

# GLOBAL DIGITAL TRANSFORMATION

## LECTURE 2 – LANDSCAPE

TOMASZ JANOWSKI

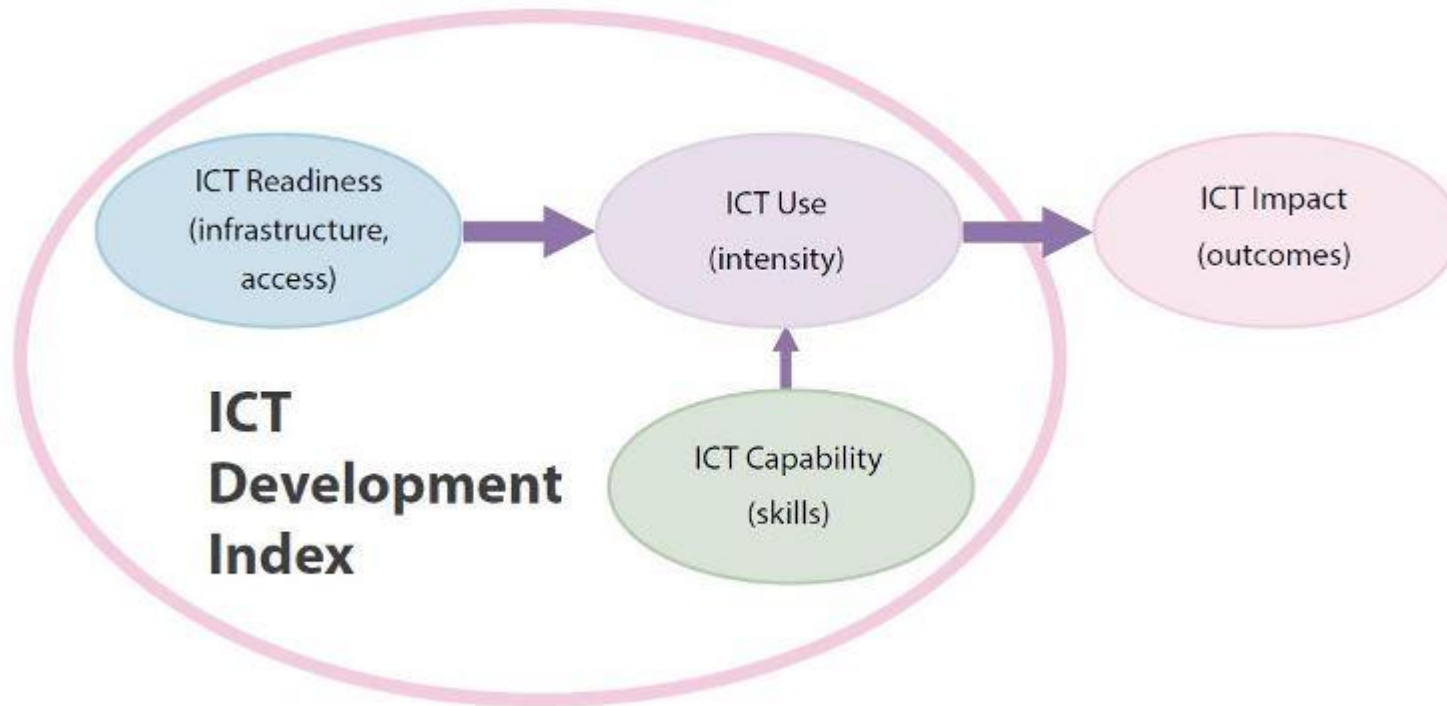
GDAŃSK UNIVERSITY OF TECHNOLOGY, POLAND

DANUBE UNIVERSITY KREMS, AUSTRIA

# COURSE

1.	BACKGROUND	What is digital transformation about?
2.	LANDSCAPE	What is the global adoption of digital transformation?
3.	INNOVATIONS	What are the cases of digital transformation?
4.	FEATURES	What features define digital transformation?
5.	BOUNTY	What benefits can digital transformation deliver?
6.	SPREAD	How unequal are the benefits of digital transformation?
7.	WINNERS	Who benefits most from digital transformation?
8.	IMPACT	What is the impact of the bounty and spread?

# FRAMEWORK



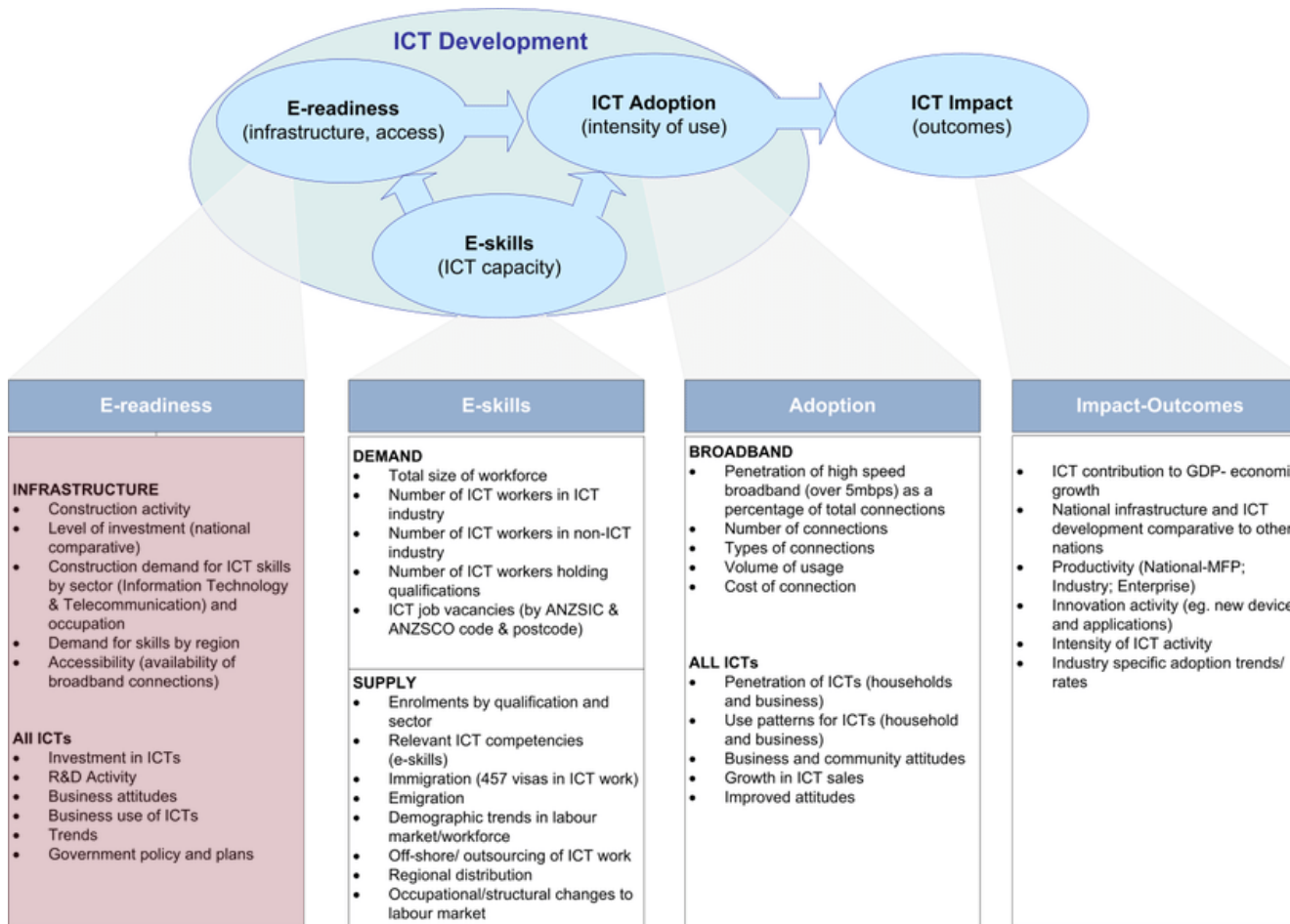
Source: ITU, *Measuring the Information Society Report 2018*, vol. 1. 2018.

# OUTLINE

1. READINESS
2. USE
3. CAPABILITY
4. IMPACT

HOW IS DIGITAL ACCESS SHAPING AROUND THE WORLD?

# FRAMEWORK



Source: ITU, *Measuring the Information Society Report 2018*, vol. 1. 2018.

# ACCESS

What kind of access?

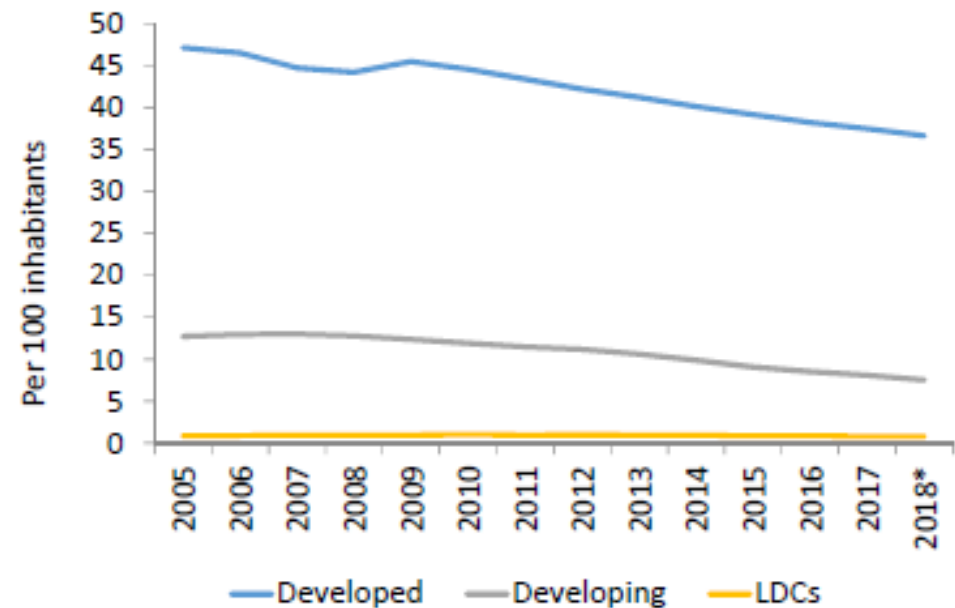
- Fixed phones
- Mobile phones
- Fixed broadband
- Mobile broadband
- Mobile coverage
- Households with computers
- Householders with Internet

# ACCESS – FIXED PHONES

Fixed penetration rates are going down, because of:

- “cord-cutters”, people who are resigning their fixed-telephone subscriptions, and
- “cord-nevers”, young people who have never subscribed to a fixed line, and will most likely never do so.

Fixed-telephone subscriptions by 100 inhabitants by level of development, 2005-2018.



Source: ITU, *Measuring the Information Society Report 2018*, vol. 1. 2018.



# ACCESS – MOBILE PHONES

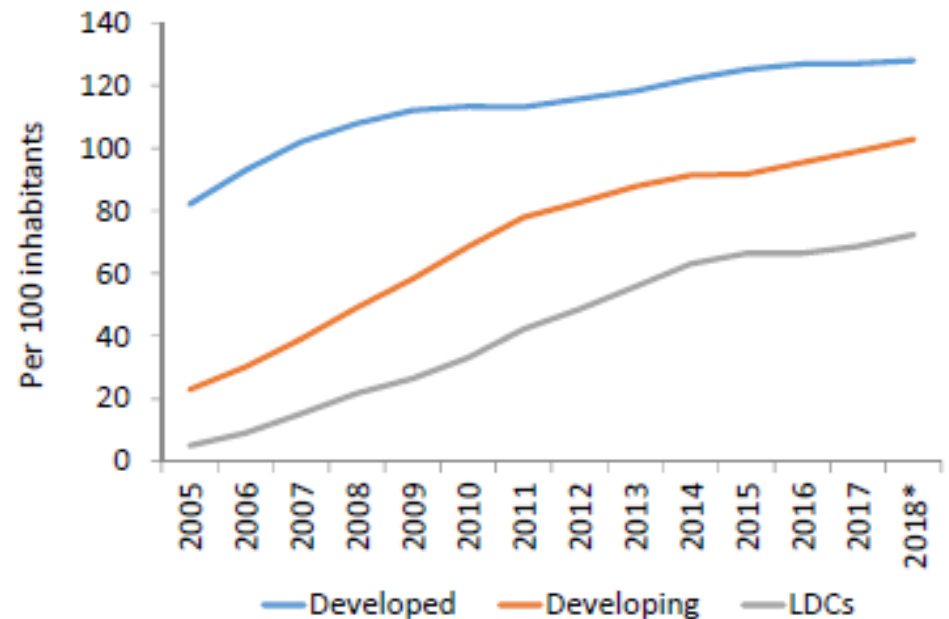
Great potential in reaching geographically or socially isolated populations.

Saturation rates are being reached in developed countries.

Growth in developing countries, especially LDCs, was sustained.

Developing countries will continue to reduce the gap with developed countries.

Mobile-cellular subscriptions per 100 inhabitants, by level of development, 2005–2018.



Source: ITU, *Measuring the Information Society Report 2018*, vol. 1. 2018.

