that the smart home market in Europe will grow from 53 million units in 2015 to 185 million in 2025. Overall, Europe is well positioned to take advantage of the technological opportunities. One potential weakness is the less aggressive culture of entrepreneurship. With the large number of small and medium-sized enterprises, the transition to digital business models may require additional support by government agencies and programmes.

4.3.2.6 The Americas

Considerable differences exist between North America and South America, so a differentiated treatment is necessary. North America is home to leading technology companies with a strong footprint across all four areas. In 2016, eight of the ten most valuable digital technology companies in the world were American companies (Apple, Alphabet, Amazon, Facebook, Uber, YouTube, eBay and Instagram), with only two Asian companies (Alibaba and Tencent) in the group (Moazed and Johnson, 2016; Parker et al., 2016). Numerous other United States companies from the major technology centres in Silicon Valley, the Pacific North-west, the South and the East Coast are among the leaders in big data, IoT, cloud computing, robotics and artificial intelligence.

Despite this strong presence across major technology industries, there is still scope for reaping more of the potential efficiency gains of digital technologies. ICT industries, media, finance and professional services are leading, whereas manufacturing and utilities are only in the early stages of digitization (Manyika et al., 2015). Telecommunication infrastructure policy is strongly driven by market forces. Given the large land mass and low average population density of the United States, this has contributed to a stronger spatial differentiation than in most other high-income countries. Some locations enjoying much better quality of service than other countries, while other areas are worse off.[28] Consequently, on average, United States performance metrics often trail the global leaders, although this perspective misses the degree of differentiation present in the United States (Bennett et al., 2013). Canada's network infrastructure and services are less differentiated but also of very high quality.

Internet usage and smartphone ownership in the United States and Canada are among the highest in the world. According to a Pew survey, 72 per cent of United States mobile users owned smartphones in 2015 (Poushter, 2016, p. 18). Network infrastructure has been upgraded continuously, with particularly rapid advances in the deployment of LTE. Upload and download speeds also are among the highest in the world. North America is expected to generate 6 844 EB per year by 2020, the highest cloud data traffic of all world regions and about twice the amount generated by the second-ranking Asia and the Pacific region. Fixed network performance ranks at par with Western Europe but below Asia and the Pacific and CIS countries (see Table 4.3). With 65 million M2M subscriptions by 2016, North America had a per-capita penetration of approximately 18.6 per cent (see Table 4.5). By 2025, the smart home market is estimated to be 254 million units.[29]

Given the lower average income in Latin America, many of the network and adoption metrics are weaker than in North America. With 9.3 Mbps average download speeds on fixed networks, the region ranks fifth in the world. It ranks sixth in terms of upload speeds on fixed networks (Table 4.3). Likewise, the average regional mobile network download and upload speeds are among the lowest in the world (fifth of the six regions distinguished in Table 4.3). Latency on both fixed and mobile networks also ranks fifth in the world. However, as in other regions, there are considerable differences between the best performing nations (Uruguay and Chile) and the weakest (Bolivarian Republic of Venezuela and Paraguay).[30] Average smartphone ownership in 2015 was 42 per cent, with considerable variation among individual countries. For example, smartphone ownership stood at 65 per cent in Chile but was lower in Peru, where only 25 per cent reported owning a smartphone (Poushter, 2016, p. 18). There were about 25.2 million M2M subscriptions, corresponding to approximately 4 subscriptions for each 100 inhabitants. By 2025, the smart home market is estimated to be 37 million units.

4.3.3 A comparison of the regions

Within each region, there is great variation about how well the four prerequisites (physical infrastructure, appropriate connectivity services, complementary user skills and conducive public policies) are provided. Any comparison must be made with great caution, as there is considerable variation among the nations in each region. There are also major differences as to how far along they are in taking advantage of the next digital transformation. Asia and the Pacific, Europe and the Americas (especially North America) fare best at meeting the prerequisites overall. There are varying but generally strong traditions of transparent governance, and collaborative programmes involving multiple public-sector agencies, so that infrastructure and educational issues can be addressed. One challenge for policy-makers is to reconcile traditional regulation with the needed flexibility for network operators and entrepreneurs to experiment with new solutions. As a region, Africa is very well positioned in terms of opportunities for entrepreneurs. The limited development of a fixed broadband infrastructure will need to be overcome to take full advantage of big data analytics and other emerging services. Moreover, additional efforts will be needed to develop the necessary quality-differentiated connectivity, using the most appropriate wireless or wireline networks, for IoT and other advanced ICTs. The region also must redouble efforts to develop policy frameworks that support entrepreneurial experimentation and to adopt broader policies to develop user skills and competencies. The Arab States fare better regarding infrastructure availability and the adoption of smart devices. In that region, a major challenge will be to work on the development of more flexible policy frameworks and on complementary user skills to take advantage of the potential entrepreneurial opportunities. In many respects, the CIS region has a strong labour force that can take advantage of the new opportunities. Infrastructure availability and policy frameworks may need additional attention. Across all regions, countries and network operators face challenges to deploy the quality-differentiated service connectivity required for advanced ICT applications. Network virtualization, introduction of quality of service guarantees by early adopters, and efforts by standardization bodies, will all be required to advance such networks and services.

4.3.4 Least developed countries

Although they have made progress in improving ICT infrastructures and services, and in some cases significant leaps forward, LDCs continue to lag behind other regions in terms of the key indicators that will influence their position in the emerging digital economy. Internet use on average is only 15.2 per cent of the population, the lowest in the world. Average Internet connection speeds in 2017 were 2.5 Mbps, also the lowest in the world. There are considerable differences among the countries in this group, with connection speeds ranging from below 1 Mbps (Comoros, Mali, Niger and Yemen) to average connection speeds of 7.7 Mbps in Rwanda.[31] LDCs face daunting challenges in taking advantage of the benefits offered by the digital transformation, although digital technology can partly help overcome these barriers. A range of applications in IoT is not contingent on high connection speeds. Reliance on unlicensed and licensed wireless connectivity may help to overcome constraints in the fixed networks. The ability of digital solutions to be adapted to local conditions also helps. A promising example is the joint initiative by the City of Kigali, Rwanda, Inmarsat and Actility to roll out a citywide Low-Power Wide-Area Network. Initially designed as a testbed for one year, the platform will provide connectivity for a range of innovative smart city projects (Information Age, 2017).

4.4 Lessons for policy: Facilitating digital innovation

The potential benefits of the four key technologies can best be harnessed in an environment that supports innovation. Historically, telecommunication regulation has paid only limited attention to the effects of policies on innovation (Bauer, 2010b, 2014; Vogelsang, 2016). Regulators and policy-makers worldwide are therefore struggling to develop a framework that is conducive to innovation while protecting important public interests. Innovation is a dynamic learning process in which new products, services, designs, business models and organizational forms emerge from a process of trial and error.

Experimentation is therefore critical for innovation to unfold freely, and public policy can help support it. In the ICT ecosystem, upper layers and lower layers of the ecosystem are in a complementary relation to each other, each enabling (and potentially constraining) the innovative opportunities of players in the complementary layer. In other words, innovation in network infrastructure is stimulated by innovation in devices, applications and services, but network innovation, in turn, also stimulates innovation in devices, applications and services. Regulators therefore need to maintain a delicate balance that allows innovation and experimentation in all layers.

Some market segments, often network infrastructure and local access markets, are more concentrated than others and entry barriers may be high. A first critical task of public policy is therefore to make sure such bottlenecks are mitigated with appropriate tools, whether regulation or competition policy. The complementarity of innovation needs to be considered when designing a response. Several countries and regions, including the United States, the European Union and Chile, have adopted network neutrality principles with the goal of supporting edge innovations, including innovations in IoT. While this discussion is ongoing, this policy may impose barriers to the development of applications in IoT that require deterministic service quality, for example in vehicle-to-vehicle communications (Knieps, 2016). A better approach would be to allow network and quality of service differentiation by network operators while preventing discrimination and sabotage, either by forms of *ex post* regulation or competition policy. Such policies will also need to ensure that players in higher layers of the ecosystem are provided with relatively open and standardized interconnection to network and computing resources. If competition and the marketplace do not generate such conditions, policy intervention may be required.

In addition to eliminating barriers and mitigating the potentially negative effects of bottlenecks, public policy has an important role to play in establishing conditions that facilitate innovation. Given the importance of wireless communications on the edges of IoT, it is important that sufficient allocations of licensed and unlicensed bands are available. Licensed bands have the advantage that they provide control over quality of service and therefore protect investment better than unlicensed bands. The latter allow entrepreneurs to experiment more freely without the need to go through lengthy processes to obtain a licence. Models in which public authorities and network operators collaborate to roll out open platforms for third-party developers are promising steps to overcoming these challenges.

Policy-makers also need to adopt policies that promote trust in IoT and other trends. This includes measures to enhance and safeguard privacy and security. The proliferation of devices has created considerable vulnerability in IoT, as demonstrated by recent cyberattacks. Measures to help reduce such risks necessitate both supply-side and demand-side measures. On the supplier side, vendors need to face stronger incentives or liabilities to improve the security of devices. Security-aware design and development, as well as certification programmes, can go a long way in this direction. On the user side, increased awareness needs to be generated. Such capacity building is a difficult undertaking, as users often do not take advantage of opportunities to learn more about security. Nonetheless, several governments offer educational initiatives.

Moreover, countries need to review their innovation policies in general and to facilitate programmes that develop the skills needed to take advantage of IoT, big data and artificial intelligence. This requires building a stronger base of professionals with computer science and data science skills. It also requires support in the private and public sectors to develop new business models that take full advantage of the opportunities offered by digital technology.
Due to the unique economic characteristic of information markets, such as high economies of scale and scope, upfront costs, but also very low or zero incremental costs,[32] a high pace of innovation, low entry barriers for second and third movers, and the high plasticity of digital technology, sustainable business models are challenging to design. Most information businesses operate in multi-sided platform markets in which differentiated products and services are offered to an increasingly finely structured set of consumers (Evans and Schmalensee, 2016; Hagiu and Wright, 2015; Parker et al., 2016; Rogers, 2016). Digital technology requires efforts to find new ways of interacting with customers to build strong

and loyal relationships. Operating in multi-sided markets requires a rethinking of pricing policies and a reassessment of competitor relations. It is no surprise that in many countries ICT industries have made more progress toward adopting such practices than agriculture, manufacturing or utilities. Essentially, countries need to develop analogue complements (skills, knowledge and practices) to the digital economy (World Bank, 2016).

Because of the high plasticity of digital innovation, many of the benefits of the emerging technologies can be realized with innovative solutions that can thrive even within a constrained infrastructure. One response by network operators and other ecosystem players is to make concerted efforts to improve digital connectivity by rolling out mobile and fixed broadband networks. After initial deployments in 2009, many countries launched LTE services. On a global scale, for the foreseeable future, most subscribers will be served by high-speed networks (Ericsson, 2016b, p. 4). Network operators also deploy platforms that provide connectivity for IoT and they regularly collaborate with public partners such as cities to deploy connectivity.[33]

To take full advantage of the technological opportunities offered by IoT, big data, cloud computing and artificial intelligence for achieving the SDGs, six major components of the broader ecosystem need to be aligned: connectivity providers, device infrastructure providers, content and platform service providers, application developers, policy arrangements, and user skills and needs. Digital technology reduces the barriers to participation in these sectors faced by lower-income countries. Moreover, as the experience with earlier communication technologies demonstrates, such projects are most successful if they respond to local user needs, the unique local economic and technological conditions, and the specific historical and cultural context (Heeks, 2008; Toyama, 2015; Unwin, 2017). In the past, a main hurdle for reaping the benefits of technological change was the design and implementation of a policy framework conducive to innovation. IoT can help to create such a framework, as it will increase transparency and reduce practices, such as corruption, that may create uncertainty and stand in the way of beneficial reforms (Bhattacharya and Suri, 2017).

While advanced ICTs have considerable upsides, they also raise broader societal challenges. The risk to open next-generation digital divides that would reduce some of the gains from earlier forms of fixed and mobile connectivity and Internet use have already been mentioned. This is but the latest iteration of the relentless cycle of inclusion and exclusion that can be observed in the history of ICTs over the past century. A second concern relates to the potential consequences of advanced ICTs, especially artificial intelligence and robotics, on employment. Historically, job losses from technological change were absorbed by other occupations, although often with considerable transitional hardships. While it is not entirely clear whether the new employment opportunities will suffice to absorb freed workers, it is understood that many of these emerging activities will require retraining of the workforce and other social support systems to mitigate transitions (Garcia-Murillo et al., 2015). Moreover, the entire education system will have to be adapted to prepare individuals for the new work environment of the future. A third concern is the effects of ICTs on income inequality. There is mounting evidence that increased connectivity is associated with, even if not necessarily a cause of, reduced inequality of average national incomes, but that it coincides with increased income inequality within many nations. Bauer (2017) explains this bifurcated and ambiguous pattern with the specific dynamics of advanced ICTs. Again, public policy may be required to include mitigating measures. A fourth concern is the major security problems associated with IoT and increased connectivity in general. Finally, advanced ICTs can be technologies of freedom or they can be abused as technologies of repression. Enlightened policy will be needed to develop workable and satisfactory responses to these potential problems, or the benefits of advanced ICTs may not be realized.

While these general principles that should govern policy hold across countries and regions, the best response is contingent on the local and national circumstances. Because the four key technologies and their applications are evolving at a fast pace, and the entire sector is in a phase of experimentation whose outcomes are not fully visible, the best practices are those that support such experimentation. The different world regions offer examples of good practices, but also illustrate the challenges that need to be overcome.

4.5 Improving measurements of the four trends

The four trends identified in this chapter will play increasingly important roles as core services and applications of the advanced information society. Harnessing their potential for society and the SDGs requires creating an environment that supports beneficial innovation and provides safeguards against potential undesirable effects. Better policies are contingent on better measurement. Current data collection efforts capture important parts of the emergent activities well, especially at the network level, where data collection has been standardized for a while. However, they do not allow a complete picture of the emerging trends and their effects to be assembled. A growing number of stakeholders – including private businesses, business associations, research arms of consulting firms, non-profit groups and academic researchers – have filled this void. Depending on how an activity such as IoT or artificial intelligence is delineated, how activities are measured, and what projections are used to forecast future developments, wildly different numbers result.[34] Given the relatively early stage of development, this high degree of uncertainty will only gradually be reduced as more actual observations become available and more standardized methods of measurement are used. To some extent, big data approaches can help overcome these measurement issues, as important metrics can be mined from the digital infrastructure. An example is the innovative use of data from mobile networks to improve transportation modelling and planning.[35]

As discussed in previous sections, IoT, big data analytics, cloud computing and artificial intelligence are contingent on the presence of complementary assets, skills and institutional arrangements. To facilitate an assessment of the state of the advanced information society and to assist public and private decision-making, a comprehensive system of metrics should address these interrelated aspects. Existing efforts to collect information, and several new initiatives, can be built upon to generate this data, most importantly information collected by ITU but also complementary indicators assembled by the World Bank and the Inter-agency and Expert Group on SDG Indicators established by the United Nations Statistical Commission in the context of the implementation of the SDGs.

However, documenting the new developments requires building on this existing agenda and broadening it to include additional aspects. A range of direct and indirect indicators is available or can be designed (see Table 4.6). Some of these metrics can be expressed in units (e.g. number of robots) or shares (e.g. percentage of businesses using big data), and others are better expressed as monetary values (e.g. revenues of artificial intelligence providers). Either can be stated in absolute numbers and relative to meaningful benchmarks (e.g. percentage of the population or percentage of gross national income). Indicators referring to the policy conditions will most likely be of a qualitative nature. Direct indicators fall into three groups: hardware, basic services and software, and intermediate applications and services. Indirect indicators reflect complementary conditions such as the coverage with and quality of advanced fixed and wireless connectivity, human capital and policy conditions. In addition to direct and indirect measures, proxies are often available that help in assessing how well a location, region or nation is positioned to take advantage of the emergent trends.

Collecting such a set of indicators will require collaboration among various stakeholders and novel approaches to harvest information from the digital infrastructures and applications directly. In this process, the role of government agencies and ITU will often be to orchestrate processes to mine appropriate data, to work with private sector organizations to allow access to data, and to curate data; it may be less focused on collecting the data in the first place. However, this will require sustained efforts by public and private sector organizations. International organizations such as ITU can take a leadership role in putting such a broader framework in place. ITU and its Member States have the most direct role and control over data related to connectivity and data documenting the policy framework, two of the enabling conditions. Here an amendment of the data collection framework would probably suffice, with Member States called upon to collect the information. Collaboration with other United Nations agencies could help generate data on human capital, also one of the preconditions. The most challenging area will be collection of data related to hardware. Except for IoT, much of the new technology is beyond the traditional realm of telecommunications in the upper layers of the new ICT ecosystem. Thus, collaboration

Table 4.6: Measuring emerging ICTs (selected metrics)

	IoT	Big data analytics	Cloud computing	Artificial intelligence
Direct measures				
Hardware	Number of connected devices; Revenues in IoT device markets	Percentage of data centre capacity dedicated to big data analytics; Investment in data analysis centres	Number of data centres; information processing capacity of data centres; Investment in cloud facilities	Number of cognitive computing/deep learning installations; Number of robots; Revenue of artificial intelligence chip manufacturers
Basic services and software	Number of M2M subscriptions	Revenues for big data analysis software	Revenues for IaaS, SaaS, PaaS	Share of small, medium and large businesses using cognitive computing
Intermediate applications and services	Number of smart homes; Number of smart city applications; Revenues generated by IoT applications and services	Percentage of businesses and government organizations using big data analytics; Revenues generated by data analytics services	Percentage of businesses and government organizations using cloud computing; Revenues generated from cloud computing applications	Percentage of businesses and organizations using artificial intelligence applications; Revenues generated by artificial intelligence applications
Enabling conditions				
Connectivity	Percentage of population covered by mobile broadband; Percentage of population covered by fixed broadband; Available bandwidth; Quality of connectivity; Access to cloud resources; Adoption of broadband; Share of small, medium and large businesses using cloud resources; Percentage of population using cloud resources			
Human capital	Number of data scientists; Number of computer scientists; Percentage of schools with broadband connectivity			
Policy arrangements	Flexible spectrum policy; Policies toward bottlenecks and market power; Interoperability requirements; Standardization; Promotion of experimentation and innovation; Open data policies			
Effects on SDGs, welfare and well-being				
Welfare effects	Efficiency gains; Improvements in service quality; Better service/price relationship; Improvements in health, education, safety, care of elderly, empowerment, environmental stewardship, etc.			

