HUAWEI

Position paper

TELCO: INVESTMENT, INNOVATION AND COMPETITION IN ICT INFRASTRUCTURE

Huawei Technologies Co., Ltd.

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Executive Summary

Information and communication technology (ICT) has been experiencing a rapid and steady growth around the globe in the past two decades. This is evidenced by the development of ICT infrastructure, improved internet penetration, the expanding bandwidth and speed of connection, and more. With the rapid growth of ICT infrastructure, ICT has become a fundamental feature of modern society, and to some extent, internet access is even considered as a basic right for all people in this information society, given its enormous potential to help achieve sustainable development of human society.

Along with the development of ICT in the past few decades, it demonstrates its ability to create both economical and societal value to the development of a country. It is a consensus in various researches[1]Does ICT Generate Economic Growth, Journal of Economic Surveys, 2018
The economic impact of broadband: evidence from OECD countries, Ofcom, 2018
Impact of information and communication technology and financial development on economic growth of OPEC developing economies, Kasetsart University, 2018

ICT and economic growth: Comparing developing, emerging and developed countries, Center for European Economic Research, 2014] that ICT development has positive effects on national economic growth, which is also re-examined in this paper. Additionally, the digital spillover effect of ICT investment is also noteworthy.

In addition to ICT's impact on national economic growth, ICT also supports societal wellbeing and public affairs. It contributes to promoting education accessibility and cultural communication, reducing unemployment rate, ensuring both public and personal safety and security, improving government efficiency and transparency, etc.

However, ICT development varies across countries, as well as different geographic areas within a country. Considering the noteworthy Digital Divide, governments of developing countries should realize the urgency and pay extra attention to the development of ICT and relevant infrastructures, to catch up on this important global trend.

Recognizing its importance to economical and societal development of a country, the development of ICT and relevant infrastructure cannot be realized by solely relying on participants within the ICT ecosystem, such as network element providers, network operators, downstream platform, application and content providers. Instead, government plays a vital role in forming a favorable environment to enable the fast and healthy development of ICT industry, and it includes three major aspects: investment, innovation, and competition.

[1]Does ICT Generate Economic Growth, Journal of Economic Surveys, 2018
The economic impact of broadband: evidence from OECD countries, Ofcom, 2018
Impact of information and communication technology and financial development on economic growth of OPEC developing economies, Kasetsart University, 2018
ICT and economic growth: Comparing developing, emerging and developed countries, Center for European Economic Research, 2014

1.ICT infrastructure and connectivity are fundamental to modern society

Information and communication technology (ICT), has been experiencing a rapid and steady growth around the globe in the past two decades. This is evidenced by the data below regarding the development of ICT infrastructure and increasingly connected devices, improved internet penetration for individuals and households, the ever-expanding bandwidth and speed of connection, and more.

With the rapid growth, ICT has become fundamental features of modern society. Given the prevalence of connectivity, to some extent, internet access is even considered as a basic right for human in this information society. ICT not only forms the backbone of today's digital economy, but also has enormous potential to help achieve sustainable development of human society, and improve people's lives fundamentally.

However, making use and integration of ICT into the economy varies across countries and different geographic areas. The noteworthy Digital Divide describes the gap in development in ICT infrastructure, accessibility and utilization, which can be explained by the "Matthew Effect" as well, indicating deepening inequality and obstacles for laggards to compete with pioneers.

1.1 The rapid growth of ICT infrastructure and improving connectivity of the world

Information and communication technology (ICT), the key for information gathering, storage, processing, transmission and display, has been progressing rapidly and steadily around the globe since the turn of the century. The development of ICT infrastructure in the past twenty years improved internet access and connectivity from ARPANET, an early switching network as the technical foundation of Internet, to a global network of mainframes, servers, routers, cellular networks, submarine fibers, satellites, and more. It has also led to an expansion in bandwidth and acceleration in connection speed. All of this fueled by Moore's Law that the number of transistors in a dense integrated circuit doubles and the cost cuts to half about every two years.

For the first time in human history, people, commercial organizations, governments, and other institutions are interconnected and communicate with one another at anytime, anywhere. In one way or the other all economic and social activities, such as agriculture, manufacturing, and government services, rely upon ICT infrastructure. Billions of people's daily lives are being supported, shaped, executed, and recorded by ICT infrastructure around the globe. Indisputably, ICT infrastructure defines modern society. We live in an unprecedented DIGITAL AGE and a truly CONNECTED globe, which is mainly characterized by increasing importance of Digital Economy, improvement in productivity, and significant changes in lifestyle.

Not only has ICT infrastructure been established extensively, but it will also continue to grow to higher levels in the coming years. This is evidenced by the data below regarding the development of ICT infrastructure and increasingly connected devices, improved internet penetration for individuals and households, the ever-expanding bandwidth speed of connection, and more.

1.1.1.Rapid development of ICT infrastructure

ICT infrastructure can be described by three key components: computing and processing capacity, connection network, and connected devices. According to the definitions from various sources (Figure 1), following are typical ICT infrastructures:

- Fixed network and broadband, e.g. land-based and sea-based fiber cables
- Mobile cellular network and broadband, e.g. cell sites
- Information gathering, processing, and display devices or applications, including computer, TV, radio, cellphone, fixed telephone, and wearable devices
- Other relevant infrastructure that fulfill the function of information gathering, storage, processing, transmission, and display, e.g. data centers, satellite and cloud systems

Core indicators on **ICT Infrastructure…fixed telephones, mobile-cellular telephone, mobile-cellular network, internet traffic, telephone traffic, computers, broadband, radios, televisions."**

-ITU: Core ICT Indicators: Partnership on Measuring ICT for Development

"ICT infrastructure including **IXPs, land-based and sea-based fiber routes…**the positive relationship between investment in the ICT infrastructure (fixed broadband and mobile broadband) and access is important in all countries of different income groups."

-UN ESCAP: A Study of ICT Connectivity for the Belt and Road Initiative (2017)

"Connectivity at present is delivered through a combination of **mobile, satellite, undersea cables and fixed networks,** and these technologies will continue to serve as the backbone of communications in the region in the future."

-World Bank: Assessment of the potential impact of the ICT revolution in the pacific on economic growth

"ICT includes any communication device or application such as **radio, television, cellular phones, computers, satellite systems as well as network hardware** and software and associated services.

-United Nations: Toolkit on Disability for Africa

Figure 1: Definition of ICT infrastructure from various sources
Source: Huawei, Roland Berger

In the past 10 years, the entire world has witnessed the accelerated progression of ICT infrastructure, including the construction of both mobile and fixed networks, increasing numbers of information processing and display devices, and the development of other relevant infrastructure.

Fixed and mobile network

Optical cable: Underpinning global communication worldwide fiber optical cable deployment has been increasing with double-digit growth, 14-16% p.a. in the past decade, from ~120 million Fiber-km in 2007 to ~470 million Fiber-km in 2017 (Figure 2). It is expected to keep experiencing steady growth, mainly driven by China fiber optical cable demand.

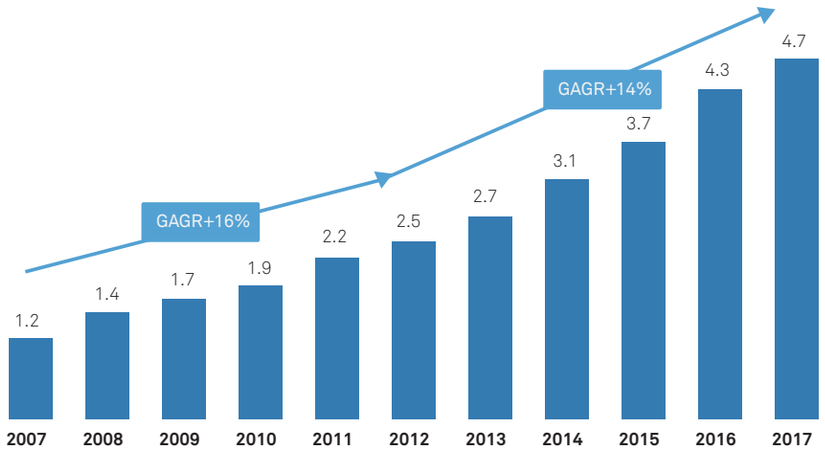

Figure 2: World total optical cable demand [00' Million Fiber-km]
Source: CRU; Roland Berger

Mobile wireless cell sites: As the central infrastructure for transmitting cellular data among mobile phones, the number of mobile wireless cell sites has been growing quickly. Among all countries, the expansion of the cell sites is impressive in China, with 3G/4G cell sites being the main driver (Figure 3). With 4.62 million 3G/4G base stations in the mainland, China's three mobile operators certainly account for the lion's share of the global 4G total – more than 40 per cent.

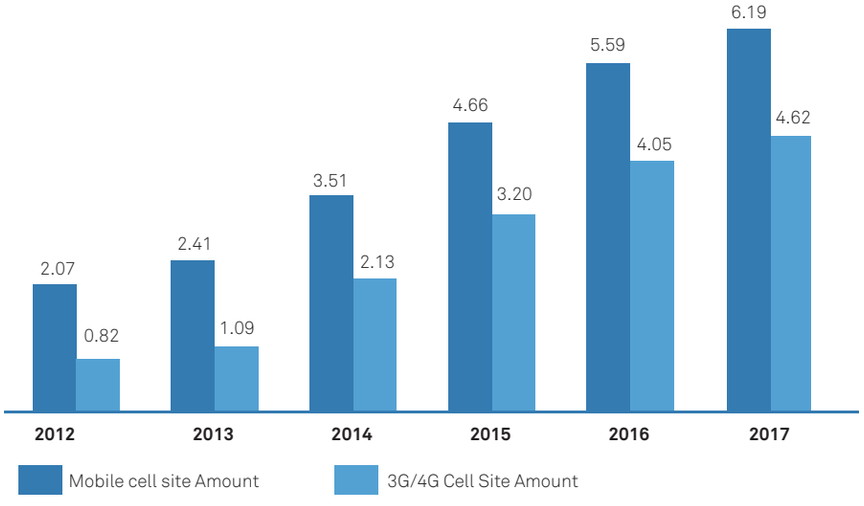

Figure 3: Number of mobile wireless cell sites in China [millions]
Source: Ministry of Industry and Information Technology; Roland Berger

Information gathering, processing, and display devices

Besides the sheer number and penetration of traditional information gathering, processing, and display devices, mobile phone (Figure 4) and computer (Figure 5) usage has also expanded, especially in mobile phone subscriptions which was 3.5 times that of 2005 by 2017. In addition, innovative devices such as IoT (Figure 6) and connected wearable devices (Figure 7) are predicted to achieve a double-digit growth in the coming 5-10 years.

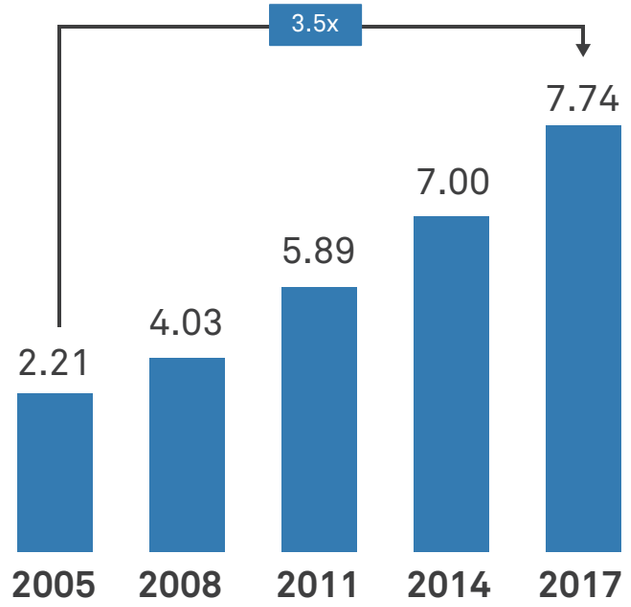

Figure 4: Global mobile phone subscriptions [billion]
Source: ITU; Roland Berger

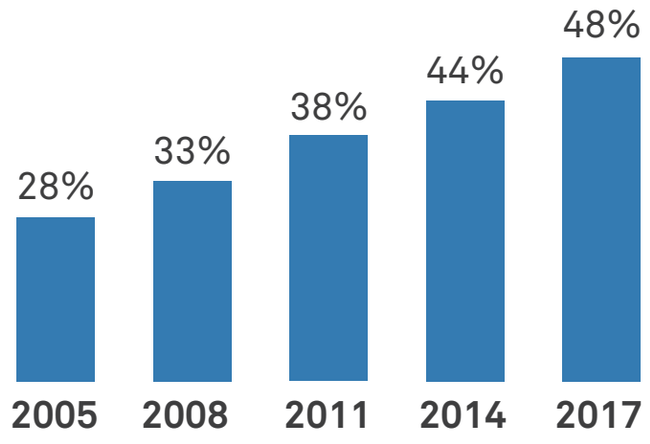

Figure 5: Global number of households with computers
Source: ITU; Roland Berger

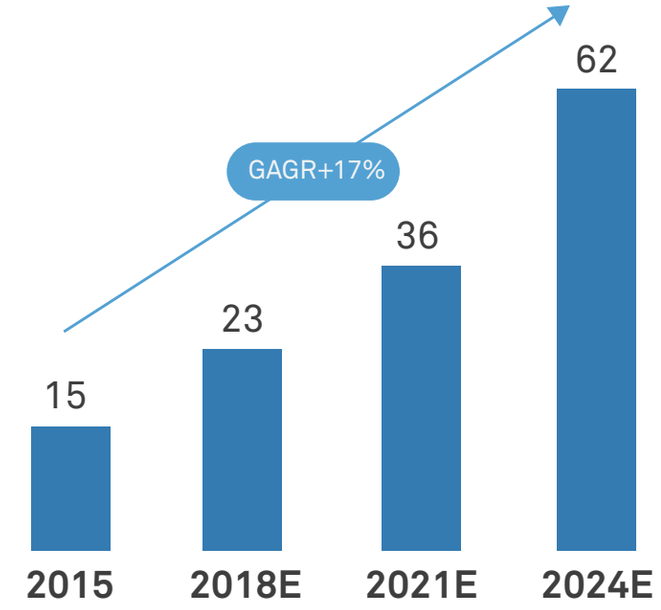

Figure 6: Internet of Things (IoT) connected devices installed base worldwide [billions]
Source: IHS; Roland Berger

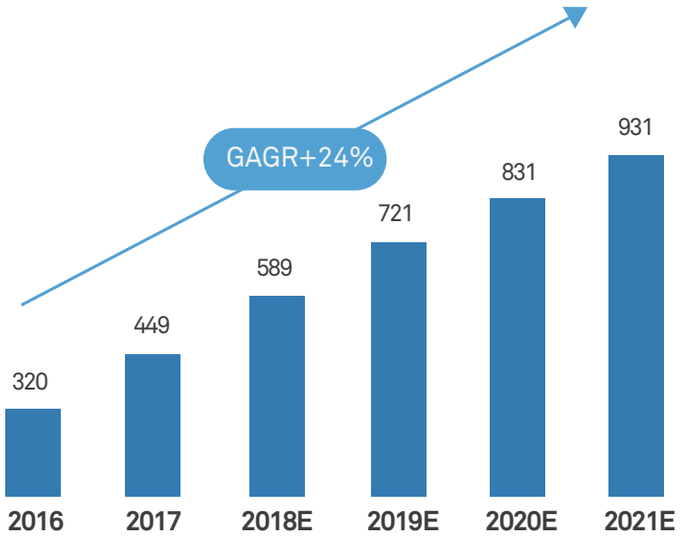

Figure 7: Number of connected wearable devices worldwide [millions]
Source: Huawei, Roland Berger

Other relevant infrastructure

Other types of ICT infrastructure have also undergone an accelerated expansion and are expected to continue growing at such a high pace. According to Huawei GIV 2025 report, 90% of computing load, 92% of storage within data centers will be done in cloud data centers. In enterprise level, all companies are expected to connect to cloud services, and 85% of enterprise applications will be deployed on the cloud by 2025. The increasing data storage capacity and higher processing capability requirements will significantly drive the development of hyperscale data centers, which works with hundreds of thousands of individual servers that are made to operate together via a high-speed network. This ever-increasing demand for hyperscale data centers which can process more information is also mainly driven by the improvement of fixed and mobile network infrastructure.

1.1.2. The significant improvement of internet access and connectivity

Given the progression of ICT infrastructure, internet access and connectivity has grown significantly in the past decade, mainly led by the upsurge in mobile network connection.

Increasing internet access for individuals and households

Other types of ICT infrastructure have also undergone an accelerated expansion and are expected to continue growing at such a high pace. According to Huawei GIV 2025 report, 90% of computing load, 92% of storage within data centers will be done in cloud data centers. In enterprise level, all companies are expected to connect to cloud services, and 85% of enterprise applications will be deployed on the cloud by 2025. The increasing data storage capacity and higher processing capability requirements will significantly drive the development of hyperscale data centers, which works with hundreds of thousands of individual servers that are made to operate together via a high-speed network. This ever-increasing demand for hyperscale data centers which can process more information is also mainly driven by the improvement of fixed and mobile network infrastructure.

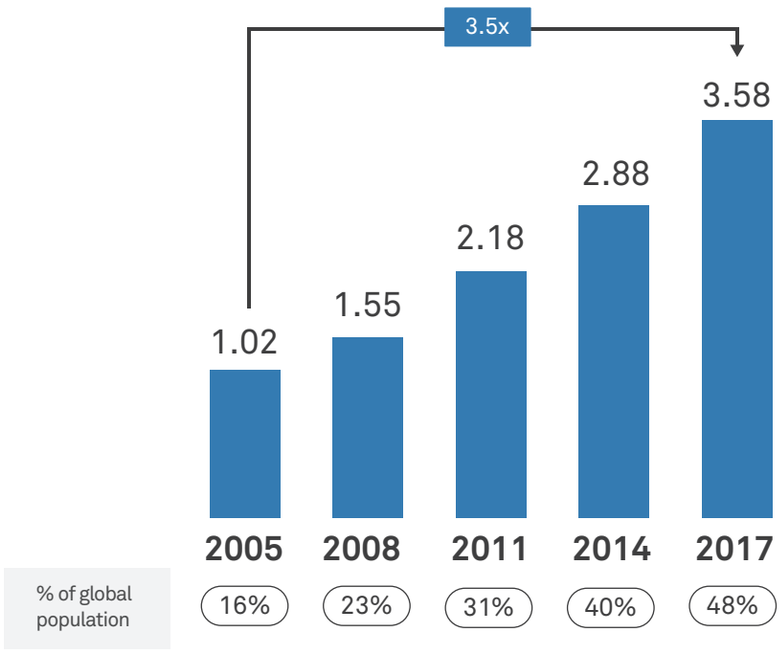

Figure 8: Global individual using the internet [billions] and % of population connected to internet
Source: ITU; Roland Berger

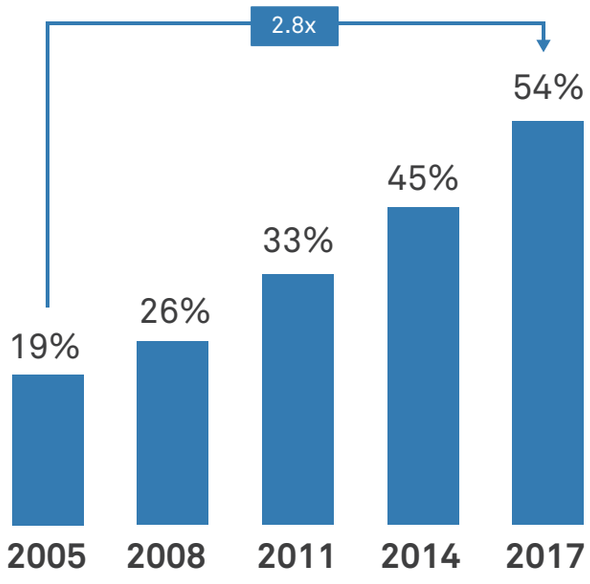

Figure 9: Global households with internet access at home
Source: ITU; Roland Berger

Increasing fixed and mobile broadband subscriptions

In addition to being connected, for individuals and households, broadband subscription is necessary to ensure quality internet connection. As shown below (Figure 10), both mobile and fixed broadband subscriptions have grown significantly. Between 2007 and 2017, the number of fixed broadband subscriptions has almost tripled. Moreover, the number of active mobile-broadband subscriptions has surged from about 270 million subscriptions in 2007 to an estimated 4.2 billion subscriptions in 2017, a staggering 147 times increase. Mobile subscriptions are predominant in the broadband market, now accounting for over 80% of broadband subscriptions worldwide.

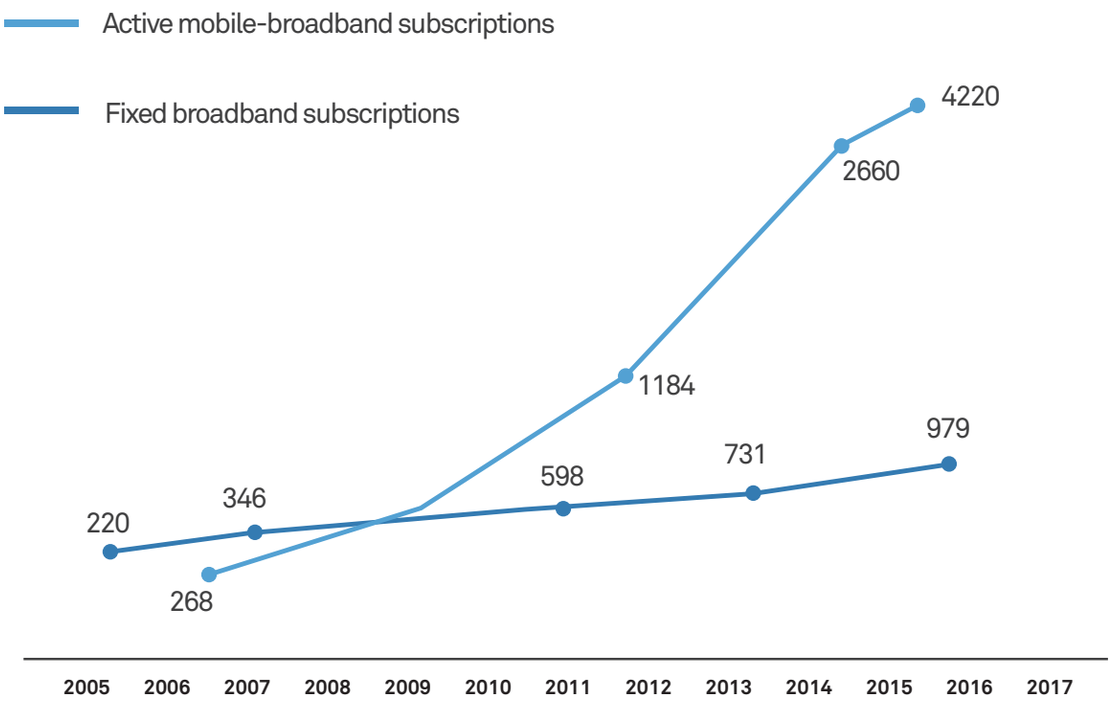

Figure 10: Global mobile and fixed broadband subscriptions [millions]
Source: ITU; Roland Berger

1.1.3. Expansion in bandwidth and acceleration in connection speed

Bandwidth, a feature of broadband indicating the maximum rate of data transferrable across a given path, has been improving steadily and quickly. Improvements in bandwidth and connection speed enable much more extensive and effective use of ICT, as well as the economic and social benefits brought by ICT development.