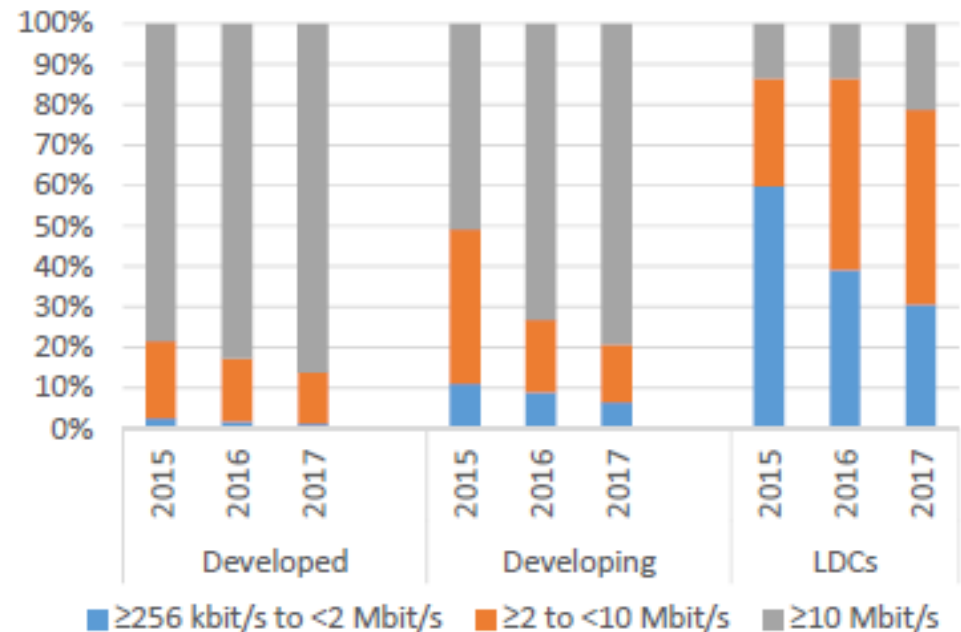
# ACCESS – FIXED BROADBAND

An increase of 1% in fixed-broadband is associated with an increase in 0.08% in GDP.

While fixed-phone subscriptions continue to decline, fixed-broadband continue to increase.

Low speed (<2 Mbit/s) virtually disappear in developed countries but constitute 30% of subscriptions in LDCs.

Fixed-broadband subscriptions per 100 inhabitants, by region, 2005–2018.



Source: ITU, *Measuring the Information Society Report 2018*, vol. 1. 2018.

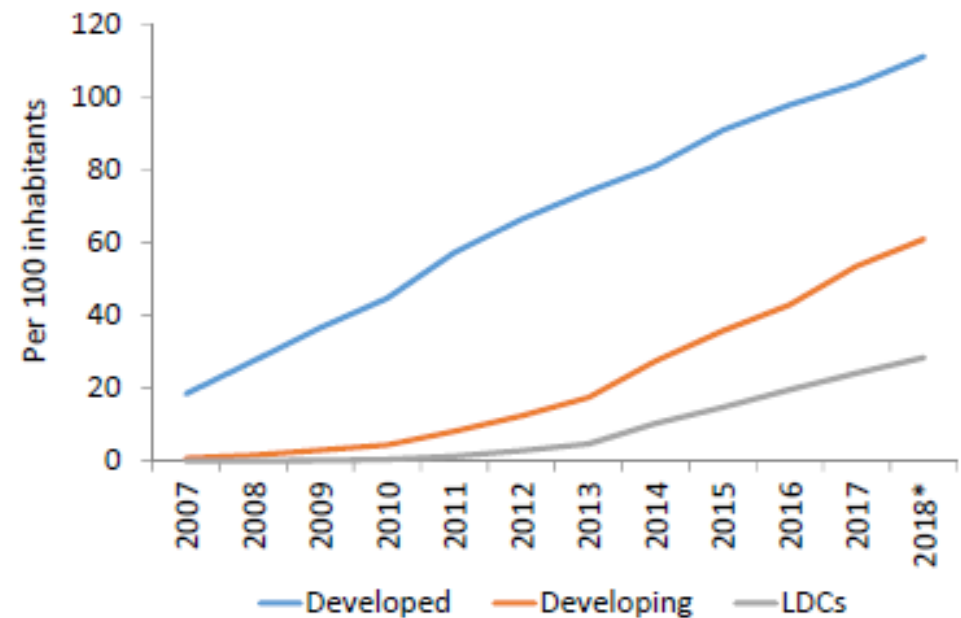
# ACCESS – MOBILE BROADBAND

Mobile-broadband has become one of the defining features of today's information society.

An increase of 1% in mobile-broadband is associated with an increase in 0.15% in GDP.

Faster growth in developing and LDCs than developed countries, also faster than fixed broadband.

Mobile-broadband subscriptions per 100 inhabitants, by level of development, 2007–2018.



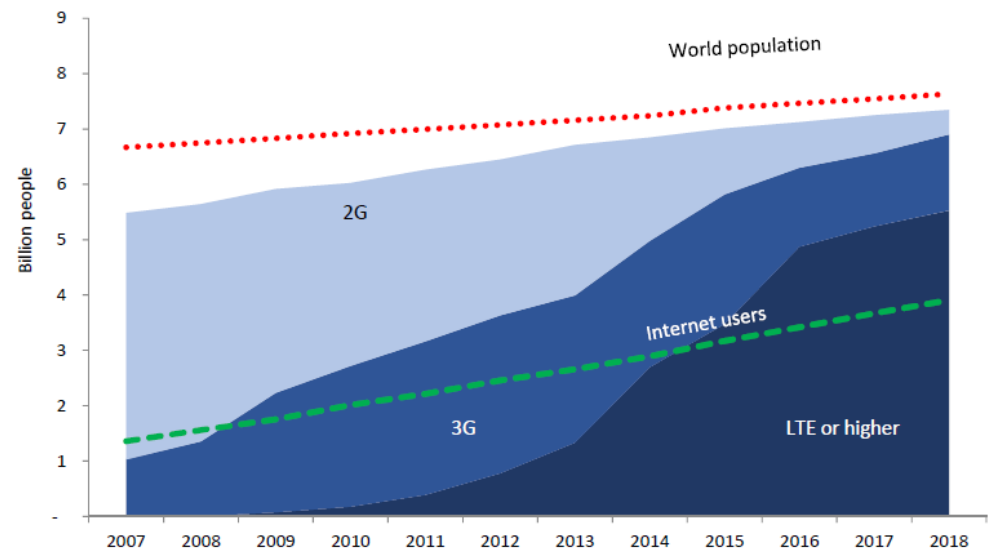
Source: ITU, *Measuring the Information Society Report 2018*, vol. 1. 2018.

# ACCESS – MOBILE COVERAGE

Almost the whole world population, 96%, lives within reach of mobile-cellular network.

90% can access the Internet through a 3G or higher network.

Mobile coverage by type of network, 2007–2018.



Source: ITU, *Measuring the Information Society Report 2018*, vol. 1. 2018.

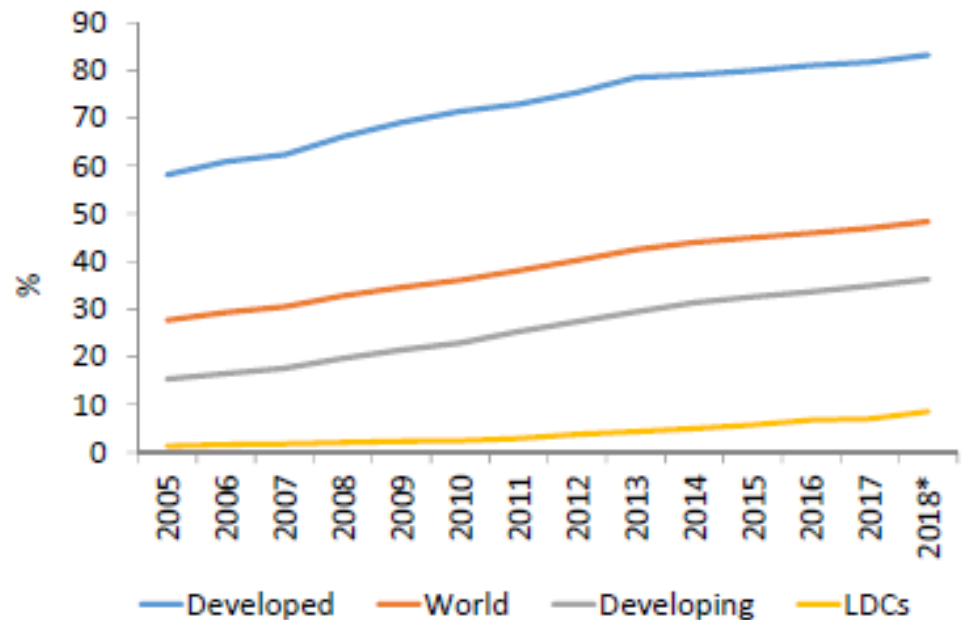
# ACCESS – HOUSEHOLDS WITH COMPUTER

Not too long ago, a computer was needed to go on the Internet.

It is no longer the case but computers still allow users to do things that can be challenging on smaller screens.

In developed countries, 83.2% of households possess a computer, compared with 36.3% in developing countries and less than 10% in LDCs.

Percentage of households with a computer, 2005–2018



Source: ITU, *Measuring the Information Society Report 2018*, vol. 1. 2018.

# ACCESS – HOUSEHOLDS WITH INTERNET

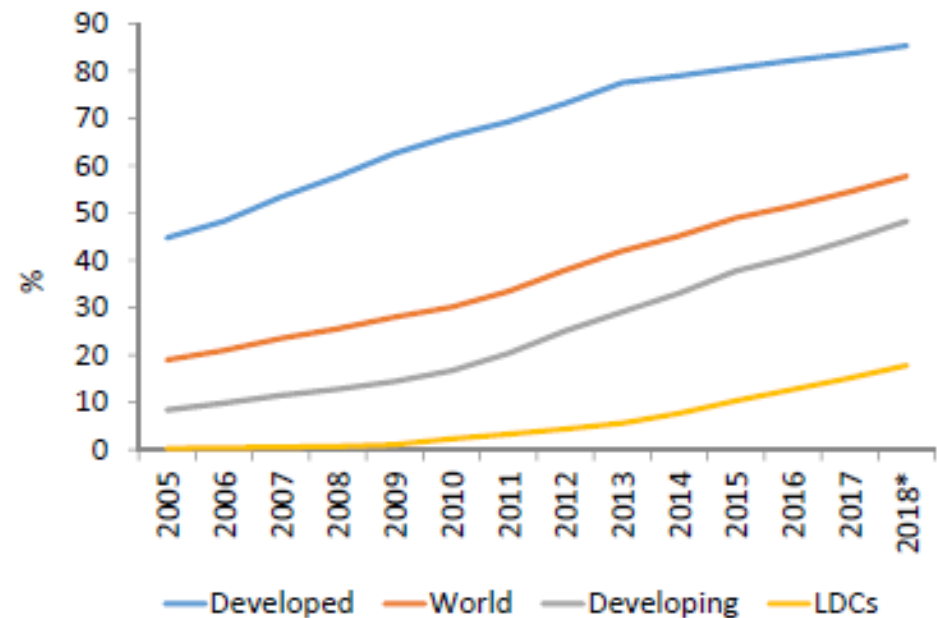
Having access to broadband at home is the most inclusive way of bringing people online.

Research has shown that children with Internet access at home perform better in school.

Developed countries have 85.3% coverage, in developing countries the coverage is almost 50%.

In LDCs Internet access can account for a large share of the family budget

Percentage of households with Internet access at home, 2005–2018.



Source: ITU, *Measuring the Information Society Report 2018*, vol. 1. 2018.

## More than half of the world's population is now online:

- 51.2% of individuals, or 3.9 billion people, are using the Internet.
- In developed countries, 80% of people are online.
- In developing countries, 45% of people are online.
- In the LDCs, 20% of people are online.

## A general upward trend in the access to and use of ICTs is continuing:

- With the exception of fixed-telephony, all indicators show sustained growth.
- However, growth is slowing for most of the access indicators, particularly in countries where large parts of the population are already connected.

Source: ITU, *Measuring the Information Society Report 2018*, vol. 1. 2018.

## Mobile access to basic telecomm services is becoming ever more predominant:

- While fixed-telephone subscriptions continue their long-term decline, mobile-cellular telephone subscriptions continue to grow.
- Although the number of mobile-cellular telephone subscriptions is already greater than the global population, the same is not true in all regions.
- Developing countries, especially LDCs, will catch up with the rest of the world.

## Broadband access continues to demonstrate growth:

- Fixed-broadband subscriptions are increasing, without a slowdown in growth.
- Almost all fixed-broadband subscriptions had download speeds of at least 2 Mbit/s, with a substantial part having speeds of more than 10 Mbit/s.
- The growth in mobile-broadband subscriptions is strong, increasing from 4.0 subscriptions per 100 inhabitants in 2007 to 69.3 in 2018.

Source: ITU, *Measuring the Information Society Report 2018*, vol. 1. 2018.



## Almost the whole population lives within range of a mobile-cellular network signal:

- Most people can access the Internet through a 3G or higher-quality network.
- The evolution of the mobile network is going faster than the growth in the percentage of the population using the Internet.

## Internet access at home is gaining traction:

- 60% of households had Internet access at home in 2018, up from 20% in 2005.
- Many households access the Internet through mobile devices or data plans in mobile-broadband subscription.
- 75% of the world's population owned a mobile phone in 2017, 56% in LDCs.

Source: ITU, *Measuring the Information Society Report 2018*, vol. 1. 2018.