Source: ITU.

with private sector organizations collecting such information, including consulting firms and industry associations, may be the most effective way forward.

In the context of the SDGs, it would also be desirable to formulate a general framework for evaluating the contribution of ICTs to welfare and well-being. Innovative research is under way, both in the private sector and in academia, aiming at the development of methods to make such assessments. As many new applications can be introduced at a smaller, local scale, evaluations can use randomized control trials to identify specific treatment effects of IoT and artificial intelligence projects. This novel approach to identify and test the role of ICTs has been applied to agricultural outcomes, food safety, mobile money and other effects of ICTs (Aker and Ksoll, 2016; Blumenstock et al., 2015; Nakasone et al., 2014; Torero and von Braun, 2006). Another approach enabled by the increasing availability of data at a more aggregated level is reliance on panel data analyses.

McKinsey and Company (2015) has generated a detailed assessment of the potential contribution of IoT (broadly interpreted) to global GDP, differentiated by sectors. In a more recent study, Accenture and Frontier Economics have generated estimates for the potential productivity improvements supported by the wide deployment of artificial intelligence (Purdy and Daugherty, 2016). One challenge of these and other studies is the quasi-public good character of many of the effects of advanced ICTs. While some of these effects, such as company productivity increases and the efficiency increases achieved in smart homes, are private goods, other aspects come with strong spillover effects and externalities whose benefits are widely diffused and potentially difficult to measure. For example, increased air quality management in a smart city will have measurable benefits for health, but it will also have broader and often intangible benefits for well-being in general. Capturing these effects in full will require methods that go beyond traditional approaches and will necessitate integrative measurement. Such initiatives can take inspiration from earlier work in the context of improving gross national income measurements (Cui and Taylor, 2012). Moreover, they can greatly benefit from big data analytics, provided that public and private data are made available for detailed examination.

4.6 Summary and conclusion

Advances in ICTs are enabling innovations that will fundamentally transform business, government and society. Four interrelated technological trends that will unfold their full impact in the coming years are IoT, cloud computing, big data analytics and artificial intelligence. These developments are enabled by exponential performance improvements and associated cost decreases in components, networking and the ubiquitous availability of connectivity and computing resources. In the virtuous cycle of the new ICT ecosystem, lower cost of connectivity, services and devices, and their continuous improvement, are going hand in hand with a proliferation of commercial and user-generated content.

Fully harnessing the economic and social benefits of these developments requires efficient and affordable physical infrastructures, generic services (connectivity, computing resources and storage), and appropriate institutional arrangements and user skills. Despite great advances, the nations and regions of the world differ widely in terms of where they stand in meeting these prerequisites. Among the six ITU regions, Asia and the Pacific, the Americas and Europe are currently best positioned to take advantage of these technologies, followed by the CIS region, the Arab States and Africa. LDCs face additional challenges due to the compounding of infrastructure challenges with weaknesses in their policy and regulatory systems, and shortcomings in capacity building and ICT education. However, within each of the world's six regions, and among the LDCs, considerable divergences exist between best and worst performers. Regional comparisons must be interpreted with caution.

While at first glance the four trends seem to widen the digital divide once more (Hilbert, 2016), they also offer rays of hope. For one, while their benefits are enhanced if deployed in an internationally networked environment, digital technologies can be deployed locally and in response to specific local conditions and challenges. Many innovative applications and services require only limited start-up capital, keeping the barriers to entry low for entrepreneurs. Likewise, as software and hardware become more efficient, some limited data analytical methods may be carried out in ways that are not contingent on the availability of massive data centres and computing resources. This may offer a limited path for weaker-performing nations towards participation in some of the potentially huge benefits of advanced ICTs. Nonetheless, for some time to come, more ambitious and more sophisticated big data analytical tasks as well as artificial intelligence applications will require high-capacity fixed and mobile connectivity and access to ubiquitous computing power.

Policy-makers contribute in important ways to overcoming these challenges and harnessing the benefits of the digital economy. Effective policy will require different policy-makers and stakeholders to work on joint solutions. Ideally, policy would create conditions that support entrepreneurship and experimentation with innovative services and solutions. Telecommunication regulation will be most effective if it supports the roll-out and continuous upgrade of mobile and fixed network infrastructure. Also, it will be important to make sufficient licensed and unlicensed spectrum available to accommodate the new increasing communication demands of smart cities, precision agriculture, education or health care applications. Safeguarding information security and privacy will be important preconditions for the building of trust and the adoption of advanced services and applications. This implies that education policy will need to prepare individuals to make better use of the opportunities of a digital future. Finally, it will be important to develop a framework of metrics that allows better tracking of the four trends. This will be an important precondition to develop supportive policy frameworks and to fully harness the tremendous power of IoT, big data analytics, cloud computing and artificial intelligence.

Endnotes

[1] Numerous books and overarching visions seek to come to grips with the opportunities and risks of the next waves of digital transformation. For additional overviews of the opportunities and challenges, see Vermesan and Friess (2016), Toyama (2015) and Unwin (2017).

[2] One area in which the accuracy of artificial intelligence already exceeds the average performance of humans is cancer diagnostics from digital images.

[3] Moore's Law refers to the observed doubling every two years in the number of transistors in a dense integrated circuit (or electronic chip). The ability to cram more components per electronic chip has contributed to the consistent increase in computing power.

[4] Cooper's Law of Spectral Efficiency refers to the observed uniform increase in the ability to transmit different radio communications simultaneously in the same place since the first radio transmission more than a century past.

[5] Cloud computing is only the latest development in the evolution of computing architectures. The locus of computational resources is influenced by the relative costs of communications and computing, as well as the transaction costs of coordinating resources. Earlier stages and related concepts include time-sharing, client-server models, grid computing and utility computing.

[6] According to Google, about 300 years of video are uploaded daily to YouTube.

[7] Sandvine traffic data documents that in 2016 about two-thirds of North American fixed network traffic was for real-time entertainment (mainly video). In Africa, the share of video traffic in total traffic was less than 25 per cent. On mobile networks, the share of video traffic was more than one-third of traffic in North America, while it was below 10 per cent in Africa.

[8] The ITU Telecommunication Standardization Sector (ITU-T) has defined IoT as "a global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies". See Recommendation ITU-T Y.2060, available at: https://www.itu.int/rec/T-REC-Y.2060-201206-I. See also (ITU, 2015).

[9] Cisco's prediction of 50 billion connected devices in the "Internet of Everything" by 2020 is widely seen as inflated. In contrast, a report by Berg Insight on IoT platforms and services estimates the number of connected devices by 2020 to just below 7 billion. See chapter 5 in ITU (2015) for a more thorough analysis of the different predictions and the main differences among them.

[10] Encryption of communications will potentially reduce the amount of data that can be mined but it will allow continued collection of metadata that can be analysed.

[11] An example is Google's effort to predict flu epidemics based on search data. The company examined 450 million alternative models to make such forecasts. For a while, the predictive accuracy was high, but over time the characteristics of the process changed and the accuracy of the real-time forecasts increasingly declined. See, for example, Lazer et al. (2014a, 2014b).

[12] In contrast to forecasts, which are typically a quantitative method of predicting future outcomes from past observations, foresight methods encompass quantitative and qualitative tools to explore potential futures.

[13] Examples include water service management solutions provided by TaKaDu in Europe, Latin America, Asia and the Middle East, in partnership with local utilities and technology companies; energy management services provided by Opower to clients worldwide; educational initiatives in India; and precision agriculture in Colombia. See Hilbert et al. (2016) for numerous additional examples.

[14] The complexity of some types of services may undermine this potential for efficiency gains if clients hold spare capacity in the cloud or if transaction costs create frictions that limit flexibility. See Harris (2015), for a critical analysis.

[15] This perspective raises complicated problems of attribution. As artificial intelligence builds on IoT and big data, the Accenture estimate of potential productivity gains likely also includes the productivity increase attributable to these technologies.

[16] One zettabyte (ZB) equals 1,000 exabytes (EB) equals 1,000 petabytes (PB) equals 1,000 terabytes (TB) equals 1,000 gigabytes (GB).

[17] Ericsson (2016a) developed a scenario of IoT communications in a dense urban setting and concludes that one NB-IoT carrier can fulfil the communication needs of the deployed metering and monitoring devices.

[18] For example, between 2014 and 2015, smartphone ownership in Turkey increased by 42 per cent, 34 per cent in Malaysia, and 26 per cent in Chile and Brazil (Poushter, 2016, p. 6).

[19] See GfK (n.d.). Smartphone unit shipments worldwide from 2013 to 2016 (in million units), by region. In *Statista - The Statistics Portal*. Retrieved June 2, 2017, from https://www-statista-com.proxy1.cl.msu.edu/statistics/412108/global-smartphone-shipments-global-region/.

[20] See Berg Insight (n.d.). Number of cellular M2M subscribers worldwide by region from 2013 to 2016 (in millions). In *Statista - The Statistics Portal*. Retrieved June 2, 2017, from https://www-statista-com.proxy1.cl.msu.edu/statistics/626241/cellular-m2m-subscribers-by-region/.

[21] Data documenting cloud use by individuals are rather incomplete and need to be interpreted with caution.

[22] See https://www.statista.com/statistics/254266/global-big-data-market-forecast/ for global market revenue forecasts, and "Middle East and Africa Big Data Market 2015 – 2020", accessed 18 July 2017 at http://www.bizjournals.com/prnewswire/press_releases/2016/05/26/BR09779, for an estimate of the market share of the African and Middle Eastern region.

[23] International comparisons of broad-based indices differ in the main analytical interest motivating the design of an index. Thus, there are deviations between them, and the rankings do not always yield consistent findings (Bauer, 2010a).

[24] Patent statistics are often used as a source of information on innovation activity. They are not always a good proxy for actual innovation activity, as many patents are taken out for competitive strategy reasons.

[25] See M. Meeker, Internet Trends 2017. Code Conference, 31 May 2017, slides 232-287, available at https://www.recode.net/2017/5/31/15693686/mary-meeker-kleiner-perkins-kpcb-slides-internet-trends-code-2017.

[26] Microsoft opened an office in 2006 and Cloudfare announced in March 2017 that if would open a data centre there. See https://blog.cloudflare.com/yerevan-armenia-cloudflare-data-center-103.

[27] See Digital Economy and Society Index, accessed 9 July 2017 at https://ec.europa.eu/digital-single-market/en/desi.

[28] For example, Akamai (2017, pp. 17–21) reports average connection speeds in states in the United States with the best connectivity rival those of global leaders in Asia (Republic of Korea and Singapore) and the Nordic countries (Norway and Sweden).

[29] See IDATE Digiworld (2016, p. 126).

[30] See https://www.akamai.com/us/en/about/our-thinking/state-of-the-internet-report/state-of-the-internet-connectivity-visualization.jsp, retrieved 20 July 2017. See also Akamai (2017).

[31] Speed data retrieved from Akamai (https://www.akamai.com/us/en/about/our-thinking/state-of-the-internet-report/state-of-the-internet-connectivity-visualization.jsp) and author's own calculations.

[32] The level of upfront costs may vary from extremely high (e.g. putting together a generic search database and infrastructure, producing a commercial digital movie) to very low for a mobile or web app that can be launched freely on the Internet. However, even digital innovations with low upfront costs have the peculiar cost structure that the upfront costs are typically much higher than the incremental costs of providing the service. While the latter group of projects poses lower entry barriers, it goes hand in hand with easier imitation and more intense competition, making it more difficult to find a sustainable revenue model.

[33] In 2016, the Netherlands became the first country with a national IoT platform. KPN rolled out a Low-Power, Long-Range Wide Area Network starting in 2015, first offering services in Rotterdam and The Hague (see http://www.zdnet.com/article/dutch-telco-kpn-deploys-lora-iot-network-across-netherlands). Other models are structured as partnerships between businesses, for example, the collaboration of Actility with Inmarsat, Cisco and Softbank. Yet others take the form of public–private partnerships, for example, the collaborative effort between Kigali, Rwanda and Actility and Inmarsat or the collaboration between the City of Los Angeles and Philips to deploy smart street lighting.

[34] An early case in point is Cisco's widely cited number of 50 billion connected devices in IoT by 2020. More recent estimates, based on a longer record of actual evidence, typically provide lower numbers. But similar discrepancies continue to plague outlooks such as valuations of the artificial intelligence market. For example, Forrester Research anticipates that the global market for cognitive computing technologies will be about USD 1.2 trillion by 2020, but Tractica Research anticipates a much lower volume of USD 38.6 billion by 2025.

[35] See the earlier examples reported in Hilbert (2016), Hilbert et al. (2016) and ITU (2015). The United Nations Global Pulse programme (http://www.unglobalpulse.org) has supported a range of projects that demonstrate the potential of big data analytics in overcoming lack of available statistics. In South Asia, LIRNE*asia* has done pioneering work.

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Annex 1. ICT Development Index methodology

This annex outlines the methodology used to compute the ICT Development Index (IDI) and provides additional details on various elements and steps involved, such as the indicators included in the Index and their definition, the imputation of missing data, the normalization procedure, the weights applied to the indicators and sub-indices, and the results of the sensitivity analysis.

1. Indicators included in the IDI

The selection of indicators was based on certain criteria, including relevance for the Index objectives, data availability and the results of various statistical analyses such as the principal component analysis (PCA).[1] The following 11 indicators are included in the IDI (grouped by the three sub-indices: access, usage and skills).

a) ICT infrastructure and access indicators

Indicators included in this group provide an indication of the available ICT infrastructure and individuals' access to basic ICTs. Data for all these indicators are collected by ITU.[2]

1. Fixed-telephone subscriptions per 100 inhabitants

The term "fixed-telephone subscriptions" refers to the sum of active analogue fixed-telephone lines, voice-over-Internet Protocol (VoIP) subscriptions, fixed wireless local loop subscriptions, Integrated Services Digital Network voice-channel equivalents and fixed public payphones. It includes all accesses over fixed infrastructure supporting voice telephony using copper wire, voice services using Internet Protocol (IP) delivered over fixed (wired)-broadband infrastructure (e.g. digital subscriber line (DSL), fibre optic), and voice services provided over coaxial-cable television networks (cable modem). It also includes fixed wireless local loop connections, defined as services provided by licensed fixed-line telephone operators that provide last-mile access to the subscriber using radio technology, where the call is then routed over a fixed-line telephone network (not a mobile-cellular network). VoIP refers to subscriptions that offer the ability to place and receive calls at any time and do not require a computer. VoIP is also known as voice-over-broadband (VoB), and includes subscriptions through fixed-wireless, DSL, cable, fibre optic and other fixed-broadband platforms that provide fixed telephony using IP.

2. Mobile-cellular telephone subscriptions per 100 inhabitants

The term "mobile-cellular telephone subscriptions" refers to the number of subscriptions to a public mobile-telephone service providing access to the public switched telephone network using cellular technology. It includes both the number of postpaid subscriptions and the number of active prepaid accounts (i.e. accounts that have been active during the previous three months). It includes all mobile-cellular subscriptions that offer voice communications. It excludes subscriptions via data cards or USB modems, subscriptions to public mobile data services, private trunked mobile radio, telepoint, radio paging, machine-to-machine (M2M) and telemetry services.

3. International Internet bandwidth (bit/s) per Internet user

The term "international Internet bandwidth" refers to the total used capacity of international Internet bandwidth, in megabits per second (Mbit/s). Used international Internet bandwidth refers to the average usage of all international links, including fibre optic cables, radio links and traffic processed by satellite ground stations and teleports to orbital satellites (expressed in Mbit/s). All international links used by all types of operators – namely fixed, mobile and satellite operators – are taken into account. The average is calculated over the 12-month period of the reference year. For each individual international link, if the traffic is asymmetric, i.e. incoming traffic is not equal to outgoing traffic, then the higher value of the two is provided. The combined average usage of all international links can be reported as the sum of the average usage of each individual link. *International Internet bandwidth (bit/s) per Internet* *user* is calculated by converting to bits per second and dividing by the total number of Internet users.