Fixed-broadband bandwidth has risen rapidly. More than 50% of the world's 142 countries reached the entry-level fixed-broadband speed of 2Mb/s or higher in 2015. This figure was only 15% back to 2008 (Figure 11).

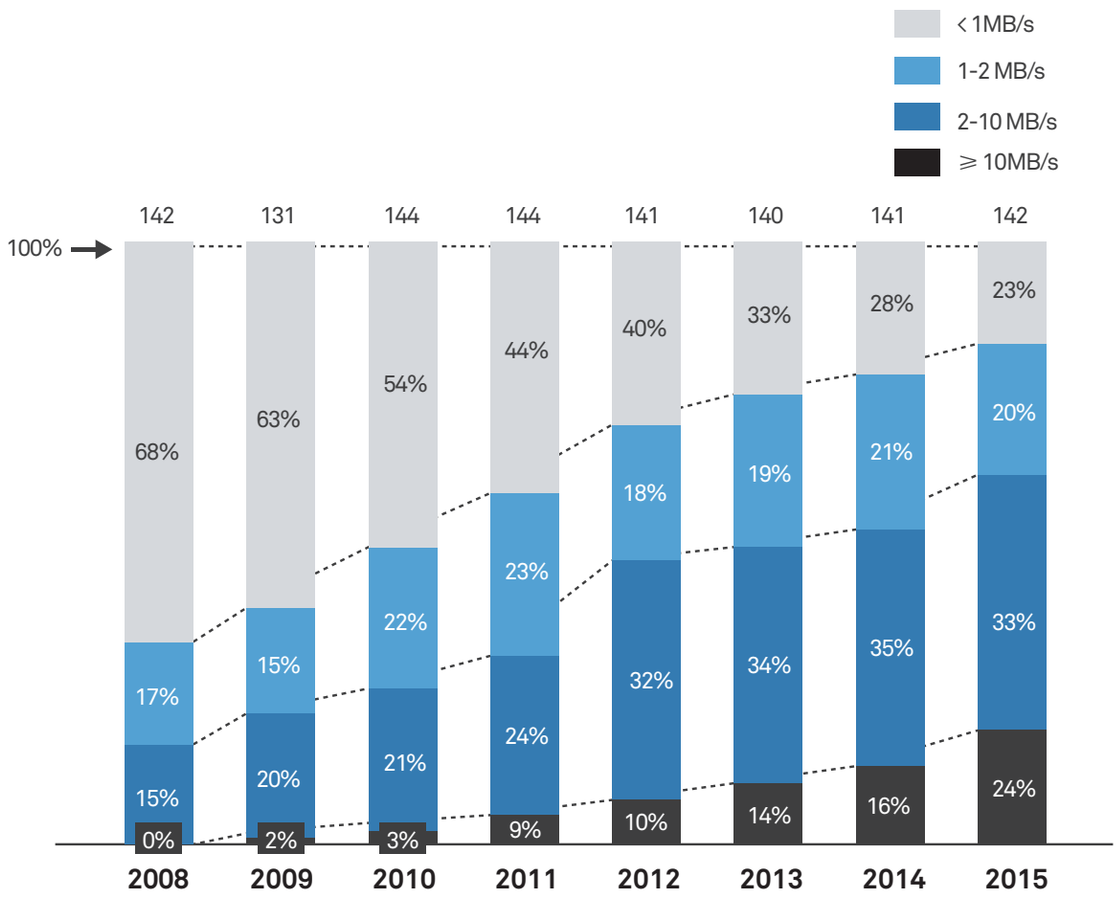

Figure 11: Most common entry-level fixed-broadband speeds [number of countries, %]
Source: ITU; Roland Berger

Mobile broadband has followed a similar trend regarding bandwidth and connection speed. Back in 2011, 78% of wireless service subscriptions were 2G services, while in 2017 65% were either 3G or 4G, with more than 10 times or even 100 times the connection speed compared with 2G. Mobile bandwidth is expected to further improve with the implementation of 5G after 2020. (Figure 12)

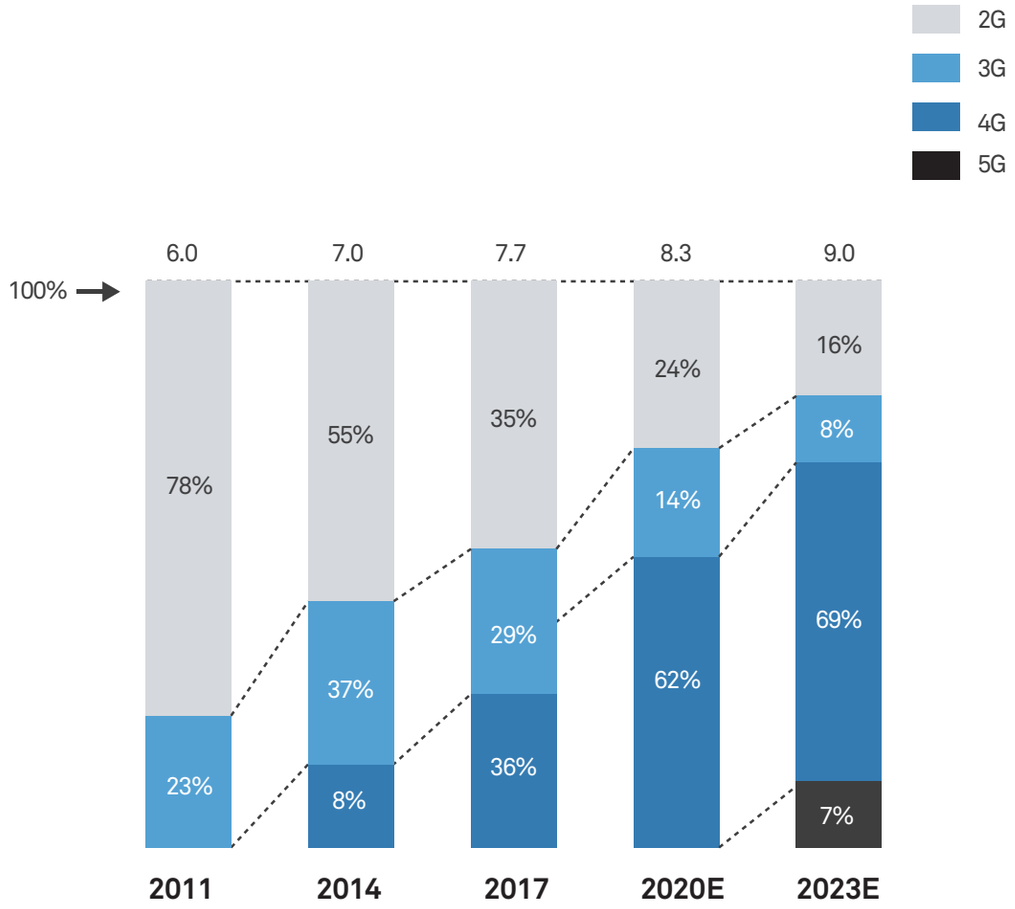

Figure 12: Global number of wireless services subscriptions by generation [millions, %]
Source: Strategy Analytics; Roland Berger

1.2. ICT becoming fundamental to modern society and helping achieve sustainable development of human society

1.2.1. ICT and connectivity is the basic building block of modern society

Around the globe, ICT grew exponentially in recent decades, and internet has reached almost 50% of the global population. In this digital age, ICT and connectivity has become more than simply a new technology; they are fundamental features of modern society (Figure 13). It exists all around us, helping to improve our lives in more ways than originally thought. ICT connectivity is truly becoming a necessity in modern society today and in the future.

> *"Digital connectivity is a **basic building block for economic productivity**, like electricity or roads. You simply can't be part of the global economy without it today, it is crucial."*
>
> *- Casey Torgusson, World Bank*

Figure 13: Importance of ICT and digital connectivity mentioned by World Bank official
Source: Huawei, Roland Berger

In December 2003, the World Summit on the Information Society (WSIS), under the auspice of the United Nations, adopted the WSIS Declaration of Principles. The Declaration announced for the first time in history that access to the internet should be a basic human right (Figure 14). Since then, the Right to Internet Access has remained a key feature of the current global conscience.

> "We reaffirm, as an essential foundation of the Information Society, and as outlined in Article 19 of the Universal Declaration of Human Rights, that everyone has the right to freedom of opinion and expression; that **this right includes freedom to hold opinions without interference and to seek, receive and impart information and ideas through any media and regardless of frontiers. Communication is a fundamental social process, a basic human need and the foundation of all social organization. It is central to the Information Society.** Everyone, everywhere should have the opportunity to participate and no one should be excluded from the benefits the Information Society offers."

Figure 14: World Summit on the Information Society Declaration of Principles
Source: Huawei, Roland Berger

1.2.2. ICT helps achieving sustainable development of human society (UN SDGs)

Referring to Sustainable Development Goals (SDGs) of United Nations (UN), ICT is tightly linked with UN SDGs (Figure 15), and is able to help progress the realization of SDGs, which is further elaborated below.

Figure 15: United Nations Sustainable Development Goals
Source: United Nations, Roland Berger

Increasing fixed and mobile broadband subscriptions

SDG 3 aims to ensure health and well-being can be achieved globally for all people, throughout all stages of their lives. SDG 3 has one of the highest correlations (72%) with ITU scores among the selected SDGs, suggesting that this is an area that could significantly benefit from greater investment in and use of ICT. ICT plays a major role enabling greater access to health information and services so that people can exchange information quickly, and provide and receive healthcare,SDG 3 aims to ensure health and well-being can be achieved globally for all people, throughout all stages of their lives. SDG 3 has one of the highest correlations (72%) with ITU scores among the selected SDGs, suggesting that this is an area that could significantly benefit from greater investment in and use of ICT. ICT plays a major role enabling greater access to health information and services so that people can exchange information quickly, and provide and receive healthcare, such as diagnostic services and emergency response.

SDG 4: Ensure inclusive and quality education for all and promote lifelong learning

ICT can be a major catalyst for improving the quality of education for children and adults worldwide, especially those living in rural environments and in low-income countries.
SDG 4 has one of the highest correlations with the ICT Sustainable Development Goals Benchmark (77%) among the selected SDGs, indicating that education is an area that could significantly benefit from investment in and use of ICT. Students and teachers, including those that are underserved and remote, can increasingly access information to support learning, online certification, student advisory services, and other educational resources through the Internet and mobile phones.

SDG 5: Achieve gender equality and empower all women and girls

SDG 5 is one of the few SDGs with an indicator specifically identifying the role ICT can play. The link between women's equality and empowerment and ICT is strong and increasing. ICT can support SDG 5 in a number of ways: providing access to new information, allowing women to collaborate and communicate with others, and increasing productivity and economic opportunities through ICT devices, communication channels, and analytics.

SDG 9: Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation

ICT continues to be essential to the development of resilient, inclusive and equitable infrastructure and industry. Modern infrastructure (e.g., power grids, water supplies, communication networks and transportation services) are all controlled or improved by ICT and society's ability to innovate benefits enormously from the open access to information and increased collaborative capabilities enabled by ICT. In addition, investment in research and development are critical to innovation and cultivation of sustainable industrial development. Given limited existing infrastructure within developing countries, ICT will play an increasingly important role in supporting cleaner, more efficient, and longer-lasting developments in infrastructure, industrialization, and innovation going forward.

SDG 11: Make cities and human settlements inclusive, safe, resilient and sustainable

Rates of urban concentration are greater in some parts of the world than others, which places increasing pressure on governments to find sustainable solutions for cities as population density grows, with a need to improve services to reduce waste, provide green spaces, address energy challenges, and provide access to economic opportunities.

ICT to date has been instrumental in improving the efficiency of individual systems (e.g. transportation, water and energy distribution infrastructure) but experts anticipate that ICT's potential impact for cities has yet to be fully realized, and may ultimately revolutionize the manner in which cities develop and operate by allowing interconnected, digitized systems to communicate to and work with one another.

SDG 13: Take urgent action to combat climate change and its impacts

ICT will continue to be important to addressing the causes of climate change and implementing mitigation efforts. ICT enables the essential collection and dissemination of planetary data and information that conveys the progress of mitigation strategies, in addition to improving the sophistication of early warning systems for environmental disasters.
ICT plays a critical role in collecting and sharing data on climate and weather, information for forecasting weather events and providing early warning systems. Remote sensing and geographic information systems (GIS) allow for improved risk analysis and data collection.

1.3. Digital divide & ICT investment to close it

Although a great variety of applications and services based on ICT infrastructure are enjoyed by billions of people around the world, people's access to or usage of internet connectivity varies substantially across different countries. The gap in accessibility and usage of ICT infrastructure, bandwidth and devices is called the "Digital Divide".

There is a significant gap in individual and household internet access between developed and developing countries. In developed countries, 80% of individuals were using the internet in 2016 while only 39% were in developing countries. The percentage of households with internet access reached 83% in developed countries in 2016, while in developing countries only 43% had access at home. (Figure 16 and 17)

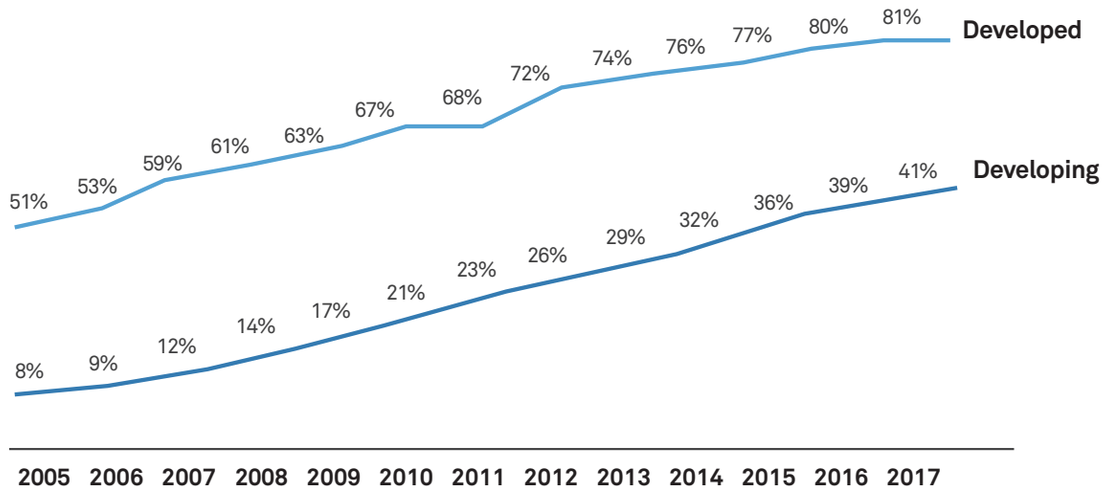

Figure 16: Individuals using the Internet
Source: ITU; Roland Berger

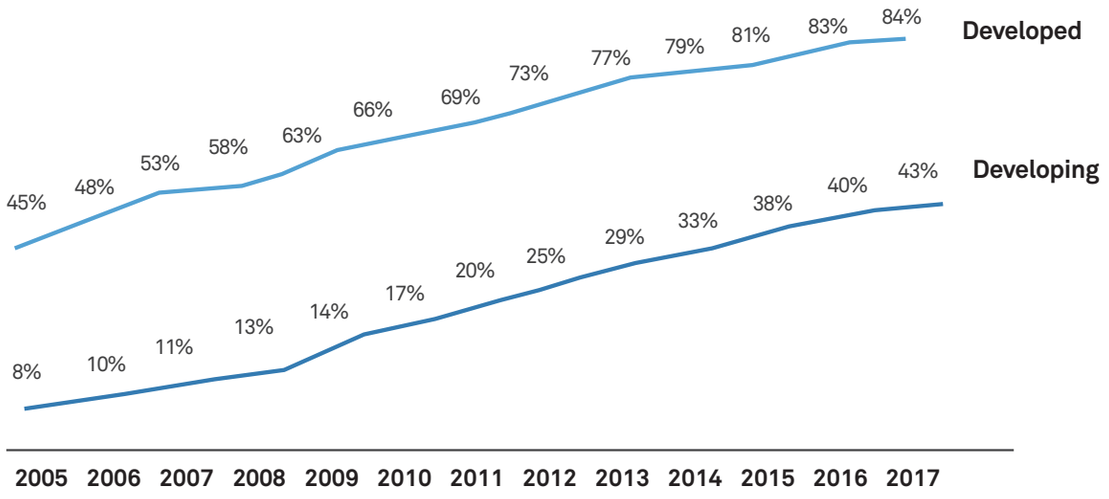

Figure 17: Households with Internet access at home
Source: ITU; Roland Berger

A similar situation occurs when it comes to penetration of ICT devices. Though the worldwide penetration rate for mobile-cellular telephones is around 90% with limited difference between developed and developing countries, computer penetration rate varies greatly. 82% of households in developed countries have a computer while only 32% of households have a computer in developing countries. (Figure 18)

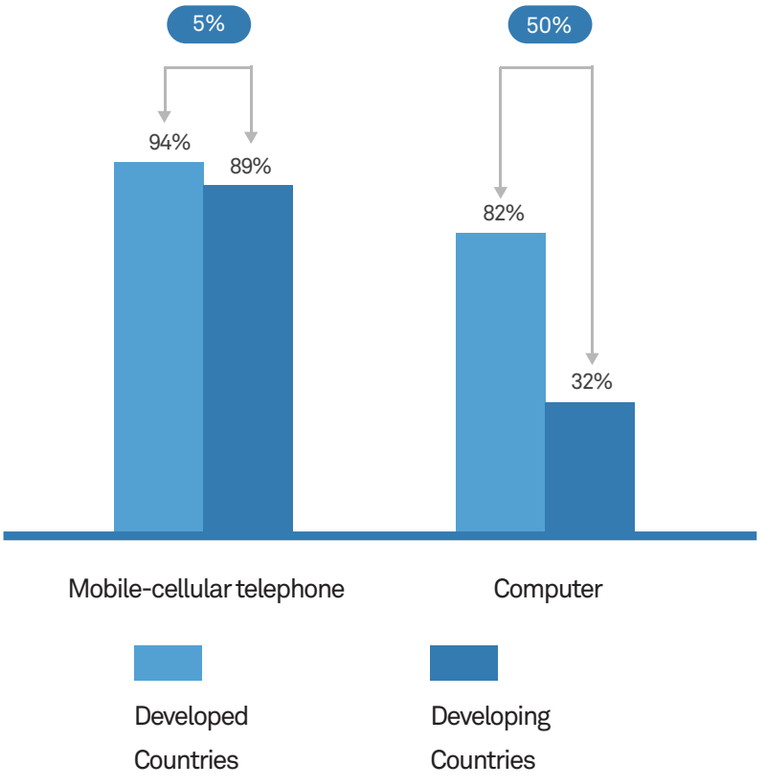

Figure 18: Proportion of households with mobile phone / computer
Source: ITU; Roland Berger

Regarding broadband accessibility, larger gaps exist between developed and developing countries in both mobile-broadband and fixed-broadband subscriptions. Developed countries almost met full mobile-broadband demand with a penetration rate at 97%, when developing countries are still 50% behind (Figure 19). It is the same for fixed-broadband subscriptions. The gap of fixed-broadband subscriptions per 100 inhabitants between developed and developing countries increased from 11% in 2005 to an estimated 21% in 2017 (Figure 20). Developing countries also lag behind in bandwidth and connection speed (Figure 21).