# VIDEO: PEW STUDY DETAILS CORD-CUTTERS AND CORD-NEVERS



Source: <https://www.youtube.com/watch?v=iUn2-mho6QQ>

# QUESTIONS

- |    |   |
|----|---|
| 1. | Why are fixed phone penetration rates going down?             |
| 2. | Which access type has proven impact on the economy? How much? |
| 3. | Which form of access is proven to benefit social development? |

# HOW IS DIGITAL ACCESS SHAPING AROUND THE WORLD?

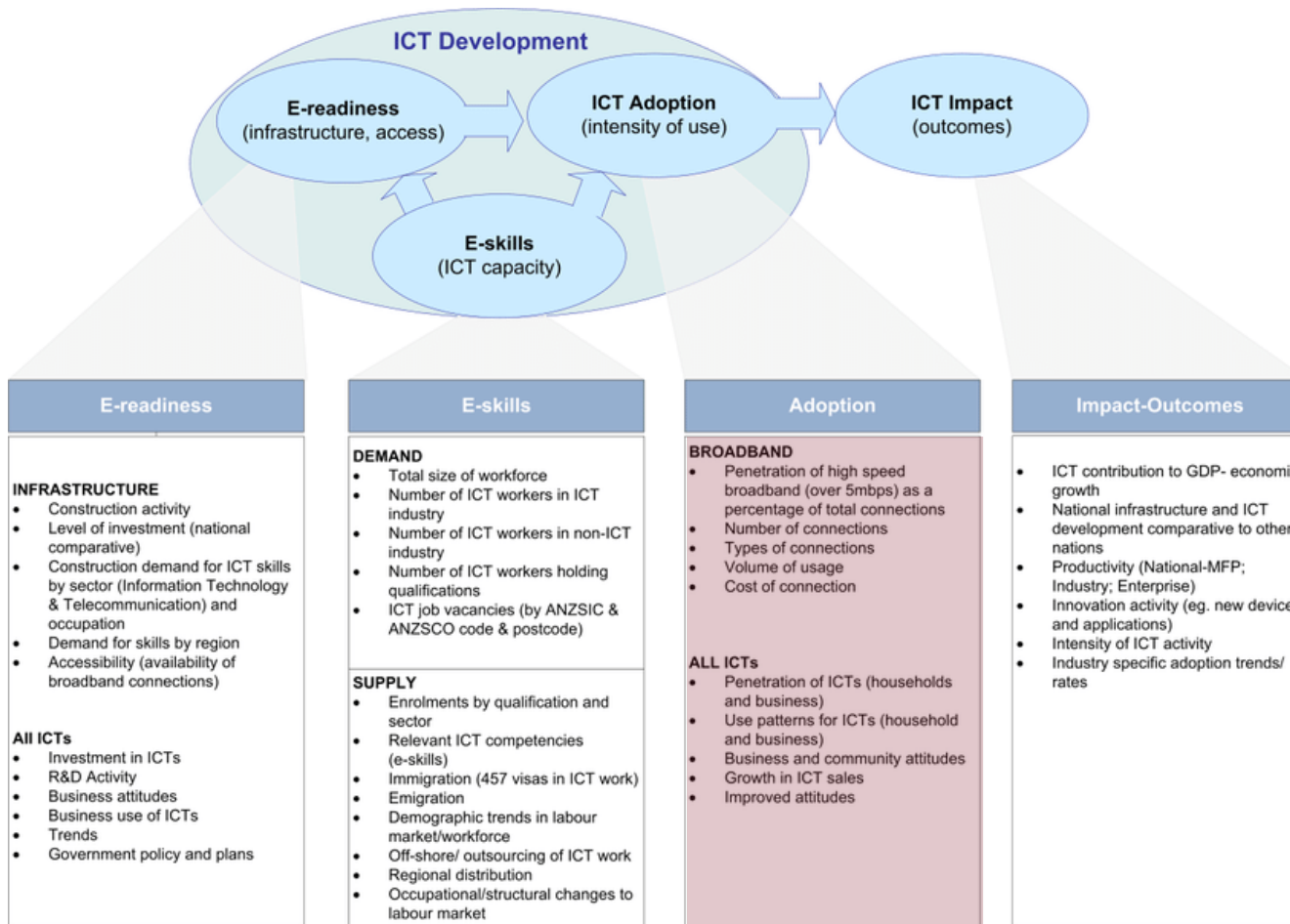
OVER HALF OF THE WORLD POPULATION IS ONLINE.  
ALMOST EVERYBODY LIVES WITHIN SIGNAL RANGE.  
MOBILE ACCESS IS BECOMING PREDOMINANT.  
INTERNET ACCESS AT HOME IS BECOMING COMMON.

# OUTLINE

1. READINESS
2. USE
3. CAPABILITY
4. IMPACT

HOW DO PEOPLE USE DIGITAL ACCESS?

# FRAMEWORK



Source: ITU, *Measuring the Information Society Report 2018*, vol. 1. 2018.

When people subscribe to a service, the objective is to also use it.

However, sometimes people:

- have more than one subscription to a service, or
- do not use the service they subscribe to.

How to measure usage?

- Individuals using the Internet
- International bandwidth
- Fixed broadband traffic
- Mobile broadband traffic

Source: ITU, *Measuring the Information Society Report 2018*, vol. 1. 2018.



# USAGE – INDIVIDUALS USING THE INTERNET

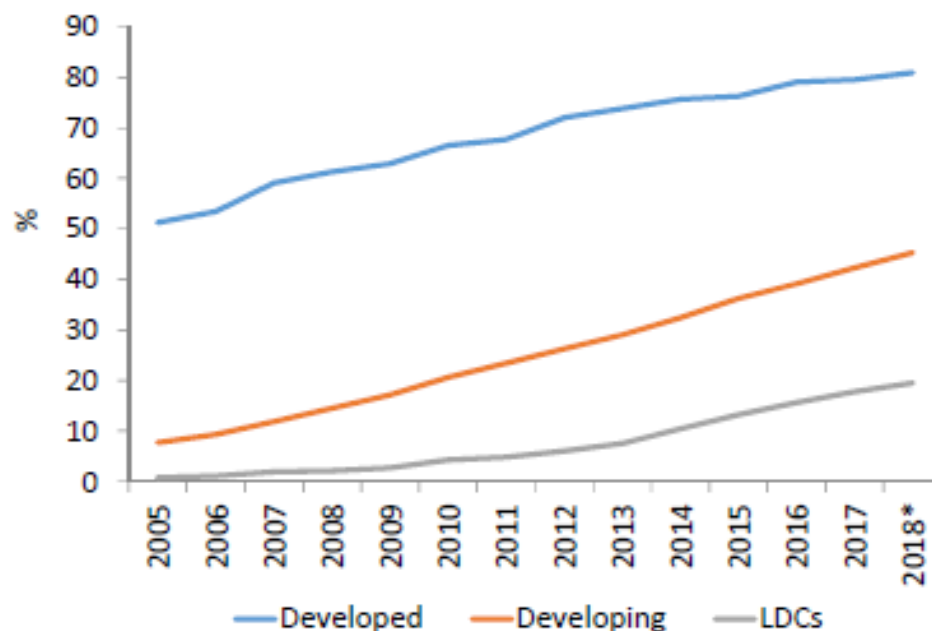
In developed countries, slow and steady growth from 51.3% in 2005 to 80.9% in 2018.

In developing countries, from 7.7% in 2005, to 45.3% in 2018.

In LDCs, the penetration rate grew from 0.8% in 2005 to 19.5% in 2018.

The expectation is that this growth will continue strongly in the foreseeable future.

Individuals using the Internet by development status, 2005–2018



Source: ITU, *Measuring the Information Society Report 2018*, vol. 1. 2018.

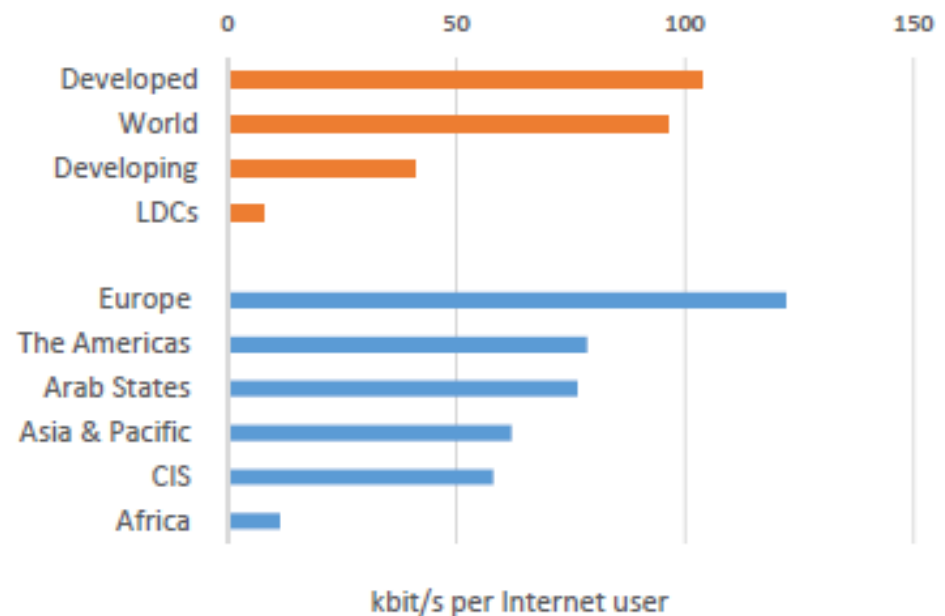
# USAGE – INTERNATIONAL BANDWIDTH

International bandwidth – total used capacity of international connections between countries for transmitting Internet and other (Vol, VPN, etc.) traffic.

A commonly used benchmark is to divide the international bandwidth by the percentage of the population using the Internet.

In developed countries, Internet users had the highest international bandwidth in 2017, at 104 kbit/s, 2.5 times the amount in developing countries and 13 times in LDCs.

International bandwidth usage per Internet user (kbit/s), 2017



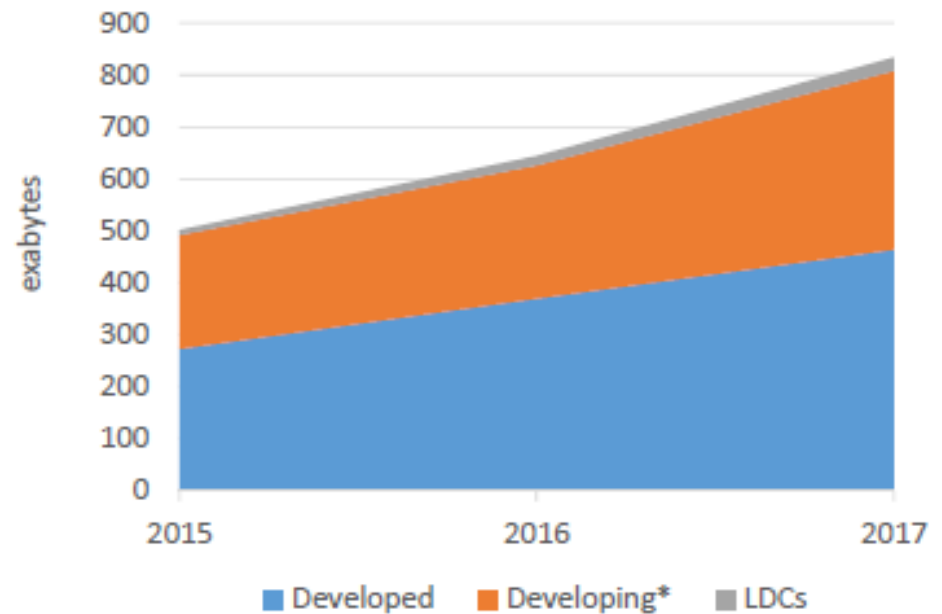
Source: ITU, *Measuring the Information Society Report 2018*, vol. 1. 2018.

# USAGE – FIXED BROADBAND TRAFFIC

The world consumed about 833 exabytes (EB) over fixed-broadband connections in 2017, up from 644 EB in 2016 and 502 EB in 2015.

Developed countries accounted for almost 56% of the total in 2017, while LDCs accounted only for 3%.

Fixed-broadband traffic, exabytes, 2015–2017



Source: ITU, *Measuring the Information Society Report 2018*, vol. 1. 2018.

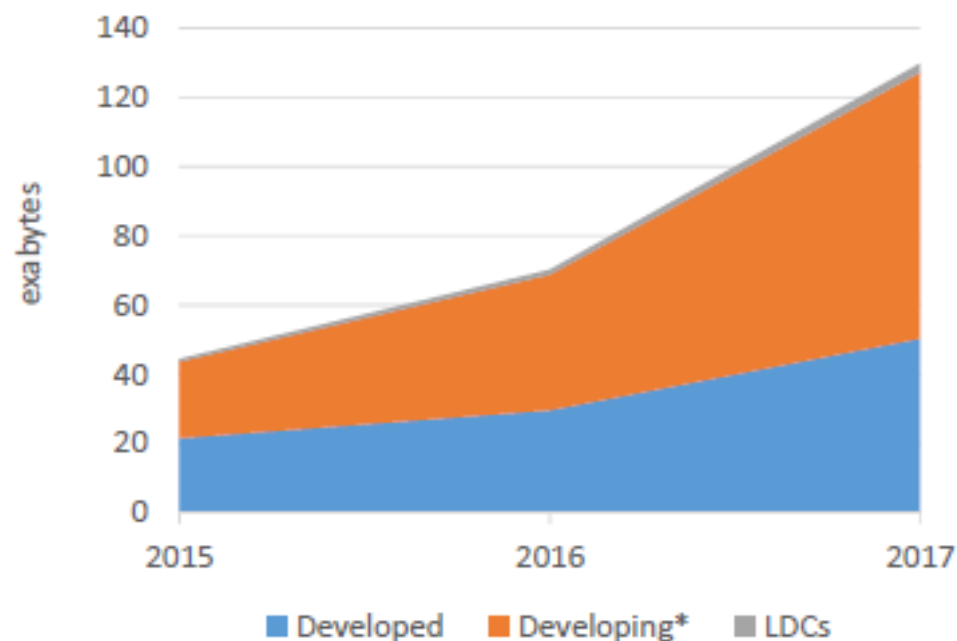
# USAGE – MOBILE BROADBAND TRAFFIC

Mobile-broadband is becoming the most ubiquitous way through which people access the Internet.