4. Percentage of households with a computer

The term "computer" refers to a desktop computer, laptop (portable) computer, tablet or similar handheld computer. It does not include equipment with some embedded computing abilities, such as smart television sets, or devices with telephony as a main function, such as mobile phones or smartphones.

Household with a computer means that the computer is available for use by all members of the household at any time. The computer may or may not be owned by the household, but should be considered a household asset.

Data are obtained by countries through national household surveys and are either provided directly to ITU by national statistical offices (NSOs) or obtained by ITU through its own research, for example, from NSO websites. There are certain data-related limits to this indicator, insofar as estimates have to be calculated for many developing countries that do not yet collect ICT household statistics. Over time, as more data become available, the quality of the indicator will improve.

5. Percentage of households with Internet access

The Internet is a worldwide public computer network. It provides access to a number of communication services, including the World Wide Web, and carries e-mail, news, entertainment and data files, irrespective of the device used (not assumed to be only a computer; it may also be a mobile telephone, tablet, PDA, games machine, digital television, etc.). Access can be via a fixed or mobile network. *Household with Internet access* means that the Internet is available for use by all members of the household at any time.

Data are obtained by countries through national household surveys and are either provided directly to ITU by NSOs or obtained by ITU through its own research, for example from NSO websites. There are certain data-related limits to this indicator, insofar as estimates have to be calculated for many developing countries which do not yet collect ICT household statistics. Over time, as more data become available, the quality of the indicator will improve.

b) ICT usage indicators

The indicators included in this group capture ICT intensity and usage. Data for all these indicators are collected by ITU.[3]

1. Percentage of individuals using the Internet

The term "individuals using the Internet" refers to people who used the Internet from any location and for any purpose, irrespective of the device and network used, in the previous three months. Usage can be via a computer (i.e. desktop computer, laptop computer, tablet or similar handheld computer), mobile phone, games machine, digital television, etc.). Access can be via a fixed or mobile network.

Data are obtained by countries through national household surveys and are either provided directly to ITU by NSOs or obtained by ITU through its own research, for example, from NSO websites. There are certain data-related limits to this indicator, insofar as estimates have to be calculated for many developing countries which do not yet collect ICT household statistics. Over time, as more data become available, the quality of the indicator will improve.

2. Fixed-broadband subscriptions per 100 inhabitants

The term "fixed-broadband subscriptions" refers to fixed subscriptions for high-speed access to the public Internet (a Transmission Control Protocol (TCP)/IP connection) at downstream speeds equal to or higher than 256 kbit/s. This includes cable modem, DSL, fibre-to-the-home/building, other fixed (wired)-broadband subscriptions, satellite broadband and terrestrial fixed wireless broadband. The total is measured irrespective of the method of payment. It excludes subscriptions that have access to data communications (including the Internet) via mobile-cellular networks. It includes fixed WiMAX and any other fixed wireless technologies, and both residential subscriptions and subscriptions for organizations.

3. Active mobile-broadband subscriptions per 100 inhabitants

The term "active mobile-broadband subscriptions" refers to the sum of data and voice mobile-broadband subscriptions and data-only mobile-broadband subscriptions to the public Internet. It covers subscriptions actually used to access the Internet at broadband speeds, not subscriptions with potential access, even though the latter may have broadband-enabled handsets. Subscriptions must include a recurring subscription fee to access the Internet or pass a usage requirement – users must have accessed the Internet in the previous three months. It includes subscriptions to mobile-broadband networks that provide download speeds of at least 256 kbit/s (e.g. WCDMA, HSPA, CDMA2000 1x EV-DO, WiMAX IEEE 802.16e and LTE), and excludes subscriptions that only have access to GPRS, EDGE and CDMA 1xRTT.

- The term "data and voice mobile-broadband subscriptions" refers to subscriptions to mobile-broadband services that allow access to the open Internet via HTTP in which data services are contracted together with voice services (mobile voice and data plans) or as an add-on package to a voice plan. These are typically smartphone-based subscriptions with voice and data services used in the same terminal. Data and voice mobile-broadband subscriptions with specific recurring subscription fees for Internet access are included regardless of actual use. Prepaid and pay-per-use data and voice mobile-broadband subscriptions are only counted if they have been used to access the Internet in the previous three months. M2M subscriptions are excluded. The indicator includes subscriptions to mobile networks that provide download speeds of at least 256 kbit/s (e.g. WCDMA, HSPA, CDMA2000 1x EV-DO, WiMAX IEEE 802.16e and LTE), and excludes lower-speed technologies such as GPRS, EDGE and CDMA 1xRTT.
- The term "data-only mobile-broadband subscriptions" refers to subscriptions to mobile-broadband services that allow access to the open Internet via HTTP and that do not include voice services, i.e. subscriptions that offer mobile broadband as a standalone service, such as mobile-broadband subscriptions for datacards, modem/dongle and tablets. Data-only mobile-broadband subscriptions with recurring subscription fees are included regardless of actual use. Prepaid and pay-per-use data-only mobile-broadband subscriptions are only counted if they have been used to access the Internet in the previous three months. M2M subscriptions are excluded. The indicator includes subscriptions to mobile networks that provide download speeds of at least 256 kbit/s (e.g. WCDMA, HSPA, CDMA2000 1x EV-DO, WiMAX IEEE 802.16e and LTE), and excludes lower-speed technologies such as GPRS, EDGE and CDMA 1xRTT. It excludes data subscriptions that are contracted together with mobile voice services.

c) ICT skills indicators

Data on gross secondary and tertiary enrolment ratios are collected by the United Nations Educational, Scientific and Cultural Organization Institute for Statistics (UIS).

1. Mean years of schooling

The term "mean years of schooling" is the average number of completed years of education of a country's population, excluding years spent repeating individual grades. It is estimated using the distribution of the population by age group and the highest level of education attained in a given year, and time series data on the official duration of each level of education.[4]

2. Gross enrolment ratio (secondary and tertiary level)

According to the UIS, the gross enrolment ratio is "the total enrolment in a specific level of education, regardless of age, expressed as a percentage of the eligible official school-age population corresponding to the same level of education in a given school-year."

2. Imputation of missing data

A critical step in the construction of the Index is to create a complete data set, without missing values. A number of imputation techniques can be applied to estimate missing data.[5] Each of the imputation techniques, like any other method employed in the process, has its own strengths and weaknesses. The most important consideration is to ensure that the imputed data will reflect a country's actual level of ICT access, usage and skills.

Imputation of missing data for access and use of ICTs by households and individuals were made by applying multiple imputation models based on multiple regression techniques using actual data from more than 100 countries. The approach took into consideration many explanatory variables of ICT development, such as national income, fixed and mobile-broadband penetration, geographic affiliation, population distribution and the proportion of the population living in urban areas, and the level of 3G and LTE population coverage. However, given that ICT access and usage are both highly correlated with national income, gross national income per capita was the most determinant variable for imputing access and use of ICTs by households and individuals. The availability of relevant data from other sources was also taken into account during the imputation process.

For example, the proportion of individuals using the Internet was estimated based on all available information on Internet use in the country from household surveys, and if no historical information was available, explanatory variables to estimate the level of Internet use were used. The estimates obtained from the regression analysis were benchmarked against estimates from other models, and against other countries in the region with similar characteristics, as well as against other key variables and data sources.

3. Normalization of data

Data normalization is necessary before any aggregation can take place, to ensure that the data set uses the same unit of measurement. Regarding the indicators selected to construct the IDI, the values must be converted into the same unit of measurement, since some values are expressed as a percentage of the population/total households, where the maximum value is 100, while other indicators can have values exceeding 100, such as mobile-cellular and active mobile-broadband penetration or international Internet bandwidth (expressed as bit/s per user).

Certain particularities need to be taken into consideration in selecting the normalization method for the IDI. For example, to identify the digital divide, it is important to measure the *relative* performance of countries (i.e. the divide among countries). Secondly, the normalization procedure should produce Index results that allow countries to track progress in their evolution towards an information society over time.

A further important criterion in selecting the normalization method is replicability by countries, as some countries have shown a strong interest in applying the Index methodology at the national or regional level. Certain methods therefore cannot be applied, for example, those that rely on the values of other countries, which might not be available to users.

For the IDI, the *distance to a reference measure* was used as the normalization method. The reference measure is the *ideal value* that could be reached for each variable (similar to a "goalpost"). For all the indicators chosen, this will be 100, except in regard to the following five indicators:

- International Internet bandwidth per Internet user, which in 2016 ranged from 0 (bit/s/user) to almost 8 397 884: Values for this indicator vary significantly between countries. To diminish the effect of the enormous dispersion of values, the data were first converted to a logarithmic (log) scale. Outliers were then identified using a cut-off value calculated by adding two standard deviations to the mean of the rescaled values, resulting in a log value of 6.33.

- Mobile-cellular subscriptions, which in 2016 ranged from 7.3 to 332.1 per 100 inhabitants: The reference value for mobile-cellular subscriptions was 120, a value derived by examining the distribution of countries based on their value for mobile-cellular subscriptions per 100 inhabitants in 2013. For countries where postpaid is the predominant mode of subscription, 120 is the maximum value attained, while in countries where prepaid is dominant (57 per cent of all countries included in the IDI have more than 80 per cent prepaid subscriptions), 120 is also the maximum value attained in a majority of countries. It was therefore concluded that 120 is the ideal value that a country could attain, irrespective of the predominant type of mobile subscription. Although the distribution of 2016 values may differ slightly from that of previous years' values, the ideal value of 120 was used to calculate this year's IDI, in the interest of consistency with the value used in previous years.

- Fixed-telephone subscriptions per 100 inhabitants, which ranged from zero to 120.7 in 2016: The reference value was calculated by adding two standard deviations to the mean, resulting in a value of 53 per 100 inhabitants. In the interest of consistency with the value used in previous years, the reference value of 60 per 100 inhabitants was used to calculate this year's IDI.

- Fixed-broadband subscriptions per 100 inhabitants: Values ranged from zero to 48.2 per 100 inhabitants in 2016. In line with fixed-telephone subscriptions, the ideal value was defined as 60 per 100 inhabitants.

- Mean years of schooling: Values ranged from 1.4 to 13.4 in 2016. The ideal value of 15 is used for this indicator, which refers to the projected maximum number of years of schooling by 2025.[6]

After normalizing the data, the individual series were all rescaled to identical ranges, from 1 to 10. This was necessary to compare the values of the indicators and the sub-indices.

4. Weighting and aggregation

The indicators and sub-indices included in the IDI were weighted on the basis of the PCA results obtained when the Index was first computed.[7]

Annex Table 1.1: Weights used for the indicators and sub-indices included in the IDI

	Weights (indicators)	Weights (sub-indices)
ICT access		0.40
Fixed-telephone subscriptions per 100 inhabitants	0.20	
Mobile-cellular telephone subscriptions per 100 inhabitants	0.20	
International Internet bandwidth per Internet user	0.20	
Percentage of households with a computer	0.20	
Percentage of households with Internet access	0.20	
ICT usage		0.40
Percentage of individuals using the Internet	0.33	
Fixed-broadband Internet subscriptions per 100 inhabitants	0.33	
Active mobile-broadband subscriptions per 100 inhabitants	0.33	
ICT skills		0.20
Mean years of schooling	0.33	
Secondary gross enrolment ratio	0.33	
Tertiary gross enrolment ratio	0.33	

Source: ITU.

5. Calculating the IDI

Sub-indices were computed by summation of the weighted values of the indicators included in the respective subgroup:

- *ICT access* is measured by fixed-telephone subscriptions per 100 inhabitants, mobile-cellular subscriptions per 100 inhabitants, international Internet bandwidth per Internet user, the percentage of households with a computer and the percentage of households with Internet access.

- *ICT usage* is measured by the percentage of individuals using the Internet, fixed-broadband Internet subscriptions per 100 inhabitants and active mobile-broadband subscriptions per 100 inhabitants.

- *ICT skills* are approximated by mean years of schooling, secondary gross enrolment ratio and tertiary gross enrolment ratio.

The values of the sub-indices were calculated first by normalizing the indicators included in each sub-index in order to obtain the same unit of measurement. The *reference values* applied in the normalization process were discussed above. The sub-index value was calculated by taking the simple average (using equal weighting) of the normalized indicator values.

For computation of the final Index, the ICT access and ICT usage sub-indices were each given a 40 per cent weighting, and the skills sub-index (because it is based on proxy indicators) a 20 per cent weighting. The final Index value was then computed by summation of the weighted sub-indices. Annex Box 1.1 illustrates the process of computing the IDI for Iceland (which tops the IDI 2017).

6. Sensitivity analysis

Sensitivity analysis was carried out to investigate the robustness of the Index results in terms of the relative position in the overall ranking, using different combinations of methods and techniques to compute the Index.

Potential sources of variation or uncertainty can be attributed to different processes employed in the computation of the Index, including the selection of individual indicators, the imputation of missing values and the normalization, weighting and aggregation of the data.

Each of the processes or combination of processes affects the IDI value. A number of tests were carried out to examine the robustness of the IDI results (rather than the actual values). The tests computed the possible Index values and country rankings for different combinations of the processes mentioned above. Results show that, while the computed Index values change, the message remains the same. The IDI was found to be extremely robust with regard to different methodologies, with the exception of certain countries, including in particular those in the "high" group.

The relative position of countries included in the "high" group (see Chapter 2) can change depending on the methodology used. Caution should therefore be exercised in drawing conclusions based on these countries' rankings. However, the relative position of countries included in the "low" group is in no way affected by the methods or techniques used, and the countries in this group ranked low in all Index computations using different methodologies. This confirms the results conveyed by the IDI.

Annex Box 1.1: Example of how to calculate the IDI value

	Iceland			
	Indicators			**2016**
	ICT access	**Ideal value***		
a	Fixed-telephone subscriptions per 100 inhabitants	60		48.4
b	Mobile-cellular telephone subscriptions per 100 inhabitants	120		118.0
c	International Internet bandwidth per Internet user**	2,158,212		997,830
d	Percentage of households with a computer	100		98.5
e	Percentage of households with Internet access	100		97.0
	ICT use			
f	Percentage of individuals using the Internet	100		98.2
g	Fixed-broadband Internet subscriptions per 100 inhabitants	60		37.6
h	Active mobile-broadband subscriptions per 100 inhabitants	100		104.0
	ICT skills			
i	Mean years of schooling	15		12.2
j	Secondary gross enrolment ratio	100		118.6
k	Tertiary gross enrolment ratio	100		81.3
	Normalized values	**Formula**	**Weight**	
	ICT access			
z1	Fixed-telephone subscriptions per 100 inhabitants	a/60	0.20	0.81
z2	Mobile-cellular telephone subscriptions per 100 inhabitants	b/120	0.20	0.98
z3	International Internet bandwidth per Internet user	log(c)/6.33	0.20	0.95
z4	Percentage of households with a computer	d/100	0.20	0.99
z5	Percentage of households with Internet access	e/100	0.20	0.97
	ICT use			
z6	Percentage of individuals using the Internet	f/100	0.33	0.98
z7	Fixed-broadband Internet subscriptions per 100 inhabitants	g/60	0.33	0.63
z8	Active mobile-broadband subscriptions per 100 inhabitants	h/100	0.33	1.00
	ICT skills			
z9	Mean years of schooling	i/15	0.33	0.81
z10	Secondary gross enrolment ratio	j/100	0.33	1.00
z11	Tertiary gross enrolment ratio	k/100	0.33	0.81
	Sub-indices	**Formula**	**Weight**	
	ICT access sub-index (L)	**y1+y2+y3+y4+y5**	**0.40**	**0.94**
y1	Fixed-telephone subsriptions per 100 inhabitants	z1*.20		0.16
y2	Mobile-cellular telephone subscriptions per 100 inhabitants	z2*.20		0.20
y3	International Internet bandwidth per Internet user	z3*.20		0.19
y4	Percentage of households with a computer	z4*.20		0.20
y5	Percentage of households with Internet access	z5*.20		0.19
	ICT use sub-index (M)	**y6+y7+y8**	**0.40**	**0.87**
y6	Percentage of individuals using the Internet	z6*.33		0.33
y7	Fixed-broadband Internet subscriptions per 100 inhabitants	z7*.33		0.21
y8	Active mobile-broadband subscriptions per 100 inhabitants	z8*.33		0.33
	ICT skills sub-index (N)	**y9+y10+y11**	**0.20**	**0.87**
y9	Mean years of schooling	z9*.33		0.27
y10	Secondary gross enrolment ratio	z10*.33		0.33
y11	Tertiary gross enrolment ratio	z11*.33		0.27
IDI	**ICT Development Index**	**((L*.40)+(M*.40)+(N*.20))*10**		**8.98**

*The ideal value for indicators a, b, c and g was computed by adding two standard deviations to the mean value of the indicator.

**To diminish the effect of the large number of outliers at the high end of the value scale, the data were first transformed to a logarithmic (log) scale. The ideal value of 2'158'212 bit/s per Internet user is equivalent to 6.33 if transformed to a log scale.

Endnotes

[1] PCA was used to examine the underlying nature of the data. A more detailed description of the analysis is available in Annex 1 to the 2009 report *Measuring the Information Society – The ICT Development Index* (ITU, 2009).

[2] More information about the indicators is available in the ITU *Handbook for the collection of administrative data on telecommunications/ICT* (ITU, 2011) and the ITU *Manual for Measuring ICT Access and Use by Households and Individuals* (ITU, 2014).