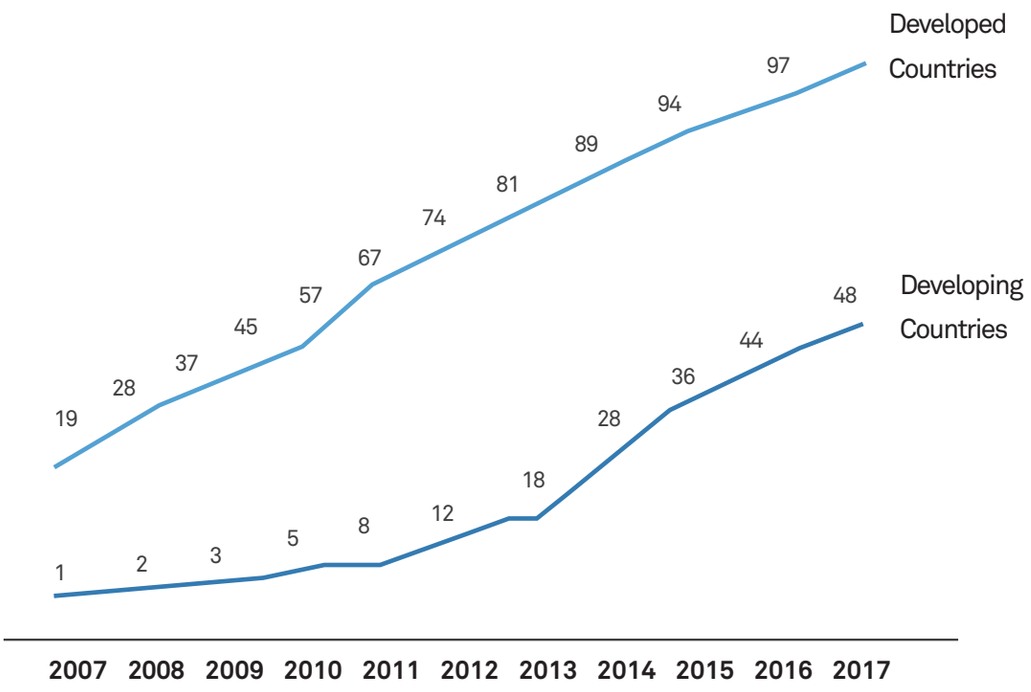

Figure 19: Active mobile-broadband subscriptions [per 100 inhabitants]
Source: ITU; Roland Berger

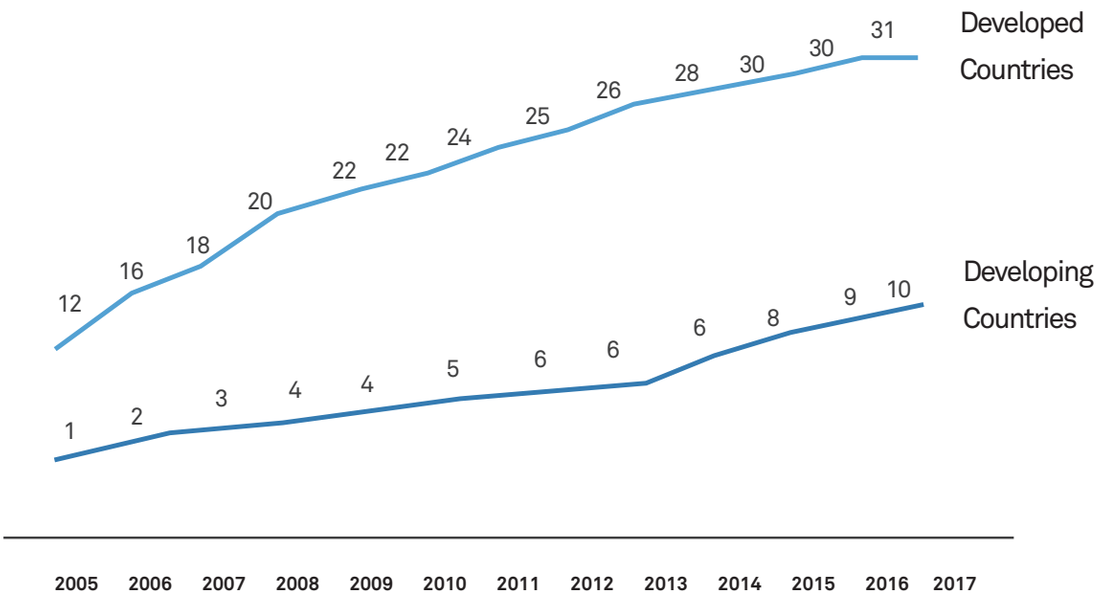

Figure 20: Fixed broadband subscriptions [per 100 inhabitants]
Source: ITU; Roland Berger

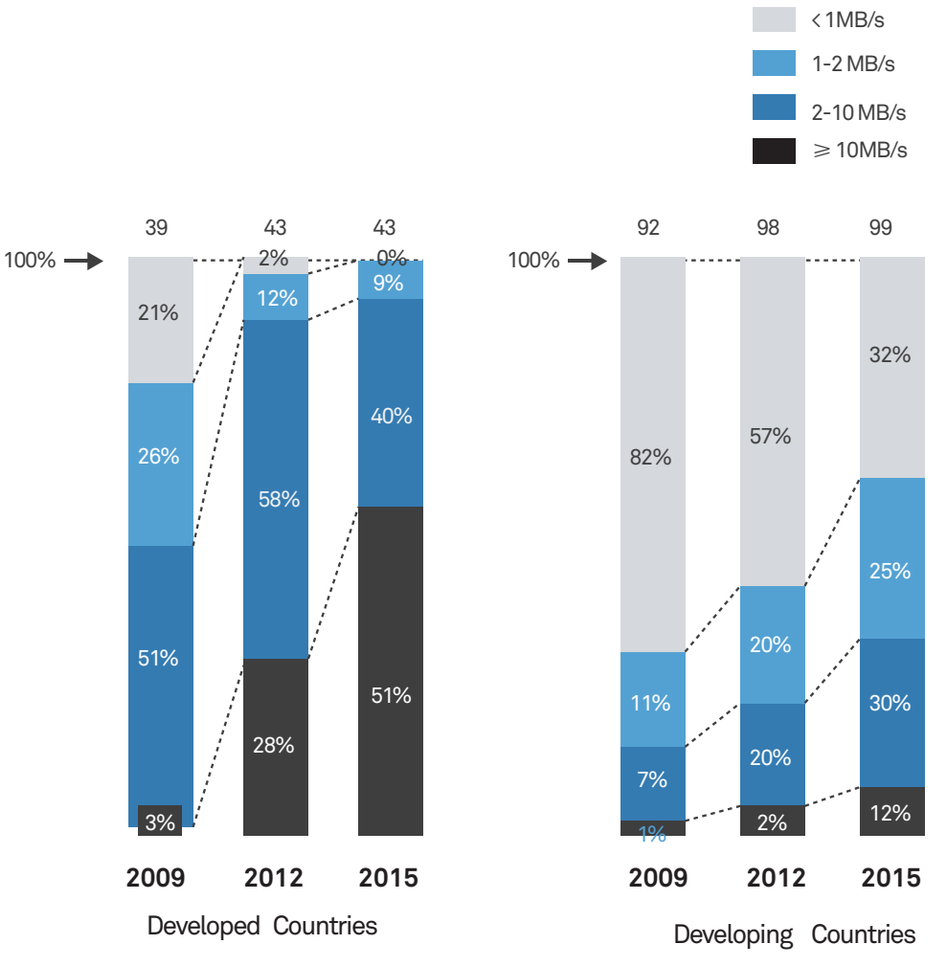

Figure 21: Most common entry-level fixed-broadband speeds [number of countries, %]
Source: ITU; Roland Berger

The Digital Divide has real and significant impacts on the countries with inadequate or outdated ICT infrastructure. Their economies can hardly benefit from new technological innovations, which causes further lag behind countries with well-developed ICT infrastructures. Citizens in these countries have less access to up-to-date information around the globe and are missing potential opportunities for development.

The "Matthew Effect" also applies to the ICT industry. Countries or regions that have an accumulated advantage over time not only succeed but leverage their initial advantage to pull farther ahead of competitors. Huawei's Global Connectivity Index has focused on the long-term effect of digital divide. It observes 50 nations' progress in Digital Transformation by dividing them into three clusters: starters, adopters and frontrunners based on 40 indicators related to ICT infrastructure. The results demonstrate a widening S-curve (Figure 22), indicating deepening inequality and obstacles for laggards to compete with pioneers.

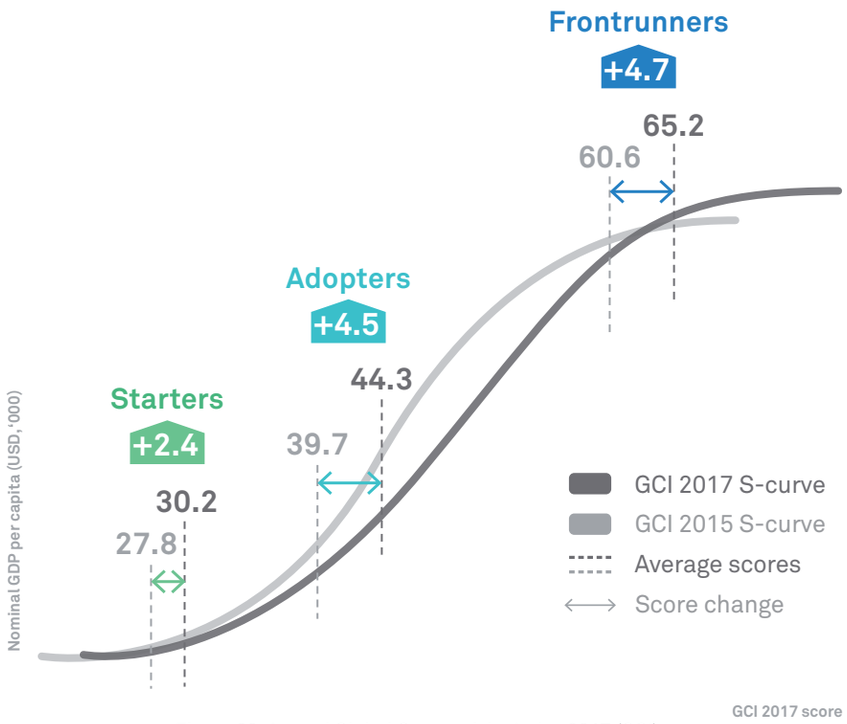

Figure 22: Annual Global Connectivity Index 2017 (GCI)
Source: Huawei, Roland Berger

Considering the noteworthy Digital Divide and the "Matthew Effect" in ICT development between developed and developing countries, as well as the importance of ICT development for sustainable development of society, governments of developing countries need to pay more attention to ICT development, and especially ICT infrastructure. More investment in ICT infrastructure is a way to close these gaps and break the vicious cycle that continues to cause some to miss out on the benefits of innovations in ICT-related services and applications.

2.ICT's impact on national economic development

The link between ICT investment and economic growth of a country has been subject of a variety of research. This paper conducted a regression analysis on a data set of 125 countries for the period 2010 to 2016 and concluded that with 16-20% increment in ICT capital services, the dependent variable GDP is about to raise 1%. Besides, Huawei and Oxford Economics found out the magnitude of digital spillover effect of ICT investment: every $1 invested in digital technologies over the past three decades has added $20 to GDP, on average.

Specifically, as for different industries, there are three major modes of how ICT development affects the economy. For traditional industries, such as agriculture, manufacturing, tourism, etc., ICT can bring either "improving" or "transformational" impact serving as a fundamental infrastructure. Additionally, development of ICT enables the birth of emerging industries like cloud computing, and AI enabled industries, which is considered to be "disruptive" impact.

2.1. ICT's impact on national economic growth

That the development of ICT is necessary for economic growth is no longer theoretical, but supported by a large body of statistical research from academics, government, and industry. The researches[2] include both qualitative and quantitative results, based on regression analysis. Although different data samples (time frame, countries, etc.), regression models, sets of independent variables, were used in these researches, all in all, the overarching consensus is that ICT development has positive effects on national economic growth (i.e. GDP growth), no matter in the developing or developed countries.

Thomas Niebel (2014) determined that growth of ICT capital service had a positive coefficient with the growth of GDP. The overall results were convincing by choosing limited but reasonable variables according to the classic Cobb-Douglas function which is a classical way to modelling macro-economic growth. The data samples, however, used were a bit out-of-date and with limited geographic coverage. This positioning paper re-examined the model[3] on a data set of 125 countries for the period 2010 to 2016 and concluded that that the growth rate of ICT capital services has a positive correlation with the growth of GDP. The reason to choose 2010 as a starting point is that with 4G being formally commercialized at the beginning of 2010, a new era of ICT has begun with faster changing pace and more effective influence on economics.

The ICT capital services defined here are the growth rates of the ICT stocks including assets like information technology equipment, communication technology equipment and software for ICT. In order to establish the casual relationship, after controlling different variables like labor increment as well as other fixed effects, the growth rate of ICT capital services shows a coefficient of 0.0629. In other words, with 16-20% increment in ICT capital services, the dependent variable GDP is about to raise 1%.

[2]See detailed research list in the Appendix

[3]See analytical explanation of the model in the Appendix

In conclusion, with the advent of the Digital Age, ICT infrastructures and ICT devices are seeing wider, deeper, and more frequent application / usage in the modern economy. Such spread of application makes ICT related industry account for an increasingly larger portion of GDP driving force in a country.

Huawei, together with Oxford Economics, evaluated the digital spillover effect of ICT investment in its joint research [4]paper . It happens when technology accelerates knowledge transfer, business innovation, and performance improvement within a company, across supply chains and amongst industries, to achieve a sustainable development economic impact. The research shows that every $1 invested in digital technologies over the past three decades has added $20 to GDP, on average. This is an enormous return compared to non-digital investments, which delivered an average return of around US $3 to US $1 invested.

2.2. ICT's impact on development of different industries

It takes time from getting the ICT infrastructure established, to propagating its applications among people and institutions in a country, and eventually working as an enabler to boost the growth of economy and its industries. ICT has different level of impacts on different industries in a country.

Three different impact modes of ICT development to economy

Based on recent cases observed in different countries around the world, there are three major modes of how ICT development affects the economy, with different degrees of impact varied by industries (Figure 23). As a fundamental infrastructure, ICT can bring either improving or transformational impact to the development of traditional industries, such as agriculture, manufacturing, tourism. Besides, development of ICT infrastructure acts as enabler to emerging industries, such as AI and cloud computing, and it is considered to be disruptive impact to the economy.

[4]Digital Spillover, Huawei and Oxford Economics, 2017

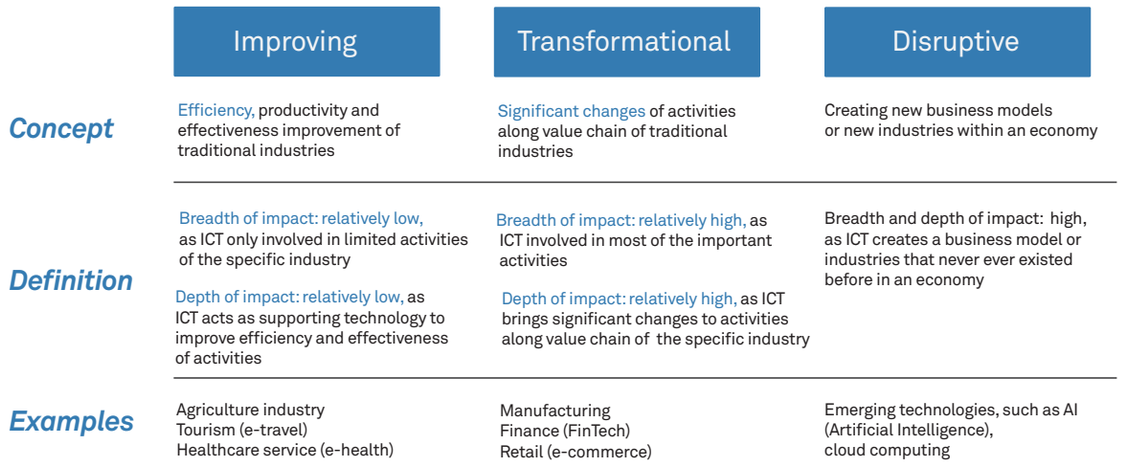

Figure 23: Introduction of three impact models
Source: Huawei, Roland Berger

1.Improving

ICT brings efficiency, productivity and effectiveness improvement to traditional industries
Example: agricultural industry, some tertiary industries such as tourism, healthcare

2.Transformational

ICT brings significant changes in activities along value chain of traditional industries
Example: manufacturing industry, finance, retail

3.Disruptive

ICT creates a business model or industries that never ever existed before in an economy
Example: emerging technologies such as AI, cloud computing

2.2.1.ICT's improving impact to economy

Agricultural industry

In the agriculture industry, ICT contributes to several important sectors and helps lift productivity and demand stimulation by providing various information services and platforms.

On supply side, by integrating weather forecast models using ICT into crop planting and harvesting and transportation, better decisions can be made in advance of crop losses due to weather perils. Weather data and analytics on field-by-field or zone-by-zone basis helps farmers make informed decisions throughout the year to maximize food production, minimize environmental impact, and reduce operating costs. According to IBM, 90 percent of crop losses are due to weather events and 25 percent of weather-related crop losses could be prevented by using predictive weather modeling.

Case Study: US

Under United States National Oceanic and Atmospheric Administration, the National Integrated Drought Information System (NIDIS) is a national drought early warning information system. It makes drought monitoring, forecasting, and impacts information available at a variety of spatial scales and geopolitical boundaries and assists decision making. As a prototype for agriculture information services, NIDIS supports timely response and preparation to climate variation and change

According to data provided by United States Department of Commerce, economic benefits from addressing reservoir optimization, short-term floods, and long-term flood events carry potential annual savings of $1.62 billion. If long-range hydrologic forecasts and water resources such as hydropower, irrigation, navigation and water supply are also optimized, additional annual savings of $766 million can be realized, which is a conservative estimate. In other words, these efforts taken together might yield annual savings of $2.39 billion.

Clearly, the value of government weather and climate data collecting by ICT is enormous. Tens of billions of dollars in annual aggregate valuation, and dramatic savings in life and property realized by improving hurricane and other forecasts

Case study: China

The China Cow Network Project is another standard case on how ICT improves agriculture productivity. In order improve the detection rate of cow estrus and increase the milk production of the farms, Huawei cooperated with China Telecom and Yinchuan Auto Technology Information Co., Ltd. to complete the NB-IoT-based cow network project. The project increased the estrus detection rate of Yinchuan Aote cows from 75% to 95%, increasing 330 USD worth of milk production per cow per 21-day estrus period

In the three-way cooperation, Yinchuan Auto provides cow special information collection terminal and information management software system. Huawei provides NB-IoT network and IoT platform to China Telecom, and provides equipment and solution integration support to China Telecom. China Telecom serves as system integrator and service provider

On demand side, the use of e-commerce in agricultural markets boosts sales significantly. A report by the China Internet Network Information Center showed that of China's 688 million Internet users by the end of 2015, 195 million (28.4%) were rural residents. China has witnessed a boom in rural e-commerce in recent years. According to a report released by Alibaba, there were 780 villages that exceeded RMB 10mn (USD 1.5mn) in online transactions in 2015 with 22.4% of online sellers coming from rural areas.

In 2016, an e-commerce service center was set up in Taiping Village, which helped more than 300 farmers sell their products and about 7,500 kilograms of a vegetable (snake gourds) were sold in one year

Last year, China's Ministry of Finance and the Ministry of Commerce announced 200 counties that would serve as demonstration bases for rural e-commerce and earmarked RMB 2Bn to help with development. According to the Minister of Commerce Mr. Gao Hucheng, rural e-commerce will reduce logistics costs, which are 15-16% of the total product costs on average – almost double that of developed countries.

Tourism industry (e-travel)

With the increasing role of ICT in this sector, a different type of tourism has emerged: electronic travel, or e-travel. E-travel is transforming the tourism industry worldwide. Now, customers primarily search for information related to travel services on the internet. Online travel services include:

- Online travel bookings, including hotels, vacation rentals, and package holidays
- Flights, long-distance travel, and cross-regional travel by train or bus in which tickets are booked online
- Car rental hires made via the internet
- Travel deals booked via online travel agencies (e.g. Expedia) or directly from a tour operator (e.g. TUI, Thomas Cook)
- Ride-sharing services like Uber, Lyft, or BlaBlaCar, Didi

Case study: Brazil

With the development of ICT in Brazil, the revenue generated in the e-travel market amounts to USD 20.4Mn in 2018 and is expected to progress at an annual growth rate (CAGR 2018-2022) of 12.0%, resulting in a market volume of USD 32.0Mn in 2022. With users increasing rapidly, the market's largest segment is "Mobility Services", with a market volume of USD14.6Mn in 2018 (Figure 24).

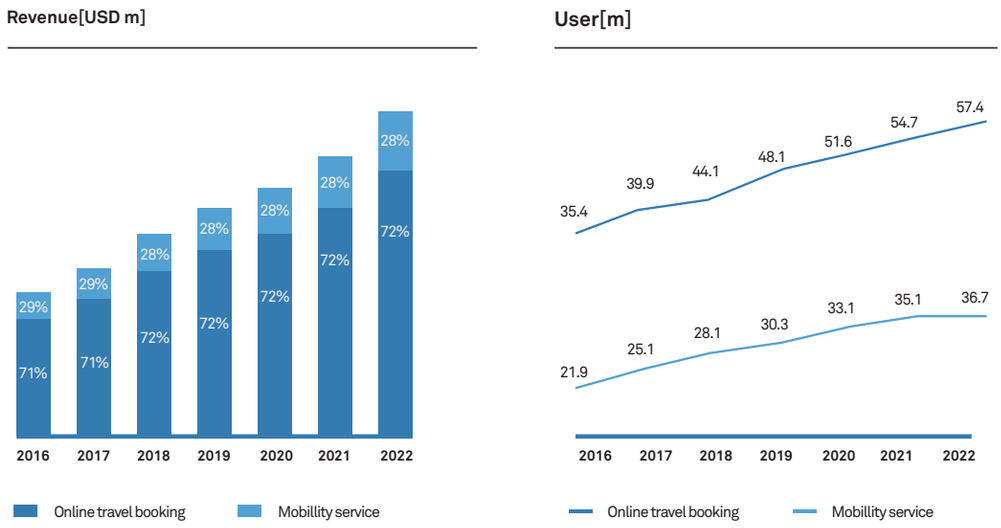

Figure 24: Revenue and user amount of E-Travel in Brazil
Source: Statista, Roland Berger

Healthcare industry (e-health)

Another successful case in the tertiary industry is e-health. E-health significantly improves productivity and reduces the costs of the traditional healthcare industry by employing a broad range of ICT-related tools such as:

- M-health: medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, and other wireless devices.
- Electronic medical records (EMRs): An electronic record of health-related information on an individual that can be created, managed, or consulted by clinicians or staff.
- Telemedicine: Clinical health care provided from a distance to overcome distance barriers and to improve access to medical services that would often not be consistently available to rural communities.
- Pharmacy information system: ICT-related system used to order, dispense, or track medications and medication orders including computerized order entry systems.
- Patient registration or scheduling system: ICT-related system used to monitor and manage the movement of patients through multistep processes or to maintain a census.
- Assistive device: ICT-related device used to help people recover from disease and injury.

Case study: India

In India, the revenue in the e-health market amounts to USD 444mn in 2018, assisted by the development of ICT. It is expected to achieve USD 729mn in 2020. The number of users in e-health is also increasing, especially in the "e-health solutions for diabetes" segment (Figure 25).

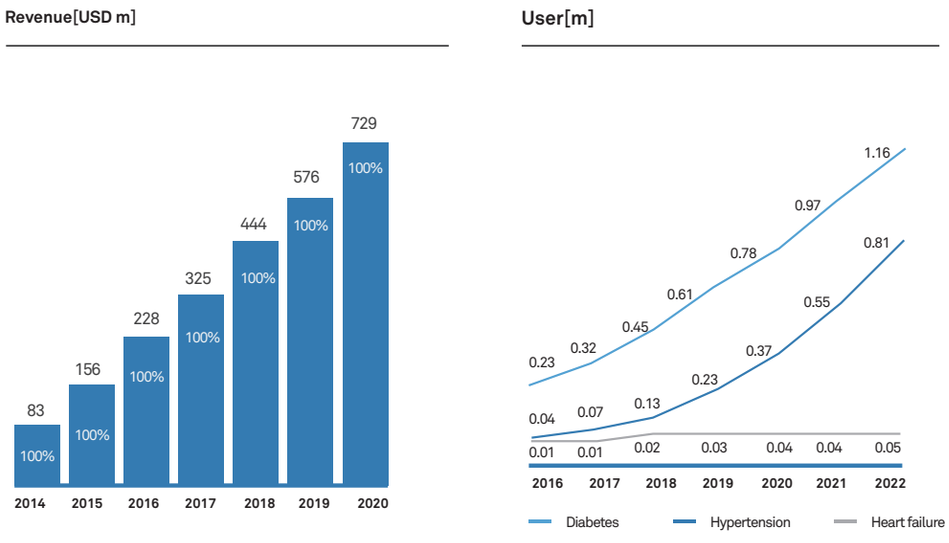

Figure 25: Revenue and user amount of E-Health in India
Source: Statista, Roland Berger

2.2.2. ICT's transformational impact to economy

Manufacturing industry

Industrial manufacturing is always evolving with the introduction of new products, infrastructure, and technologies. In the fourth industrial revolution, with substantial amounts of data and an increasing prevalence of communication, advanced technologies such as robotics and big data have been applied in the industry. The global manufacturing industry has geared up for the next level of industrial revolution, the Industry 4.0[5] era (Figure 26).