Traffic channeled through mobile-broadband networks stood at 130 EB in 2017, compared with 833 EB over fixed-broadband.

In contrast with fixed-broadband, developing countries (excluding LDCs) accounted for the largest share of this total, 59%.

Mobile-broadband traffic, exabytes, 2015–2017



Source: ITU, *Measuring the Information Society Report 2018*, vol. 1. 2018.

# USAGE SUMMARY

- Half of the world population is already using the Internet by the end of 2018.
- The other half – an estimated 3.8 billion people – are unconnected and unable to benefit from key social and economic resources of the digital world.
- International bandwidth usage increased strongly to satisfy the growing data needs of a larger population of Internet users.
- Growth in international bandwidth and Internet traffic has been stronger than growth in access to ICTs and the percentage of the population using the Internet.
- This could be explained by people spending more time online and by spending that time doing data-intensive activities, such as watching videos.
- Video traffic will be 82% of all consumer Internet traffic by 2021 from 73% in 2016.

Source: ITU, *Measuring the Information Society Report 2018*, vol. 1. 2018.

# VIDEO: GOOGLE'S SUPER-FAST SUBMARINE INTERNET CABLE



Source: <https://www.youtube.com/watch?v=0TZwiUwZwIE>

# QUESTIONS

- |    |  |
|----|--|
| 1. | Why is access not accurate to represent the usage of such technology?  |
| 2. | How is the international bandwidth calculated?   |
| 3. | How to explain that international broadband and Internet traffic grow faster than access to ICT or Internet users? |

## HOW DO PEOPLE USE DIGITAL ACCESS?

HALF OF THE WORLD POPULATION USE THE INTERNET.  
INTERATIONAL BANDWIDTH IS INCREASING STRONGLY.  
MORE TIME SPENT ON DATA-INTENSIVE ACTIVITIES.  
VIDEO TRAFFIC REACHES ABOVE 80% ALL TRAFFIC.

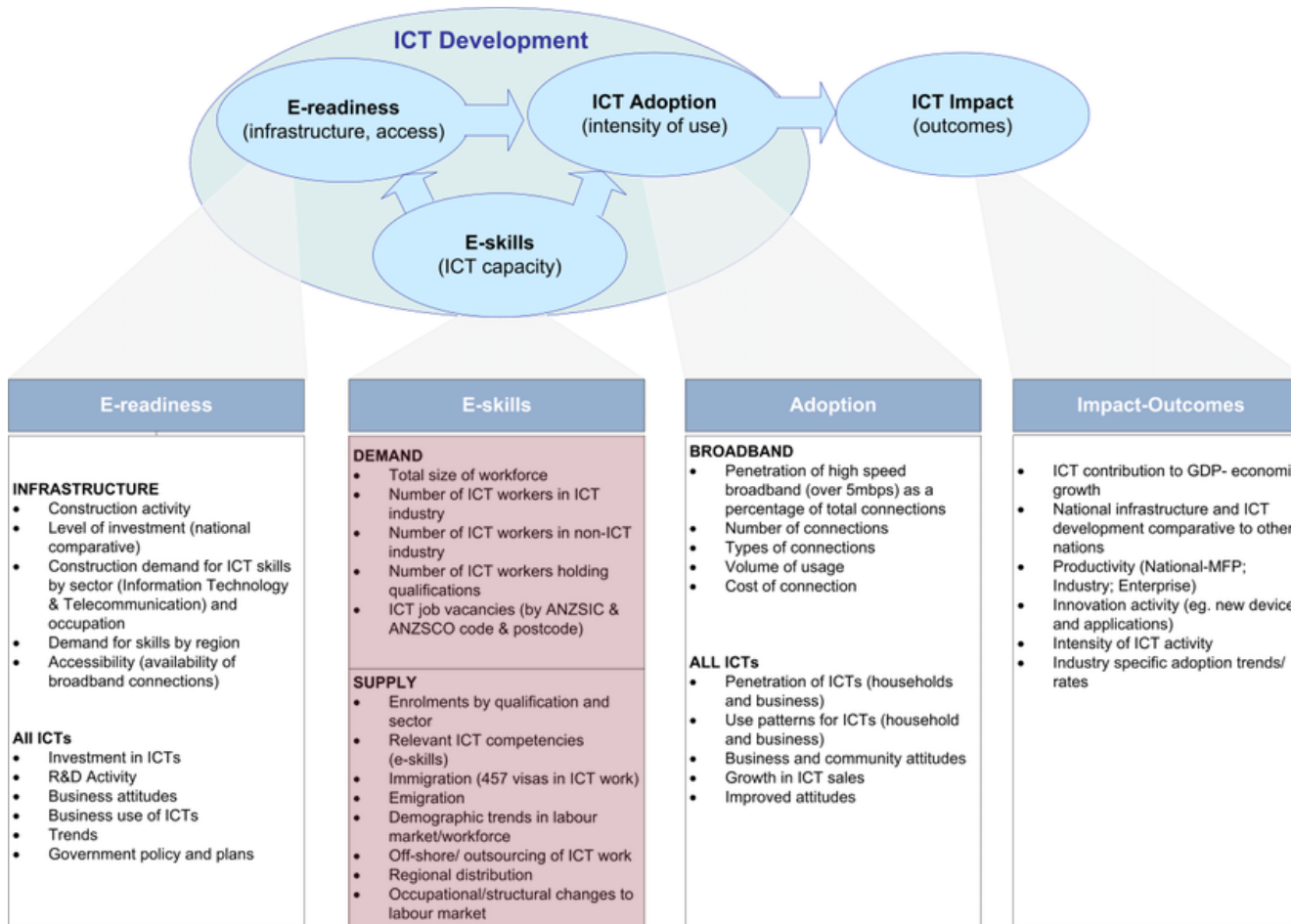


# OUTLINE

1. READINESS
2. USE
3. CAPABILITY
4. IMPACT

WHAT DIGITAL SKILLS ARE EMERGING?

# FRAMEWORK



Source: ITU, *Measuring the Information Society Report 2018*, vol. 1. 2018.

# SKILLS

Digital skills – the ability to use digital technologies in ways that help individuals to achieve beneficial, high-quality outcomes in everyday life for themselves and others, now and in an increasingly digital future.

They comprise the extent to which one is able to increase the benefits of ICT use and reduce potential harm associated with more negative aspects of digital engagement.

Digital skills have been linked:

- at the individual level, to higher social and economic well-being and
- at the national level, to a more dynamic and competitive economy.

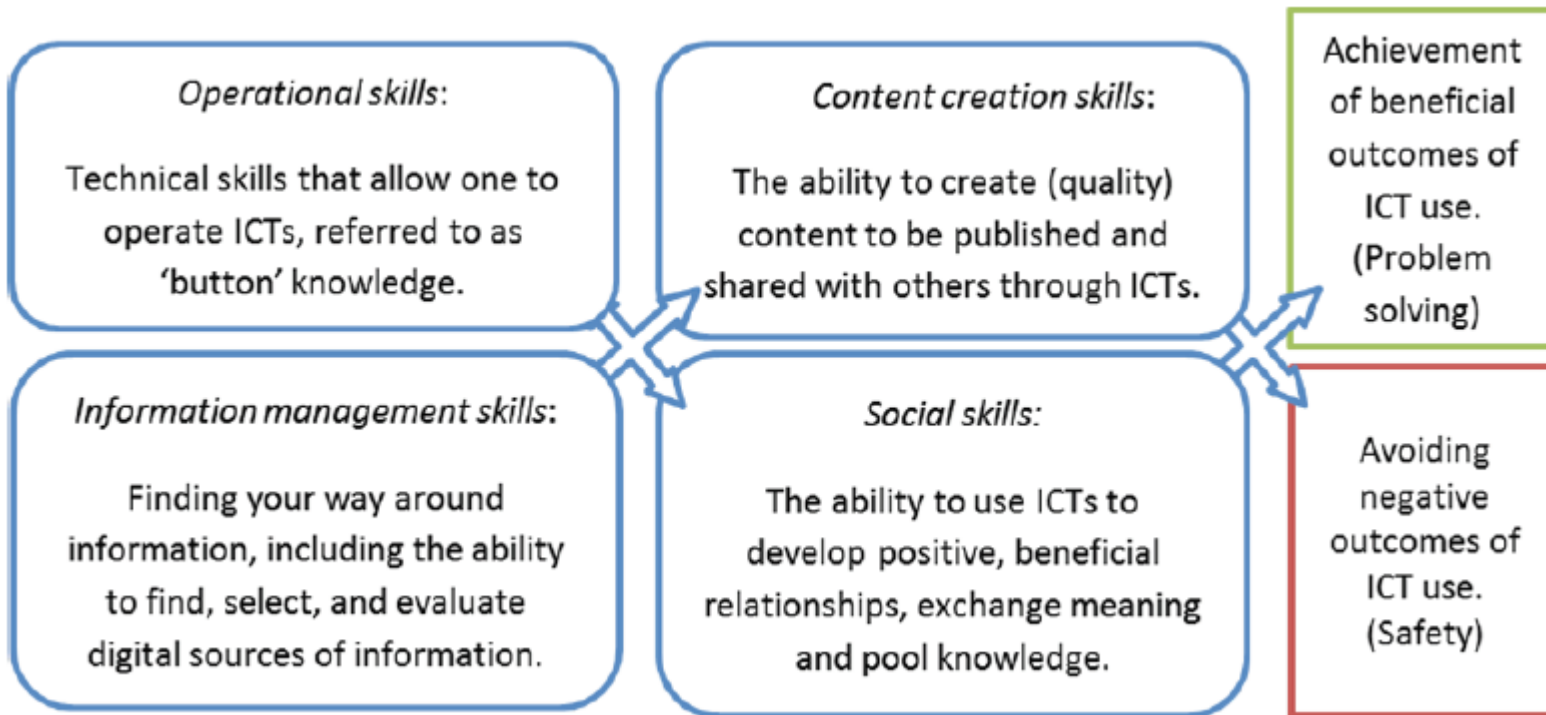
Source: ITU, *Measuring the Information Society Report 2018*, vol. 1. 2018.

# SKILLS – DIGITAL TRENDS

- Internet access is rapidly increasing.
- ICT costs have gone down and capacity has increased exponentially.
- Content and services are moving online, replacing offline information and services.
- Using social media and creating content have become common activities.
- Algorithms influence what content people see and who they connect with.
- Bots that impersonate users and are programmed to promote extreme views or reinforce behavioral trends are related to polarization of views and tribalization.
- There is a shift to the Internet of Things (IoT) and Artificial Intelligence (AI).
- ICTs are increasingly invisible.
- Security and privacy risks are magnified in complex ICT systems.

Source: ITU, *Measuring the Information Society Report 2018*, vol. 1. 2018.

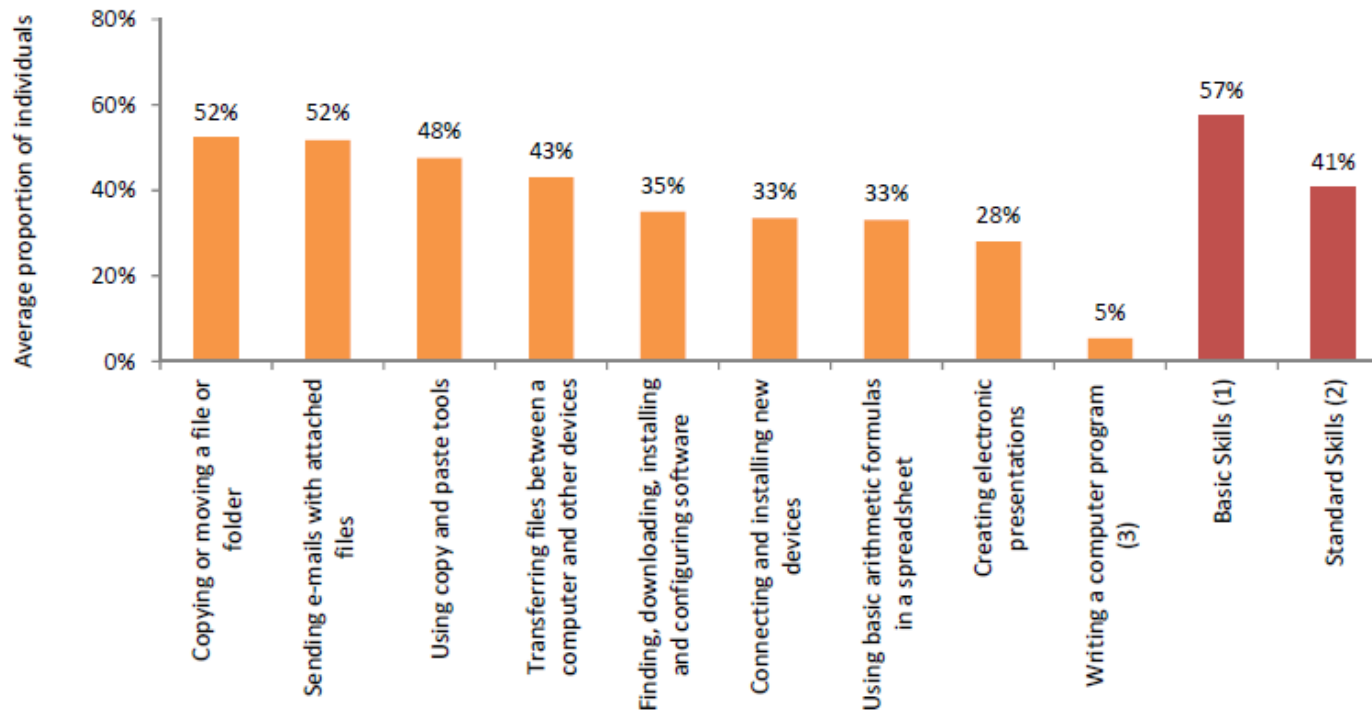
# SKILLS – TYPES



Source: ITU, *Measuring the Information Society Report 2018*, vol. 1. 2018.