[3] See endnote 2.

[4] See http://www.uis.unesco.org/Education/Documents/Mean-years-schooling-indicator-methodology-en.pdf. Data used in the calculation of the Index were based from the United Nations Development Programme Human Development Index 2016, available from http://hdr.undp.org/en/2016-report.

[5] See OECD and European Commission (2008).

[6] See Human Development Report 2015, Technical Notes, available at http://hdr.undp.org/sites/default/files/hdr2015_technical_notes.pdf.

[7] For more details, see Annex 1 to ITU (2009).

Annex 2. Statistical tables of indicators used to compute the IDI

Access indicators

	Economy	Fixed-telephone subscriptions per 100 inhabitants		Mobile-cellular subscriptions per 100 inhabitants		International Internet bandwidth Bit/s per Internet user		Percentage of households with computer		Percentage of households with Internet	
		2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
1	Afghanistan	0.3	0.3	61.6	66.0	14,124	11,967	*2.9*	*3.4*	*3.9*	*4.8*
2	Albania	7.1	7.6	106.4	105.1	*43,232*	56,964	*25.7*	*27.7*	*35.5*	*37.0*
3	Algeria	8.0 [1]	8.2 [1]	106.4 [1]	117.0 [1]	30,119	40,015	37.0	*38.4*	31.9	*34.7*
4	Andorra	48.0	47.4	88.1	87.2	82,857	106,390	85.6	85.1	83.6	83.3
5	Angola	1.2	1.3	60.8	55.3	6,518	8,796	*11.1*	*10.5*	*10.2*	*10.0*
6	Antigua & Barbuda	*21.8*	24.3	*191.7*	*194.1*	*77,790*	88,622	*57.6*	*59.1*	*56.3*	*58.6*
7	Argentina	23.9 [2]	23.4	146.7 [2]	150.7	*35,925*	*41,130*	67.0	*67.6*	62.0	*63.8*
8	Armenia	18.4	17.8	115.9	114.8	66,892	59,860	61.9	64.7	57.8	*60.5*
9	Australia	35.5 [3]	33.8 [2]	107.7 [3]	109.6 [2]	*77,766*	*88,304*	83.0	*85.9*	85.9	*88.5*
10	Austria	42.2 [4]	41.5 [3]	157.4	166.1	*130,957*	*149,988*	82.1	*83.2*	82.4	85.1
11	Azerbaijan	18.7	17.5	111.3	106.3	35,127	34,255	62.4	64.3	76.7	77.4
12	Bahamas	31.2	30.9	80.3	91.8 [3]	225,877	*198,447*	*69.2*	*70.7*	*61.1*	*66.0*
13	Bahrain	20.6	20.8	185.3	216.9	89,425	112,770	94.8	94.8	88.7	98.0
14	Bangladesh	0.5	0.5 [4]	81.9	77.9 [4]	8,736 [1]	9,154	*8.2*	*9.6*	*10.1*	*14.5*
15	Barbados	52.0	48.4	116.5	115.0	247,474	284,571	*70.8*	*71.7*	*62.9*	*67.7*
16	Belarus	49.0	49.0	123.6	124.2	128,875	168,518	63.1	67.0	59.1	62.5
17	Belgium	40.1	39.0	114.2	111.0	*159,436*	*189,254*	82.1	*82.2*	81.8	84.8
18	Belize	6.8 [5]	*6.5*	61.0 [4]	*63.9*	*38,654*	*44,633*	*34.0*	*36.0*	*25.6*	*30.2*
19	Benin	1.8	1.1	85.6	79.6	1,811	1,656	*5.1*	*5.8*	*5.4*	*6.6*
20	Bhutan	2.8 [6]	2.7 [5]	87.0 [5]	88.8 [5]	11,220 [2]	18,077	*24.6*	*26.0*	*31.7*	*33.0*
21	Bolivia	8.0	7.7	92.2	90.7	24,950	36,347	*29.7*	*33.9*	*23.8*	*26.6*
22	Bosnia and Herzegovina	20.2	19.5	90.2	89.2	*82,289*	*98,452*	*47.1*	*49.2*	*53.6*	*57.1*
23	Botswana	7.8 [7]	6.9 [6]	169.0	158.5	8,387	7,880	*25.3*	*28.5*	*41.7*	*43.7*
24	Brazil	21.4	20.4	126.6	118.9	*44,196*	*66,181*	49.6	*51.0*	50.9	*52.4*
25	Brunei Darussalam	17.7 [8]	17.1 [7]	108.1	120.7	69,907	76,226	*92.5*	93.0	*74.0*	75.0
26	Bulgaria	23.3	21.0 [8]	129.3	127.2 [6]	153,312	175,869	59.0	*60.2*	59.1	63.5
27	Burkina Faso	0.4	*0.3*	80.6	83.6	3,191	*2,810*	*5.2*	*5.8*	*7.5*	*10.6*
28	Burundi	0.2	0.2 [9]	46.2	48.0 [7]	*5,702*	*6,083*	*2.0*	*3.4*	*2.0*	*3.5*
29	Cambodia	1.6 [9]	1.4	133.0	124.9 [8]	17,792	23,573	9.8 [1]	10.5	*21.0*	26.0
30	Cameroon	4.5 [10]	4.4 [10]	71.8 [6]	68.1 [9]	*992*	2,549	*12.7*	*13.7*	*8.6*	*10.5*
31	Canada	43.5 [11]	41.4	83.0	84.1 [10]	*112,039*	*141,885*	*85.1*	*86.8*	*86.6*	*89.2*
32	Cape Verde	11.5	11.6	118.6	122.0	15,382	23,357	*34.2*	*37.4*	58.4	*62.0*
33	Central African Rep.	0.0	0.0 [11]	25.9	25.5	*121*	*1,695*	*2.8*	*2.9*	*2.9*	*3.1*
34	Chad	0.1	*0.1*	40.2	*44.5*	1,987	*3,762*	*3.1*	*3.3*	*3.1*	*3.5*
35	Chile	19.2	*19.2*	129.5	*127.1*	129,825	*175,556*	*61.9*	*63.9*	*59.7*	*61.1*
36	China	16.5	14.7	92.2	96.9	6,530	14,699	*49.6*	*52.5*	*54.2*	*55.5*
37	Colombia	14.4 [12]	14.2 [12]	115.7 [7]	117.1 [11]	105,050	150,871	45.5	45.2	41.8	45.8
38	Comoros	1.9	1.7	55.2	57.7	12,187	12,729	*8.1*	*8.7*	*4.7*	*5.1*
39	Congo (Dem. Rep.)	0.0	0.0	53.0	39.5	*369*	770	*2.3*	*2.7*	*2.4*	*2.8*
40	Costa Rica	17.2 [13]	*16.3*	150.7 [8]	*159.2*	61,746	*68,449*	53.2 [2]	51.7	60.2	64.8
41	Côte d'Ivoire	1.3	1.3	119.3	126.0	4,984	6,825	*8.8*	*10.4*	*17.2*	*22.7*
42	Croatia	34.7	33.9	103.8	104.1	57,038	*118,953*	76.8	*79.5*	76.7	*77.2*
43	Cuba	11.5	11.8	29.7	35.5	*571*	*1,152*	13.0	*15.1*	5.6	*7.5*
44	Cyprus	38.4	38.0	131.8	134.5	*159,145*	*188,904*	71.5	71.8	71.2	74.4
45	Czech Republic	17.7	15.6 [13]	115.6 [9]	115.5 [12]	*161,342*	*180,697*	73.1	75.6	73.1	76.1

	Economy	Fixed-telephone subscriptions per 100 inhabitants		Mobile-cellular subscriptions per 100 inhabitants		International Internet bandwidth Bit/s per Internet user		Percentage of households with computer		Percentage of households with Internet	
		2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
46	Denmark	30.0	27.4	125.0	122.9	*199,293*	*239,874*	92.3	95.0	91.7	94.0
47	Djibouti	2.5	2.7	34.9	37.8	*10,255*	*15,228*	*19.1*	*20.3*	*8.1*	*9.1*
48	Dominica	28.3	18.3	106.3	107.4	*201,092*	*176,449*	*52.2*	*54.0*	*58.4*	*60.0*
49	Dominican Rep.	12.3 [14]	12.5 [14]	82.6	80.8	*18,024*	*22,061*	30.1	*32.0*	23.6	*26.2*
50	Ecuador	15.5 [15]	14.8 [15]	79.8 [10]	84.3 [13]	43,717	*43,677*	40.8	42.3	32.8	36.0
51	Egypt	7.4	7.1	111.0	113.7	10,743	17,194	50.9	*53.1*	42.3	*43.3*
52	El Salvador	14.7	14.4 [16]	145.3	140.7 [14]	62,219	63,622	20.1	*20.8*	14.0	*16.9*
53	Equatorial Guinea	1.4	*1.2*	66.7	*65.9*	2,130	*2,397*	*14.6*	*16.0*	*8.9*	*9.4*
54	Eritrea	*1.0*	1.0	*7.0*	7.3	*2,629*	*3,601*	*2.8*	*3.3*	*1.7*	*1.9*
55	Estonia	30.3	29.0	148.7 [11]	148.7 [15]	*173,936*	*210,798*	87.9	*89.6*	87.7	86.2
56	Ethiopia	0.9	1.1	42.8 [12]	50.5	1,959	2,242	*4.4*	5.0	*14.4*	15.4
57	Fiji	8.1	8.3	108.2	103.3	29,868	23,726	*39.2*	*41.7*	*31.3*	*33.6*
58	Finland	9.8	8.3	135.4 [13]	134.5 [16]	*187,722*	*216,391*	82.1	84.5	82.2	84.6
59	France	59.9	59.7	102.6	103.5	*84,255*	*97,653*	81.5	*81.8*	82.6	*85.9*
60	Gabon	1.1	1.1	161.1	144.2	*4,511*	*4,844*	*29.2*	*31.0*	*29.3*	*34.4*
61	Gambia	2.3	1.9	137.8	139.6	13,843	13,297	*8.9*	*9.3*	*8.6*	*11.2*
62	Georgia	22.1	19.4	129.0	129.1	96,324	92,145	49.7	*52.5*	45.1	*49.8*
63	Germany	54.9 [16]	*53.7*	116.7 [14]	*114.5*	*91,443*	*107,489*	91.0	*91.4*	90.3	*90.8*
64	Ghana	1.0	0.9	129.7	139.1	7,461	9,851	*18.5*	*20.8*	*28.6*	*32.5*
65	Greece	47.3	46.1	113.0	112.8	74,346	68,698	68.6	*71.7*	68.1	69.1
66	Grenada	25.3	25.0	112.3	111.1	*191,597*	*229,948*	*48.1*	*52.4*	*42.8*	*44.7*
67	Guatemala	10.6	*10.1*	111.5 [15]	*115.3*	23,215	*24,022*	*22.2*	*23.4*	*17.4*	*20.5*
68	Guinea	0.0	*0.0*	87.2	*85.3*	*384*	*589*	*2.6*	*2.8*	*6.4*	*7.7*
69	Guinea-Bissau	0.0	0.0 [17]	69.3 [16]	70.3 [17]	*4,013*	*4,707*	*2.7*	*2.8*	*2.1*	*2.2*
70	Guyana	19.1	*18.9*	67.2	*66.4*	28,770	*34,675*	*29.1*	*31.2*	*26.1*	*28.2*
71	Haiti	0.1	0.1	68.8	60.5	2,375	2,337	*9.4*	*10.1*	*4.4*	*4.7*
72	Honduras	5.9	5.2	95.5	91.2	17,497	33,443	*23.0*	*23.5*	*22.8*	*24.6*
73	Hong Kong, China	59.2	58.7	228.7	234.0	4,741,239	4,906,023	80.4	*81.0*	79.0	*82.0*
74	Hungary	31.2	31.5	118.9	119.1	*134,830*	*154,765*	75.0	*76.4*	75.6	*78.6*
75	Iceland	49.9	48.4	114.0	118.0	*725,806*	*997,830*	*98.5*	*98.5*	*96.5*	*97.0*
76	India	2.0 [17]	1.9 [18]	78.1 [17]	87.0 [18]	5,725 [3]	15,956	*14.1*	*15.2*	*20.0*	*22.6*
77	Indonesia	4.1 [18]	4.0	132.6	149.1	26,988	24,947	18.7	19.1	38.4	47.2
78	Iran (I.R.)	38.3	38.3	93.4	100.1	8,267	15,238	57.4	61.4	55.5	62.2
79	Ireland	40.9 [19]	39.7 [19]	103.7	103.6	*188,191*	*183,943*	83.5	*84.1*	85.0	87.0
80	Israel	43.1 [20]	41.6 [20]	133.5 [18]	131.7 [19]	*143,150*	*158,696*	80.3	*81.1*	74.3	*75.7*
81	Italy	33.1 [21]	33.1 [21]	143.4 [19]	140.4 [20]	*70,546*	*82,335*	63.9	64.7	66.2	69.2
82	Jamaica	9.0	11.0	111.5	115.6	36,639	47,949	36.5	*39.1*	34.6	*36.7*
83	Japan	50.2	50.6 [22]	126.5 [20]	129.8 [21]	64,180 [4]	83,010 [1]	79.7	*81.0*	97.2	*97.2*
84	Jordan	4.8	4.6	179.4	*196.3*	24,450	8,229	*50.6*	*53.1*	*75.9*	*79.0*
85	Kazakhstan	24.7	23.2	156.9	150.0	69,583	87,235	74.2	76.2	82.2	84.4
86	Kenya	0.2 [22]	0.2 [23]	80.7	81.3	87,046	69,014	*13.1*	*14.8*	*19.6*	*22.3*
87	Kiribati	1.4	*0.9*	38.8	*51.3*	2,916	*4,426*	*6.7*	*7.3*	*6.3*	*6.9*
88	Korea (Rep.)	58.1	56.1	118.5	122.7	46,894	54,252	77.1	75.3	98.8	99.2
89	Kuwait	*13.4*	11.0	163.2	146.6	77,395	69,516	*82.0*	*83.5*	*76.9*	*77.7*
90	Kyrgyzstan	7.1	6.6	132.8	131.4	44,790	65,377	*19.5*	*21.4*	*16.5*	*18.8*
91	Lao P.D.R.	13.7 [23]	17.7 [24]	53.1 [21]	55.4 [22]	16,795 [5]	17,487	*11.4*	*12.3*	*13.4*	*18.7*
92	Latvia	17.5 [24]	18.2 [25]	127.5 [22]	131.2 [23]	*213,210*	246,666	76.1	*78.0*	76.0	77.3
93	Lebanon	*20.0*	*21.0*	*92.2*	*96.4*	40,913	*55,086*	*76.5*	*78.1*	*75.7*	*77.7*
94	Lesotho	1.9	1.9	100.9	106.6	3,311	4,484	*7.8*	*8.2*	*25.4*	*27.9*
95	Libya	16.8	21.5	154.3	119.8	*5,133*	*5,286*	*22.0*	*23.5*	*20.4*	*22.0*