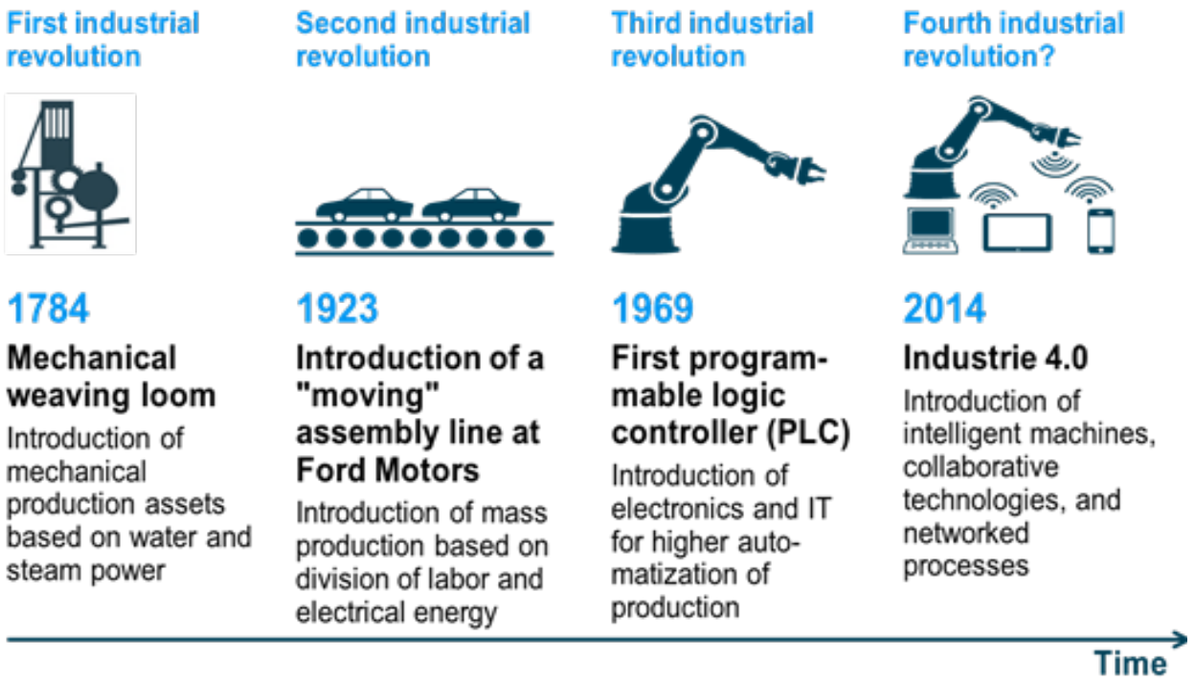

Figure 26: Development stages of industrial manufacturing
Source: Huawei, Roland Berger

Aiming at achieving higher level of flexibility, productivity, value, and efficiency, Industry 4.0 brings about many benefits. It helps design and manufacture better products by enabling adaptation of manufacturing methods by region (e.g. automated zero-defect manufacturing). It can improve process efficiency and save costs by connecting digital and real processes to identify and address manufacturing issues in advance. It even creates new business models with more visible value chain and eliminated need for intermediaries. Furthermore, additional business will be generated along with more innovation.

[5] Sometimes called Industrie 4.0, which originated from a project in high-tech strategy of the German government, and is now widely accepted and used to describe to current trend of automation and data exchange in manufacturing technologies, as well as referred to the fourth industrial revolution

about many benefits. It helps design and manufacture better products by enabling adaptation of manufacturing methods by region (e.g. automated zero-defect manufacturing). It can improve process efficiency and save costs by connecting digital and real processes to identify and address manufacturing issues in advance. It even creates new business models with more visible value chain and eliminated need for intermediaries. Furthermore, additional business will be generated along with more innovation.

According to a study by Roland Berger, Industry 4.0 significantly affects the typical automotive supplier. Return on Capital Employed (ROCE) will increase by 25%. Better plant utilization, lower machine parc, and higher profits, asset turnover, and staff investment are observed as below (Figure 27).

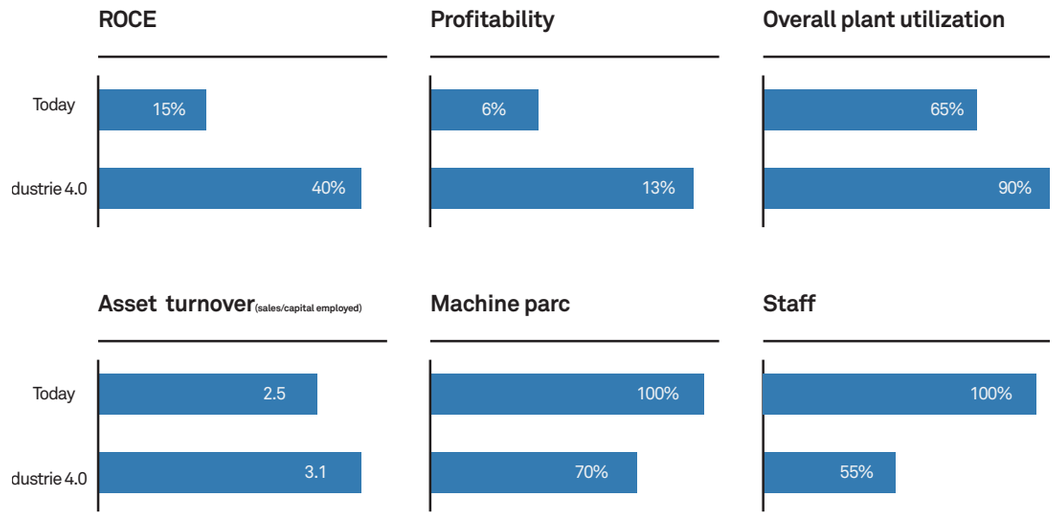

Figure 27: Selected effects brought by Industry 4.0 to industrial manufacturing
Source: Huawei, Roland Berger

Industrial robot is one of the key elements of Industry 4.0. Between 2015 and 2016, the global average number of robot workers increased from 66 units per 10,000 human workers to 74. According to data from the International Federation of Robotics (IFR) in 2016, the density of installed industrial robots shows no signs of slowing down either. Today, South Korea has 631 robots per 10,000 human workers, the most of any nation so far (Figure 28)

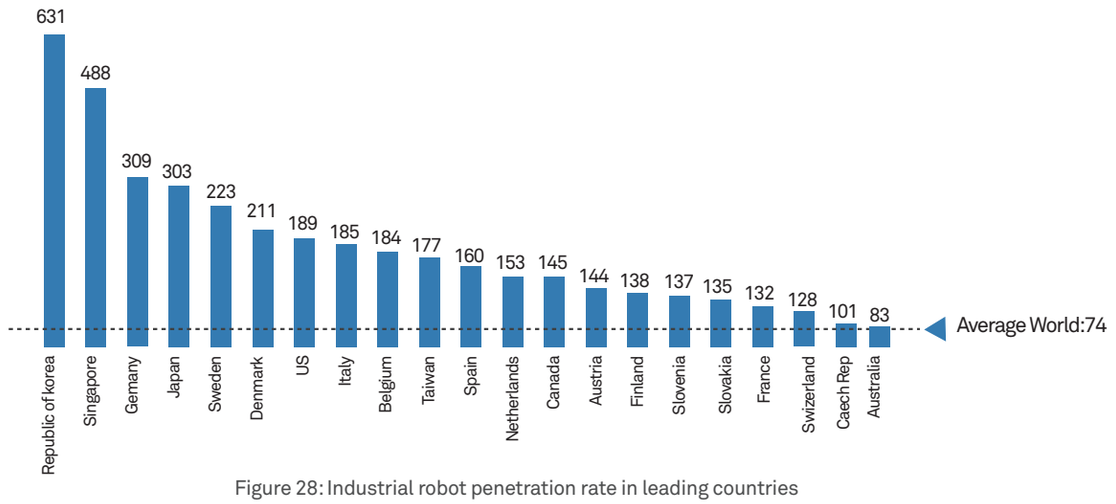

Figure 28: Industrial robot penetration rate in leading countries
Source: World Robotics 2017, Roland Berger

Case study: Germany

As the pioneer in Industry 4.0, Germany is Europe's most automated country, ranking third worldwide. It has 309 robot workers per 10,000 people. According to the IFR, Germany also accounted for 41% of total robot sales in Europe in 2016, with supply expected to grow by 5% between 2018 and 2020.

Several companies and institutions have started incorporating robotics to improve productivity and manufacturing efficiency.

- International utility and robotic giant ABB launched a two-armed robot called YuMi in 2015 that is specifically designed to assemble small parts alongside humans. Its dual armed robots have flexible hands, parts feeding systems, camera-based part location, and state-of-the-art robot control.
- Mercedes C-Class has its rear axle built with human robot collaboration using the Kuka robot, which is adept at force guided assembly tasks. More than 500,000 rear-axle gear boxes have been built for Daimler AG as a part of an assembly pilot program.
- ARENA 2036 is a research campus for next generation of automobiles in Germany where academics work on versatile production and functionally integrated fiber composite lightweight constructions in the series production of automobiles.

Retail industry (e-commerce)

Retail is a tertiary industry which unlike agriculture and manufacturing, traditionally relies heavily on human capital and face-to-face customer interaction. Even though limited hardware equipment is required, ICT still plays an extremely crucial role in its development because it offers more options for customers to choose how they experience the service.

The most revolutionary effect of e-commerce is in retail industry. The use of ICT-related devices enables retailers to shift from offline physical stores to online virtual stores. The appearance of such sales of physical goods via digital channels to private users provides the industry with more potential and could be categorized as industry transformation.

Case Study: China

With the development of ICT, China is now generating the most revenue from the e-commerce market in the world, which is estimated to be USD 584 billion in 2018 – USD 110 billion higher than the United States (Figure 29). China also had the highest e-commerce sales as percentage of total retail sales around the world, i.e. 23.1% in 2017 (Figure 30).

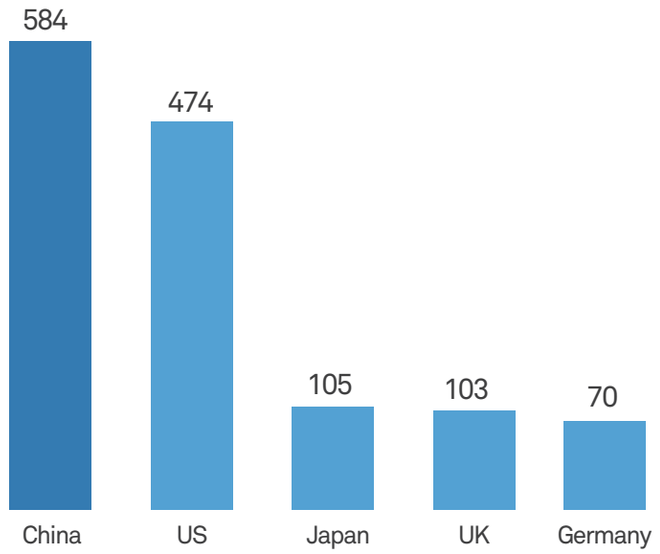

Figure 29: Estimated e-commerce revenue of top 5 countries in 2018 [USD billions]
Source: Statista, Roland Berger

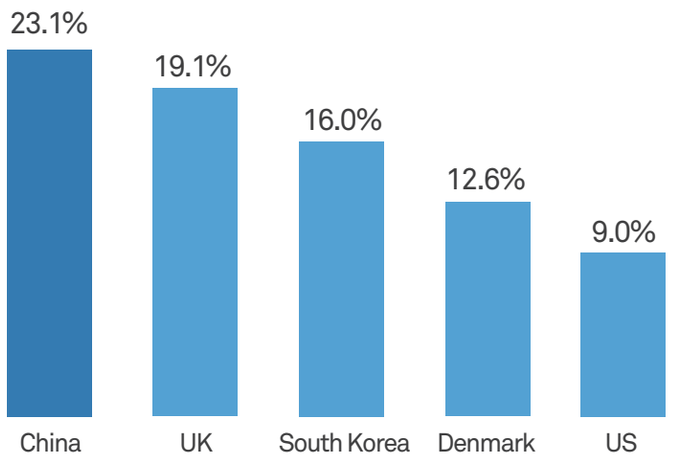

Figure 30: E-commerce sales as percentage of total retail sales in 2017, top 5 countries
Source: eMarketer, Roland Berger

Given further development of ICT, especially the increasing penetration of mobile internet and mobile e-commerce, the e-commerce market in China is expected to display an annual growth rate of 12.0% from 2018 to 2022, achieving a market size of USD 918 billion. In addition, the e-commerce user penetration rate of total population, 46.8% in 2018, is expected to hit 67.0% in 2022 (Figure 31).

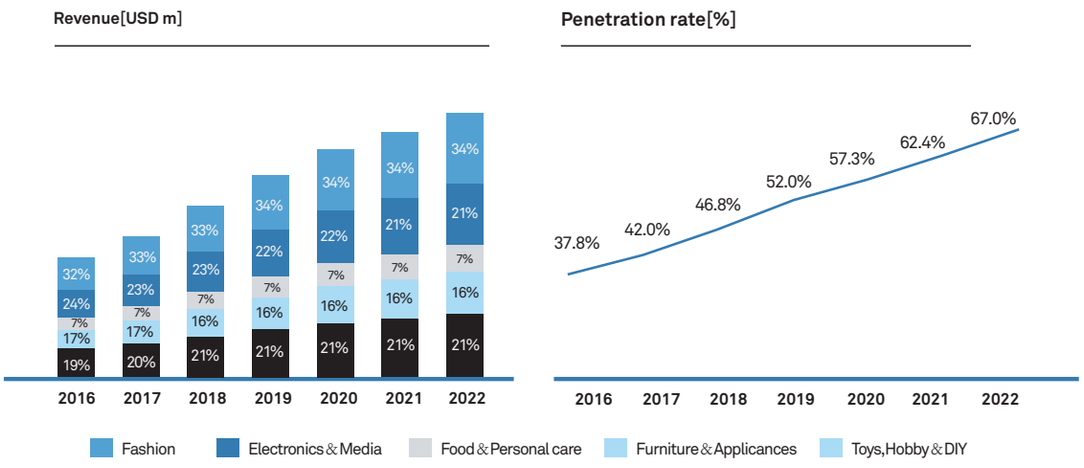

Figure 31: Revenue and user penetration of e-commerce
Source: Statista, Roland Berger

Financial industry (FinTech)

FinTech is a term used to describe the companies operating in the financial technology sector. It relates mainly to small start-up companies which develop innovative technological solutions in such areas as online and mobile payments, big data, alternative finance and financial management. As of February 2015, bank spending on new technologies in North America was projected to reach 17 billion U.S. dollars in 2015 and increase to 19.9 billion in 2017.

Case study: India

The Indian FinTech industry is growing fast. Its transaction value is expected to grow steadily from USD 33.4bn in 2016 to an estimated USD 98.3bn in 2022, with digital payment users predicted to quadruple (Figure 32).

The digital payments sector in India is estimated to grow from USD 50bn in 2016 to USD 500bn by 2020, representing around 15% of GDP. Mobile payment solutions, such as electronic wallets, P2P transfer applications, and mobile points of sale are currently enjoying strong user adoption.

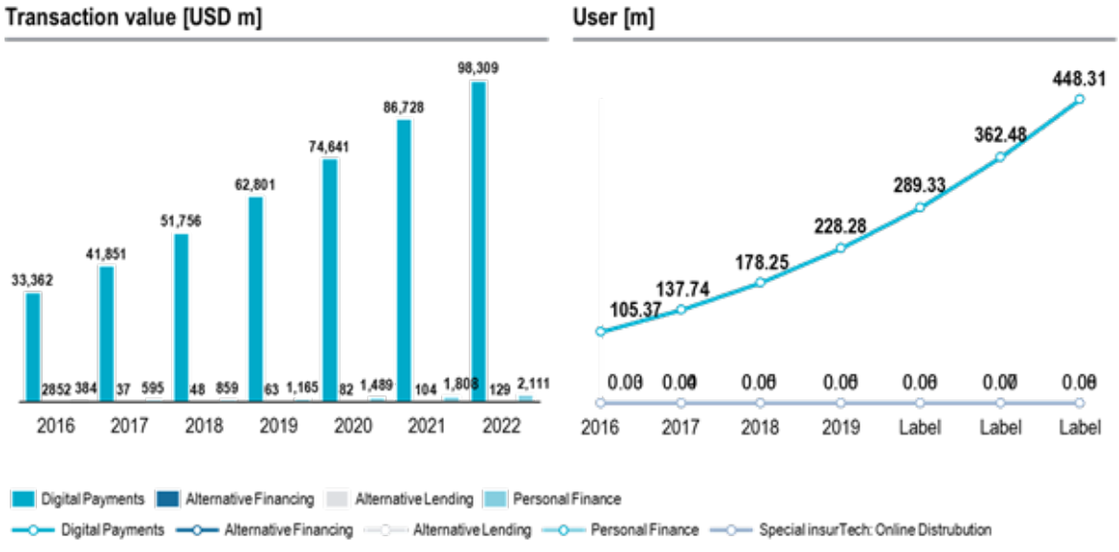

Figure 32: Indian FinTech transaction value and user amount
Source: Statista, Roland Berger

With the smartphone user base expected to expand to about 500 million users by 2020, up from about 150 million in 2016, the digital banking footprint is projected to grow faster than ever before. The National Payments Council of India (NPCI) has introduced several innovative products, such as RuPay cards, which allow for immediate money transfers and provide a more convenient experience for the customer. These initiatives provide a solid foundation for a digitally enabled financial sector in India, giving FinTech startups the opportunity to leverage these technologies and initiatives to be adopted into the mainstream banking experience in India.

2.2.3. ICT's disruptive impact to economy

When emerging industries contribute more and more to the economy, ICT contributes enormously to the emergence and development of various emerging technologies, such as AI, cloud computing, etc. and their downstream applications. Without the connectivity and the accessibility of data, many innovative technologies and business models would have been impossible to achieve.

Artificial Intelligence (AI)

Artificial intelligence refers to the creation of intelligent hardware or software able to replicate "human" behaviors such as learning and problem solving. It allows machines to complete various "human" tasks, from driving automobiles and reacting to their environment, to providing virtual assistance or playing games.

This recent technology is closely connected with ICT because in order to produce a large amount of AI research, countries need to have the capability to absorb technology. Therefore, the returns on investment in AI are likely to be higher among those countries with high technological absorptive capacity.

Case study: China

Given well-established ICT infrastructure and advancement in the digital economy, China's advantages include a vast population and diverse industry mix that has the potential to generate huge volumes of data and an enormous market.

With large IT companies, institutional investors, as well as government driving significant investments in R&D, China is a leading global hub for AI development. China is now one of the top countries in terms of AI R&D in the world, not only in terms of R&D quantity (Figure 33), but also quality (Figure 34).

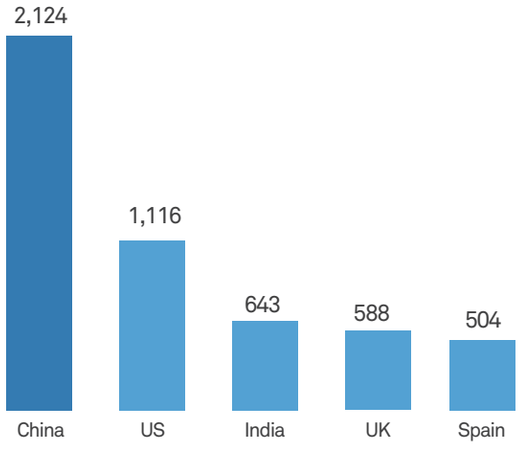

Figure 33: Number of AI publications cited (2015)
Source: SCImago Journal Rank 2015, Roland Berger

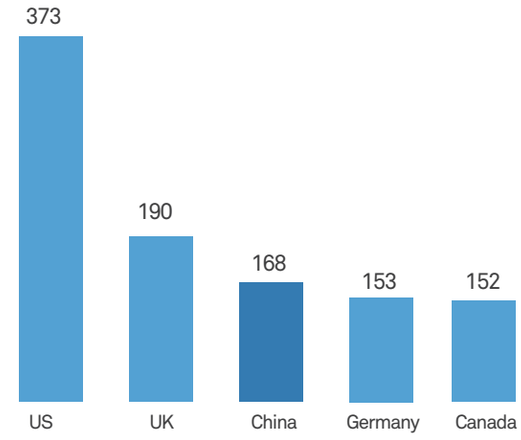

Figure 34: Publication influence: H-index[6] (2015)

The number of new AI companies has exploded in recent years and China ranks second in the global market with close to 1,500 AI companies across the country. Investment passion in artificial intelligence startups has been observed in China, as it has overtaken the US in AI startup funding in 2017, with an equity funding share of 48% of the global total (Figure 35)

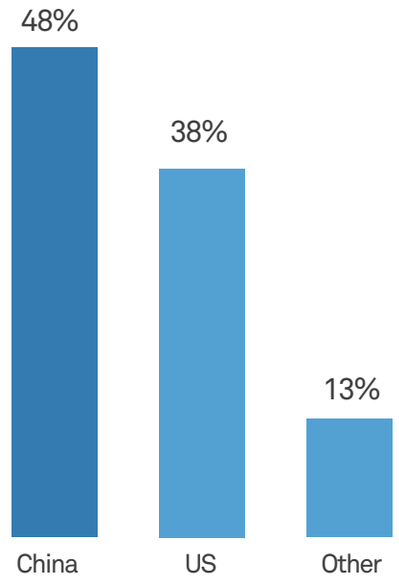

Figure 35: Share of artificial-intelligence startup funding in 2017, by leading country
Source: CB Insights, Roland Berger

China expects that AI will lift its economy to the next level. President Xi Jinping vows China will become a global leader in AI by 2030, creating a domestic industry worth nearly USD 150bn

[6]The H-index ranks both the productivity of scholars and the citation impact of their publications. A higher H-index number indicates more publications that are widely cited

Cloud Computing

One other technology benefiting from the growth of ICT and big data is cloud computing. Cloud computing describes the use of networks of remote servers - usually accessed over the Internet - to store, manage, and process data. With more worldwide ICT infrastructure being developed, the market revenue of cloud computing is expected to grow steadily, from USD 175bn in 2015 to an estimated USD 383bn in 2020 (Figure 36).