# SKILLS – DISTRIBUTION OF DIGITAL SKILLS AMONG INDIVIDUALS

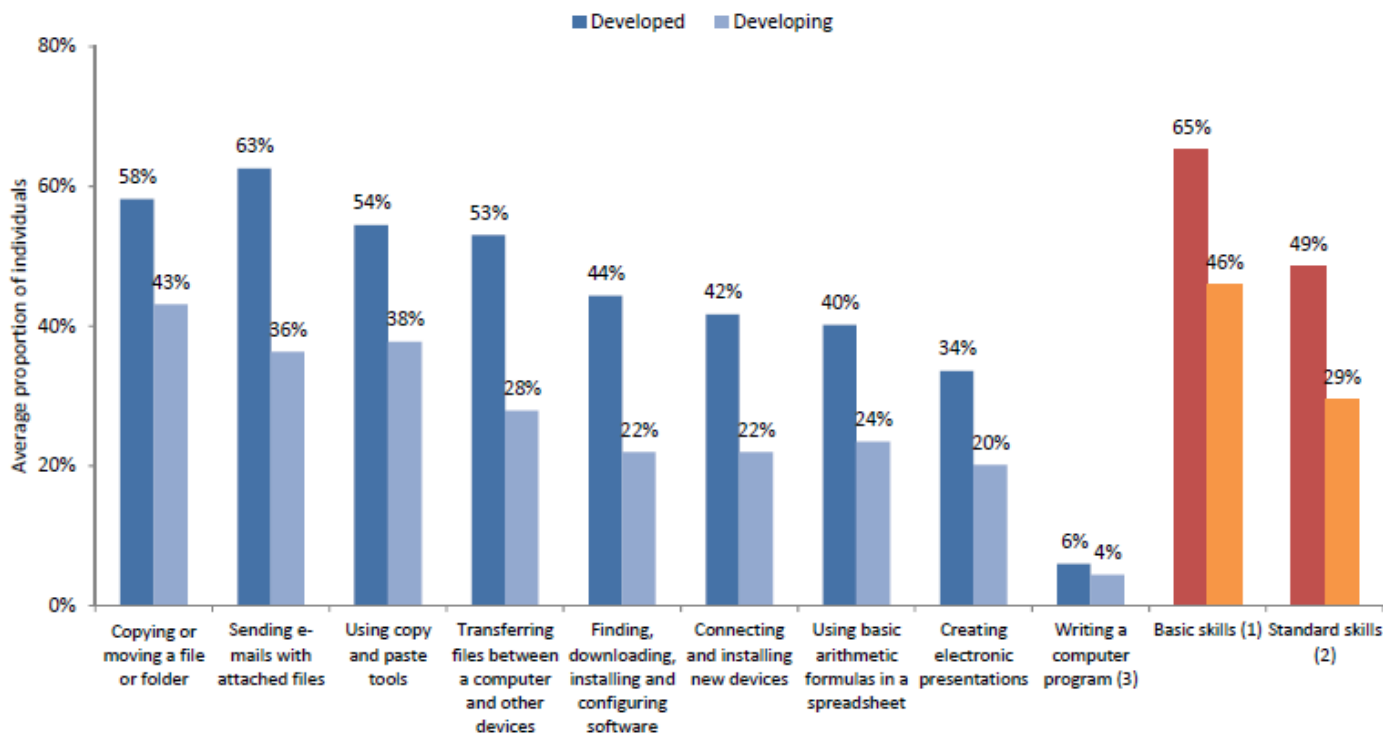
57% have basic skills such as copying files or using copy and paste, 41% have standard skills such as installing software, and 4% can write computer programs.



Source: ITU, *Measuring the Information Society Report 2018*, vol. 1. 2018.

# SKILLS – DISTRIBUTION OF SKILLS AMONG DEVELOPMENT GROUPS

In skill levels, the developed countries are ahead, with basic and standard skills around 20% higher. The smallest difference is in programming skills.

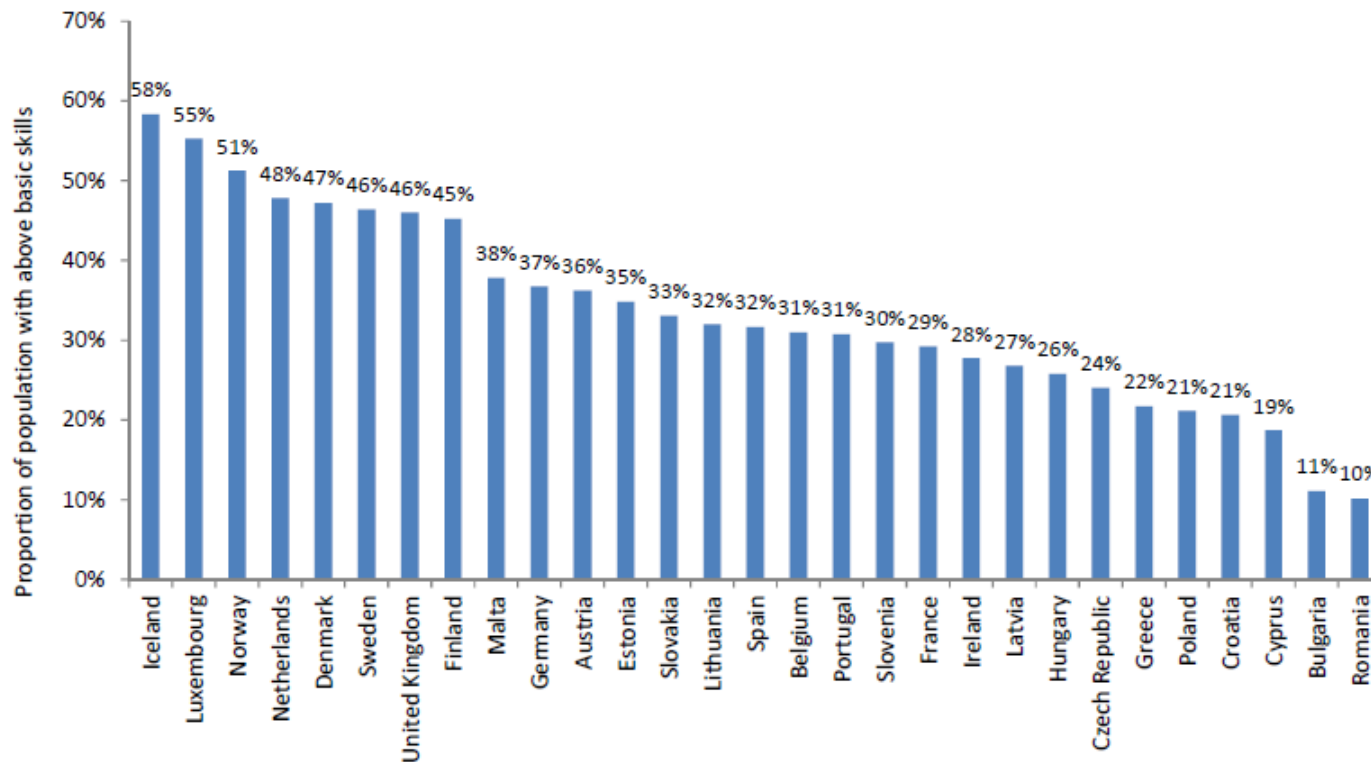


Source: ITU, *Measuring the Information Society Report 2018*, vol. 1. 2018.



# SKILLS – ABOVE BASIC DIGITAL SKILLS IN THE EU

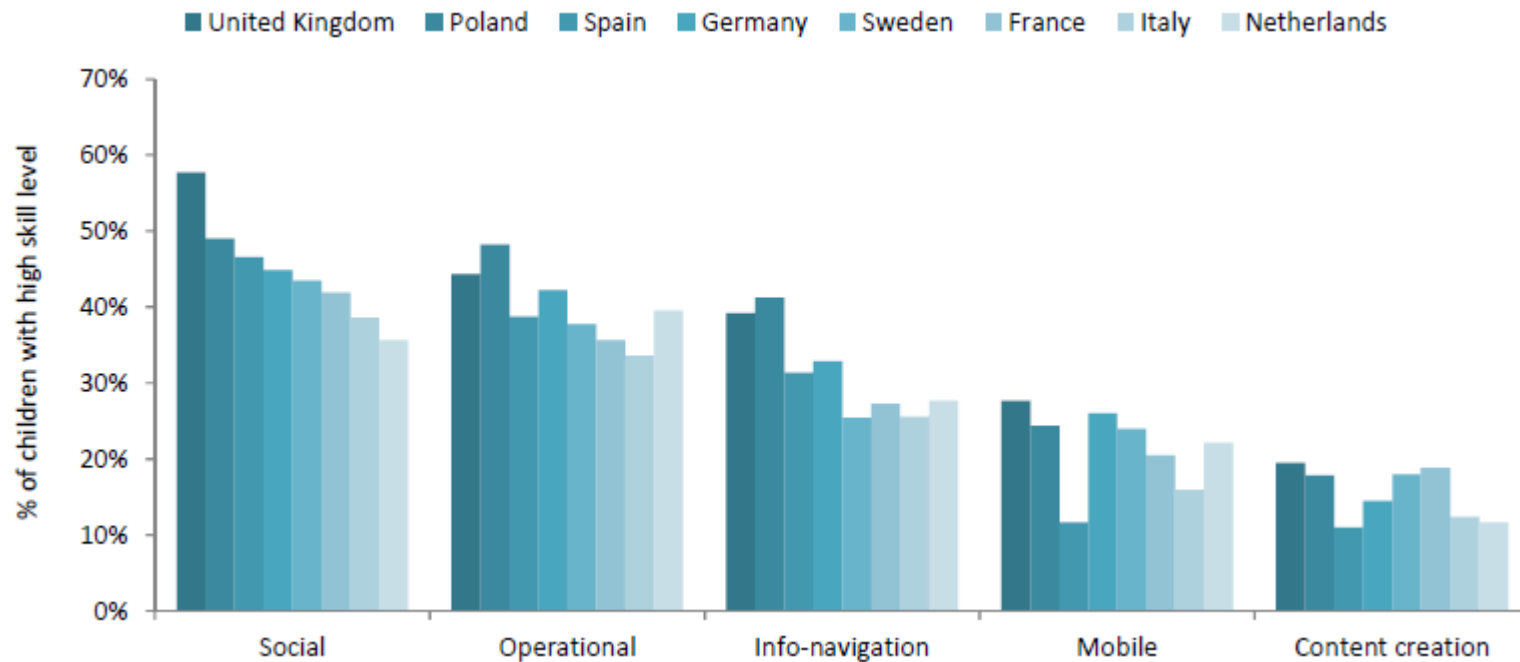
Within Europe, the Nordic countries have the most skilled citizens, while Southern and Eastern European countries have the fewest citizens with high skill levels.



Source: ITU, *Measuring the Information Society Report 2018*, vol. 1. 2018.

# SKILLS – DIGITAL SKILLS LEVELS AMONG CHILDREN

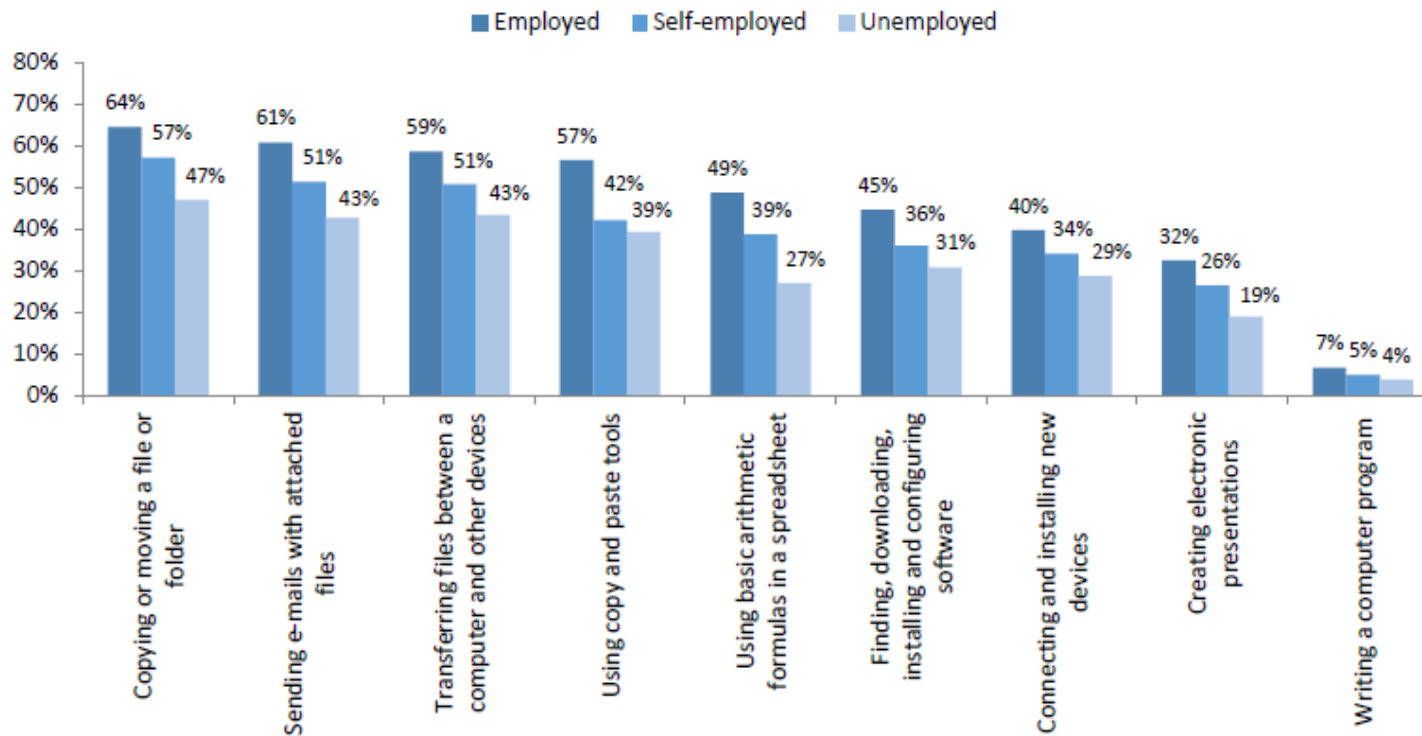
Spain's children are highly ranked in terms of social skills but low in mobile skills. Dutch children have high mobile and operational skills but lower social digital skills.