	Economy	Fixed-telephone subscriptions per 100 inhabitants		Mobile-cellular subscriptions per 100 inhabitants		International Internet bandwidth Bit/s per Internet user		Percentage of households with computer		Percentage of households with Internet	
		2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
96	Lithuania	18.7	17.8	139.5	140.7	138,946	198,564	67.6	70.5	68.3	71.7
97	Luxembourg	51.0 [25]	*50.9*	148.5	*147.8*	*7,186,378*	*8,397,884*	95.3	*95.9*	96.8	*96.4*
98	Macao, China	25.0 [26]	*23.9*	324.4	*332.1* [24]	111,931	*252,868*	79.0	77.9	86.3	88.6
99	Madagascar	1.0	0.6	44.1	41.8	12,420	14,258	*5.3*	*6.2*	*5.8*	*7.0*
100	Malawi	0.1 [27]	0.1	37.9 [23]	40.3	1,631 [6]	4,201	*5.8*	*6.4*	*9.1*	*11.5*
101	Malaysia	14.6	14.5	143.9	141.2	34,119	42,627	67.6	72.2	70.1	76.9
102	Maldives	6.1	5.8	206.7	223.0	*48,147*	*59,669*	*68.5*	*71.1*	*49.6*	*54.7*
103	Mali	1.0	1.2	139.6	120.3	*344*	598	3.3	3.2	8.2	8.9
104	Malta	53.4	54.2	121.5	124.8	*1,220,570*	1,596,254	81.1	*81.6*	81.9	81.1
105	Mauritania	1.3	1.3	89.3 [24]	86.5 [25]	*3,785*	*4,477*	*4.7*	*5.0*	*7.7*	*11.2*
106	Mauritius	30.3	30.7 [26]	140.6 [25]	144.2 [26]	33,896	63,491	57.0	*61.2*	60.0	*63.8*
107	Mexico	15.4	15.5 [27]	86.0	88.2 [27]	*29,775*	*37,598*	44.9	45.6	39.2	47.0
108	Moldova	35.0	34.3	108.0 [26]	111.0 [28]	153,430	144,087	68.0 [3]	71.0 [1]	68.0 [1]	76.0 [1]
109	Monaco	128.1	120.7	88.8	86.3	64,287	95,232	*84.0*	*84.1*	*76.6*	*78.3*
110	Mongolia	8.7	7.6	105.0	113.6	*162,429*	166,056	42.6	23.6	24.5	23.6
111	Montenegro	24.8	23.8	162.2	167.5	96,835	202,876	56.0	*58.2*	67.5	69.8
112	Morocco	6.5	6.0	126.9	120.7	18,316	25,702	54.8	54.9	66.5	68.5
113	Mozambique	0.3	0.3	74.2	66.3 [29]	1,519	1,115	*6.1*	*6.5*	*13.2*	*16.2*
114	Myanmar	1.0	0.9	75.7	89.3	5,214	6,426	*11.3*	*13.6*	*19.7*	*24.4*
115	Namibia	7.6	7.7	106.6	109.2	19,579	15,915	*17.7*	*20.0*	*24.5*	*29.5*
116	Nepal	3.0 [28]	3.0 [28]	96.7 [27]	111.7 [30]	3,200	*3,886*	*8.9*	*11.2*	*12.0*	*15.0*
117	Netherlands	41.3	40.3 [29]	123.5	130.0 [31]	*177,467*	*196,105*	88.3 [4]	89.6 [2]	90.9 [2]	92.2 [2]
118	New Zealand	40.2	39.2 [30]	121.8	125.0 [32]	63,624	109,601	*82.3*	*86.6*	*82.8*	*85.7*
119	Nicaragua	5.7 [29]	5.8 [31]	116.1 [28]	122.1 [33]	*23,871*	*29,161*	*11.8*	*13.1*	*14.0*	*16.2*
120	Nigeria	0.1	0.1 [32]	82.2	81.8	*5,783*	11,257	*9.8*	*10.6*	*12.5*	*15.2* [3]
121	Norway	18.4	16.6 [33]	111.1	110.1 [34]	*206,668*	*268,953*	96.5	*97.6*	96.6	*97.1*
122	Oman	10.5	9.8 [34]	159.9	159.2	67,052	66,071	*87.5*	87.5	*84.0*	86.1
123	Pakistan	1.9 [30]	1.6 [35]	66.9 [29]	71.4 [35]	15,309 [7]	16,636	*15.2*	16.1	*19.0*	22.1
124	Palestine*	8.9	9.3	77.6	76.8	0	0	*66.7*	*70.4*	*52.4*	*56.5*
125	Panama	15.6 [31]	15.8 [36]	174.2 [30]	172.3 [36]	*38,193*	*55,072*	39.6	*42.5*	52.7	53.9
126	Paraguay	5.5	*5.1*	105.4	104.8 [37]	16,421	21,015	29.0	*30.3*	22.7	*26.0*
127	Peru	9.3	9.7 [37]	109.9 [31]	117.1 [38]	*31,297*	*33,315*	32.6	33.5	23.2	26.4
128	Philippines	3.2	*3.7*	115.8	*109.2* [39]	*28,353*	*43,440*	*32.5*	*34.0*	*36.1*	*39.1*
129	Poland	23.7 [32]	*24.5*	142.7	*146.2*	*78,216*	83,299	77.9	80.1	75.8	80.4
130	Portugal	44.1	45.1	110.4 [32]	109.1 [40]	*148,747*	*177,808*	71.1	*72.7*	70.2	74.1
131	Qatar	17.6	19.3	159.1	147.1	71,566	86,950	88.3	*89.0*	95.8	*95.8*
132	Romania	19.8	19.1 [38]	107.1 [33]	106.4 [41]	146,012 [8]	155,516 [2]	68.7	*74.0*	67.7	72.4
133	Russian Federation	25.0	22.8	160.0	163.3	26,845	51,888	72.5	74.3 [3]	72.1	74.8 [4]
134	Rwanda	0.1 [33]	0.1 [39]	70.5	69.9	5,661	7,455	*4.0*	4.5	*6.7*	9.3
135	S. Tomé & Principe	3.2	2.8 [40]	91.2	85.3 [42]	*20,627*	37,317	*14.9*	*16.8*	*16.6*	*20.0*
136	Samoa	5.9 [34]	3.7 [41]	62.4 [34]	69.2 [43]	7,842 [9]	13,159	*22.6*	*24.0*	*25.5*	*29.1*
137	Saudi Arabia	12.5	12.0	176.6	157.6	88,669	78,163	67.0	69.0	94.0	94.6
138	Senegal	2.0	1.9	99.9	98.7	*5,338*	*4,977*	*12.9*	*15.1*	*15.7*	*19.9*
139	Serbia	36.5	36.0	120.5	120.6	23,693	26,292	64.4	65.8	63.8	64.7
140	Seychelles	22.8	22.1	158.1	161.2	41,126 [10]	52,433 [3]	*54.6*	*56.7*	*52.4*	*55.2*
141	Singapore	35.9	35.0 [42]	146.5 [35]	146.9 [44]	*765,829*	*982,923*	87.0	86.6	88.2	91.1
142	Slovakia	15.9	15.1	122.3	128.0	*41,269*	52,351	80.5	80.9	79.5	80.5
143	Slovenia	36.2	35.1	113.2	114.6	*186,317*	*239,168*	77.8	*78.1* [4]	77.6	78.4
144	Solomon Islands	1.3	1.2	72.7	69.9	7,100	11,971	*6.7*	*7.4*	*6.3*	*8.5*

	Economy	Fixed-telephone subscriptions per 100 inhabitants		Mobile-cellular subscriptions per 100 inhabitants		International Internet bandwidth Bit/s per Internet user		Percentage of households with computer		Percentage of households with Internet	
		2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
145	South Africa	7.7	6.6	164.5 [36]	142.4 [45]	*147,630*	263,030	20.1	*24.4*	50.0	*53.0*
146	Spain	41.5	41.3	108.2	109.7	*87,791*	*112,997*	75.9	77.1	78.7	81.9
147	Sri Lanka	15.2 [35]	11.4 [43]	110.6	118.5	15,815	22,038	*24.2*	*25.4*	*18.1*	*21.1*
148	St. Kitts and Nevis	35.7	31.2	131.8	136.9	*131,203*	*165,372*	*70.8*	*71.7*	*70.5*	*72.6*
149	St. Lucia	18.9	18.8	101.5	94.8	7,704	*7,558*	*41.1*	*43.7*	*39.7*	*43.1*
150	St. Vincent and the Grenadines	22.7	18.8	103.7	103.0	*158,187*	*188,740*	*61.8*	*63.9*	*49.4*	*51.0*
151	Sudan	0.3 [36]	0.3	70.5	68.6	2,189	2,035	*17.1*	*18.0*	*32.3*	*33.6*
152	Suriname	16.8	16.1	136.8	145.9	3,884	66,533	*45.2*	*46.4*	*39.1*	*42.4*
153	Sweden	36.7	34.1 [44]	130.4	126.7 [46]	*421,237*	*505,650*	88.3	88.5	91.0	92.0
154	Switzerland	50.3 [37]	48.4 [45]	136.5 [37]	135.6 [47]	*233,990*	269,222	*88.4*	*89.3*	84.7	86.8
155	Syria	15.9	15.2	64.3	54.2	7,125	12,813	*49.9*	*49.9*	*42.3*	*43.6*
156	Tanzania	0.3	0.2	75.9	74.4	*2,199*	*1,741*	*3.9*	*3.9*	*5.1*	*8.5*
157	TFYR Macedonia	17.6	17.4 [46]	98.8	100.7 [48]	*91,492*	*109,004*	68.4	*69.8*	69.4	*70.4*
158	Thailand	7.9 [38]	7.0	152.7 [38]	172.6	55,020	49,244	29.5 [5]	28.4	52.2	59.8
159	Timor-Leste	0.2	0.2	117.4	125.0	*2,010*	*1,888*	*14.8*	*16.2*	*21.8*	*23.9*
160	Togo	0.7 [39]	0.5 [47]	67.7	74.9	7,310	4,490	*6.1*	*6.8*	*4.1*	*7.7*
161	Tonga	12.4	*10.3*	69.1	*74.7*	17,025 [11]	*33,947*	*37.1*	*38.8*	*39.5*	*42.6*
162	Trinidad & Tobago	20.1	20.2	157.7	160.6	122,703	182,808	*67.9*	*71.4*	65.0	*70.9*
163	Tunisia	8.4	8.6	129.9	125.8	22,013	31,167	34.5	*37.0*	30.7	*33.0*
164	Turkey	15.0	14.3	96.0	96.9	59,034	68,058	55.6	58.0	69.5	76.3
165	Uganda	0.8 [40]	0.9 [48]	50.4 [39]	55.1 [49]	4,993 [12]	5,510	*6.7*	*7.6*	*7.2*	*8.9*
166	Ukraine	21.6	19.8	144.0	132.6	*73,425*	*79,885*	*59.2*	*65.1*	50.2	*54.8*
167	United Arab Emirates	23.6	23.4	187.3	204.0	108,791 [13]	133,749 [4]	*89.3*	91.0	*95.4*	94.3
168	United Kingdom	52.0	52.2	124.1	122.3	*374,554*	*449,137*	89.9	*89.8*	91.3	*91.3*
169	United States	38.4 [41]	37.1 [49]	117.6 [40]	127.2 [50]	*99,011*	*126,545*	86.8	*87.0*	81.5	*84.0*
170	Uruguay	32.3	32.4	150.6 [41]	148.7 [51]	73,151 [14]	96,707 [5]	68.0	69.5	59.7	61.8
171	Uzbekistan	9.5	11.3	73.3	77.3	2,075	5,683	43.2	*43.9*	75.4	*75.4*
172	Vanuatu	1.8	1.6	66.2	71.3	*35,468*	*21,921*	*21.0*	*22.6*	*27.4*	*29.5*
173	Venezuela	24.9 [42]	24.4 [50]	93.0 [42]	87.0 [52]	16,310	18,937	*44.1*	*42.7*	*34.7*	*34.0*
174	Viet Nam	7.8	5.9	128.8	128.0	41,300	91,252	*22.0*	*23.5*	*24.1*	*25.9*
175	Zambia	0.7	0.6	74.5	74.9	3,187	3,925	7.1	*8.1*	*12.7*	*14.3*
176	Zimbabwe	2.2	2.0	84.8	83.2	4,590	9,119	*11.8*	*12.9*	*21.6*	*22.1*

Note: Data in italics are ITU estimates. *Palestine is not an ITU Member State; the status of Palestine in ITU is the subject of Resolution 99 (Rev. Busan, 2014) of the ITU Plenipotentiary Conference.
Source: ITU World Telecommunication/ICT Indicators database.

Use indicators

	Economy	Percentage of individuals using the Internet		Fixed-broadband subscriptions per 100 inhabitants		Active mobile-broadband subscriptions per 100 inhabitants	
		2015	2016	2015	2016	2015	2016
1	Afghanistan	*8.3*	*10.6*	0.0	0.0	6.0	14.3
2	Albania	*63.3*	*66.4*	7.6	8.2	40.6	52.6
3	Algeria	*38.2*	*42.9*	5.6 [1]	6.9	40.2 [1]	*46.8*
4	Andorra	*96.9*	*97.9*	37.9	39.8	42.1	47.8
5	Angola	*12.4*	*13.0*	0.7	0.5 [1]	19.3	17.1
6	Antigua & Barbuda	*70.0*	*73.0*	*10.9*	10.0	*33.8*	*44.2*
7	Argentina	68.0	*70.2*	16.3	16.9	78.4 [2]	*80.5*
8	Armenia	59.1	*62.0*	9.6	*10.1*	40.3	53.9
9	Australia	84.6 [1]	*88.2*	28.5 [2]	30.4 [2]	126.5 [3]	130.2 [1]
10	Austria	83.9 [2]	84.3	28.7	29.4	70.5	88.3
11	Azerbaijan	77.0 [3]	78.2	19.8	18.6	60.9	57.4
12	Bahamas	*78.0*	*80.0*	20.9	22.0 [3]	47.1	51.2
13	Bahrain	93.5 [4]	98.0	18.6	16.8	131.8	162.1
14	Bangladesh	*14.4*	*18.2*	3.1	3.8 [4]	15.7	17.8 [2]
15	Barbados	*76.1*	*79.5*	27.2	30.1	54.9	59.3
16	Belarus	67.3 [5]	71.1	31.4	33.3	61.8	69.5
17	Belgium	85.1 [6]	86.5 [1]	36.8	38.0	62.1	66.7
18	Belize	*41.6*	*44.6*	5.0 [3]	*6.2*	12.1 [4]	*13.8*
19	Benin	*11.3*	*12.0*	0.7	*0.8*	4.2	*5.6*
20	Bhutan	*39.8*	*41.8*	3.6	*3.9* [5]	46.7 [5]	47.9 [3]
21	Bolivia	*35.6*	*39.7*	1.6	2.6	33.8 [6]	57.6 [4]
22	Bosnia and Herzegovina	*65.1*	*69.3*	16.6	17.4	33.5	37.4
23	Botswana	*37.3*	*39.4*	1.8	2.8 [6]	67.6	67.9 [5]
24	Brazil	58.3	*59.7*	12.2 [4]	13.0	88.6	89.5
25	Brunei Darussalam	*71.2*	75.0	8.0	8.3	94.9	116.6
26	Bulgaria	56.7 [7]	59.8	22.7 [5]	23.3 [7]	81.3	88.4 [6]
27	Burkina Faso	*11.4*	*14.0*	0.0	*0.0*	15.3	*19.9*
28	Burundi	*4.9*	*5.2*	0.0	0.0 [8]	7.6	8.3 [7]
29	Cambodia	*19.0*	25.6	0.5	0.6	42.8	50.2
30	Cameroon	*20.7*	*25.0*	*0.1*	0.2 [9]	*4.3*	*9.6*
31	Canada	*88.5*	*89.8*	36.3	37.3	61.4	66.1 [8]
32	Cape Verde	*48.0*	*48.2*	3.3	3.0	69.6	70.0
33	Central African Rep.	*3.8*	*4.0*	*0.0*	*0.0*	2.6 [7]	3.3
34	Chad	*3.5*	*5.0*	0.1 [6]	*0.1*	*1.4* [8]	*9.5*
35	Chile	*64.3*	*66.0*	15.2	*16.0*	56.1	*69.0*
36	China	*50.3* [8]	53.2	19.8	22.9	55.5	66.8
37	Colombia	55.9 [9]	58.1	11.2 [7]	11.8 [10]	41.0 [9]	45.5 [9]
38	Comoros	*7.5*	*7.9*	*0.3*	0.4	0.0	*0.0*
39	Congo (Dem. Rep.)	*3.8*	*6.2*	*0.0*	0.0	8.5	14.2
40	Costa Rica	59.8 [10]	66.0	11.2	*11.6*	97.2	*109.5*
41	Côte d'Ivoire	*21.9*	*26.5*	0.5	0.6	40.4	47.5
42	Croatia	69.8 [11]	72.7	23.2	24.6	73.1	79.7
43	Cuba	37.3 [12]	*38.8*	0.1	0.1	0.0	*0.0*
44	Cyprus	71.7 [13]	75.9	30.9	33.0	75.7	97.5
45	Czech Republic	75.7 [14]	76.5 [2]	27.3 [8]	27.7 [11]	72.0	76.0 [10]