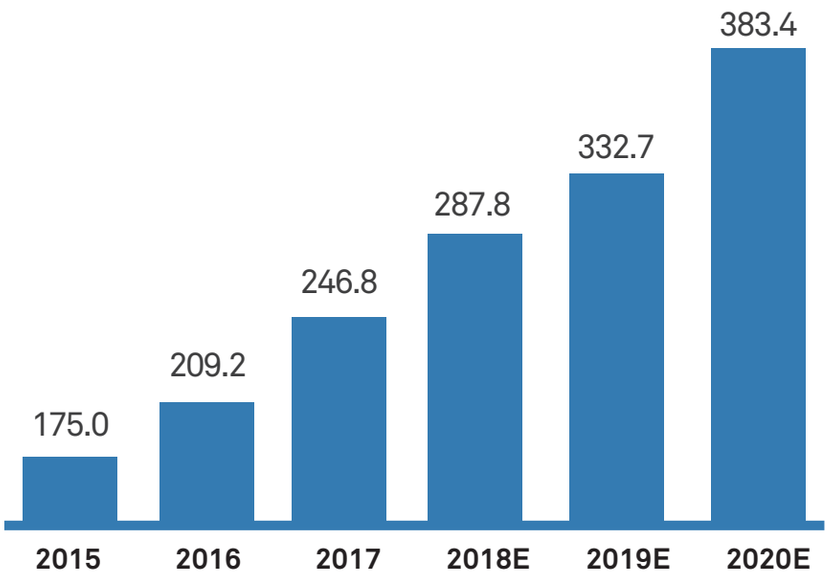

Figure 36: Cloud computing market revenues worldwide from 2015 to 2020 [USD bn]
Source: Clairfield International; Gartner, Roland Berger

Case Study: South Korea

In such a promising market, South Korea acts as an outperformer among the world because of its sound ICT infrastructure and policy support. The volume of Korea's cloud market was USD 1.06bn in 2016, a 55.2% increase from the previous year. Number of South Korea cloud related companies have also increased 51.6% (from 353 in 2015 to 535 in 2016), according to NIPA, 2016 Survey of Cloud Industry.

South Korea boasts a strong commitment to the promotion of the digital economy as they foresee the benefits it may bring to national economic development. Therefore, the country started to officially support cloud computing through the "First Basic Plans for Cloud Development (2016~2018)" in November 2015, presenting three strategies and nine tasks to be completed before 2018 for the vision of "Becoming a Leading Cloud Nation by 2021" (Figure 37). The benefits of ICT in improving national economic growth are implied by such supportive policies and the South Korean government's focus on cloud computing development.

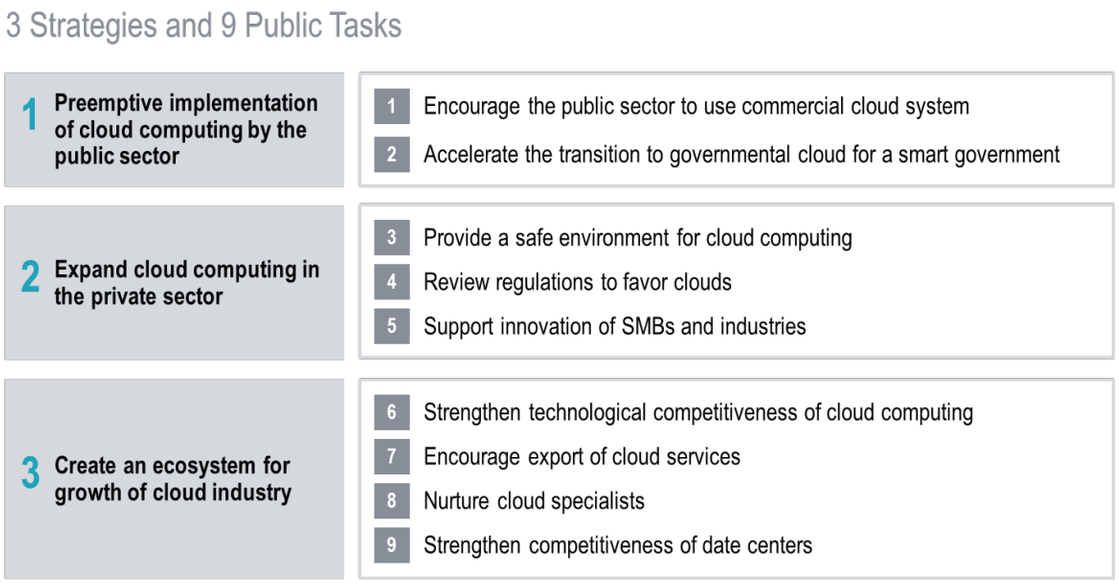

Figure 37: First Basic Plans for Cloud Development, 2015
Source: MSIT, Roland Berger

3.ICT's impact on societal wellbeing and public affairs

The link between ICT investment and economic growth of a country has been subject of a variety of research. This paper conducted a regression analysis on a data set of 125 countries for the period 2010 to 2016 and concluded that with 16-20% increment in ICT capital services, the dependent variable GDP is about to raise 1%. Besides, Huawei and Oxford Economics found out the magnitude of digital spillover effect of ICT investment: every $1 invested in digital technologies over the past three decades has added $20 to GDP, on average.

3.1. ICT changes education approach and increases accessibility

As many cutting-edge teaching and learning methods and tools are enabled by ICT, education accessibility improves significantly, especially for people in rural and remote areas. More diversified education options also increase teaching efficiency, effectiveness as well as recreational experience.

Online educational platforms reduce the cost of education services drastically, while increasing the number of participants. Virtual classrooms, as an example of cutting-edge tools, extend the structure and services that accompany formal education directly to learners wherever they may be. Mobile learning, defined as the provision of education and training using mobile devices such as tablets and smartphones, also enables teaching and learning to take place anywhere at any time. The development of education tools leads to the emergence of blended learning, which is a new education approach that utilizes a combination of different tools, technologies, and resources to improve student learning experience and effectiveness, such as Virtual Reality and digital libraries

Moreover, in the cutting-edge research and education fields, ICT has made the learning process no longer a linear process, but an exponential way in collaborative and effective manners: communication technologies have made efficient work collaboration possible, whereas information technologies have exponentially improved the speed of data processing and understanding. As Google's Director of Engineering, Ray Kurzweil points out, “if you've solved 1% of the problem, it means that you're not 1/100 of the way there (i.e. 99 tiny linear steps to go), it means you're only a few more exponential steps away”

Case Study: TED and Coursera

TED and Coursera are pioneers in the ICT Education industry, as they provide the possibility for both urban and rural area to access majority of degree level study and educational speech.

TED is a non-profit organization devoted to offering free knowledge and inspiration from the world's most inspired thinkers. These short videos cover a wide range of topics presented by some of the leaders of their fields. These videos are released under a Creative Commons license, so they can be freely shared and reposted, and viewers can view TED related content on YouTube. TED's user number had grown to 1 billion since 2013, and with a growth rate of 10% and growth number 1-2 million per year approximately.

Coursera is an online learning platform that works with universities and other organizations to offer online courses, specializations, and degrees in a variety of subjects, ranging from engineering, humanities, medicine, biology, social sciences, mathematics, business, computer science, digital marketing to data science. Till 2018, Coursera possesses 33 million users, 100,000 monthly active users, and has more than 2,400 courses, working with more than 800 universities.

Case Study: The Virtual University of Pakistan

The Virtual University of Pakistan (VUP) uses technology to share its knowledge and expertise by making educational services available to large sets of people.

VUP aims to become an internationally acclaimed technology-based university that increases access to higher education while maintaining the highest standards of quality. This mission is centered on providing the highest quality of education and research opportunities to all aspiring students irrespective of age, gender, religion, and geographical location by using modern ICT with content developed by top experts of their respective fields.

VUP uses a combination of free-to-air television broadcasts, internet and multimedia technologies, as well as video lectures, reading material, audio/video tutorials and e-classrooms for imparting knowledge. Currently, more than 35 degree programs are offered; it has reached over 100 cities in the country with more than 190 associated institutions providing infrastructure support to the students. The number of admitted candidates for The Virtual University of Pakistan is about 12,000 in 2018.

Case Study: UNESCO Virtual Reality Project

The UNESCO Mahatma Gandhi Institute of Education for Peace and Sustainable Development (UNESCO MGIEP) has teamed up with Samsung India to collaborate on their Virtual Reality Project to create meaningful content for an immersive learning experience through AR, VR, and [7]MR .

The project aims to bridge the digital gap between rural and urban India and provide equal opportunities for quality education to children from all backgrounds. Specific activities include:

- Signing of the Memorandum of Understanding for a long-term collaboration between Samsung India electronics Pvt Ltd and UNESCO MGIEP
- Launch of the Samsung- MGIPE Panoramic 360 VR Project Pilot
- Smart Classroom

[7]MR, refers to mixed reality where physical and digital objects co-exist and interact in real time.

Samsung India, through its CSR (Corporate Social Responsibility) in Education Project, provided this experiential content to Jawahar Navodaya Vidyalayas (JNV), a system of alternative schools for gifted students in India, where over 683 Samsung Smart Class have been implemented till 2018. The Samsung Smart Class program has benefitted over 250,000 students so far and has trained over 8,000 teachers on how to effectively use interactive technology in the Samsung Smart Class to teach their students.

Case Study: Pakistan HEC National Digital Library

The Higher Education Commission National Digital Library is a program that provides researchers within public and private universities in Pakistan and non-profit research and development organizations access to international, scholarly literature based on electronic delivery, providing access to high quality, peer-reviewed journals, databases, articles, and e-books across a wide range of disciplines. The e-books support program will give researchers access to the most important text and reference books electronically in a variety of subject areas. Currently, around 75,000 documents of electronic content have been made available through the Digital Library Program.

Thanks to the development of the Digital Library Program, Pakistani researchers' research capability grows significantly. As shown in the graph, the articles published have been growing from 1,264 per year in 2004 to 13,723 in 2016 (Figure 38). As Figure 43 shows, ICT greatly helps to facilitate exponential learning, which works through electronic collaboration of resources, results, and journals, and helps solve many big problems like human genome, climate research, etc.

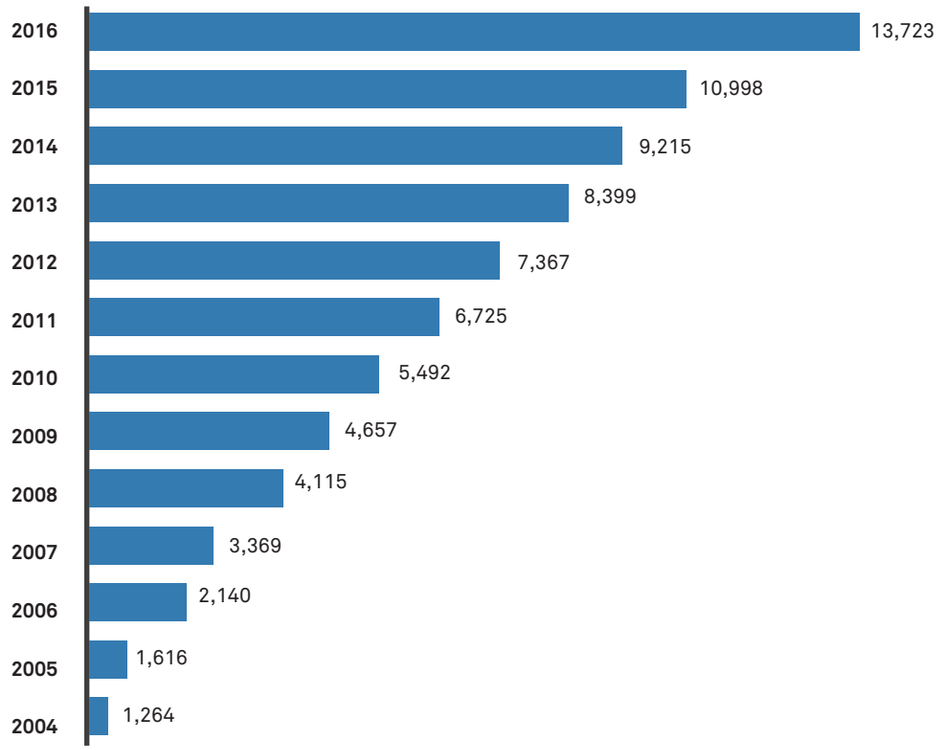

Figure 38: Articles Published by Pakistani Researchers
Source: HEC National Digital Library, Roland Berger

3.2. ICT promotes culture communication and exchange

ICT is a key driver of cultural communication and globalization. It supports the flow of cultural exchanges around the globe, enabling more people than ever before to connect, get to know each other, understand each other from different cultural backgrounds, and create and maintain this new sense of collectivity.

A new policy term, e-culture, is being used to describe this ever-changing relationship between ICT and the production and consumption of culture and arts. Examples of e-culture products and services include smart phone apps for museums, AR apps for architecture guide, interactive digital libraries etc.

E-culture has many extensions into cultural activities such as dancing, music, theatre, poetry, literature, and painting. One of the examples is electronic galleries that use computers to expand cultural exhibitions into the digital era by digitizing their collections and producing huge databases, which can also eliminate the circulation of counterfeit pieces. In addition, communication and exchange through music exists wherever there is online access and distribution and broadcast transmission, all made possible by technologies like audio encoding, high bandwidth telecommunications networks, and end-user resources and behaviors. Meanwhile, e-literature helps facilitate and promote the writing, publishing, and reading of literature in electronic media such as with the Electronic Literature Organization.

Case study: Europeana Collections

Europeana Collections works with 3500+ museums, galleries, libraries, and archives across Europe to share cultural heritage for enjoyment, education, and research and provides free access to over 56,692,065 digitized items (Figure 39) - books, music, works of art, fashion, music, photography, blogs, and exhibitions to inform and inspire. The website is available in 27 languages. Thus, it highly promotes the globalization of culture by enabling more and more countries to access the content and share the art collections.

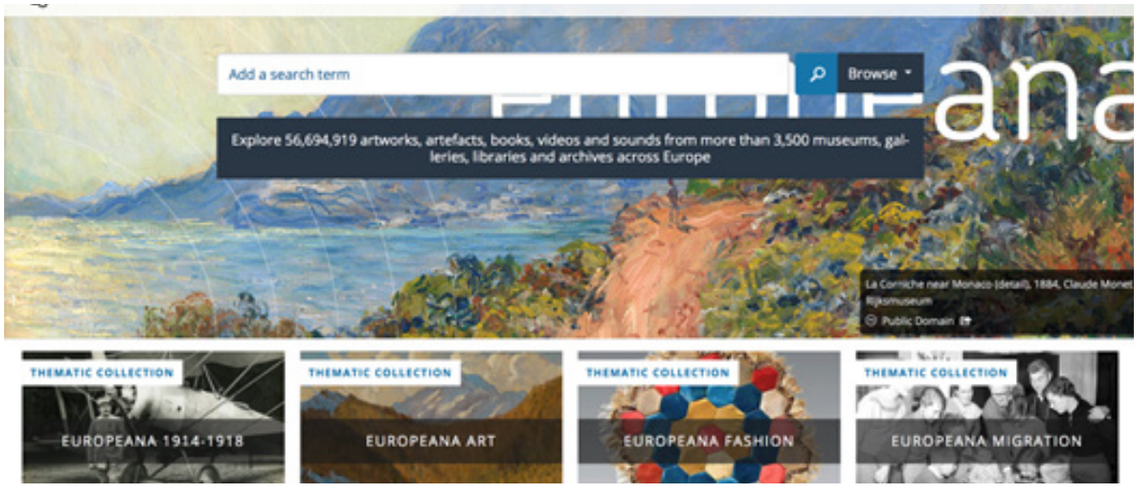

Figure 39: Europeana Collections Official Website Home Page
Source: Europeana Collections, Roland Berger

A series of social media applications, as known as low-brow e-culture, are critically important in driving cultural of communication and globalization as they are truly connecting each other worldwide, and providing a wonderful platform for real-time idea sharing. Further, the steady upward trend in monthly active user is a persuasive proof that low-brow e-culture is popularizing the modern society. (Figure 40)

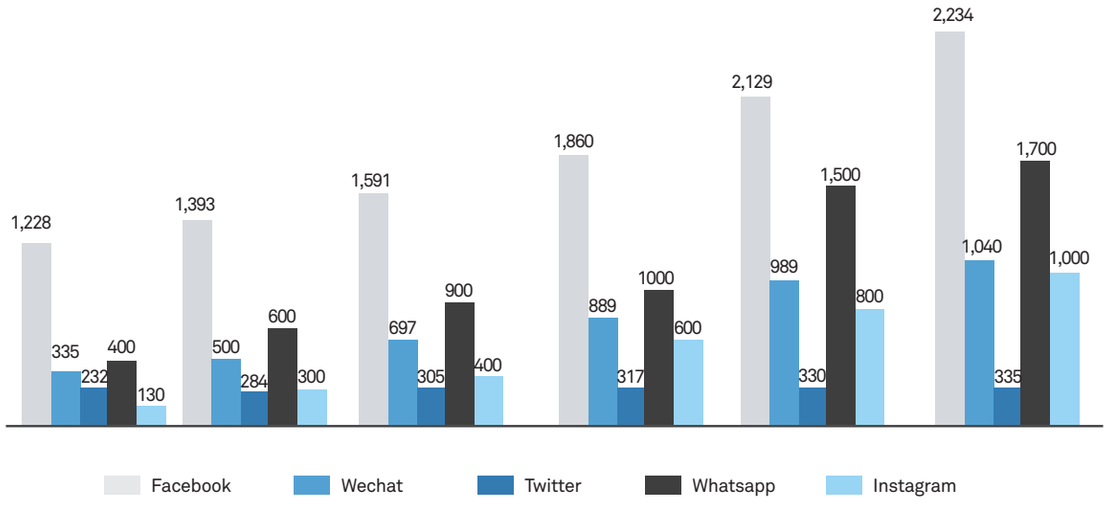

Figure 40: Monthly Active Users of Selected Social Media Apps Worldwide [millions]
Source: Statista, Roland Berger

3.3. ICT helps relief unemployment issues

ICTs are influencing employment both as an industry that creates jobs and as a tool that empowers workers to access new forms of work, in new and more flexible ways. The emerging ICT-enabled employment opportunities matter because countries around the world are looking to create more good jobs, which have positive economic and social implications for workers and for society."

-- Chris Vein, World Bank Chief Innovation Officer for Global ICT Development.

The development of ICT is transforming the employment market, creating new job opportunities and making labor markets more accessible, inclusive, and globalized, through innovative tools enabled by ICT infrastructure.

ICT provides new avenues for job creation which could help countries tackle global unemployment problem. For instance, ICT also supports innovation that has created new, more flexible forms of employment and work. Microwork platforms break down large business processes into smaller discrete tasks, such as data entry and verification, copy-writing, or graphic design, and distribute these tasks to workers across geographic boundaries.

Case Study: Kenya Digital Skill Training Program

Kenya has started a digital skills training program aimed at enabling 1 million young people to secure freelance work online in 2018 in a bid to tackle the country's acute youth unemployment problem.
According to World Bank research, Kenya has the highest rate of youth joblessness in East Africa. 17% of all young people eligible for work are lacking jobs due to the capital-intensive industry structure, while neighboring Tanzania and Uganda have comparable rates of 5.5% and 6.8% respectively.

Right now, there are an estimated 40,000 Kenyans who have secured online work ranging from transcription services to software development on sites like Amazon's Mechanical Turk (MTurk) and the Kenyan-owned KuHustle platform. Mr. Joe Mucheru, the Minister for Information, Communication and Technology, said that the digital jobs initiative aims to boost that number to 1 million, using a partially government-funded program called Ajira, which means "employment" in Swahili.

ICT brings greater accessibility to the global labor market by connecting more people to more jobs, given its low marginal costs for information communication and exchange. It is expected that up to 540 million individuals could benefit from online talent platforms by 2025 worldwide.

Case Study: LinkedIn

LinkedIn, as a business and employment-oriented service, operates via websites and mobile apps, offering jobs from entry level to Executive in various sectors. It could be considered as the most representative case as response to the topic that ICT creating more jobs. According to official data, LinkedIn possesses 467 million users in 2017, and 122 million users had found a job by submitting resume via LinkedIn, approximately 26% among all users. According to the stable upward trend (Figure 41), LinkedIn has connected significant amount of people to its online employment market, and the trend will continue.

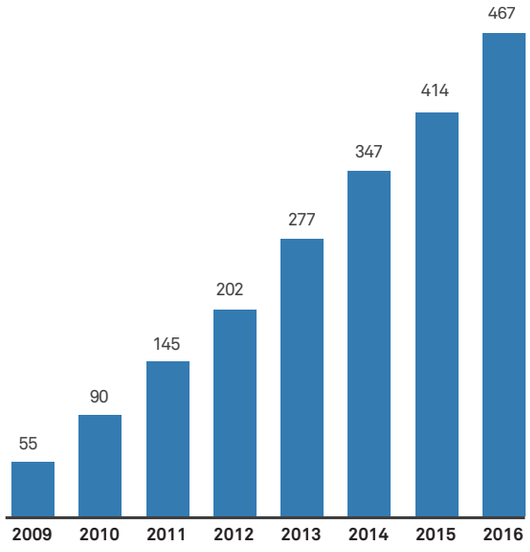

Figure 41: LinkedIn Global Member Amount [millions]
Source: Statista, Roland Berger

3.4. ICT improves safety and security of both individuals and society

Public and personal safety and security also benefit from ICT development. Not only can ICT provide timely alerts on natural disasters to protect the essential safety of individuals, but it can also help preventing crime and other man-made damage within a society.

With the wide use of ICT, natural disaster prediction has become much more concise and predictive, so citizens can be informed of potential risk and secure themselves and others as early as possible.