Source: ITU, *Measuring the Information Society Report 2018*, vol. 1. 2018.

# SKILLS – BY EMPLOYMENT STATUS

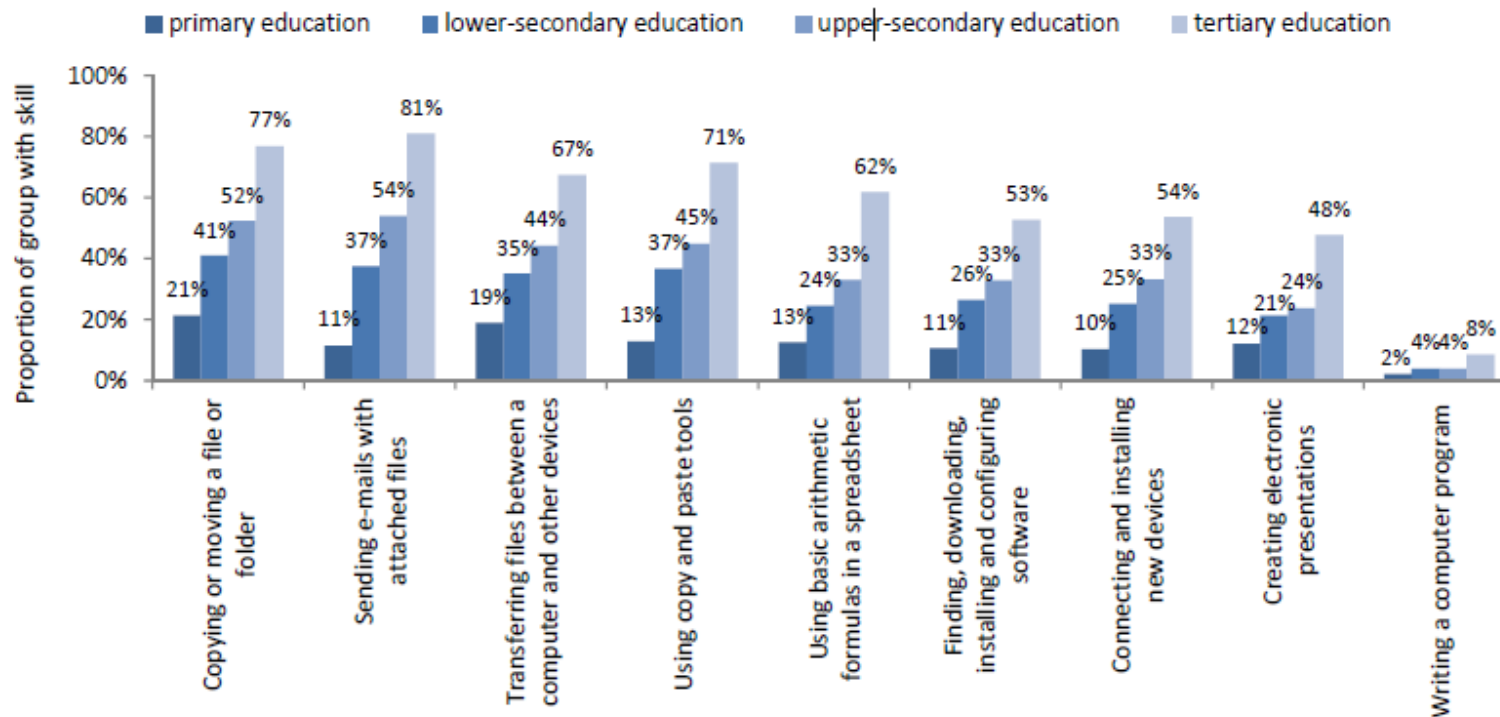
Those individuals who are unemployed have lower skill levels than those who are either self-employed or employed.



Source: ITU, *Measuring the Information Society Report 2018*, vol. 1. 2018.

# SKILLS – BY LEVEL OF EDUCATION

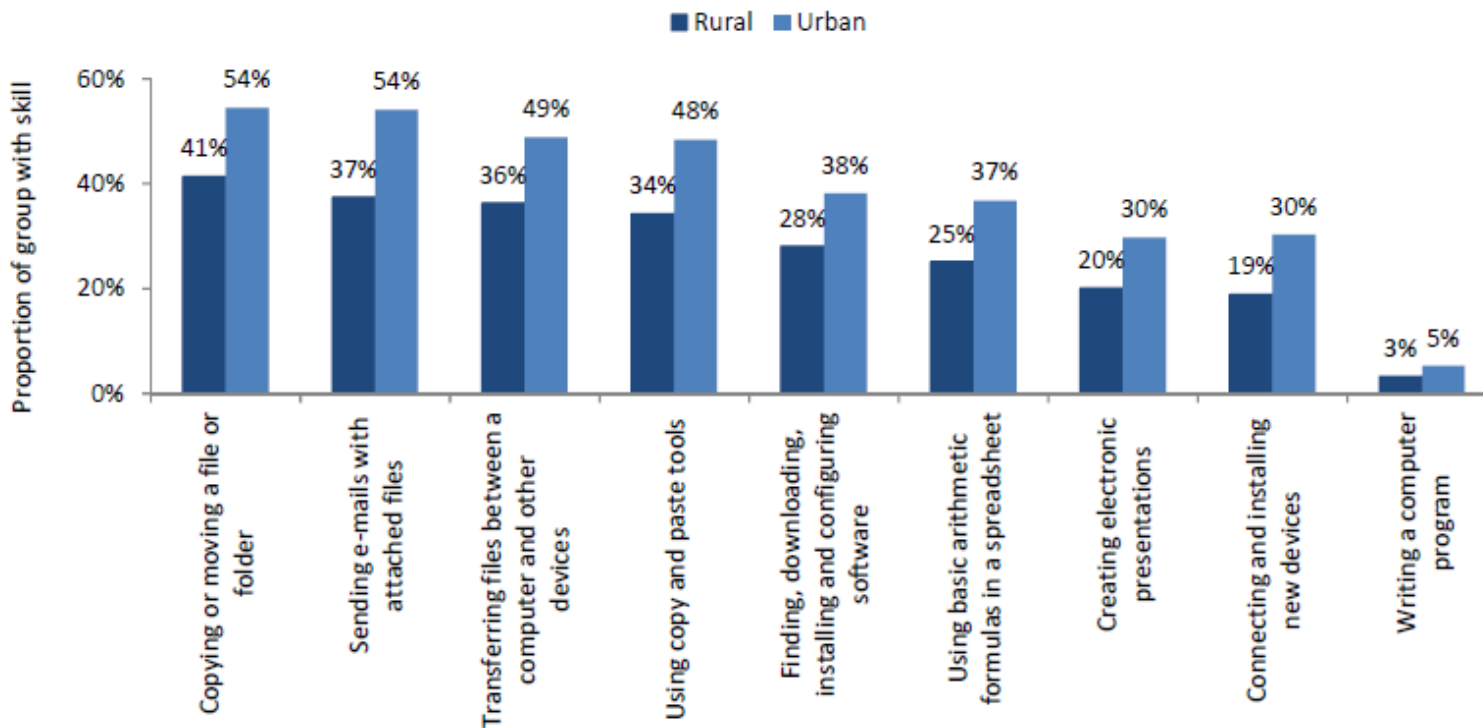
Individuals with higher education are much more likely to have all digital skills than those with secondary and especially primary education.



Source: ITU, *Measuring the Information Society Report 2018*, vol. 1. 2018.

# SKILLS – BY URBAN VERSUS RURAL POPULATION

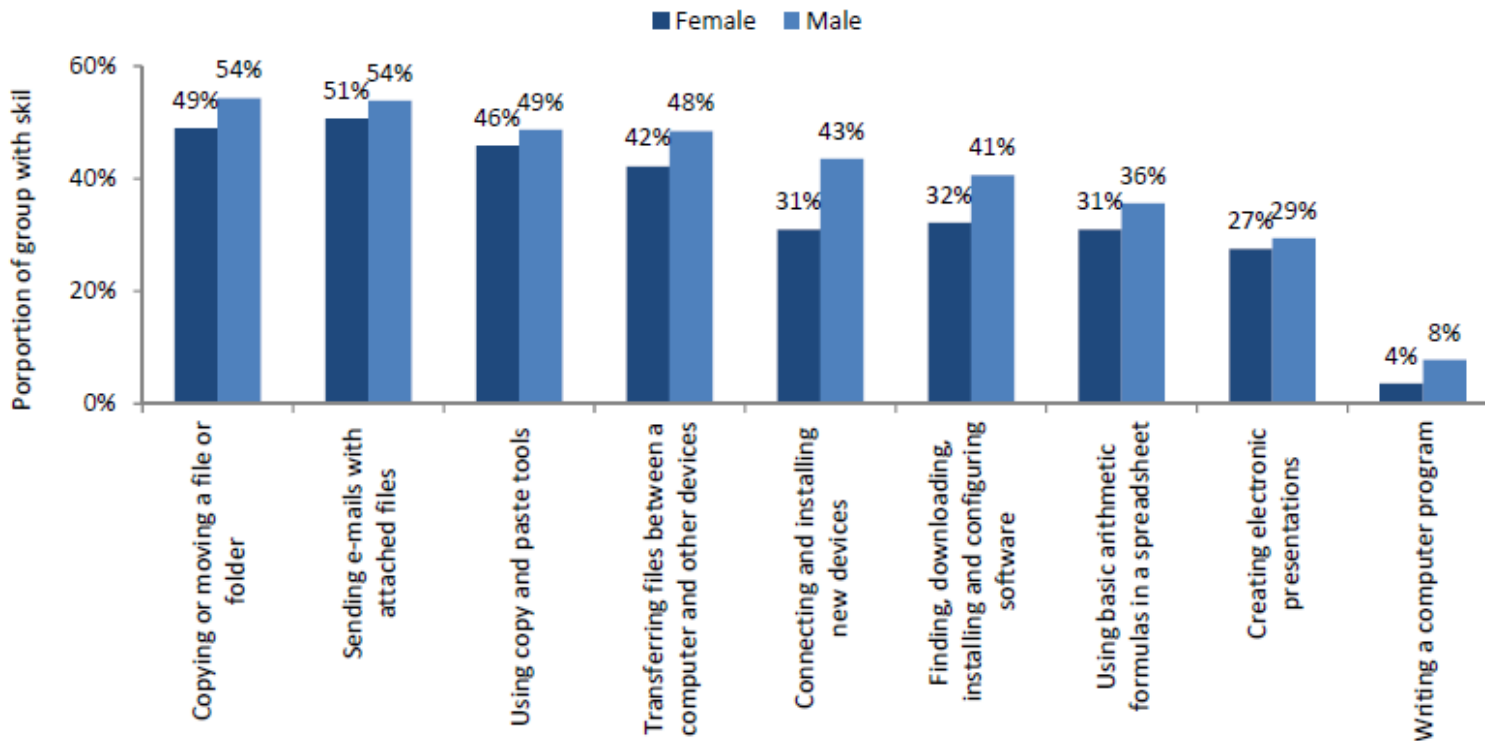
Individuals living in urban areas are much more likely to have basic and standard skills than those living in urban areas.



Source: ITU, *Measuring the Information Society Report 2018*, vol. 1. 2018.