	Economy	Percentage of individuals using the Internet		Fixed-broadband subscriptions per 100 inhabitants		Active mobile-broadband subscriptions per 100 inhabitants	
		2015	2016	2015	2016	2015	2016
46	Denmark	96.3 [15]	97.0	42.5 [9]	42.8 [12]	117.6	124.2
47	Djibouti	*11.9*	*13.1*	2.7	*3.0*	*5.6*	*11.6*
48	Dominica	*65.0*	*67.0*	20.9	21.2	42.2	41.0
49	Dominican Rep.	54.2 [16]	*61.3*	6.4	6.5	39.6	49.2
50	Ecuador	48.9 [17]	54.1	9.7 [10]	9.7	35.1	47.2
51	Egypt	37.8 [18]	*39.2*	4.5	5.2	50.7	52.6
52	El Salvador	26.8	*29.0*	5.5	6.0 [13]	19.9	*28.5*
53	Equatorial Guinea	*21.3*	*23.8*	0.5	*0.5*	0.0 [10]	*0.1*
54	Eritrea	*1.1*	*1.2*	*0.0*	*0.0*	*0.0*	*0.0*
55	Estonia	88.4 [19]	87.2	30.0	31.1	112.9	125.0
56	Ethiopia	*11.6*	15.4	0.5	0.6	3.7 [11]	5.3
57	Fiji	*42.5*	*46.5*	1.4	1.4	*48.2*	*54.3*
58	Finland	86.4 [20]	87.7 [3]	31.7	31.2	144.0	153.0
59	France	84.7 [21]	85.6	41.3	42.4	74.7	81.7
60	Gabon	*45.8*	*48.1*	0.6	0.7	36.3	66.1
61	Gambia	*16.5*	*18.5*	0.2	0.2	13.5	21.3
62	Georgia	47.6 [22]	*50.0*	14.7	15.8	50.5 [12]	57.7
63	Germany	87.6 [23]	89.6	37.2	38.1 [14]	70.8	*80.2*
64	Ghana	*31.4*	*34.7*	0.3	0.3	66.8	71.3
65	Greece	66.8 [24]	69.1	30.9 [11]	32.5	45.6	51.3
66	Grenada	*53.8*	*55.9*	18.5	19.4	28.8	32.9
67	Guatemala	*28.8*	*34.5*	2.8	*3.0*	10.1 [13]	*13.9*
68	Guinea	*8.2*	*9.8*	*0.0*	*0.0*	13.9	*15.0*
69	Guinea-Bissau	*3.5*	*3.8*	0.1 [12]	0.0 [15]	*0.0*	6.9
70	Guyana	*34.0*	*35.7*	6.6	*7.6*	0.2	*0.2*
71	Haiti	*12.2*	*12.2*	0.0	0.0	0.2	*10.3*
72	Honduras	*27.6*	*30.0*	*2.3*	2.6	17.2 [14]	22.5 [11]
73	Hong Kong, China	84.9 [25]	*87.3*	32.1	35.5	107.2	105.9
74	Hungary	72.8 [26]	79.3	27.4	28.5	39.8	44.5
75	Iceland	*98.2*	*98.2*	37.0	37.6	93.4	104.0
76	India	*26.0*	*29.5*	1.3 [13]	1.4 [16]	9.4 [15]	16.8 [12]
77	Indonesia	22.0 [27]	25.4	*1.6*	1.9	42.0	*67.3*
78	Iran (I.R.)	45.3 [28]	53.2	10.9	11.6	20.0	33.8
79	Ireland	80.1 [29]	82.2 [4]	27.7	28.5	95.0 [16]	98.2 [13]
80	Israel	77.4 [30]	*79.8*	27.4 [14]	28.1 [17]	84.6	93.4 [14]
81	Italy	58.1 [31]	61.3 [5]	24.4 [15]	25.4 [18]	82.1 [17]	86.7 [15]
82	Jamaica	42.2 [32]	*45.0*	8.1	10.1	53.5	56.2
83	Japan	91.1	*92.0*	30.7	31.5 [19]	128.3 [18]	131.9 [16]
84	Jordan	*60.1*	*62.3*	4.2	5.8	98.4	118.8
85	Kazakhstan	72.9 [33]	76.8	13.7	13.7 [20]	73.1	71.0
86	Kenya	*21.0*	*26.0*	0.3	0.3	15.5	26.2
87	Kiribati	*13.0*	*13.7*	0.1	*0.1*	0.3	*0.9*
88	Korea (Rep.)	89.6 [34]	92.7	40.2	41.1	109.7	111.5
89	Kuwait	*77.5*	*78.4*	1.5	2.8	52.5	66.8
90	Kyrgyzstan	*30.2*	*34.5*	3.7	4.1	31.0	46.1
91	Lao P.D.R.	*18.2*	*21.9*	0.5 [16]	0.3 [21]	14.2 [19]	34.7 [17]
92	Latvia	79.2 [35]	79.9	24.8 [17]	25.6 [22]	67.0 [20]	77.0 [18]

	Economy	Percentage of individuals using the Internet		Fixed-broadband subscriptions per 100 inhabitants		Active mobile-broadband subscriptions per 100 inhabitants	
		2015	2016	2015	2016	2015	2016
93	Lebanon	*74.0*	*76.1*	*25.4*	*25.6*	*57.7*	*67.2*
94	Lesotho	*25.0*	27.4	0.1	0.1	39.2	36.9
95	Libya	*19.0*	*20.3*	*1.0*	2.6	*31.8*	34.9
96	Lithuania	71.4 [36]	74.4	27.8 [18]	28.7 [23]	67.6	76.8 [19]
97	Luxembourg	97.3 [37]	97.5	35.9 [19]	*36.7*	87.8	*90.2*
98	Macao, China	77.6 [38]	81.6	29.1	*30.0* [24]	324.4	*332.1* [20]
99	Madagascar	*4.2*	*4.7*	0.1	0.1	13.2	10.5
100	Malawi	*9.3*	*9.6*	0.0	0.0	16.2	18.5
101	Malaysia	71.1 [39]	78.8	10.0	8.7	90.6 [21]	91.7
102	Maldives	*54.5*	*59.1*	6.5	7.2	63.6 [22]	72.7 [21]
103	Mali	*10.3*	11.1	0.0	0.0	18.8 [23]	24.4
104	Malta	76.2 [40]	77.3	37.8	39.6	62.6	71.4
105	Mauritania	*15.2*	*18.0*	0.2	0.3	23.1	30.2 [22]
106	Mauritius	50.1 [41]	*53.2*	15.7 [20]	16.9 [25]	37.0 [24]	51.7 [23]
107	Mexico	57.4 [42]	59.5	11.8	12.7 [26]	51.0	58.8 [24]
108	Moldova	63.3	71.0	15.5	16.3	51.9	55.5
109	Monaco	*93.4*	*95.2*	47.9	48.2	67.1 [25]	64.8 [25]
110	Mongolia	21.4 [43]	22.3	7.1	7.6	76.0	82.0
111	Montenegro	68.1 [44]	69.9	18.1	18.5	58.2	60.7
112	Morocco	57.1 [45]	58.3	3.4	3.7	39.3	46.0
113	Mozambique	*16.9*	*17.5*	0.2	0.1 [27]	44.9 [26]	49.5
114	Myanmar	*21.7*	*25.1*	0.1	0.1	33.5 [27]	47.6
115	Namibia	*25.7*	*31.0*	1.9	2.2	35.8	66.1
116	Nepal	*17.6*	*19.7*	1.1 [21]	0.8 [28]	26.4 [28]	*30.8*
117	Netherlands	91.7 [46]	90.4 [6]	41.7	42.2 [29]	81.6	87.8 [26]
118	New Zealand	*88.2*	*88.5*	31.6 [22]	32.4 [30]	114.2	101.3 [27]
119	Nicaragua	*19.7*	*24.6*	1.9 [23]	2.8 [31]	7.2	22.8
120	Nigeria	*24.5*	*25.7*	0.0	0.0	21.0	21.8
121	Norway	96.8 [47]	97.3	39.7	40.4 [32]	100.2	101.8 [28]
122	Oman	*66.1*	69.8	5.6 [24]	6.2	78.3	91.3
123	Pakistan	*14.0*	15.5	1.0 [25]	0.9 [33]	13.0 [29]	20.1 [29]
124	Palestine*	*57.4*	*61.2*	6.0	6.9	*0.0*	0.0
125	Panama	51.2 [48]	*54.0*	7.9 [26]	9.5 [34]	32.7	29.7
126	Paraguay	48.4 [49]	*51.3*	3.1 [27]	3.4 [35]	39.2 [30]	41.7 [30]
127	Peru	40.9 [50]	45.5	6.4	6.7	55.0 [31]	62.0 [31]
128	Philippines	*53.7*	*55.5*	4.8 [28]	*5.5*	*41.6*	*46.3*
129	Poland	68.0 [51]	73.3 [7]	19.0 [29]	*19.2*	57.4 [32]	*58.9*
130	Portugal	68.6 [52]	70.4	29.6	31.8	52.0	61.1
131	Qatar	92.9 [53]	*94.3*	10.1	10.8	120.5	129.2
132	Romania	55.8 [54]	59.5	19.8 [30]	20.7 [36]	63.7 [33]	73.7 [32]
133	Russian Federation	73.4 [55]	76.4 [8]	18.9	19.5	71.2	75.0
134	Rwanda	*18.0*	*20.0*	0.2	0.2	25.9	27.0
135	S. Tomé & Principe	*25.8*	*28.0*	0.6	0.7 [37]	17.7	24.0 [33]
136	Samoa	*25.4*	*29.4*	1.1 [31]	1.2 [38]	9.6 [34]	26.6 [34]
137	Saudi Arabia	69.6 [56]	73.8	11.9 [32]	10.8	111.7	78.5
138	Senegal	*21.7*	*25.7*	0.7	0.6	26.4	*26.1*
139	Serbia	65.3 [57]	67.1	17.4	18.9	*66.9*	67.4

	Economy	Percentage of individuals using the Internet		Fixed-broadband subscriptions per 100 inhabitants		Active mobile-broadband subscriptions per 100 inhabitants	
		2015	2016	2015	2016	2015	2016
140	Seychelles	*54.3*	*56.5*	14.3	14.9	19.1	22.6
141	Singapore	79.0	*81.0*	26.5	25.4 [39]	143.2 [35]	144.6 [35]
142	Slovakia	77.6 [58]	80.5 [9]	23.3	24.5	67.5	78.7
143	Slovenia	73.1 [59]	75.5	27.4	28.3	52.0	62.3
144	Solomon Islands	*10.0*	*11.0*	0.2	0.2	11.4 [36]	12.9
145	South Africa	*51.9*	*54.0*	2.6	2.8	59.5	58.6
146	Spain	78.7 [60]	80.6	28.7	29.5	82.7	87.3
147	Sri Lanka	*30.0*	*32.1*	2.9	4.1	15.8	18.3
148	St. Kitts and Nevis	*75.7*	*76.8*	29.6	*29.3*	71.0	77.1
149	St. Lucia	*42.5*	*46.7*	15.4	15.9	33.6	37.0
150	St. Vincent and the Grenadines	*51.8*	*55.6*	15.5	20.0	39.0	49.4
151	Sudan	*26.6*	*28.0*	0.1	0.1	29.4	*25.2*
152	Suriname	*42.8*	*45.4*	9.6	12.9	66.6	69.6
153	Sweden	90.6 [61]	91.5	36.1	36.3 [40]	122.1	125.2 [36]
154	Switzerland	87.5 [62]	89.4	45.1 [33]	46.3 [41]	102.0 [37]	103.7 [37]
155	Syria	*30.0*	*31.9*	3.1	4.0	10.5	10.4
156	Tanzania	*10.0*	*13.0*	*0.2*	*0.3*	*9.0*	9.2
157	TFYR Macedonia	70.4 [63]	72.2	17.2	17.9 [42]	53.5	59.0 [38]
158	Thailand	39.3 [64]	47.5	9.2 [34]	10.7	88.6 [38]	94.7
159	Timor-Leste	*23.0*	*25.2*	0.1	0.1	*37.5*	64.6
160	Togo	*7.1*	*11.3*	0.9 [35]	0.6 [43]	6.0	*19.6*
161	Tonga	*38.7*	*40.0*	2.3	*2.8*	50.0	*56.0*
162	Trinidad & Tobago	*69.2*	*73.3*	20.0	18.9	32.9	47.3
163	Tunisia	*48.5*	*50.9*	5.1	5.6	61.9	63.0
164	Turkey	53.7 [65]	58.3	12.4	13.6	50.9	66.8
165	Uganda	*17.8*	*21.9*	0.2 [36]	0.3 [44]	18.3 [39]	33.7 [39]
166	Ukraine	48.9 [66]	*52.5*	11.8	12.0	*8.1*	22.6
167	United Arab Emirates	*90.5*	90.6 [10]	12.9	13.3	130.9 [40]	156.7
168	United Kingdom	92.0 [67]	94.8	38.6	39.2	87.5 [41]	*91.4*
169	United States	74.6 [68]	*76.2*	31.4 [37]	32.4 [45]	115.5 [42]	120.0 [40]
170	Uruguay	64.6 [69]	66.4	26.3 [38]	26.8	77.7 [43]	102.0 [41]
171	Uzbekistan	*42.8*	*46.8*	6.0	9.1	44.0	55.9
172	Vanuatu	*22.4*	*24.0*	1.6 [39]	1.6	18.9 [44]	22.3 [42]
173	Venezuela	*61.9*	*60.0*	8.2 [40]	8.2 [46]	43.0 [45]	44.6 [43]
174	Viet Nam	*43.5*	*46.5*	8.2	9.9	38.3	46.6
175	Zambia	*21.0*	*25.5*	0.2 [41]	0.2	13.8	32.2
176	Zimbabwe	*22.7*	*23.1*	1.1	1.1	39.0	38.1

Note: Data in italics are ITU estimates. *Palestine is not an ITU Member State; the status of Palestine in ITU is the subject of Resolution 99 (Rev. Busan, 2014) of the ITU Plenipotentiary Conference.
Source: ITU World Telecommunication/ICT Indicators database.

Skills indicators

	Economy	Gross enrolment ratio				Mean years of schooling	
		Secondary		Tertiary			
		2015	2016	2015	2016	2015	2016
1	Afghanistan	54.3	55.6	3.7	8.7	3.2	3.6
2	Albania	96.4	95.8	62.7	58.1	9.3	9.6
3	Algeria	97.6	99.9	34.6	36.9	7.6	7.8
4	Andorra	130.8	130.8	84.6	84.6	10.3	10.3
5	Angola	31.5	28.9	9.9	9.9	4.7	5.0
6	Antigua & Barbuda	102.3	102.7	23.5	23.5	9.2	9.2
7	Argentina	106.3	106.8	80.0	82.9	9.8	9.9
8	Armenia	95.9	88.5	46.6	44.3	10.9	11.3
9	Australia	137.6	137.6	86.6	90.3	13.0	13.2
10	Austria	99.3	100.0	80.0	81.5	10.8	11.3
11	Azerbaijan	102.8	102.8	23.2	25.5	10.6	11.2
12	Bahamas	92.9	92.6	57.1	57.1	10.9	10.9
13	Bahrain	95.5	99.4	36.8	37.4	9.4	9.4
14	Bangladesh	58.3	63.5	13.2	13.4	5.1	5.2
15	Barbados	109.2	109.2	60.8	65.4	10.5	10.5
16	Belarus	107.0	107.1	88.9	87.9	12.0	12.0
17	Belgium	163.1	164.8	72.3	73.3	11.4	11.4
18	Belize	80.2	80.8	24.2	23.3	10.5	10.5
19	Benin	54.4	56.8	15.4	15.4	3.3	3.5
20	Bhutan	84.2	84.2	10.9	10.9	3.0	3.1
21	Bolivia	84.7	86.4	37.7	37.7	8.2	8.2
22	Bosnia and Herzegovina	89.3	89.3	37.7	37.7	9.2	9.0
23	Botswana	83.9	81.4	27.5	27.5	8.9	9.2
24	Brazil	105.8	102.0	25.6	49.3	7.7	7.8
25	Brunei Darussalam	99.1	96.1	31.7	30.8	8.8	9.0
26	Bulgaria	100.9	99.0	70.8	73.9	10.6	10.8
27	Burkina Faso	30.3	33.7	4.8	4.8	1.4	1.4
28	Burundi	37.9	42.5	4.4	4.4	2.7	3.0
29	Cambodia	45.0	45.1	15.8	13.1	4.4	4.7
30	Cameroon	56.4	58.1	11.9	17.5	6.0	6.1
31	Canada	103.4	109.9	66.6	66.6	13.0	13.1
32	Cape Verde	92.6	92.9	23.0	21.7	4.7	4.8
33	Central African Rep.	17.4	17.4	2.8	2.8	4.2	4.2
34	Chad	22.8	22.4	3.4	3.4	1.9	2.3
35	Chile	100.5	100.6	83.8	88.6	9.8	9.9
36	China	96.2	94.3	30.2	43.4	7.5	7.6
37	Colombia	93.0	98.1	51.3	55.6	7.3	7.6
38	Comoros	59.3	60.4	8.7	8.9	4.8	4.8
39	Congo (Dem. Rep.)	43.5	43.5	6.6	6.6	6.0	6.1
40	Costa Rica	120.3	123.1	53.0	53.6	8.7	8.7
41	Côte d'Ivoire	40.1	43.9	8.7	9.2	4.3	5.0
42	Croatia	98.4	99.0	61.6	69.5	11.0	11.2
43	Cuba	99.7	100.4	41.0	36.3	11.5	11.8
44	Cyprus	99.4	99.8	53.1	60.1	11.7	11.7
45	Czech Republic	104.4	105.1	65.4	66.0	12.3	12.3
46	Denmark	129.8	129.9	81.2	81.5	12.7	12.7