To reduce the impact of and, when possible, prevent the severe effects of climate change-induced emergencies, more and more cities are turning to ICT. Geographic Information Systems (GIS), for example, are helping governments identify flood zones on maps, measure communities' vulnerability to flooding, and plan for new flood-prevention infrastructure like drainage systems and levees. Through mobile phones, citizens are being alerted via SMS texts to coming floods or cyclones. In addition, Early Warning Systems are simulating weather patterns and predicting disasters in advance. All of these tools play a pivotal role in saving lives and reducing recovery costs.

Case study: Mexico Earthquake Early Warning System

Several ICT-based technologies have been used in Mexico's earthquake early warning system. The monitoring systems communicate with data collection centers in cities receiving Mexican Seismic Alert System alerts through a reliable system of satellite links, internet links, and radio in case any of these communication lines fall silent during an earthquake. The alerts to the public are then sent through radio receivers, television, and radio stations in several cities that have subscribed to receive the alerts and by municipal loudspeakers in Mexico City. From 1993 to 2017, the network has recorded 6896 earthquakes and has issued 158 seismic early warnings. And lately, the Earthquake Early Warning System was able to give residents in Mexico City almost two minutes prior warning to the arrival of strong seismic waves in June 2017.

ICT can help reduce crime by improving the efficiency of the overall public security system. The public security system has benefited from having tools enabled by ICT, such as accurate GPS location, live video, and the face recognition. At the precaution stage, ICT enabled technologies can offer more accurate and broader monitoring. If a crime occurs, ICT can also help quickly track the location of crime and mobilize a police force when needed. In the arrest process, e-policing can also improve efficiency by having all relevant data available online to share with the police force.

Case study: Pakistan Hotel Eye

Hotel Eye (Figure 42) is a web-based system for the Punjab police to log the check-ins, checkouts and personal details of guests at hotels across the province, which helps prevent crime and accelerate arrests. The software was rolled out in phases and the pilot project was launched on an experimental basis in Lahore in January 2015

By July 2018, the official website reveals that in Punjab, Hotel Eye has helped police arrest more than 70 criminals so far. Making the Hotel Eye Software a permanent feature of the security process, the police have linked nearly 600 hotels using this application. As many as 1,260,591 check-ins have been registered across the province and 5,723 criminal record holders were traced.

Figure 42: Hotel Eye System Overview
Source: MIT Technology Review Pakistan, Roland Berger

Case study: South Africa-Cape Town ShotSpotter

ShotSpotter, implemented as a crime prevention and arrest tool, can greatly increase the tracking efficiency and reduce gun violence and murders in Manenberg and Hanover Park in South Africa. When a gunshot goes off, ShotSpotter triangulates the location – allowing officers to respond within two minutes. The officers also receive a text message with a link to the audio file on their phones, which means police on the ground immediately have more information to work with (Figure 43).

The response time has been brought down from an hour to just 10 minutes after ShotSpotter was implemented. For the month of September 2016, a total of 31 incidents were recorded, down from 128 in August and 211 in July. With the increasing awareness of gunfire and detection, 54 guns have been removed from the streets in seven months, a figure that was only achieved over a six-year period previously.

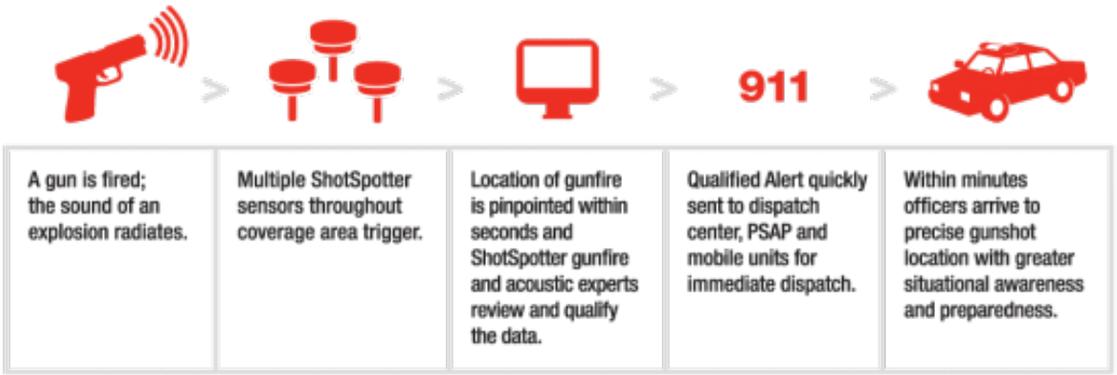

Figure 43: ShotSpotter Technology Overview
Source: ShotSpotter, Technical.ly, Roland Berger

Case Study: E-policing in Estonia

Estonia is a prime example of a country with an e-policing model. The model consists of a portable, weatherproof tablet computer which hosts a software solution that can be used by officers to access all the information they need. It is connected to multiple key databases through a secure data exchange channel which provides police officers with all the necessary information on the spot. For example, officers can use the system to see if a driver's license is valid or make sure that there is no arrest-warrant issued for any person they are questioning. These information requests now take a mere 2-3 seconds, while it could have taken up to a minute to access this information previously. Moreover, the solution has even gone beyond Estonia's boundaries as a result of its cross-border integration. By using the e-policing system, police could potentially access a dozen relevant databases, and the system is integrated with the information system of the Schengen Zone, allowing them to see if the vehicle is stolen or if the driver is wanted in another country.

Case study: Nairobi Safe City

Nairobi, with limited existing infrastructure and an increasing crime rate deploys a safe city solution to reduce its crime rate. With massive applications of ICT technologies, a new Integrated Emergency Command Centre and a unified communications system to increase sharing of information between command and emergency responders were deployed. The upgrade solution also included an eLTE trucking network including hundreds of nodes, over 1,800 surveillance cameras, a video management and storage system, and ANPR (Automatic Number Plate Recognition) analytics integrations.

As a result, Nairobi's investment has already yielded strong results with the city seeing a 46% reduction in crime since deploying its safe city solution. There has also been a 50% increase in the city investment score, and there has also been a significant increase in tourism numbers in the first half of calendar year 2016.

3.5. ICT enhances efficiency and transparency of affairs government

With the utilization of ICT to enhance the efficiency and effectiveness of service delivery by the public sector, a new term, e-government, has come into being. E-government (or digital government) is defined as "the employment of the Internet and the world-wide-web for delivering government information and services to the citizens", according to United Nations in 2006. E-government consists of the digital interactions between a citizen and their government (C2G), between governments and other government agencies (G2G), between government and citizens (G2C), between government and employees (G2E), and between government and businesses (G2B)

The rise of e-government greatly improves government efficiency and promotes citizens' participation in public affairs. More and more countries are making an effort through e-government to ensure that public institutions are more inclusive, effective, accountable, and transparent, by creating online channels for communication,

establishing "one-stop" online service platforms, enabling data access for citizens, and tracking government activities. Ultimately, an increasing number of countries are moving towards participatory decision-making.

According to UN E-government Survey, in 2003, only 45 countries had a one-stop platform, and only 33 countries provided online transactions. In 2016, 90 countries have offered one or more single entry portals on public information or online services, or both and 148 countries have provided at least one form of online transactional services.

Case study: Armenian E-government

Established in 2004, the Armenian e-government brings together all tools and databases created by Armenian state agencies to provide a user-friendly online environment. It includes more than twenty services and tools, including search engines, allowing users to find the government's and the Prime Minister's decisions, the agenda of the next cabinet sitting, information on state purchases, the electronic tax reporting system, the online application system of the Intellectual Property Agency, the information search system of the Intellectual Property Agency, as well as the Electronic Signature and Electronic Visa (e-visa) sections. The Electronic Signature is used in several other services when a user wants to submit an application or receive information. As a universal system, it is used by both state officials and citizens. There are more than twenty tools and databases provided to public services.

Case study: The Government of China's Official Web Portal

Beijing, Shanghai, Chongqing and many other cities have opened “data.gov.cn” websites in order to allow citizens to freely access government data. Beijing’s open government database contains over 400 datasets, including tourism, education, transportation, land use zoning and medical treatment. Providing free information about maps, bus lines, and other services, the availability of data also helps locals and visitors spend less. The website also provides a special “APP” column where people can upload an application developed based on the available government data, so that others may download and use it. At present, there are many examples of newly developed apps with applications for “Food Security”, “I Love Health”, and “Travelling in Beijing” among others.

Luohu District, as one of the major financial centers in Shenzhen, Guangdong Province, has Luohu Port serving as the most significant port of entry bridging mainland China and Hong Kong. The cloud computing infrastructure Luohu constructed consists of a virtualization e-government platform with unified management and technical support and all the applications.

The eGovernment project solved several problems by eliminating information silos. Resource utilization has improved because of resource sharing which leads to lower operational costs, while assuring service security and reliability. Hardware utilization has improved from 5% to 70% and hardware costs are reduced by 50%. Other key advantages include unified monitoring and management capabilities, simplified deployment of services, and reduced maintenance costs.

4.Government creating a favorable environment for ICT investment, innovation and competition

The development of ICT and relevant infrastructure cannot be realized by solely relying on participants within the ICT ecosystem, such as network element providers, network operators, downstream platform, application and content providers (Figure 44). Instead, the development requires supports from the government in three major aspects: investment, innovation, as well as competition (Figure 45). The government plays a vital role in forming a favorable environment to enable the fast and healthy development of ICT industry, and hence, benefiting a country's economics and societal wellbeing to the most.

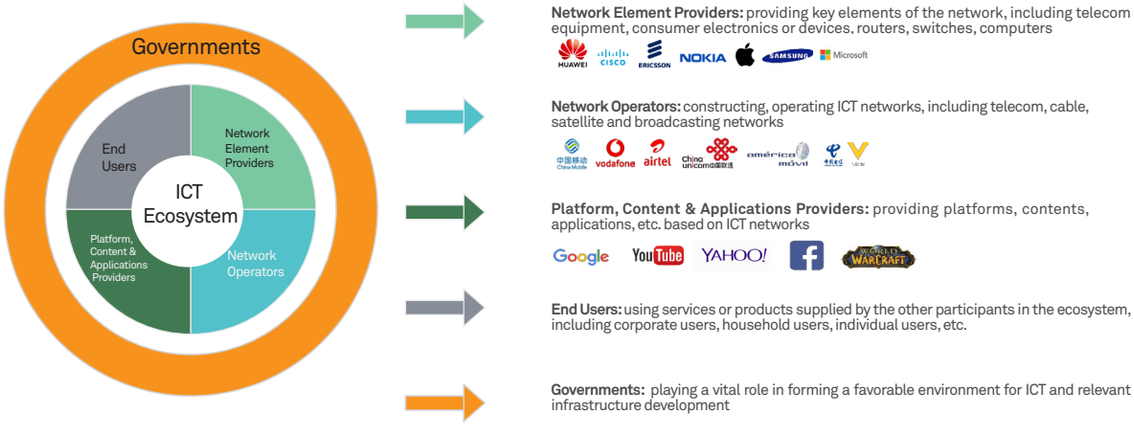

Figure 44: ICT ecosystem and government's role for ICT development
Source: Huawei, Roland Berger

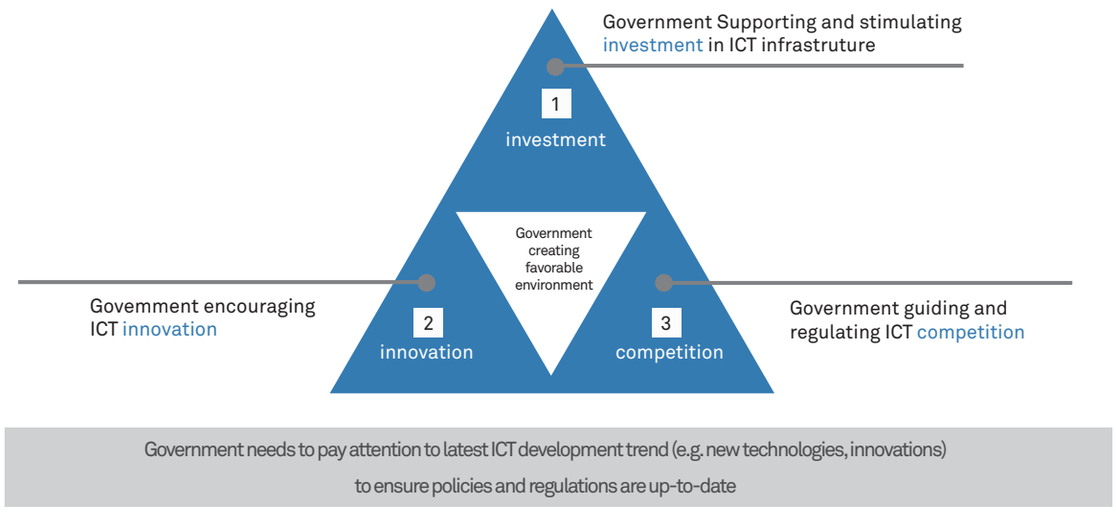

Figure 45: Government creating favorable environment for ICT development from three major aspects
Source: Huawei, Roland Berger

4.1. Government supporting and stimulating investment in ICT infrastructure

The development of ICT and relevant infrastructure relies heavily on ICT infrastructure manufacturing, installation and operation. ICT infrastructure manufacturing ensures the abundant supply of its basic hardware and equipment, including relevant devices, network components/elements, while ICT infrastructure installation and operation includes network and broadband cable laying, cell sites building, fixed and mobile network operation, data center setup and operation, etc.

Governments should set up appropriate ICT infrastructure development objectives based on the development stage of the country, which act as a leading guide and convey the government's attitude towards ICT development to all the participants within the ICT ecosystem. Development objectives include broadband coverage, connection quality and speed.

For example, Malaysia published its broadband development planning for 2020, setting the target for coverage, as well as connection speed, aiming to realize 95% of population coverage on broadband with 100 Mbps of connection speed in state capitals and selected high impact growth areas.

As for China, the government aims to support around 150,000 villages in installing broadband infrastructures, while upgrading the current infrastructure of 220,000 villages. The China State Council will invest over RMB 140 billion by 2020 to install and upgrade the systems of over 500,000 villages that currently do not have broadband infrastructure. By 2020, 98% of all villages will have at least 12 Mbps bandwidth

To achieve the ICT infrastructure development objectives, the government needs to use various policy tools to stimulate investment in ICT infrastructure manufacturing, installation and operation, to ensure the sufficient and high-quality infrastructure supply. Usually the government supports and stimulates investment in ICT and relevant infrastructure with the following methods:

- Public-private partnership: often seen in ICT infrastructure construction, where governments provide public resources and favorable policy supports, and private sector to invest capital
- Tax relief and subsidy: providing tax exemption as an incentive to ICT industry
- Tariff Concession: cutting down on tariffs of certain ICT infrastructure-related items
- Infrastructure construction collaboration: leveraging existing infrastructure, and/or binding different types of new infrastructure construction together in the first place
- Right of Way: proper and simplified Right of Way rules expedite the deployment of underground (optical fiber) and over ground (mobile towers) ICT infrastructures
- Innovative technology for ICT infrastructure: being technology neutral and actively adopting innovative technology (e.g. WTTx) to improve broadband coverage in a more cost-effective way

4.1.1. Public-private partnership

Public-private partnership (PPP) is a mature tool that has been proven effective in other industries, especially those with intensive need for initial investment that will generate not only commercial income in the long run but also social benefits; for example, road construction. Currently, most countries choose to use the Build-Operate-Transfer (BOT) model of PPP in ICT construction, where governments mainly provide public resources and favorable policy supports to attract social capital, instead of making heavy investment directly.

Case study: Italy

In its efforts to reach Italian Government's goal to reduce digital divide and provide 99% of the population with a broadband connection by 2012, the Province of Brescia chose a public-private partnership model for its broadband network access improvement plan. The partnership identified Cisco as the physical infrastructure constructor and operator, who shared risks and potential market opportunities. Whereas Megabeam was chosen as the service provider for 15 years, responsible for maintenance and access while paying a fee yearly to the Province of Brescia as the sole service provider. The ownership of the network remained with the government.

As a result, the broadband solutions that Cisco provided benefited 120 towns (210 towns in the second phase of the project) spreading across the entire mountainous province, including one of the largest industrial areas in Italy. The reduction of the digital divide in a mostly rural area and the stimulation of economic activities make the Province of Brescia broadband project one of the leading projects in Italy.

Case study: Rwanda

In 2013, in the hope to make Rwanda the Information and Communication Technology hub in Africa, the Rwanda Development Board (RDB), and Korea Telecom (KT) established a public-private partnership in the form of a Joint Venture Company to deploy high-speed broadband services based on 4G LTE technology, where KT controlled the management of the firm, while the Rwandan government was set to provide financial and administrative support.

With the completion of the project in May 2018, Rwanda became Africa's first country with nationwide 4G LTE network, with 8.6 million mobile subscribers among its 12 million population.

Case study: France

In France, the government has launched the France's Very High-Speed Plan in 2013, which calls for bringing very high-speed broadband service to every home, business and government office in France by 2022. As an implementation of the project, the Department of Hérault signed a PPP contract with the infrastructure operator Covage, for the deployment and commercialization of a fiber-optic network in the areas of the department, located in the Occitanie region in the south of France.

Covage and its financial partners will invest more than USD 490 mn, more than 90% of the costs, to carry out the project, which will cover 255,000 homes and businesses, and will be fully installed in five years. The special purpose company Hérault THD established by Covage will be responsible for its design, construction, commercialization and operation for a period of 25 years.

4.1.2. Tax relief and subsidy

Tax relief and subsidy can also help stimulate ICT development by giving direct financial incentive to companies involved.
Similarly, reducing ICT sector-specific taxes and fees is also recommended. The discriminatory ICT taxation, for example, a number of different taxes payable by consumers at the point of purchase and use of mobile services in some countries, could inefficiently lower consumption and prevent the realization of the full volume of positive spill-overs from the sector. And reducing sector-specific tax and fees to align them with those that apply to other standard goods and services has the potential to stimulate investment in extending connectivity, increase mobile service adoption, deliver economic growth and deliver higher tax revenues for the government.

Case study: Malaysia

For example, Malaysia has launched its tax exemption as an incentive to the ICT industry.
ICT companies undertaking Approved Service Projects (ASPs) of national and strategic importance in the service sector can enjoy the exemption of income tax on 100% of statutory income for 10 years. The companies can also enjoy the exemption of up to 70% of statutory income for a year of assessment computed at 60% on qualifying capital expenditure incurred within 5 years from the date which the approval is to take effect. Moreover, accelerated capital allowance of 100% is given on capital expenditure incurred on ICT equipment.

Case study: Dominica

The Dominican government provides substantial financial incentives for companies investing in the ICT industry. These companies can register as international businesses, enjoying tax holidays of up to 20 years or can register as local companies and enjoy the benefits under the Funding Act. Details are listed as below.

- 100% return of profits
- Import duty exemptions
- Exemption of Capital Item VAT
- Simplified work permits for management

4.1.3. Tariff concession

Considering the limited R&D capability and production capacity in developing countries, the supply of some ICT infrastructure, including devices, network components, etc., relies on importation from foreign countries. Therefore, tariffs become a considerable cost for entities conducting importation activities. Tariff concession policies would help relieve pressure from the cost side, thus ensuring ICT infrastructure supply.

Case study: Zimbabwe

Zimbabwe, has cut down on tariffs of certain ICT infrastructure-related items to lower the obstacles for ICT development. Customs duties on the importation of products such as computers, printers, tablets were abolished in order to promote the development of the information and communication technology sector.

Case study: WTO ITA

It has become a worldwide trend to reduce tariffs on items related to the ICT industry to speed up the development of ICT infrastructure construction.
The Information Technology Agreement (ITA) – (ITA I adopted in 1997, ITA II revised and extended in 2015) – aims to gradually eliminate tariffs on ITA products, as listed below, originating from any WTO member. In total, there are 144 unique, six-digit HS2007 product codes under ITA I and 270 unique codes under ITA I+II.

The total annual value of ITA products after list extension in 2015 has reached 1.7 trillion USD. The main categories of ITA products are listed as below

- Telephones for cellular networks
- Portable automatic data processing machines
- Photosensitive semiconductor devices (fixed network cable)

4.1.4. Infrastructure construction collaboration

The infrastructure construction of broadband cables and fibers are just as important as the construction of other necessary infrastructure components, such as water pipes and electric cables. Construction of different types of infrastructure mentioned above share similar construction requirements. Hence, supportive policies should be applied to ensure the construction and to have better collaboration.

Leverage the old

For regions that have already finished the construction and installation of other infrastructure but need to draw in or upgrade ICT infrastructure should leverage the existing power or water infrastructures, such as, pipes, poles, and sites is an efficient manner to enlarge ICT infrastructure penetration at lower costs. Policy that supports facilitating the cooperation of power companies, water companies, etc., with telecom or ICT companies, can be introduced to roll out the establishment or upgrade of ICT infrastructure based on similar network topologies.

Case study: Ireland

Back in 2014, the Irish national power company, ESB, cooperated with Vodafone by establishing a joint venture, named SIRO, to build up a 100% Fiber to the Home (FTTH) network by deploying the existing distribution network that ESB had set up. By the end of 2016, SIRO claimed that 17 towns across the country were covered by ongoing construction. This was a win-win; ESB gets more control over the network and lowers its maintenance cost, while Vodafone gets a shortcut to quickly spread out its fiber network.

Case study: Italy

Cooperation between power networks and telecoms has become a global market trend since it gives rise to a synergy effect. These companies are seeking opportunities to reuse existing infrastructure for power companies in deploying fiber networks (Figure 46 and 47). Enel, the major power company in Italy, established a business entity to deploy Fiber to the Home (FTTH) in Italy, known as Enel Open Fiber. Open Fiber (OP) has assessed the potential of re-using existing infrastructure such as towers, cabinets, ducts, and poles in its fiber roll-out and study shows that OP plans to reuse 60% of this existing infrastructure. Measures such as these are able to reduce costs and increase efficiency in deploying fiber networks.