# SKILLS – BY GENDER

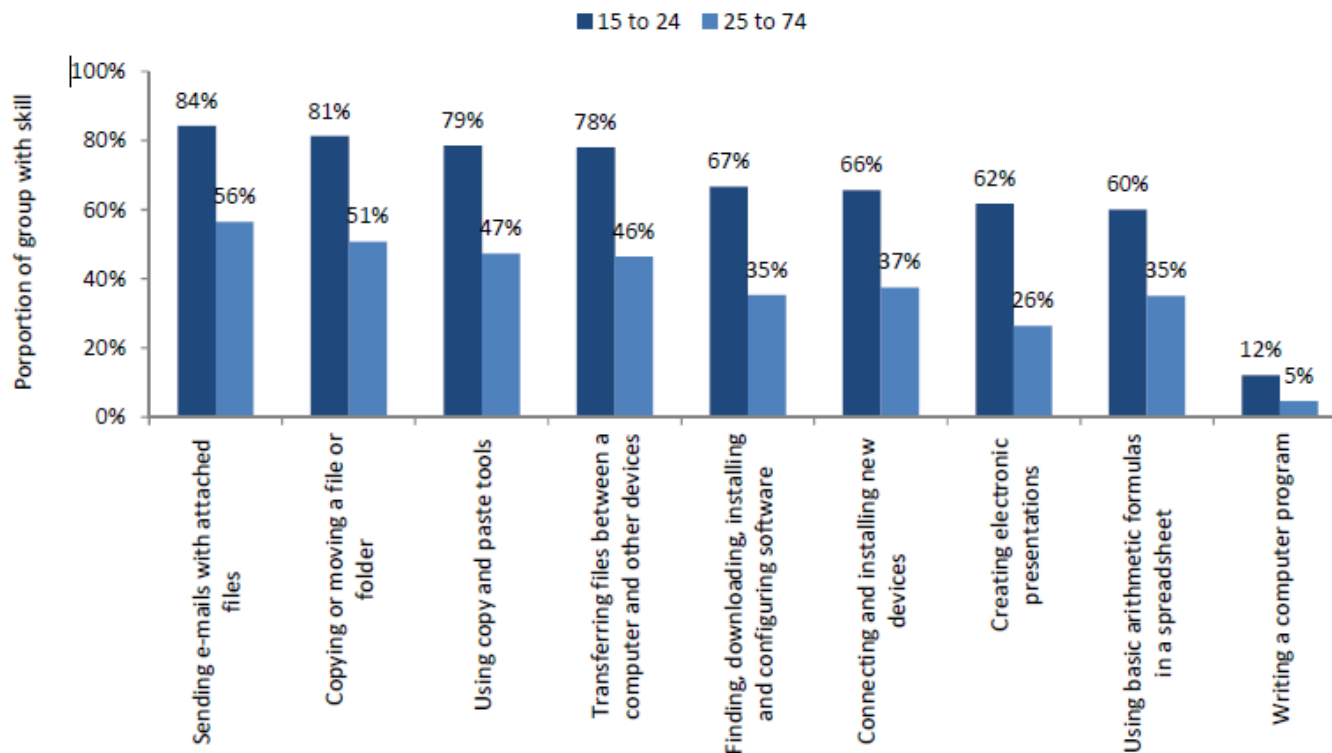
Men indicate higher levels for all digital skills, though this difference is less pronounced when looking at inequalities within countries.



Source: ITU, *Measuring the Information Society Report 2018*, vol. 1. 2018.

# SKILLS – BY AGE

Those who are younger are more likely to have a specific skill than are those in the older generation; social isolation, health and lower education explain this better.



Source: ITU, *Measuring the Information Society Report 2018*, vol. 1. 2018.

**There is an increased need for “soft” skills beyond technical and navigational skills:**

- Technical, operational, information, social and content-creation skills will be fundamental for achieving positive and avoiding negative outcomes.
- Algorithms, bots, and Internet of Things and Artificial Intelligence, will demand critical information and advanced content-creation skills.
- With the increased complexity of ICT, and an increase in the amount of data being collected, transferable digital skills and lifelong learning are key.

**There are considerable gaps across the board in the skills needed at all levels:**

- A third lacks basic digital skills, such as copying files or using copy and paste.
- 41% have standard skills, such as installing software or using spreadsheets.
- 4% are using specialist language to write computer programs.

Source: ITU, *Measuring the Information Society Report 2018*, vol. 1. 2018.



## Developing countries are particularly disadvantaged when it comes to digital skills:

- Inequalities reflect other inequalities between the different regions of the world, particularly in relation to basic skills.

## Within-country inequalities reflect historical patterns of inequality:

- Those in employment were 10% more likely to have a skill than the self-employed, who are 10% more likely to have a skill than the unemployed.
- Those with higher education are 2 times more likely to have a skill than those with secondary education, and 4 times that those with primary education.
- Individuals in rural areas are 10% less likely than urban dwellers to have a skill.
- 5% difference also exists between men and women in having certain skills.
- Skill inequalities between children reflect those between adults. Digital inequalities are not generational and will persist into the future.

Source: ITU, *Measuring the Information Society Report 2018*, vol. 1. 2018.

# VIDEO: THE DIGITAL SKILLS GAP AND THE FUTURE OF JOBS 2020



Source: <https://www.youtube.com/watch?v=Y9FOyoS3Fag>

# QUESTIONS

- |    |  |
|----|--|
| 1. | What types of digital skill can you describe?                                      |
| 2. | Why are soft skills needed in today's information society?                         |
| 3. | Explain how inequalities in digital skills follow traditional inequality patterns. |

# WHAT DIGITAL SKILLS ARE EMERGING?

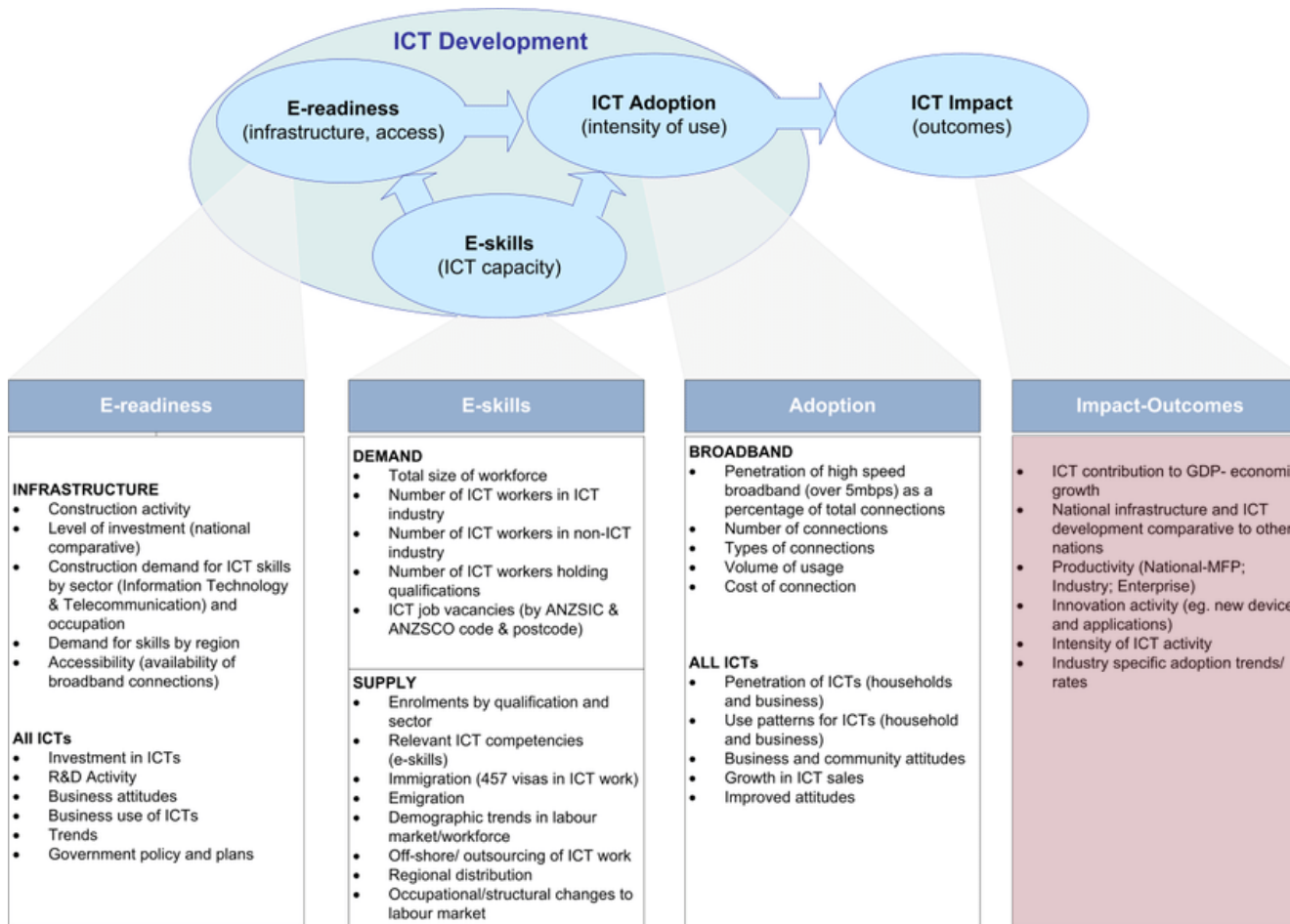
NEED FOR SKILLS BEYOND TECHNICAL AND NAVIGATIONAL  
CONSIDERABLE GAPS IN SKILL LEVELS  
PARTICULAR GAPS IN DEVELOPING COUNTRIES  
DIGITAL INEQUALITIES REFLECT HISTORICAL PATTERNS

# OUTLINE

1. READINESS
2. USE
3. CAPABILITY
4. IMPACT

HOW IS THE DIGITAL ECONOMY GROWING?

# FRAMEWORK



Source: ITU, *Measuring the Information Society Report 2018*, vol. 1. 2018.

# ICT SECTOR

The ICT sector is powering the global economy as industry players are connecting consumers across the globe to smart societies.

Transformation of the sector:

- from the analogue era of the 1970s
- to the convergence era of the early 2000s, powered by the Internet,
- to the digital transformation phase since 2010.

<b>ICT manufacturing industries</b>
Manufacture of electronic components and boards
Manufacture of computers and peripheral equipment
Manufacture of communication equipment
Manufacture of consumer electronics
Manufacture of magnetic and optical media
<b>ICT trade industries</b>
Wholesale of computers, computer peripheral equipment and software
Wholesale of electronic and telecommunication equipment and parts
<b>ICT services industries</b>
Software publishing
Telecommunications
Computer programming, consultancy and related activities
Data processing, hosting and related activities; web portals
Repair of computers and communication equipment

Source: ITU, *Measuring the Information Society Report 2018*, vol. 1. 2018.



# ICT SECTOR – GROWTH IN VALUE ADDED

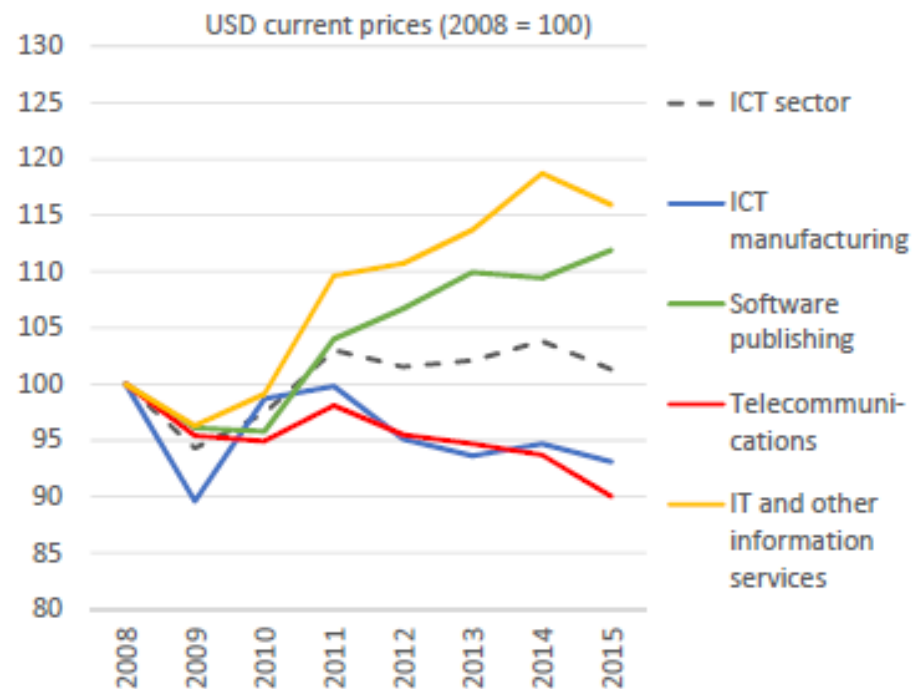
In 2015, the ICT sector accounted on average for 5.4% of total value added for its Member States.

Growth is increasingly driven by software production and services, the latter 80% of ICT value added.

Value added decreased in traditional branches such as electronics manufacturing (-7%) or telecommunications (-10%).

Value added increased by 12% in software and 16% in IT services during the same period.

Growth in ICT sector value added, by subsector



Source: ITU, *Measuring the Information Society Report 2018*, vol. 1. 2018.