	Economy	Gross enrolment ratio				Mean years of schooling	
		Secondary		Tertiary			
		2015	2016	2015	2016	2015	2016
47	Djibouti	47.1	48.3	4.9	5.0	3.8	4.1
48	Dominica	96.7	100.5	34.2	34.2	7.9	7.9
49	Dominican Rep.	78.4	77.8	47.5	47.5	7.7	7.7
50	Ecuador	104.2	107.2	40.5	40.5	7.6	8.3
51	Egypt	86.0	86.1	30.3	36.2	6.6	7.1
52	El Salvador	78.1	81.1	29.2	28.9	6.5	6.5
53	Equatorial Guinea	28.2	27.4	3.3	3.2	5.5	5.5
54	Eritrea	34.8	30.5	2.3	2.6	3.9	3.9
55	Estonia	108.6	115.2	72.9	69.6	12.5	12.5
56	Ethiopia	28.9	37.7	6.3	8.1	2.4	2.6
57	Fiji	88.3	88.7	16.1	16.1	9.9	10.5
58	Finland	143.2	149.5	91.1	87.3	10.3	11.2
59	France	110.9	110.6	62.1	64.4	11.4	11.6
60	Gabon	53.9	53.3	8.5	8.4	7.8	8.1
61	Gambia	57.5	57.5	3.4	3.1	2.8	3.3
62	Georgia	99.4	103.7	39.2	43.4	12.3	12.2
63	Germany	102.5	102.7	61.1	68.3	13.5	13.2
64	Ghana	71.0	71.0	15.6	15.9	7.0	6.9
65	Greece	108.2	106.5	110.2	113.9	10.5	10.5
66	Grenada	101.1	99.2	52.8	91.1	8.6	8.6
67	Guatemala	63.5	63.5	18.3	18.3	7.0	6.3
68	Guinea	38.8	38.8	10.8	10.8	2.4	2.6
69	Guinea-Bissau	34.5	32.6	2.6	2.5	2.8	2.9
70	Guyana	101.0	89.3	12.9	12.5	8.5	8.4
71	Haiti	29.4	29.4	6.5	6.5	5.1	5.2
72	Honduras	68.4	70.8	21.2	21.2	6.2	6.2
73	Hong Kong, China	100.6	100.8	68.8	68.5	11.2	11.6
74	Hungary	108.2	105.2	57.0	50.9	11.6	12.0
75	Iceland	112.0	118.6	81.4	81.3	10.6	12.2
76	India	68.9	74.3	23.9	25.5	5.4	6.3
77	Indonesia	82.5	82.5	31.3	31.1	7.6	7.9
78	Iran (I.R.)	88.4	89.2	66.0	71.9	8.2	8.8
79	Ireland	126.5	127.2	73.2	77.6	12.2	12.3
80	Israel	101.5	101.9	66.3	66.2	12.8	12.8
81	Italy	102.4	102.6	63.5	63.1	10.1	10.9
82	Jamaica	83.0	82.1	27.4	27.2	9.7	9.6
83	Japan	101.9	101.7	62.4	63.4	11.5	12.5
84	Jordan	87.8	82.4	46.6	44.9	9.9	10.1
85	Kazakhstan	109.1	112.0	46.0	46.3	11.4	11.7
86	Kenya	67.0	67.6	4.0	4.0	6.3	6.3
87	Kiribati	86.4	87.1	17.0	17.0	7.8	7.8
88	Korea (Rep.)	97.7	97.7	95.3	95.3	11.9	12.2
89	Kuwait	92.5	95.0	27.0	27.0	7.2	7.3
90	Kyrgyzstan	90.8	90.8	47.3	45.9	10.6	10.8
91	Lao P.D.R.	57.2	61.7	17.3	16.9	5.0	5.2
92	Latvia	110.5	115.4	67.0	67.0	11.5	11.7
93	Lebanon	68.2	61.2	42.8	38.5	7.9	8.6
94	Lesotho	52.2	53.8	9.8	9.8	5.9	6.1

	Economy	Gross enrolment ratio				Mean years of schooling	
		Secondary		Tertiary			
		2015	2016	2015	2016	2015	2016
95	Libya	101.6	101.6	61.1	61.1	7.3	7.3
96	Lithuania	105.4	106.8	72.0	68.5	12.7	12.7
97	Luxembourg	102.4	102.3	19.7	19.4	11.7	12.0
98	Macao, China	96.1	96.5	69.4	75.6	7.5	9.8
99	Madagascar	38.4	38.4	4.2	4.8	6.0	6.1
100	Malawi	39.5	43.4	0.8	0.8	4.3	4.4
101	Malaysia	71.1	77.6	38.5	26.1	10.0	10.1
102	Maldives	72.3	69.8	13.2	16.2	5.8	6.2
103	Mali	43.5	41.3	7.5	6.9	2.0	2.3
104	Malta	85.5	85.8	45.1	47.0	11.3	11.3
105	Mauritania	29.9	30.6	5.5	5.3	3.8	4.3
106	Mauritius	97.9	95.7	38.7	36.7	8.5	9.1
107	Mexico	87.0	90.5	29.2	29.9	8.4	8.6
108	Moldova	88.3	86.1	41.3	41.2	11.9	11.9
109	Monaco	109.7	109.7	54.9	54.9	11.4	11.4
110	Mongolia	90.7	91.5	64.3	68.6	9.3	9.8
111	Montenegro	90.3	90.3	55.5	55.3	11.2	11.3
112	Morocco	68.9	69.1	24.6	28.1	4.4	5.0
113	Mozambique	24.5	32.4	6.0	6.0	3.2	3.5
114	Myanmar	51.3	51.3	13.4	13.5	4.1	4.7
115	Namibia	64.8	64.8	9.3	9.3	6.2	6.7
116	Nepal	67.2	69.6	15.8	14.9	3.3	4.1
117	Netherlands	130.7	132.3	77.3	78.5	11.9	11.9
118	New Zealand	117.2	117.5	79.7	80.9	12.5	12.5
119	Nicaragua	68.9	74.2	17.9	17.7	6.0	6.5
120	Nigeria	43.8	55.7	10.4	10.1	5.9	6.0
121	Norway	113.0	113.0	76.1	76.7	12.8	12.7
122	Oman	93.5	104.2	28.1	28.1	8.0	8.1
123	Pakistan	41.6	44.5	10.4	9.9	4.7	5.1
124	Palestine*	82.2	83.0	44.0	44.3	8.9	8.9
125	Panama	75.5	75.5	38.7	38.7	9.3	9.9
126	Paraguay	69.6	76.6	34.5	35.1	8.1	8.1
127	Peru	95.6	95.7	42.6	40.5	9.0	9.0
128	Philippines	88.4	88.4	35.8	35.8	8.9	9.3
129	Poland	108.7	108.7	71.2	71.2	11.9	11.9
130	Portugal	119.7	116.4	66.2	65.6	8.9	8.9
131	Qatar	111.6	109.4	15.8	17.2	9.8	9.8
132	Romania	97.9	92.3	52.2	53.2	10.6	10.8
133	Russian Federation	98.8	100.6	78.0	78.7	12.0	12.0
134	Rwanda	40.2	39.1	7.5	7.5	3.7	3.8
135	S. Tomé & Principe	84.9	86.2	9.8	13.4	5.3	5.3
136	Samoa	86.9	85.0	7.5	7.6	10.3	10.3
137	Saudi Arabia	108.3	108.3	61.1	63.1	8.7	9.6
138	Senegal	41.0	49.6	7.6	10.4	2.5	2.8
139	Serbia	94.3	96.7	58.1	58.3	10.8	10.8
140	Seychelles	74.6	81.6	6.5	14.3	9.4	9.4
141	Singapore	97.2	97.2	43.8	69.8	11.6	11.6
142	Slovakia	91.8	91.9	54.4	52.9	12.1	12.2

	Economy	Gross enrolment ratio				Mean years of schooling	
		Secondary		Tertiary			
		2015	2016	2015	2016	2015	2016
143	Slovenia	110.9	110.7	85.2	82.9	12.1	12.1
144	Solomon Islands	48.4	48.4	16.2	16.2	5.0	5.3
145	South Africa	98.2	92.0	19.7	19.4	10.3	10.3
146	Spain	131.1	129.8	87.1	89.7	9.8	9.8
147	Sri Lanka	99.7	99.7	20.7	19.8	10.8	10.9
148	St. Kitts and Nevis	91.5	90.4	79.1	79.6	8.4	8.4
149	St. Lucia	86.5	85.1	16.9	16.8	9.3	9.3
150	St. Vincent and the Grenadines	104.7	106.4	18.2	18.2	8.6	8.6
151	Sudan	40.7	42.7	16.9	16.3	3.1	3.5
152	Suriname	78.5	81.1	12.1	12.7	7.7	8.3
153	Sweden	128.5	132.9	63.4	62.4	12.3	12.3
154	Switzerland	96.3	99.8	56.3	57.2	13.8	13.4
155	Syria	50.5	50.5	34.5	44.0	6.3	5.1
156	Tanzania	32.3	32.3	3.6	3.6	5.1	5.8
157	TFYR Macedonia	82.8	78.6	39.4	39.6	9.3	9.4
158	Thailand	86.2	129.0	51.4	48.9	7.3	7.9
159	Timor-Leste	73.1	76.8	17.7	18.1	4.4	4.4
160	Togo	54.9	54.7	10.1	10.6	4.5	4.7
161	Tonga	90.6	90.1	6.3	6.3	10.7	11.1
162	Trinidad & Tobago	85.5	85.5	12.0	12.0	10.9	10.9
163	Tunisia	90.1	88.2	34.6	34.6	6.8	7.1
164	Turkey	114.6	100.3	79.0	86.3	7.9	7.9
165	Uganda	27.6	26.1	9.1	4.5	5.4	5.7
166	Ukraine	99.2	99.2	82.3	82.3	11.3	11.3
167	United Arab Emirates	83.6	83.6	22.0	22.0	9.5	9.5
168	United Kingdom	124.4	127.8	56.9	56.5	13.3	13.3
169	United States	95.9	97.6	88.8	85.8	13.6	13.2
170	Uruguay	90.3	95.1	63.2	63.1	8.6	8.6
171	Uzbekistan	105.2	95.9	8.9	9.1	10.9	12.0
172	Vanuatu	59.5	54.0	4.7	4.7	6.8	6.8
173	Venezuela	91.6	89.7	78.1	77.0	8.9	9.4
174	Viet Nam	77.2	77.2	30.5	28.8	7.5	8.0
175	Zambia	45.5	45.5	2.4	2.2	6.6	6.9
176	Zimbabwe	47.2	47.6	5.9	8.4	7.3	7.7

Note: Note: *Palestine is not an ITU Member State; the status of Palestine in ITU is the subject of Resolution 99 (rev. Busan, 2014) of the ITU Plenipotentiary Conference.
Source: Gross enrolment ratio refer to latest available data from UIS. Mean years of schooling data are from UNDP HDR and UIS.

Notes

The notes are presented here as submitted by countries to ITU.

Access indicators

Fixed-telephone subscriptions per 100 inhabitants, 2015

1) Incl. 254132 WLL subscriptions. Source: ARPT/Algérie Télécom. 2) Preliminary. 3) As of June 2016. Source: Australian Communications and Media Authority, 2016, Communications report 2015-16, ACMA, Sydney, p. 7. Change in data source in 2016 to ACCC retail and resale data collected from the providers stated in the Division 12 Record Keeping Rules. 2015 data has been revised to be consistent with the 2016 data collection method and differs from data reported in the previous Communications report. 4) Incl. ISDN channels measured in ISDN B channel equivalents. 5) Incl. PSTN and CDMA fixed base. 6) Bhutan Telecom is the only service provider for fixed-lines in Bhutan. 7) December 2015. 8) Including bundled packages. 9) Decrease due to the reduction of FWLL services which contributes to 78 per cent of total fixed-telephone subscriptions. 10) Sept. 11) Total retail access lines. 12) Source: Sistema de Infromación Integral Colombia TIC. 13) Preliminary. 14) Incl. IP lines. 15) Incl. public payphones. 16) Including ISDN voice-channel equivalents. Data based on estimates. 17) December 2015. 18) Decrease was due to consumer preference in using mobile phones instead of fixed phones since proliferation of fixed telephone lines (infrastructure) has also decreased, and main priority is in rolling out fiber optic networks for broadband. 19) Incl. PSTN lines, ISDN paths, FWA subscriptions, public payphones and VOIP. 20) Incl. PRI access lines. 21) Source: AGCOM. 22) The major fixed network provider shut down its fixed wireless network and migrated the subscribers to its GSM network. 23) Data from 4 main operators, LTC, BEELINE, UNITEL, ETL. 24) Data on 11.08.2016, source- Public Utilities Commission. 25) Incl. digital lines. Without including separate ISDN channels (fixed-telephone subscriptions). 26) Excl. ISDN channels and fixed wireless subscriptions. 27) 2014 subs included CDMA subscribers however fixed subs only were 18,963. 28) December 2015. Source: January 2016 Management Information System Report. 29) Estimate. 30) Figures are as on 31st December, 2015 based on data received from Fixed Line Operators. 31) Estimate. 32) All fixed subscribers, public payphones and VoIP subscribers. 33) Inactive fixed telephones were disconnected. 34) Refers to Bluesky and Digicel, the two main operators. 35) Ninety day period has been taken into consideration for active fixed telephone subscriptions. 36) Strong decrease due to the disconnection of inactive subscriptions. 37) Estimate. 38) NBTC. 39) Only includes fixed subscriptions (WLL and ISDN) but excludes CDMA. 40) December. 41) Data as of June 30, 2015. 42) Preliminary.

Fixed-telephone subscriptions per 100 inhabitants, 2016

1) Incl. 229950 WLL subscriptions. 2) As at June 2016. Source: Australian Communications and Media Authority, 2016, Communications report 2015-16, ACMA, Sydney, p. 7. Change in data source in 2016 to ACCC retail and resale data collected from the providers stated in the Division 12 Record Keeping Rules. 3) Incl. ISDN channels measured in ISDN B channel equivalents. 4) December 2016. 5) Bhutan Telecom is the only service provider for fixed-lines in Bhutan. 6) 42705 7) Incl. bundled packages. 8) Preliminary data. 9) Agence de Régulation et de Contrôle des Télécommunications. 10) 30/06/2016 11) Q3 2016 12) Source: Colombia TIC. 13) The figure for 2016 is based on provisional data and therefore represents an estimate. 14) Incl. IP lines. 15) Incl. public payphones. 16) Data as of 30 September 2016. 17) Fixed network in operation since 2010. 18) December 2016. 19) Incl. PSTN lines, ISDN paths, FWA subscriptions, public payphones and VOIP. 20) Incl. PRI access lines. 21) Source: AGCOM. 22) The number of fixed public payphones is as of March 2016. (This data is reported by carriers every March.) 23) This includes fixed lines and fixed wireless subscriptions. During the year, an operator introduced fixed wireless however the subscriptions are low. 24) Data from 4 main operators, LTC, BEELINE, UNITEL, ETL. 25) Source - Public Utilities Commission. 26) Information and Communication Technologies Authority of Mauritius. 27) Preliminary-December 2016. 28) Based on NTA January 2016 Management Information System Report. 29) Data Q3 2016 30) Estimated fixed lines with a voice service. 31) Estimate. 32) Decrease was due to the migration of one operator subscribers to GSM network. 33) First half 2016. 34) The total fixed telephone subscriptions has declined due to the technical adjustments in the calculation by the service providers as per ITU definitions. 35) Figures are as on 31st December, 2016. 36) Estimate. 37) Incl. public telephone lines. 38) Provisional data. 39) The number of fixed telephones have continued to decrease. 40) Used mostly for public services. 41) Bluesky Samoa Limited, only fixed line service provider in Samoa. 42) Data as of Dec 2016. 43) Ninety day period has been taken into consideration for active fixed telephone subscriptions. 44) As per 30 June 2016. No data yet available for 31 December 2016. 45) Estimates. 46) Value in the third quarter of 2016. 47) Only includes fixed subscriptions (WLL and ISDN) but excludes CDMA. 48) December. 49) FCC trend-based estimate using recent historical data. 50) Preliminary.

Mobile-cellular subscriptions per 100 inhabitants, 2015

1) Source: ARPT. 2) Preliminary. 3) As at June 2015. Source: Australian Communications and Media Authority, 2016, Communications report 2015-16, ACMA, Sydney, p. 7; Bureau of Communications and Arts Research Calculations. 4) Incl.

mobile GSM mobile base. 5) Bhutan Telecom and Tashi Cell combined. 6) Sept. 7) Source: Sistema de Infromación Integral Colombia TIC. 8) Preliminary. 9) Excl. M2M services. 10) Operators cleaned inactive lines. Incl. public mobile telephony. 11) Excl. 2 351 881 prepaid cards that are used to provide Travel SIM/WorldMobile service. 12) There was a Telecom Expansion Project (TEP) ongoing which results in about 12 Million new subscriber than the previous year. 13) Excl. data-only subscriptions. 14) Excl. data-only SIM cards and M2M cards. 15) No tax was applied, therefore the number of subscriptions experienced growth. 16) Data correspond to two operators (Orange et MTN). The third operator (Guinétel) is no longer operative. 17) December 2015. Including cellular and fixed wireless local loop. 18) Estimate. 19) Source: AGCOM. 20) Incl. PHS and data cards, cannot be separated. 21) Data from 4 main operators: LTC, BEELINE, UNITEL, ETL. 22) Source- Public Utilities Commission. 23) Data from 4 operators including 2 CDMA providers. 24) Active subscriptions. 25) Information and Communication Technologies Authority of Mauritius. 26) Active subscriptions (85.88per cent of the total). 27) December 2015 Source: NTA Management Information System Report. 28) Incl. inactive. 29) Figure is reported after bio-metric re-verification of SIMs in 2015 by all Cellular Mobile Operators. 30) Estimate. 31) Excl. data-only subscriptions. 32) Excl. 492.761 M2M subscriptions. 33) Includes active (in the last 6 months) prepaid accounts. 34) Refers to Bluesky and Digicel, the two main operators. 35) Data as at end Mar 2016. 36) This number is different from the one provided during short questionnaire because we had a good response rate from licensees. 37) Estimates. 38) NBTC. 39) December. 40) UBS Investment Research Data as of 6/30/15 as reported in the FCC's Eighteenth Mobile Wireless Competition Report. 41) Excl. subscriptions via data cards or USB modems. 42) Preliminary.