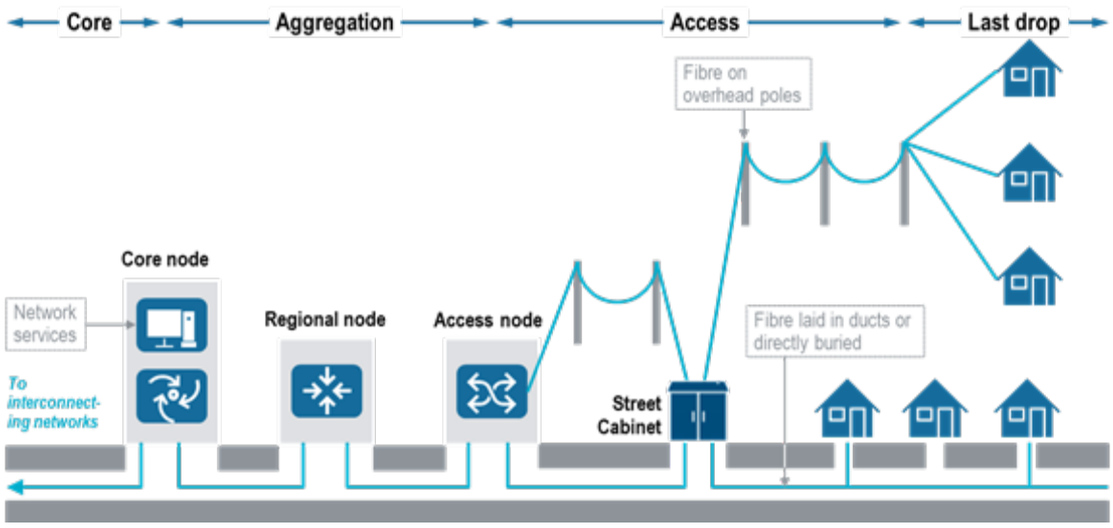

Figure 46: Typical FTTH network topology
Source: Analysys Mason, EON Networks, Roland Berger

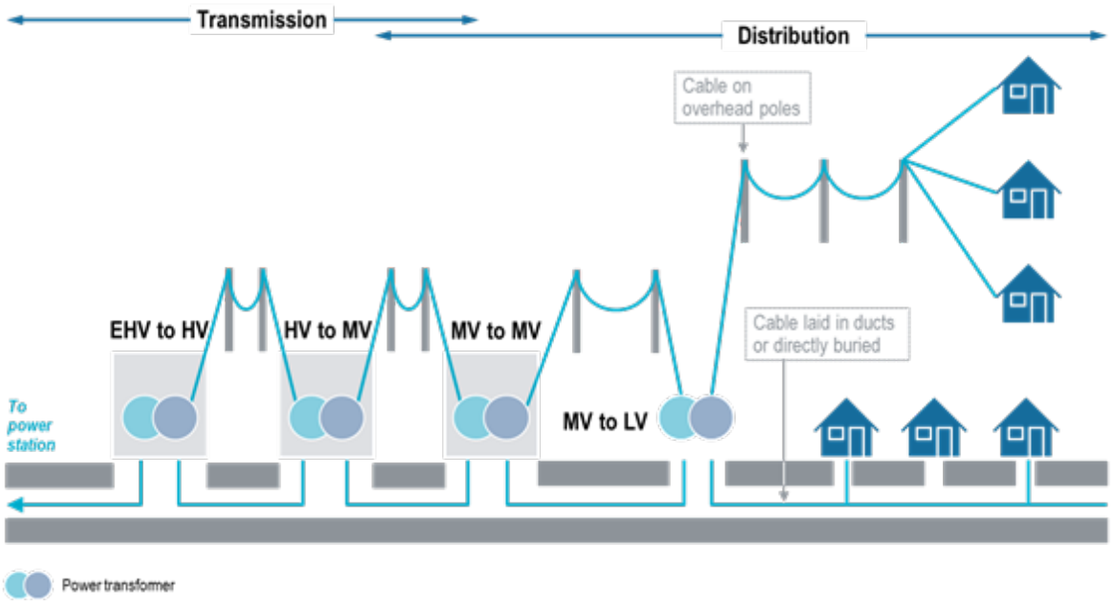

Figure 47: Typical power network topology
Source: Analysys Mason, EON Networks, Roland Berger

Bind the new

Another common scenario is that new towns and cities are springing up with massive infrastructure construction needs. In these cases, linking and binding different types of infrastructure construction together, to avoid re-working later, is a practice that governments are utilizing to maximize efficiency.

Case study: US Dig Once

With the goal of accelerating fiber interment deployment throughout the country, the "Dig Once" policy has already been implemented in several states across the US and is on track to become US law in 2018. The policy mandates the installation of broadband conduit during the construction of roads that receive federal funding and seeks to diminish the amount of excavation required to install infrastructure and uses public rights-of-way to bridge the digital divide. This is conducive to reducing costs and increasing access to internet for communities across the US. In addition, states and broadband providers have more opportunities to enter underserved markets.

Case study: China

China has also introduced policies addressing fiber pre-deployment. The policies require that newly constructed buildings must deploy fiber optic infrastructure before being sold to residents. The Chinese government published "Code for design of communication engineering for fiber to the home in residential districts and residential buildings", which states design requirements for installing communication facilities in residential districts and buildings, such as design specification of hand holes and the location requirement of indoor cables. In addition, "Code for construction and acceptance of communication engineering for fiber to the home in residential districts and residential buildings" mandates the examination of field and operation for constructing and operating the fiber optic infrastructures and laying down the duct including underground communication duct, manhole and hand hole, and wiring pipes for buildings, installing cables both outdoors and indoors. These new codes aim to ensure engineering quality and residents' safety in the deployment of Fiber to the Home (FTTH).

Case study: Germany

A similar situation can be found in Germany. To accelerate the country's digitalization development and reach European Commission's target in network speedup and coverage for 2020, Germany introduced the DigiNetzG Act, to facilitate the Deployment of High-Speed Digital Networks. The Act states that fiber-optic cables must be laid during the construction of new roads and buildings. In addition, public infrastructure such as roads, railways, and waterways are allowed to be co-used for installing fiber optic cables. With the help of these existing resources, the installation work of fiber became more efficient in reducing costs and saving time on construction.

4.1.5. Right of Way

The proper Right of Way rules are considered as a key enabler for expediting the deployment of underground (optical fiber) and over ground (mobile towers) infrastructure.

Case study: Vietnam

Vietnam's new Law on Telecommunications enacted in 2011 – just before huge growth in both the mobile and fixed broadband segments – established new laws encouraging broader competition, administrative reforms, and infrastructure planning. Specifically addressing the latter, Chapter IX of the law mandates planning of telecommunications facilities are required to be part of master plans on development of urban and residential areas, industrial parks, export-processing zones, technology parks and special economic zones in order the ensure orchestrated construction investment and development.

Case study: India

India Department of Telecom has adopted the Indian Telegraph Right of Way Rules to simplify the approval process in 2016, aims to rationalize administrative expenses across the country to a maximum of 1000 Rs per km for fiber, and a maximum of 10,000 Rs per application for overhead towers. The approval process is made more efficient through assigning a single point-of-contact to take charge, which reduces the communication cost. The online channel for applications provides real-time tracking of the approval process and the government also sets 60 days as the longest responding lead time to all the applications.

Though the implementation of the RoW rules is still facing difficulties, i.e. only a few states have aligned their RoW rules with Department of Telecom due to lack of clarity and some local implementation hurdles, it is expected that given a few more years the RoW rules could largely benefit the telecom sector.

4.1.6. Innovative and alternative technologies for ICT infrastructure – e.g. WTTx

The proper Right of Way rules are considered as a key enabler for expediting the deployment of underground (optical fiber) and over ground (mobile towers) infrastructure.

In many developing countries, it is a severe problem that rural area has low broadband penetration rate and many people are excluded from the digital world. In addition to the government's goal of increasing broadband coverage and developing fixed-line broadband networks, and connecting home and commercial buildings via fiber, the innovative technology for broadband connection such as WTTx (wireless to the x) is another alternative

solution. WTTx uses wireless to provide fiber-like broadband access for households and commercial sites, and it can provide relatively high-quality services with fast ROI and quick deployment. By sharing the site resources and carrier resources with mobile broadband business, WTTx is also more cost-efficient for network operators when doing construction.

Case study: Sri Lanka

Sri Lanka has a low home broadband penetration rate of approximately 12%, and 5 million people still cannot access home broadband. Dialog, as the largest mobile operator in Sri Lanka, has diligently been committed to providing cutting-edge telecommunications services to the society. While the cost of deploying fixed broadband is high and time to market is too long, Dialog capitalizes on advantages in networks, spectrum resources, and sites, and began to partner with Huawei and deploy wireless broadband (WBB) in 2013 to provide broadband service for households and SME. Now, the global WTTx subscribers have increased to more than 50 million households and the number of subscribers is still growing.

4.2. Government encouraging ICT innovation

Governments can support ICT innovation directly by providing physical innovation hubs or incubators, as well as funding and investment for innovation. In addition, training and cultivating high-quality ICT talents is equally important for achieving ICT innovation. Lastly, Cyber security and privacy supervision is very critical to form a healthy environment and prevent potential problems brought by innovation.

4.2.1. Innovation hub and incubator

The core idea is to let ICT relevant content and application innovation drive the growth of the overall ICT industry and provide better products and services to the end users. Typical participants in the downstream innovation include internet companies and high-tech companies. The Government could set up innovation centers, or incubators, to help nurture rising internet and high-tech startups.

Case study: Germany

The Federal Ministry for Economic Affairs and Energy of Germany setup the "De-Hub" project, setting up 12 digital hubs to encourage digital innovation, bringing startups and investors together to enhance cooperation, and creating great and continuous demand for the ICT industry while utilizing ICT to a deeper extent (Figure 48). By its one-year anniversary in April 2018, the “De-Hub” project has brought together more than 350 startups, 150 companies and 45 universities at a total of its twelve locations.

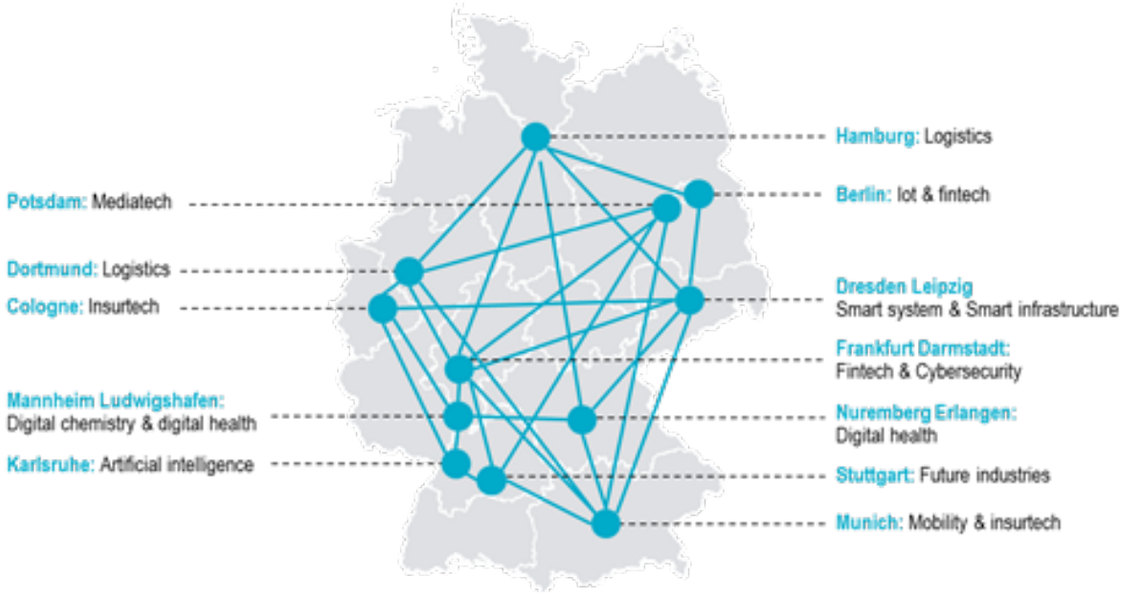

Figure 48: DE.DIGITAL, digital hub map around Germany
Source: De.Digital, Roland Berger

Case study: Malaysia

Under the support of the Malaysian government, Alibaba – one of the largest internet players in China – announced its collaboration with the Malaysian Digital Economy Company (MDEC) to establish a digital hub for local startups in 2017. The new hub offers tax break incentives as well as other facilities to allow startups to operate in a less capital-intensive approach, to position Malaysia as the regional hub for startup companies.

The digital hub is also the first step to setting up an e-world trade platform (eWTP), an initiative by Alibaba which allows small businesses in one country to sell to customers in another with low or no import duties, speedy customs clearance, and better access to logistics. The eWTP has put its first pilot project into use in Kuala Lumpur in November 2017, which is also expected to bring continuous vitality to the ICT industry downstream.

4.2.2. Funding and investment

Other than setting up physical environment for ICT innovation, government can also set up incentive policies to provide corresponding funding and investment to encourage ICT innovation.

Case study: United Arab Emirates

Through government funding, the United Arab Emirates has been a pioneer in encouraging ICT R&D. The ICT Fund was launched in 2007 by the Telecommunications Regulatory Authority to achieve rapid, progressive and concrete development within the ICT sector in the UAE. The fund will support basic research and applied R&D initiatives with the goal of developing new cutting-edge ICT products, product enhancements, and new services. All of which will benefit the economy of the UAE. By 2014, the ICT Fund has invested more than USD 435 mn.

So far, 5 projects including smart government initiatives, research and development and building a national telescope and space observatory have been invested. For instance, the ICT Fund has invested USD 19 million and jointly established the research and innovation center with Khalifa University of Science, Technology and Research (KUSTAR), BT and Etisalat, in its efforts to advance the technologies for Next Generation Networks (NGNs) and NGN-enabled ICT applications and services. To date, the organization has delivered tangible outcomes to address business, infrastructure and societal challenges in the UAE, with over 200 publications.

Case study: Nigeria

Nigeria provides another example here. The Nigerian Minister of Communication Technology, Mr. Omobola Johnson, has disclosed that the government would soon launch an ICT Innovation Fund that will raise about $20 million for ICT entrepreneurs to boost growth in this increasingly relevant sector. Subsequently with the establishment of the Office for ICT Innovation and Entrepreneurship (OIIE), the organization has served as an incubator, an accelerator, and an investor. And it thrives to nurture, cultivate and expand the ICT innovation and entrepreneurship within Nigeria through policies, initiatives and programs that will assist tech startups to establish successful businesses.

Genii Games, as an example of the successful startups that have been sponsored by OIIE, provides a growing collection of interactive mobile apps and web videos for kids to learn about African Cultures in fun ways. The startup got in top 10 out of 400 start-ups in the startup pitch competition in 2016 GITEX Technology Week in Dubai, the largest technology event in the Middle East, Africa & South Asia.

4.2.3. Talent training and cultivation

To achieve innovation in ICT downstream, it requires large amount of ICT talents, and therefore governments can take various actions to attract and cultivate talents to dedicate to ICT development. Different programs are designed for different age groups or educational levels, and they all contribute greatly to the development of the ICT industry.

Case study: Malaysia

In Malaysia, the national ICT custodian, the Multimedia Development Corporation (MDeC) has established close relationship with Huawei, especially in ICT talent development. In 2011, Huawei signed a memorandum of understanding (MoU) with MDeC which underlined the company's commitment to providing ICT training to 10,000 Malaysians to support the development of the telecommunication sector over the next five years. In 2012, Huawei opened its Global Training Centre in Cyberjaya to train 20,000 engineers on an annual basis. In June 2013, Huawei and MDeC signed a MoU to jointly promote the Digital Education solution in Malaysia's primary, secondary, and tertiary education systems. By 2013, Huawei has established scholarships with 18 Malaysian universities.

Case study: Australia

Funded by the Australian Government, Digital Careers is an Australian government backed, independent program aimed at positively engaging students, parents and teachers in digital technology. Digital Careers highlights the diverse, exciting and rewarding opportunities in ICT careers for young Australians, through engaging with new technology, education options and advice. Industry leaders, education providers, and the government contribute to this national program to boost interest in ICT careers and reveal it as an attractive option for a brilliant career.

Digital Careers focuses on reducing the critical shortage of Australian ICT professionals by raising awareness and interest in digital careers and by growing the number of students preparing for a career in the ICT industry. The program provides information, activities and opportunities for primary and secondary school students (school years 5-10), and for their parents, teachers and school based career advisors.

In corporation with SAP, a German software company, Digital Careers holds a non-profit competition "Young ICT Explorers". The competition's alignment with the school curriculum also enables students to apply what they learn in their ICT/Digital Technologies classroom to develop a technology related project of their choice. Each project is assessed on the criteria of creativity, uniqueness, quality, level of difficulty and project documentation. The competition not only recognizes and rewards student achievements in technology, but also provides guidance for future career development.

Case study: China

In 2004, Chinese Ministry of Information Industry (now renamed “Industrial and The Ministry of Information Technology”) launched “Communications and Information Innovation Technology Talent Training Project” (CIIT), to cultivate talents that meet industry and enterprise needs. Tailoring to industry trends, the program establishes standardized training curriculum and skill assessment certification procedures and practices by opening training and testing centers and training bases across the nation.

By 2014, the program had established 15 IT-related testing standards, over 260 training bases, and had offered over 300 courses, benefiting more than 4 million talents in various fields. The main categories of courses offered covers Internet of Things, Smart City, Cloud Computing, and etc.

Case study: Singapore

The Ministry of Communications and Information announced a new ICT Manpower Development Plan on 11 April 2016, to accelerate professional development and enhance employability outcomes for Singaporeans. The new overarching initiative called the "TechSkills Accelerator" (or TeSA) tailors for ICT professionals and those aspiring to join or convert to the ICT profession. TeSA will aggregate training and job placement programs through a network of key hirers and partner providers in the ICT industry. An integrated approach to ICT skills, both in core ICT skills and in sector-specific ICT skills, and business domain knowledge required by different sectors of the economy will be provided. By Feb. 2018, over 27,000 training places have been taken up or committed, and the government set aside an additional USD 105 mn to further develop the program.

4.2.4.Caber security

With fast pace innovation in ICT application and content, cyber security problem requires attention. To address such concerns, countries have passed various rules and laws to ensure a safer cyber environment to protect all users in the digital world.

Case study: US

In US, most states include either "cyberbullying" or "electronic harassment" in their bullying laws, and the nationwide trend is toward greater accountability for bullying in general, both in school and off campus, including criminal statutes.

In California, for example, state law defines "bullying" in the context of an educational facility to include "communications ... by means of an electronic act," while the Safe Place to Learn Act, along with other code sections, establish a student’s "inalienable right to attend classes on school campuses that are safe,

secure, and peaceful." The use of "an electronic communication device" to cause someone to fear for their life is charged as a misdemeanor, punishable by up to one year in jail and/or a fine of up to $1,000.

Case study: Egypt

The Egyptian parliament approved a cybercrime bill aiming at combating the illegal use of computers and information networks in May 2018. The Anti-Cyber and Information Technology Crimes Law defines commonly used concepts such as “websites, traffic data, digital directory, personal statements and national security”. And the bill regulates Internet Service Providers’ (ISPs) activities and their obligation to provide national security authorities with information on users suspected of spreading terrorist and extremist ideologies via the internet. It also aims at securing personal data of internet users.

Accordingly, article 18 offers punishment of no less than one month in prison or a fine of no less than LE 50,000 ($2,800 USD) and no more than LE 100,000 ($5,600 USD) for anyone who breaches or harms someone’s personal email account or website. Parliament also approved article 9 of the cybercrime law, allowing the Attorney General or specialized investigative authorities to impose travel bans on persons charged of committing or attempting to commit cybercrimes, if enough evidence against them exists.

4.3. Government guiding and regulating ICT competition

In addition to stimulating ICT investment and encouraging ICT innovation, government also needs to guide and regulate competitions within ICT industry, especially regarding operator competition regulation, as well as frequency spectrum management.

4.3.1. Operator competition regulation

Operator competition regulation, as a crucial topic for ICT development to ensure high quality and cost-effective network service provision, should include the following two aspects:

- Market entry authorization: government sets up basic criteria for market entrants, and license certain number of operators for fixed and mobile network operation within a country
- Competition monitoring: government monitors the competition among operators, and eliminates inefficiency due to potential monopoly, e.g. mergers and acquisitions between operators

Market entry authorization

Depending on the country and depending on the intended service, operators might needto obtain a license, which is issued by governments or regulators. Such licenses generally describe key rights and obligations of licensees and often define conditions relating to the provision of services.

In the light of rapid technological development and service innovations, countries are increasingly moving towards the adoption of multi-service and technology neutral authorization frameworks away from technology-specific authorization. These authorizations feature technology neutral, using any type of infrastructure and technology as long as they are capable of delivering the desired services.

Another advent of new licensing approach to simplify licensing is that broad categories of services are bundled together, allowing licensees to offer a range of services under the umbrella of a single license. Consolidation of licenses involves the reclassification of existing telecommunications services into different categories, which is based on technology and service neutrality.

Traditionally governments issue one specific license per service type. Nowadays, some countries start consolidation of licenses and usually divide services into three or four major categories, such as network facility license, network service license, application service license, and content service license. This has been the option followed by many countries, including Malaysia, Tanzania, Uganda, and Singapore. Some more liberalized countries are now using unified licensing, where a single license is created that covers an extensive range of services. The trend has been adopted, or is being adopted in more and more countries, such as Argentina, EU member states, India, Kenya, Nigeria, and Peru.

Competition monitoring

In addition to market entry regulation, government has to monitor the competition among network operators, and eliminate inefficiency due to potential monopoly, e.g. mergers and acquisitions between network operators.

Despite the difference in market entry authorization and competition monitoring among different countries, majority of the countries have one or two fixed line operators, and two to four mobile operators (Figure 49), due to the natural economies of scale effect of network operation.

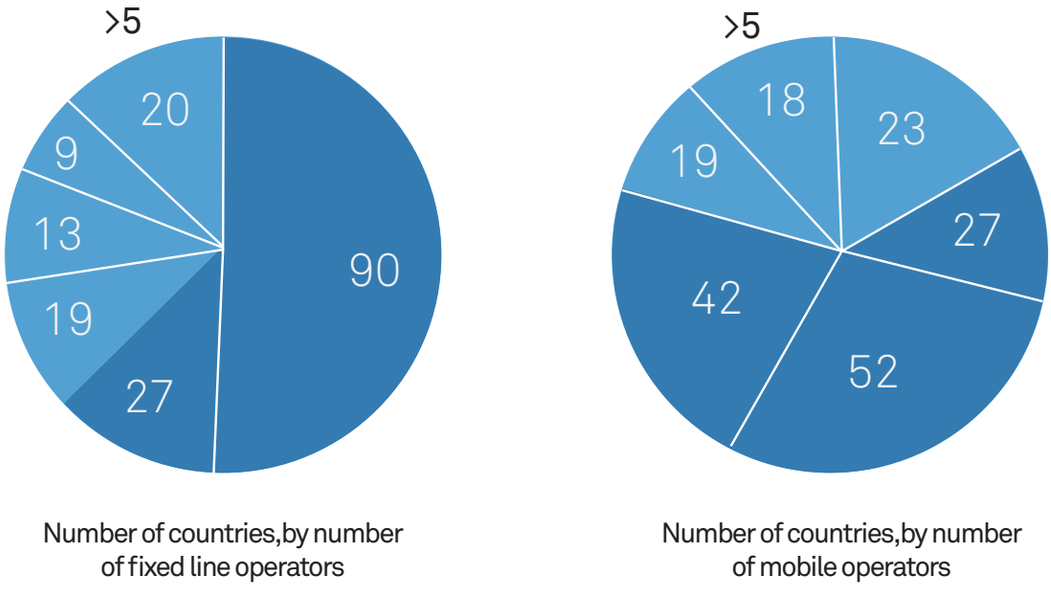

Figure 49: Number o–f countries, by number of fixed line and mobile operators
Source: Huawei, Roland Berger

Case study: US

The United States allows the competition to happen as the market evolves, but still avoiding the monopoly to ensure the benefit of the end consumers. Back in 2011, AT&T and Sprint attempted to merge with T-Mobile to better develop their mobile operation. However, the Federal Communications Commission (FCC) denied the proposal. The virtuous competition from smaller players guaranteed the service quality which stimulates the introduction of new service categories, and most importantly, stabilizes the price to ensure the access to connection for the common population.