# ICT SECTOR – GROWTH IN EMPLOYMENT

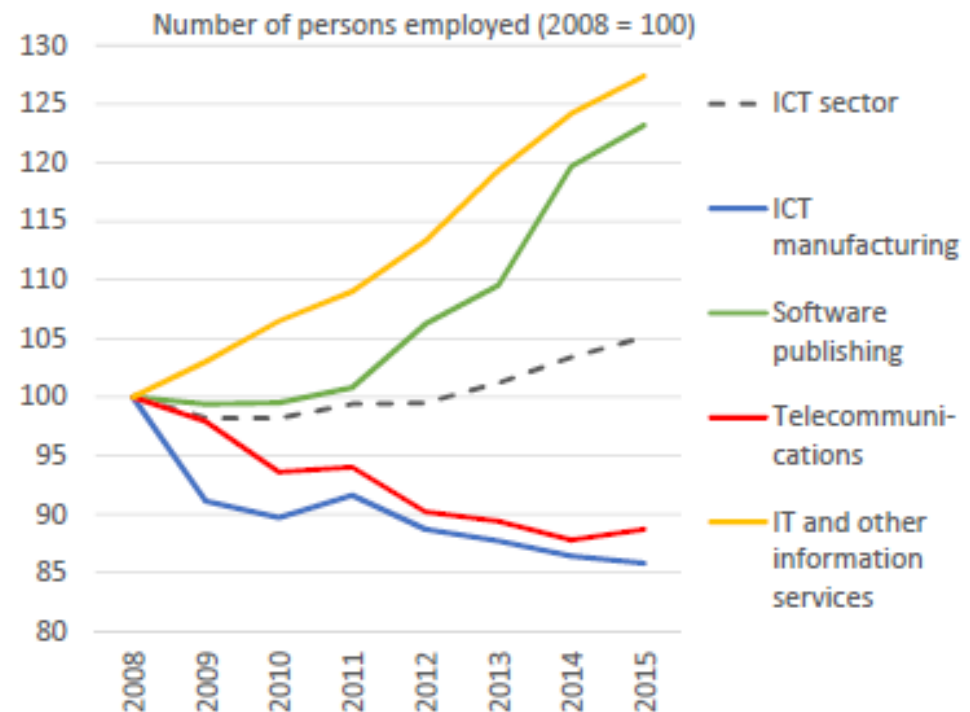
In 2015, ICT services accounted for 1.5% of global employment.

ICT services represented almost 80% of total ICT employment.

Employment in the sector grew faster than total employment between 2008 and 2015.

That growth is largely fueled by employment in services and software, while declining in manufacturing and telecomm.

Employment in ICT sector, by subsector



Source: ITU, *Measuring the Information Society Report 2018*, vol. 1. 2018.

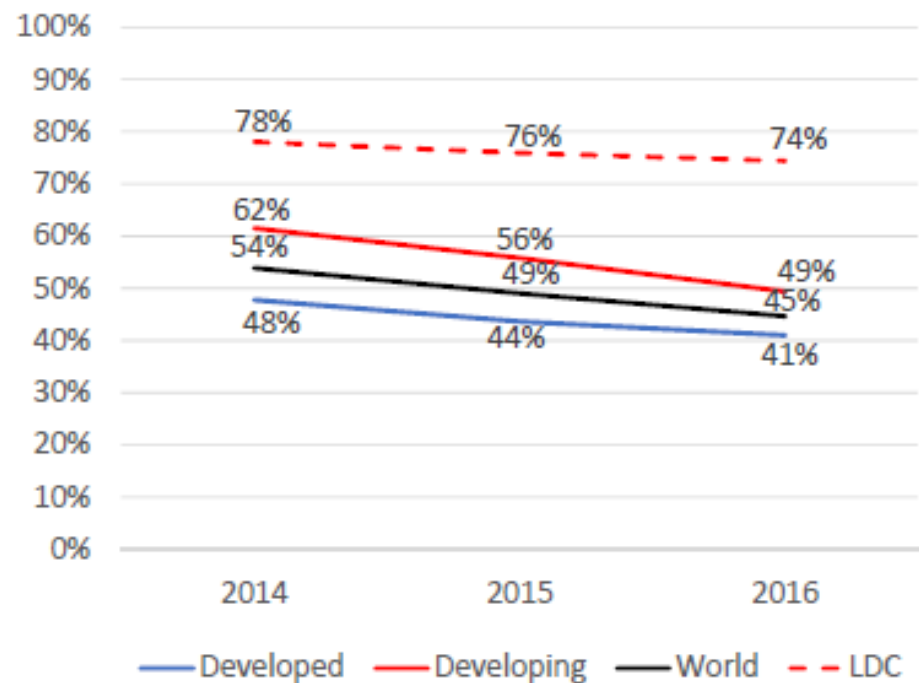
# ICT SECTOR – MOBILE VOICE REVENUES

Revenue from traditional mobile voice services declined globally.

In 2016, voice revenues accounted for 49% of mobile revenues across developing economies, compared to 41% across the developed countries.

That share had fallen from 62% and 48% respectively in 2014.

Voice revenues as a percentage of mobile revenues.



Source: ITU, *Measuring the Information Society Report 2018*, vol. 1. 2018.

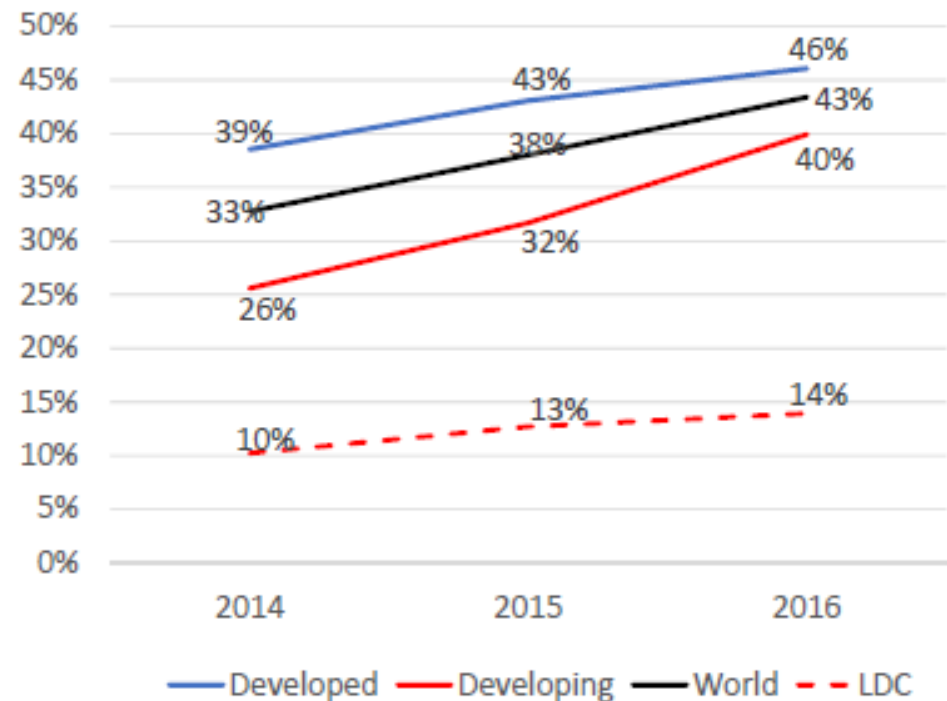
# ICT SECTOR – MOBILE DATA REVENUES

10% increase in mobile data revenue during 2014-2016.

The increase in data revenue is lower than the loss in voice revenue.

Asia and the Pacific and the US and Canada are the only two zones where the increase in mobile data revenues between 2014 and 2016 was greater than the loss in voice revenues.

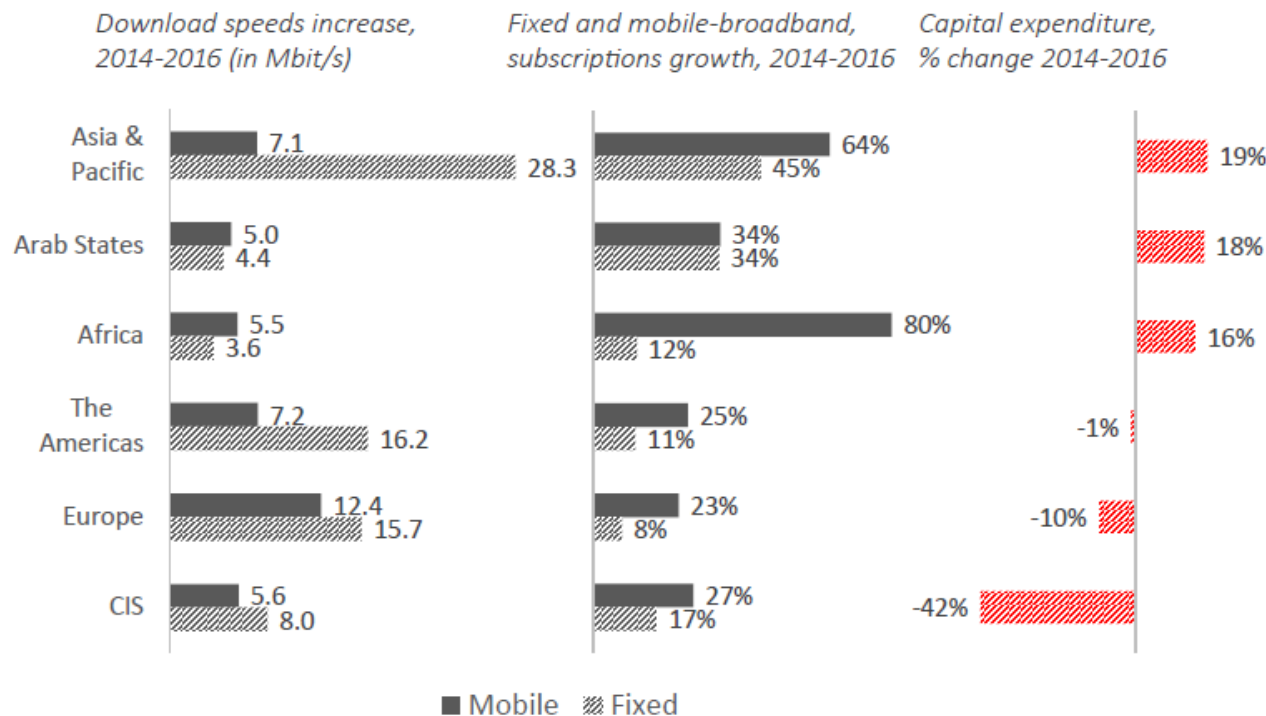
Data as a percentage of mobile revenue



Source: ITU, *Measuring the Information Society Report 2018*, vol. 1. 2018.

# ICT SECTOR – DOWNLOADS, SUBSCRIPTIONS, CAPITAL EXPENDITURE

Capex follows technology life-cycles. After LTE deployments between 2009 and 2013, mobile operators focus on network maintenance until 5G investment is needed.



Source: ITU, *Measuring the Information Society Report 2018*, vol. 1. 2018.

**The telecommunication sector plays an important role in the global economy:**

- telecommunication revenues in 2016 represented on average 3% of GDP in Africa and the Arab States,
- compared to 2% in Asia and the Pacific and the Americas and
- less than 2% in the CIS and Europe.

**Greater market maturity levels translate to slow performance during 2014-2016:**

- global telecommunication revenues declined by 5% during the period
- the number of full-time equivalent employees working for telecommunication operators declined by 6% globally

Source: ITU, *Measuring the Information Society Report 2018*, vol. 1. 2018.

## Fixed-line revenue represented half of telecomm revenues in 2016:

- Fixed-mobile convergence, and the race to smart societies, are gaining in importance in mature markets, where subscriptions and revenue are stalling.

## Mobile voice revenues declined by 7% between 2014 and 2016:

- As mobile becomes ubiquitous, growth in mobile voice revenues is stalling.
- Between 2014 and 2016, mobile voice revenues declined by 10% in the developing world, compared to 5% in the developed world.
- There is a correlation between economic growth and mobile voice revenue growth in markets where prepaid is dominant.
- Four in five mobile subscriptions in developing countries are prepaid.

Source: ITU, *Measuring the Information Society Report 2018*, vol. 1. 2018.

## Global increase in data revenues was lower than the loss recorded in voice revenues:

- Asia and the Pacific and the US/Canada were the only two regions in which the increase in mobile data revenues was greater than the loss in voice revenues.
- The relative importance of data revenues over voice revenues is correlated with a country's Internet penetration.
- In most developing economies, mobile-broadband subscriptions have grown enormously, countering the slowdown in mobile-cellular subscriptions.

## Mobile revenue growth is impacted by the uptake in over-the-top (OTT) services:

- The success of IP-messaging apps is to the detriment of traditional text usage and the associated revenue.
- The number of SMS messages sent fell by half between 2014 and 2016.

Source: ITU, *Measuring the Information Society Report 2018*, vol. 1. 2018.



**The ICT sector is characterized by large infrastructure investments:**

- telecommunication capex went up by 4% between 2014 and 2016
- developing economies are driving this growth – USD 23.5 billion capex increase compared to USD 10 billion capex reduction in the developed world

**These trends denote a market context with financial pressures and competition:**

- these are forcing service providers to transform their business models to look for new revenue streams
- growth of the Internet of Things (IoT) and machine-to-machine (M2M) communications is creating revenue opportunities in mature markets
- as IoT investment opportunities are scaling up, enablers, such as Artificial Intelligence, big data analytics (BDA) and Blockchain, are gaining momentum
- these lay the foundation for “smart societies”

Source: ITU, *Measuring the Information Society Report 2018*, vol. 1. 2018.

# VIDEO: THE DIGITAL ECONOMY NEEDS FAIR TAXATION



Source: <https://www.youtube.com/watch?v=Psn4fgAWR68>

# QUESTIONS

- |    |   |
|----|---|
| 1. | What is the structure of the ICT sector?  |
| 2. | Which part of the ICT sector shows the greatest growth?                             |
| 3. | What is the main difference between taxation of digital and traditional businesses? |

# HOW IS THE DIGITAL ECONOMY GROWING?

TELECOMM SECTOR IS IMPORTANT IN THE GLOBAL ECONOMY  
GREATER MATURITY TRANSLATES TO SLOWER PERFORMANCE  
LOSS IN VOICE REVENUES, INCREASE IN DATA REVENUES  
STRONG MARKET COMPETITION

THANK YOU FOR YOUR ATTENTION

Tomasz Janowski

[tomasz.janowski@pg.edu.pl](mailto:tomasz.janowski@pg.edu.pl)