Mobile-cellular subscriptions per 100 inhabitants, 2016

1) Source: ARPT. 2) As of June 2016. Source: Australian Communications and Media Authority, 2016, Communications report 2015-16, ACMA, Sydney, p. 7; Bureau of Communications and Arts Research Calculations. 3) Annual report 2016. 4) December 2016. Including cellular and fixed wireless local loop. 5) Bhutan Telecom and Tashi Cell combined. 6) Preliminary. 7) Agence de Régulation et de Contrôle des Télécommunications. 8) Decrease was due to enforcement on sim cards that have no Identity document. 9) December 2016. 10) These figures are based on quarterly data and will be revised in the long form survey with annual data. 11) Source: Colombia TIC. 12) SIM cards for internet access service without voice services (subscriptions via data cards or USB modems) and M2M SIM cards were not included. The figure for 2016 is based on provisional data and therefore represents an estimate. 13) Incl. public payphones. 14) Data as of 30 September 2016. 15) Excl. 320 502 prepaid cards that are used to provide Travel SIM. 16) Excl. data-only subscriptions. 17) Data correspond to two operators (Orange et MTN). The third operator is not operative since 2010. 18) December 2016. Including cellular and fixed wireless local loop. 19) Estimate. 20) Source: AGCOM. 21) Incl. PHS and data cards, cannot be separated. 22) Data from 4 main operators: LTC, BEELINE, UNITEL, ETL. 23) Source- Public Utilities Commission. 24) CTT website. 25) Active subscriptions. 26) Information and Communication Technologies Authority of Mauritius. 27) Preliminary- December 2016. 28) Active subscriptions (85.5 per cent). 29) SIMs that are not registered are suspended. 30) NTA MIS January. 31) Data Q3 2016. 32) Estimated active in last 90 days. 33) Incl. inactive. 34) First half 2016. 35) Data as of 31st December 2016. 36) Estimate. 37) December 2016. 38) Excl. data-only subscriptions. 39) Estimate of active subscriptions. 40) Excl. 758.680 M2M subscriptions. 41) Provisional data. Incl. active (in the last 6 months) prepaid accounts. 42) Active subscriptions. 43) Figures from Bluesky Samoa and Digicel Samoa Ltd. 44) Data as of Dec 2016. 45) One operator lost around 29 per cent of its subscriptions. 46) As per 30 June 2016. 47) Estimate. 48) As of Q3 2016. 49) December. 50) UBS Data. 51) Excl. subscriptions via data cards or USB modems. 52) Preliminary.

International Internet bandwidth per Internet user, 2015

1) December 2015. 2) 2867.2 Mbit/s for Bhutan Telecom and 600 Mbit/s for TashiCell. 3) Source: TRAI. 4) ITU research based on Telegeography's website. 5) Ref. LTC&UNITEL. 6) Four operators only. 7) As per data received from PTCL and TWA. 8) Contracted capacity. 9) Figures obtained from Bluesky and Digicel 10) Downlink capacity. 11) Tonga Cable Limited. 12) December. 13) Incl. UAEs Yahsat & Thuraya 14) Installed capacity.

International Internet bandwidth per Internet user, 2016

1) ITU research based on Telegeography's website. 2) Contracted capacity 3) Downlink capacity. 4) Incl. UAEs Yahsat & Thuraya. 5) Installed capacity.

Percentage of households with a computer, 2015

1) Estimate. 2) As of 2015, incl. tablets. 3) According to the Analytical Survey report "Citizens" perception, uptake and support for the e- Transformation of Governance in the Republic of Moldova" – 2015, the share of households that own at least one computers is 68 per cent. 4) Households with population 12+. 5) Incl. desktop, notebook and tablet, and excl. PDA and smartphone.

Percentage of households with a computer, 2016

1) According to the Analytical Survey report "Citizens" perception, uptake and support for the e-Transformation of Governance in the Republic of Moldova" – 2016, the share of households that own at least one computers is 71 per cent. 2) Households with population 12+. 3) Private households, observation units- individuals aged from 15 to 72 (members of these households). 4) ITU estimate based on the 2015 data from Statistical Office of Slovenia.

Percentage of households with Internet, 2015

1) According to the Analytical Survey report "Citizens" perception, uptake and support for the e- Transformation of Governance in the Republic of Moldova" – 2015, the share of households with computers connected to the Internet is 68 per cent. 2) Households with population 12+.

Percentage of households with Internet, 2016

1) According to the Analytical Survey report "Citizens" perception, uptake and support for the e- Transformation of Governance in the Republic of Moldova" – 2016, the share of households with computers connected to the Internet is 76 per cent. 2) Households with population 12+. 3) Estimate based on the results from the 2015-2016 General Household Survey. 4) Private households, observation units- individuals aged from 15 to 72 (members of these households).

Use indicators

Percentage of individuals using the Internet, 2015

1) Population age 15+. 2) Population age 16-74. 3) Population age 7+. 4) Population age 15+. 5) Break in series. Population age 6-72. 6) Population age 16-74. Last three months. 7) Population age 16-74. 8) Permanent residents at the age of 6 or above. In the last 6 months. 9) Population age 5+. 10) Population age 5+ in the last three months. 11) Population age 16-74. 12) Population age 6+. 13) Population age 16-74. 14) Population age 16+. 15) Population age 16-74. 16) Population age 12+. 17) Population age 5+. 18) Population age 6+. 19) Population age 16-74. 20) Population aged 16-89. 21) Population age 16-74. 22) Population age 6+. Break in comparability, reference period in the last 3 months. 23) Population age 16-74. 24) Population age 16-74. 25) Population age 10+. 26) Population age 16-74. 27) Population age 5+. 28) Country estimate. 29) Population age 16-74. Last three months. 30) Population age 20+. 31) Population age 6+. 32) Country estimate. 33) Population age 6-74. 34) Population age 16-74. 35) Population age 16-74. 36) Population age 16-74. 37) Population age 16-74. 38) Population age 3+. 39) Population age 15+. 40) Population age 16-74. 41) Population age 5+. 42) Population age 6+. Break in comparability: as of 2015 the respondent of ICT use questions is a self-respondent randomly selected and the survey is a stand-alone ICT survey. Before the ICT survey was a module attached to a main survey and respondent was an informed person of the household who responded about self and the other members of the household. 43) All population. 44) Population age 16-74. 45) Population age 5+ using Internet in the last 3 months. 46) Population age 12+. 47) Population age 16-74. 48) Population age 10+ 49) Population age 10+. 50) Population age 6+. 51) Population age 16-74. Last three months. 52) Population age 16-74. 53) "Mainstream" population age 15+ living in households. 54) Population age 16-74. 55) Percentage of population aged 15-72 years who used the Internet in the last 12 months. 56) Population age 12-65 over total population 57) Population age 16-74. 58) Population 16-74. Last three months. 59) Population age 16-74. 60) Population age 16-74. 61) Population age 16-74. 62) In the last 6 months. Population age 14+. 63) Population age 16-74. 64) Population age 6+. 65) Population age 16-74. 66) All population. 67) Population age 16-74. 68) Population age 3+. 69) Population age 6+.

Percentage of individuals using the Internet, 2016

1) Population age 16-74. Last three months. 2) Population age 16+. 3) Population aged 16-89. 4) Population age 16-74. Last three months. 5) Population age 6+. 6) Population age 12+. 7) Population age 16-74. Last three months. 8) Percentage of population aged 15-72 years who used the Internet in the last 12 months. 9) Population 16-74. Last three months. 10) Population age 15-74 in the last 3 months.

Fixed-broadband subscriptions per 100 inhabitants, 2015

1) A few subscriptions between 128 and 256 kbps are still included. 2) Internet activity survey December 2015. 3) Incl. Ded Inet, HSI & EVDO. 4) Estimate. 5) Information provided by 92.3 per cent of all ISPs. 6) ADSL, ADSL+, CDMA. 7) Source: Colombia TIC. 8) Incl. WiFi subscriptions (not WiFi hotspots). Estimates. 9) Incl. 144 kbit/s to less than 256 kbit/s. Excl. subscriptions with unspecified download capacity. 10) Updated data. 11) There are 63.267 lines that are not classified by the

operators to indicated speed categories. 12) Fixed Wimax. Incl. 861 subscriptions at speeds of 128-255 kbps 13) December 2015. Subscriptions with download speeds of at least 512 Kbps. 14) Dec. 2015- Inc. DSL and cable. 15) Source: AGCOM. 16) There are Ref.no from 4 main operators, LTC, BEELINE, UNITEL, ETL. 17) Source- Public Utilities Commission. 18) Wimax included to the mobile. 19) Incl. non-residential customers (ca 49'000). 20) Information and Communication Technologies Authority of Mauritius. 21) December 2015. Source: Management Information System. 22) As of June 2015. 23) Estimate. 24) Incl. less than 40 subscriptions below 256 Kbps. 25) Figure is based on data received from Broadband Operators. 26) Estimate. 27) Estimate. 28) Incl. fixed wireless. 29) Speeds equal to or grater than 144 kbit/s. 30) Incl. subscriptions at downstream speeds equal to or greater than 144 kbit/s (the number of subscriptions that are included in the 144-256 range is insignificant). SIM based fixed connections are included. 31) Refers to Bluesky and Digicel, the two main operators. 32) Incl. subscriptions to fixed LTE. 33) Estimates. 34) NBTC. 35) ADSL, dedicated internet line, Wimax, Ev-Do. 36) December. 37) Please note that FCC collects information about broadband Internet access subscriptions in service that have downstream bandwidths exceeding 200 kbps, rather than 256 kbps. 38) Incl. ADSL and FTTH + LMDS. 39) Incl. xDSL, fixed wireless data subscription and fixed broadband internet subscribers. Numbers are believed to have dropped as some subscribers have preferred to switch to mobile broadband alternatives as prices for these services have fallen and quality has increased. 40) Preliminary. 41) ISP subscriptions with Internet speed of at least 256 kbps.

Fixed-broadband subscriptions per 100 inhabitants, 2016

1) Decrease due to companies that closed. 2) Source: Australian Bureau of Statistics, 2017, Internet Activity, Australia, December 2016, cat. No. 8153.0 (Table 1), ABS, Canberra; Bureau of Communications and Arts Research Calculations. 3) Annual report 2016. 4) December 2016. 5) Data only for one operator (Bhutan Telecom). 6) 01/12/2016 7) Preliminary data. 8) Agence de Régulation et de Contrôle des Télécommunications. 9) Adsl, fttx and LS. 10) Source: Colombia TIC. 11) Incl. WIFI subscriptions (not WIFI hotspots). The figure for 2016 is based on provisional data and therefore represents an estimate. 12) Incl. 144 kbit/s to less than 256 kbit/s. Excl. subscriptions with unspecified download capacity. 13) Data as of 30 September 2016. 14) Data as of 30/06/2016. 15) Speeds > 128 and ≤ 256Kbps = 721 (Fixed Wimax)- Operator Orange only. 16) December 2016. Subscriptions with download speeds of at least 512 Kbps. 17) Dec. 2016- Inc. DSL and cable. 18) Source: AGCOM. 19) December 2016. 20) Incl. fixed wired and fixed wireless broadband subscriptions. 21) There are Ref.no from 4 main operators, LTC, BEELINE, UNITEL, ETL. 22) Source- Public Utilities Commission. 23) Wimax included to the mobile. 24) CTT website. 25) Information and Communication Technologies Authority of Mauritius. 26) Preliminary-December 2016. 27) The number of subscribers are from TDM, Teledata, IS and TVCabo. Most of the subscriptions are related to connection and from that link there are more users. 28) NTA MIS January report. DSL, fibre and cable modem. 29) Data Q3 2016. 30) As at June 2016 and as provided to OECD. 31) Estimate connections. 32) Source: Statistics Norway. 33) Figures are as of 31st December 2016. 34) Estimate. 35) Estimate as of December 2016. 36) Provisional data. Incl. subscriptions at downstream speeds equal to or greater than 144 kbit/s (the number of subscriptions that are included in the 144-256 range is insignificant). SIM based fixed connections are included. 37) Mostly used for public services. 38) Figures obtained from Bluesky, CSL and Digicel Samoa. 39) Data as of December 2016. 40) As per 30 June 2016. No data yet available for 31 December 2016. 41) Estimate. 42) Value as of Q3 2016. 43) ADSL, dedicated internet line, Wimax, Ev-Do. 44) December. 45) FCC trend-based estimate using recent historical data. Please note that FCC collects information about broadband Internet access subscriptions in service that have downstream bandwidths exceeding 200 kbps, rather than 256 kbps. 46) Preliminary.

Active mobile-broadband subscriptions per 100 inhabitants, 2015

1) Source: ARPT. 2) Preliminary. 3) Source: Australian Bureau of Statistics, 2017, Internet Activity, Australia, December 2016, cat. No. 8153.0, ABS, Canberra; Bureau of Communications and Arts Research Calculations. 4) GPRS/EDGE and LTE. 5) Combined number for two operators. The increase is due to increased growth of smart phones and increase in 3G network. 6) Activity criteria: data communication in the last month. 7) Number of subscriptions from the operators offering 3G services. 8) December 2015. 9) Source: Colombia TIC. 10) Only postpaid mobile-broadband subscriptions. 11) Data screening was made and the previous years data is found to include GPRS and EDGE internet users. 12) Before 2014, Mobitel offered only 2G. In 2015 it received an LTE license and launched the service. 13) Does not incl. prepaid smartphones. 14) Speeds equal or greater than 1 Mbit/s. 15) December 2015. Subscriptions with download speeds of at least 256 kbit/s. 16) Users who have made a transaction in the last 90 days via a handset, dongle/USB modem or other mobile Internet device, whereby they accessed advanced data services such as web/Internet content, online multiplayer gaming content, VoD or other equivalent data services (excluding SMS and MMS). 17) Source: AGCOM. 18) Incl. standard and dedicated mobile broadband Wimax. 19) There are Ref.no from 4 main operators, LTC, BEELINE, UNITEL, ETL. 20) Source- Public Utilities Commission. 21) The increase was due to the attractive price offered in postpaid and prepaid packages; pay per use subscriptions and the introduction of LTE package. 22) Equal to dedicated mobile broadband subs as CAM does not report on standard mobile broadband pay-as-you-go subscriptions. 23) Incl. both Orange and Sotelma customers. 24) Information and Communication Technologies Authority of Mauritius. 25) Estimation DCE. 26) Big increase due to the entrance of a new operator. 27) Active MPT and Telenor subscriptions. 28) Estimate. Activity period: 6 months. 29) Figures are as on 31st December, 2015 based on data received from cellular mobile Operators. 30) Estimate. Activity period: 6 months. 31) Incl. handset-based mobile broadband. 32) Speeds equal to or greater than 144 kbit/s. 33) includes active subs (in the last 6 months), by 3G and higher

technologies. SIM based fixed connections are excluded. 34) Figures obtained from Bluesky Samoa Digicel Samoa and Lesa Telephone Service. 35) Data as of end Mar 2016. 36) Slight drop due to upgrades on data services network by the two operators in April, Sept, Dec. 37) Estimate. Activity period: 6 months. 38) NBTC. 39) December. 40) Revised data received from Sector. 41) Excl. M2M subscriptions. 42) Based on data from Ovum. 43) Incl. subscriptions with potential access. 44) TRR estimates for active subscriptions. The number of subscriptions with theoretical ability to use mobile broadband is 78216. 45) Preliminary.

Active mobile-broadband subscriptions per 100 inhabitants, 2016

1) Source: Australian Bureau of Statistics, 2017, Internet Activity, Australia, December 2016, cat. No. 8153.0, ABS, (Table 1: Mobile wireless and Table 5: No of mobile handset subscribers) Canberra; Bureau of Communications and Arts Research Calculations. 2) December 2016. 3) Only for one operator (Bhutan Telecom) The increase is due to increased growth of smart phones and increase in 3G network and introduction of LTE. 4) Activity criteria: data communication in the last month. 5) 01/12/2016 6) Preliminary data. 7) Agence de Régulation et de Contrôle des Télécommunications. 8) These figures are based on quarterly data and will be revised in the long form survey with annual data. 9) Source: Colombia TIC. 10) The figure for 2016 is based on provisional data and therefore represents an estimate. 11) Speeds equal or greater than 1 Mbit/s. 12) December 2016. Subscriptions with download speeds of at least 512 kbit/s. 13) Users who have made a transaction in the last 90 days via a handset, dongle/USB. 14) Estimate. 15) Source: AGCOM 16) December 2016, incl. standard and dedicated mobile broadband Wimax 17) Increase due to wider coverage- all township can access to 3G and LTE network. 18) Source - Public Utilities Commission. 19) Data as of July 2016. 20) CTT website. 21) Equal to dedicated mobile broadband subs as CAM does not report on standard mobile broadband pay-as-you-go subscriptions. 22) Active subscriptions. 23) Information and Communication Technologies Authority of Mauritius. 24) Preliminary- December 2016. 25) Estimation DCE. 26) Data Q3 2016. 27) As reported to the OECD. 28) First half 2016. 29) Figures are as on 31st December, 2016. 30) Data as of June 2016. 31) Incl. handset-based mobile broadband. 32) Provisional data. Incl. active subs (in the last 6 months), by 3G and higher technologies. SIM based. 33) New services and tariffs at low costs. 34) Figures obtained from Bluesky and Digicel Samoa. 35) Data as of December 2016 36) As per 30 June 2016. No data yet available for 31 December 2016. 37) Estimates. 38) Value in the third quarter of 2016. 39) December. 40) Based on data from Ovum. Data as of June 30, 2016. 41) Incl. subscriptions with potential access. 42) TRR estimates for active subscriptions. The number of subscriptions with theoretical ability to use mobile broadband is 101,438. 43) Preliminary.

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