Even though the number of operators in one market is stable, the operator's actions need to be monitored as well. Poland is a great example showing how government works to ensure effective competition.

Case study: Poland

The European Commission has imposed a fine of €127,554,194 on telecoms operator Telekomunikacja Polska S.A. (TP) for abusing its dominant position in the Polish market in breach of EU antitrust rules (Article 102 of the Treaty on the Functioning of the EU).

Poland has one of the lowest broadband penetration rates in Europe - in January 2010 it reached only 13%, significantly below the EU average of 24%. Consumers have also suffered from lower connection speeds: 66% of Internet access lines in Poland do not exceed the speed of 2Mbit/s compared to an EU average of just 15%. Finally, monthly prices per advertised Mbit/s were much higher than the prices in other Member States and the second highest in the OECD area.

To use the incumbent's network, operators need to acquire wholesale broadband access products, namely wholesale broadband access and local loop unbundling. In Poland, these are exclusively provided by TP, on which alternative operators are dependent to compete on the retail market. Alternative operators encountered numerous difficulties to obtain access to TP's broadband wholesale products. For instance, TP proposed unreasonable conditions, delayed the negotiation processes, rejected orders in an unjustifiable manner and refused to provide reliable and accurate information to alternative operators. Together, the above practices prevented alternative operators from competing effectively in the market and constituted an abuse of TP's dominant position on the Polish broadband market.

Telekomunikacja Polska's total turnover in 2010 was € 3.9 billion (15.7 billion PLN). The fine takes account of the duration and gravity of the infringement and has been calculated on the basis of the average value of TP's broadband sales between 2005 and 2009 in Poland.

4.3.2. Frequency spectrum allocation and management

Importance of proper allocation and management of frequency spectrum

Spectrum are regulated by governments for two major reasons. The first is that radio interference may happen if the radio emissions fail to co-ordinate accordingly. The second reason is that radio spectrum is a scare resource and therefore rules are needed to decide for which purpose and to whom spectrum is allocated.
In terms of international spectrum planning, ITU-R World and Regional Radiocommunication Conferences are held every two to three years to establish and revise treaty level regulations, agreements and plans for the global use of the radio frequency spectrum, whereas national spectrum planning varies among countries. When it comes to allocating spectrum to a specific usage within the nation, the most commonly used authorization regime for spectrum is individual spectrum licenses. Individual spectrum licenses give the holder the exclusive right to use and manage the frequency band in a pre-determined geographic area. And the licenses are long-term in duration, usually 15-25 years, corresponding with the expected life of a mobile network.

Auctions for frequency spectrum are widely leveraged

Since the number of licenses available is less than anticipated demand, selection is necessary for spectrum licensing. Before the 1990s, the majority of countries assigned spectrum bands for the mobile telecommunication service according to the command and control policy, based on so-called "beauty contests". In this method, entities interested in obtaining a license are assessed in terms of their coverage plans and technology. During the 1990s and later, the auction model took hold in most countries of the world, including United States, Britain, Germany, Australia, New Zealand, India, Columbia, Hungary, Argentina, etc.

License authorization and renewal process should be predictable, timely and open

It is very important that government needs to follow predictable, timely and open license authorization and renewal process, especially by clearly stating the followings:

- How soon after the award of licenses, will new licenses be introduced and how will they be awarded?
- How will the government handle the expiry of license?

These are extremely important to provide sufficient certainty to support substantial network investment from the operators.

License authorization should be technology and service neutral

The traditional command-and-control approach to spectrum management tightly restricts the use of specific spectrum bands to particular services and particular technologies. However, usage restrictions have not kept pace with fast changes in technology and demand happening in recent decade. Restrictive licensing requirements delay the introduction of new, more efficient technology and services. An increasing number of countries have moved towards allowing more flexible use of spectrum. Technology neutrality has been used to enable mobile operators to leverage their existing spectrum assignments for use with newer technologies.

Case study: South Korea

On Jun. 18, 2018, South Korea completed its 5G spectrum auction, where 3.5GHz and 28GHz spectrum were available for bidding. The result was that SK Telecom and KT each won 100MHz of the 3.5GHz spectrum, while LG Uplus clinched 80MHz. All three telecoms secured 800MHz of the 28GHz spectrum. The total price paid reached USD 3.2 bn, USD 300 mn higher than the starting price. The winners can start using the spectrum on December 1, 2018. They can use the 3.5GHz spectrum for the next 10 years and 28GHz spectrum for five years.

5.Conclusion and recommendation

5.1. ICT development is an important trend that significantly benefits economics and societal wellbeing of countries around the globe

Information and communication technology (ICT), the key for information gathering, storage, processing, transmission and display, has been experiencing a rapid and steady growth around the globe in the past two decades. This is evidenced by the development of ICT infrastructure, such as fixed and mobile networks, information gathering, processing, and display devices, etc., improved internet penetration for individuals and households, the ever-expanding bandwidth and speed of connection, and more. With the rapid growth of ICT infrastructure, ICT has become fundamental features of modern society, and to some extent, internet access is even considered as a basic right for human in this information society, given it enormous potential to help achieve sustainable development of human society.

Along with the development of ICT in the past few decades, it demonstrates its ability to create both economical and societal value to the development of a country, which raises the attentions from governments.

At a macro-economic level, the consensus is that ICT development has positive effects on national economic growth, measured by gross domestic production (GDP). This paper conducted a regression analysis on a data set of 125 countries for the period 2010 to 2016 and concluded that with 16-20% increment in ICT capital services, the GDP is about to raise 1%. Additionally, Huawei and Oxford Economics found out the magnitude of digital spillover effect of ICT investment: every $1 invested in digital technologies over the past three decades has added $20 to GDP, on average.

Specifically, as for different industries, there are three major modes of how ICT development affects the economy. For traditional industries, such as agriculture, manufacturing, tourism, etc., ICT can bring either "improving" or "transformational" impact serving as a fundamental infrastructure. Besides, development of ICT enables the birth of emerging technologies like cloud computing, and AI enabled industries, which is considered to be "disruptive" impact to economy.

In addition to ICT's impact on national economic growth, ICT also supports societal wellbeing and public affairs. It contributes to promoting education accessibility and cultural communication, reducing unemployment rate, ensuring both public and personal safety and security, improving government efficiency and transparency.

However, ICT development varies across countries, as well as different geographic areas within a country. Considering the noteworthy Digital Divide, describing the gap in development in ICT infrastructure, accessibility and utilization, and the "Matthew Effect", indicating deepening inequality and obstacles for laggards to compete with pioneers, governments of developing countries should realize the urgency and pay extra attention to the development of ICT and relevant infrastructures, to catch up on this important global trend.

5.2. Government creating a favorable environment for ICT investment, innovation, and competition is very critical

Government, recognizing ICT's importance to economical and societal development of a country, makes ICT policy a subject for national policy and not for a sector policy (e.g. telecommunications) only. The development of ICT and relevant infrastructure cannot be realized by solely relying on participants within the ICT ecosystem, such as network element providers, network operators, downstream platform, application and content providers (Figure 50). Instead, it requires supports from the government in three major aspects: investment, innovation, as well as competition (Figure 51). The government plays a vital role in forming a favorable environment to enable the fast and healthy development of ICT industry.

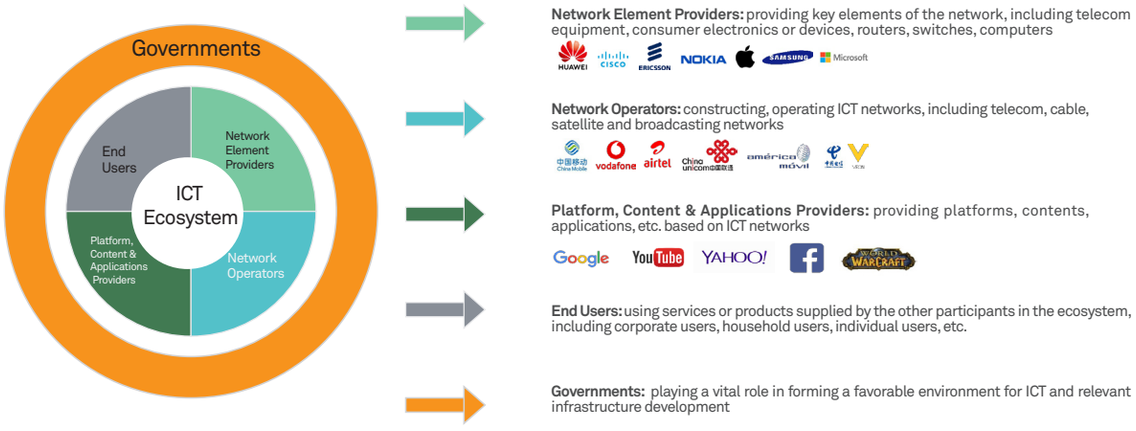

Figure 50: ICT ecosystem and government's role for ICT development
Source: Huawei, Roland Berger

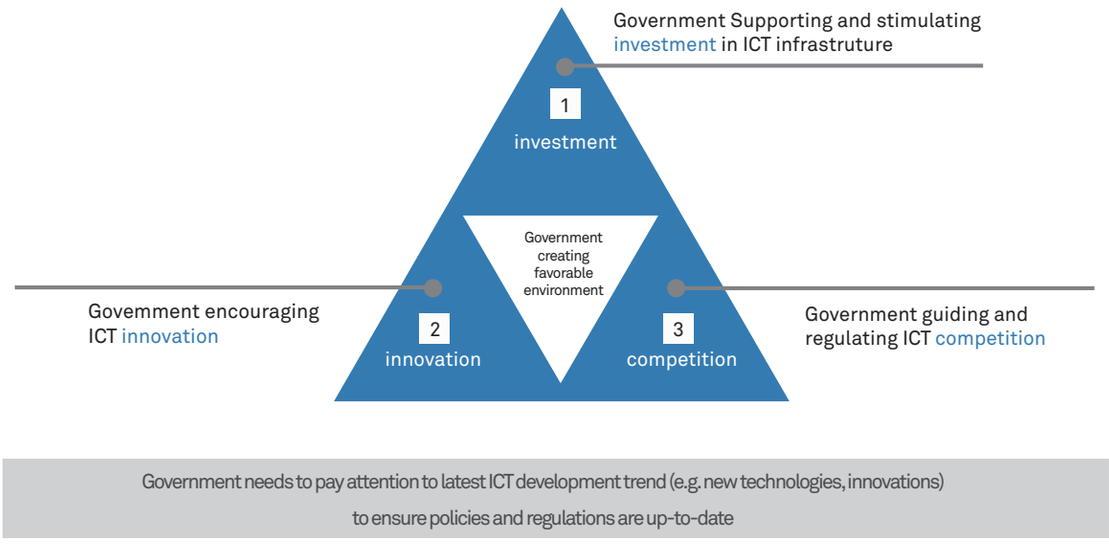

Figure 51: Government creating favorable environment for ICT development from three major aspects
Source: Huawei, Roland Berger

5.2.1. Government supporting and stimulating investment in ICT infrastructure

The development of ICT and relevant infrastructure relies heavily on ICT infrastructure manufacturing, installation and operation. Governments should set up appropriate ICT infrastructure development objectives based on the development stage of the country, which act as a leading guide and convey the government's attitude towards ICT development to all the participants within the ICT ecosystem. Development objectives include broadband coverage, connection quality and speed.

To achieve the ICT infrastructure development objectives, government usually supports and stimulates investment in ICT and relevant infrastructure with the following methods:

Public-private partnership: often seen in ICT infrastructure construction; currently most countries choose to use the Build-Operate-Transfer (BOT) model of PPP in ICT construction, where governments mainly provide public resources and favorable policy supports to attract social capital, instead of making heavy investment directly

Tax relief and subsidy: tax relief and subsidy can also help stimulate ICT development indirectly by giving financial incentive to companies involved in ICT industry

Tariff Concession: cutting down on tariffs of certain importing ICT infrastructure-related items, to ensure the supply in developing countries, esp. those with the limited R&D capability and production capacity

Infrastructure construction collaboration: leveraging existing infrastructure in regions that have already finished the construction and installation of other infrastructure but need to draw in or upgrade ICT infrastructure; binding different types of new infrastructure construction together in the first place in newly developing regions to avoid re-working later

Right of Way: proper and simplified Right of Way rules expedite the deployment of underground (optical fiber) and over ground (mobile towers) ICT infrastructures

Innovative technology for ICT infrastructure: being technology neutral and actively adopting innovative technology (e.g. WTTx) to improve broadband coverage in a more cost-effective way

5.2.2. Government encouraging ICT innovation

To fully leverage the ICT infrastructure and benefit both economic and societal development of a country, encouraging ICT innovation from government is very critical.

Innovation hub and incubator

Setting up ICT innovation infrastructures such as hub and incubators is typical supportive policy, which helps nurture rising internet and high-tech startups.

Funding and investment

Other than setting up physical environment for ICT innovation, government can also set up incentive policies to provide corresponding funding and investment to encourage ICT innovation.

Talent training and cultivation

In addition, to achieve innovation in ICT downstream, it requires large amount of ICT talents, and therefore governments can take various actions to attract, cultivate and provide training to talents to dedicate to ICT development.

Cyber security and privacy

With fast pace innovation in ICT application and content, cyber security and privacy problems requires attention. To address such concerns, governments have to establish various rules and laws to ensure a safer cyber environment to protect all users in the digital world.

5.2.3. Government guiding and regulating ICT competition

In addition to stimulating ICT investment and encouraging ICT innovation, government also needs to guide and regulate competitions within ICT industry, especially regarding operator competition regulation, as well as spectrum management and frequency allocation.

Operator competition regulation

Operator competition regulation is crucial topic for ICT development to ensure high quality and cost-effective network service provision. Market entry authorization and competition monitoring are two major issues.

Regarding market entry authorization, the trend is towards adopting multi-service and technology neutrality away from technology-specific authorization. Another advent of new licensing approach is to bundle broad categories of services together to achieve service neutrality. As for monitoring competition and eliminating inefficiency due to potential monopoly, governments also takes various action to control the player amount in the market and supervise their performance.

Frequency spectrum allocation and management

With limited resource, selection is necessary for spectrum licensing, and auctions for frequency spectrum are now widely leveraged in frequency spectrum allocation. License authorization and renewal process should be predictable, timely and open to provide sufficient certainty to support substantial network investment from the operators. License authorization should also be technology and service neutral. An increasing number of countries have moved towards allowing more flexible use of spectrum.

5.3. Government should support ICT development thereby benefiting economics and social well-being

To conclude, governments should recognize the fundamentality of ICT infrastructure and contribute to a healthy ICT ecosystem by setting supportive policy tools and regulation. Different problems need to be addressed in different sectors, from investment, innovation to competition.

Thereby, if better environment has been created for ICT development, governments are able to gain further improvement in both national economic and societal well-being from the whole ICT ecosystem.

Appendix

Appendix 1: Literature review on ICT-to-GDP analysis

Selected studies regarding ICT's impact on economic growth, which assist analysis of this report, are elaborated as following:

Selected studies regarding ICT's impact on economic growth, which assist analysis of this report, are elaborated as following:

The study conducted by Kasetart University showed the positive effect of ICT development on the economic growth of OPEC countries. By looking at data during the period of 2002 – 2015 and using Panel Generalized Methods of Moment, they concluded that the ICT index, addressed by ITU to indicate ICT development level, is positively correlated with GDP growth, meaning that a higher ICT index, referring to better ICT development of a country, results in higher GDP growth (Figure 52)

Table 5
Results of model estimation (Panel-GMM)

Independent variable	(1)	(2)	(3)	(4)	(5)
Log GDP per capita (−1)	.13** (2.47)	.26*** (3.75)	.27*** (4.19)	.33*** (3.5)	.35*** (3.99)
Log finance development	.14*** (13.55)	.07*** (5.58)	.086*** (7.47)	.064*** (4.42)	.048** (2.025)
Log ICT	.034*** (2.65)	.021 (1.25)	.021** (2.16)	.047** (2.52)	.050*** (2.65)
Log government expenditure	–	.12*** (4.99)	.096*** (5.45)	–	–
Log degree of trade openness	–	−.17*** (−5.19)	−.19*** (−6.71)	−.14*** (−4.56)	−.15*** (−5.21)
Log active labor	–	.19*** (3.14)	.18*** (3.26)	.156** (2.05)	.158** (2.13)
Inflation rate	–	–	−.0014* (−1.94)	−.0014** (−2.60)	−.0015** (−2.51)
Log private sector credit	–	–	–	.040** (2.20)	.046** (2.63)
Log fixed capital formation	–	–	–	–	.031 (1.097)
Sargan test	P = .39	P = .13	P = .19	P = .72	P = .79

Notes: t-statistic in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%

Figure 52: Panel-GMM results
Source: Kasetart Journal, Roland Berger

The economic impact of broadband: evidence from OECD countries, Ofcom (2018)

The UK's communication regulator, Ofcom, released a report on economic impact of broadband by measuring the direct effect of broadband development on local economy. Using an OECD panel of countries, the report found that the broadband penetration rate of OECD countries grew from 3.8 connections per 100 people in 2002 to 31.3 connections per 100 people in 2016 on average. The broadband penetration rate is an important indicator of ICT development and also points to the positive correlation between ICT development and GDP growth. In conclusion, this research stated that the increase in broadband connections per 100 people from 2002 to 2016, contributed to a cumulative GDP increase of 4.34% for the countries in the sample.

Does ICT Generate Economic Growth, Journal of Economic Surveys (2018)

Despite phenomenal technological progress and exponential growth in computing power, economic growth remains comparative sluggish. In this paper, two core issues are investigated: (1) is there really no connection between ICT and national economic growth? and (2) what factors moderate the ICT–growth relationship? Meta-regression analysis was applied to 466 estimates drawn from 59 econometric studies that explore the Solow or Productivity Paradox that there is little impact of ICT on economic growth and productivity. The differential impact of ICT on developed and developing countries and the differential impact of different types of ICT are explored: landlines, cell phones, computer technology and Internet access. After accommodating potential econometric misspecification bias and publication selection bias, evidence is detected that ICT has indeed contributed positively to economic growth, at least on average. Both developed and developing countries benefit from landline and cell technologies, with cell technologies' growth effect approximately twice as strong as landlines. However, developed countries gain significantly more from computing than do developing countries. In contrast, we find little evidence that the Internet has had a positive impact on growth.

ICT and economic growth: Comparing developing, emerging and developed countries, Center for European Economic Research (2014

A report from Center for European Economic Research analyzed the contribution of growth in ICT capital services, as an ICT-related variable, to GDP growth. According to the OECD's definition, capital services are the productive inputs flowing to production from a capital asset per period. The value of these capital services is the quantity of services provided by the asset multiplied by the price of those services. It reached a positive result based on a sample of 59 countries for the period 1995 to 2010, leveraging the Cobb-Douglas production function. Therefore, growth of ICT capital service, referring to the quantity of ICT capital input in the production, had a positive coefficient with the growth of GDP – between 0.087 and 0.088 – by different regression methods.

Appendix 2: Regression model methodology and data

Re-examination of analysis used by Center for European Economic Research

The model that Center for European Economic Research used was informative by choosing limited but reasonable variables according to the classic Cobb-Douglas function, but the data samples used were a bit out-of-date and with limited geographic coverage. This positioning paper re-examined the model with a data set of 125 countries for the period 2010 to 2016. The reason to choose the period of 2010 to 2016 is that with 4G being formally commercialized at the beginning of 2010, a new era of ICT has begun with faster changing pace and more effective influence on economics.

$$\Delta \ln Y_{c,t} = \beta_{ICT} \Delta \ln K_{c,t}^{ICT} + \beta_{NICT} \Delta \ln K_{c,t}^{NICT} + \beta_L \Delta \ln L_{c,t} + \beta_X \mathbf{X_{c,t}} + \lambda_t + \mu_c + \epsilon_{c,t}$$

- ΔlnYc,t - the growth rate of GDP
- ΔlnKICTc,t , ΔlnKNICTc,t , ΔlnLc,t - the growth rates of the input factors ICT capital services, non-ICT capital services and labor services in country c at time t
- Xc,t - additional control variables in an augmented Cobb-Douglas production function setting controlling for differences in the production technology between countries
- λt - time dummies
- μc – country dummies (in the fixed effects setting)
- ϵc,t – the general error term

	ΔlnKICTc,t	ΔlnKNICTc,t	ΔLc,t	Constant	Year Dummies
Coefficient	0.0629***	0.466***	0.261***	0.2258	Yes
Std. Err	0.0141	0.0434	0.0469	0.2159	
R Square=0.3307, Adjusted R-Square=0.3330					
* p<0.10, ** p<0.05, *** p<0.01					

Figure 53: Regression analysis result using pooled OSL model
Source: Center for European Economic Research, Roland Berger

[7]The pooled OSL model controlled for year dummies for common shocks arising for (almost) all countries such as the global financial crisis around 2008

Figure 53 presents the results for the Cobb-Douglas production function estimation. All the tested variables are significant at 1% level. The growth rate of ICT capital services shows a coefficient of 0.0629. In other words, with 1% increment in ICT capital services, the dependent variable GDP is about to raise 0.0629%. Such outcome is also known as digital spill overs.

Combining two studies: (1) this position paper concluded that with 1% increment in ICT capital services, GDP raises 0.0629%, i.e. 16% increment in ICT capital services, GDP raises 16%; (2) Huawei's GCI report concluded that 20 percent increase in ICT investment will expand the GDP of a country by 1 percent, we found that with 16-20% increment in ICT capital services, the dependent variable GDP is about to raise 1%.

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