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White Paper

Financing a Forward-Looking Internet for All

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Contents

Foreword

Widespread digital connectivity has been a defining development of our time. The internet and the mobile internet have become essential parts of everyday life around the globe and across all segments of society. Still, an estimated 3.8 billion people – half the world's population – remain unconnected to the internet.[1] Launched in 2015, the World Economic Forum Internet for All project has mounted a multi-year effort to help bridge this digital divide with a focus on expanding internet access and increasing internet adoption.

Two previous White Papers of the Internet for All series have addressed this situation. Released in 2016, "Internet for All: A Framework for Accelerating Internet Access and Adoption" proposed an ecosystem-based approach to closing the digital divide, focusing on both the supply side and the demand side.[2] It identified the major barriers preventing internet for all: insufficient information and communications technology **infrastructure**; inadequate **affordability** of internet service and digital devices; a **deficit of digital skills, awareness and cultural acceptance**; and limited **availability of locally relevant digital content**, especially that in local languages or targeting users in specific regions.

The second paper, "Internet for All: An Investment Framework for Digital Adoption" released in 2017, developed a model for determining the investment required to overcome these barriers on a national or regional basis. The paper was published together with a series of spreadsheets designed to help provide a cost estimate in drafting broadband development plans.

This third paper goes a step further. It makes the case that governments should think beyond closing the digital divide to investing in the development of a robust digital ecosystem that can facilitate participation in the Fourth Industrial Revolution. This perspective, called a "forward-looking internet for all", notes that a major imperative for closing the digital divide is to prevent industries enabled by the Fourth Industrial Revolution from becoming concentrated in a handful of advanced economies and perpetuating global inequality. This paper recognizes that the traditional binary view of connected versus unconnected individuals is therefore more nuanced. National internet ecosystems are at different levels of maturity, measured not just by the number of users but also by data throughput, quality of service and latency.

Higher maturity levels come with economic benefits but also demand significant investments. To address this, perspectives are included on alternative financing models designed to make such investments more practical.

We are grateful to the members of the Internet for All Steering Committee for their thoughtful and useful inputs at every step along the course of this White Paper's development. We also thank The Boston Consulting Group (BCG) for its invaluable support as our project Knowledge Partner. In particular, Gregory Lamontagne, on secondment to the World Economic Forum from BCG, served as Project Manager and deserves special recognition.

Executive summary

The economic impact on gross domestic product (GDP) of increasing broadband penetration has been well documented. Empirical studies have shown that each 10% increase in internet penetration correlates with an increase of up to 2.8 percentage points in the rate of GDP growth.[3] Less discussed are the growth benefits from faster download speeds which, when doubled, result in a 0.3 percentage-point increase in per-capita GDP growth.[4] Such findings reflect intuition: faster, high-quality internet permits more intensive uses of the web – from streaming media to the internet of things to self-driving cars – which in turn drives increased productivity, industrial growth and better quality of life.

This paper develops a framework of internet "maturity levels" to provide a common vocabulary for the extent to which the internet is incorporated into individuals' lives, and facilitates discussion between the public, private and civic spheres. It also makes the case that inclusive growth depends not simply on providing internet access, but on supplying access with sufficient quality and speed to support a mature internet ecosystem.

Advanced connectivity has significant implications for infrastructure. It requires building a forward-looking internet infrastructure capable of handling more traffic and at higher speeds than might otherwise be appropriate for short-term needs. For fixed-line connections, fibre infrastructure provides the only clear path forward for full integration of the internet's evolving benefits. For the mobile internet, planning for 3G or even 4G connectivity no longer suffices; the traffic volumes and uses of the future will require advanced network capabilities contemplated for 5G and beyond.

Planning for advanced infrastructure has considerable implications for how to finance the upgrading of older networks and the construction of new ones. Most financing for information and communications technology (ICT) infrastructure has traditionally come from private-sector companies, namely network operators, internet service providers and tower builders. In contrast, governments and multilateral players, such as development banks, have played a relatively minor role, especially compared to the scale of their investment in other infrastructure sectors. The reasons for this include the persistent perception that providing internet connectivity is the private sector's responsibility, and the failure of ICT infrastructure to establish itself as a truly investible "asset class".

However, a shift in perspective is required to close the access gap and ensure increased forward-looking internet access. The paper provides recommendations across multiple sectors and calls for more innovative financing arrangements to improve the business cases for private investors. Recommendations for the public sector include specific policies (e.g. "dig once" policies, reworked tax incentives); government anchor tenancies to provide guaranteed data consumption on new networks; release of new spectrum in a timely and affordable manner; incentives to deploy small cells, such as providing expedited access to site locations; and incentives to promote internet exchange points to reduce latency and costs.

Recommendations focused on the private sector or multilateral actors include the development of ICT-specific infrastructure funds that bundle multiple projects for investment; development of securitization mechanisms to promote investment in funds and in individual projects; development of co-investment vehicles allowing mobile network operators to solicit infrastructure financing from other players; risk guarantees to improve investment environments; project preparation facilities to address early-stage project risks; and development of infrastructure marketplaces to bring together infrastructure project owners, investors and other actors to promote and invest in infrastructure projects.

Introduction

Expanding basic network connectivity is a vast challenge unto itself. Building adequate network capacity and functionality to meet increasingly sophisticated user demand adds significant complexity and cost. But as internet usage has expanded and data traffic has skyrocketed, information and communications technology (ICT) infrastructure capable of handling rapidly advancing user needs is a prerequisite for an expanding digital economy. Cisco estimates that global internet traffic in 2021 will exceed 125 times the traffic volume of 2005.[5] Average monthly traffic per person is expected to triple from 10 gigabytes (GB) in 2016 to 30 GB by 2021.[6] Moreover, the nature of this traffic – for example, mission-critical data transmitted among devices on the internet of things (IoT) – requires that networks achieve new levels of speed and reliability.

The changes taking place mean that internet connectivity can no longer be thought of in terms of "basic use," such as web browsing, interpersonal communication and simple entertainment. While that level of basic connectivity may prove indefinitely sufficient for some users, many will find it advantageous to pursue uses and applications that require high-quality service and reliability. Policy-makers, business leaders and other stakeholders with an interest in furthering digital adoption and use need to think about how to extend connectivity that is capable of handling far greater traffic volumes and supporting more advanced use cases. To do otherwise would be to hold users back by preventing them from accessing all the internet's benefits, thwarting economic and social development, and widening the digital divide between developed countries and many emerging markets.

Advanced connectivity has significant implications for infrastructure, discussed at length in the coming chapters. For fixed-line connections, fibre infrastructure paves the only clear path forward for full integration of the internet's evolving set of benefits. From a mobile internet perspective, planning for 3G or even 4G connectivity no longer suffices; the traffic volumes and uses of the future will require advanced network capabilities contemplated for 5G and beyond. Planning for advanced infrastructure has considerable implications for how to finance upgrades of older networks and the construction of new ones.

This White Paper examines the state of financing for digital infrastructure and makes a case for reframing the current model. It argues that planning for basic internet access is no longer sufficient. The current financial models, which rely primarily on investment by network operators based on company-by-company business cases, are overly narrow in scope and increasingly outdated. For individuals, companies and countries to participate fully in the digital economy and society, all users must have a credible pathway for accessing the full array of social, educational and economic advantages of contemporary high-speed internet use. This requires new ways of thinking about ICT infrastructure from an investment point of view, including factoring broader social and economic returns into traditional rate-of-return calculations.

The following chapter presents the case for forward-looking internet access and a framework for considering internet "maturity levels" and their impact on infrastructure needs. The current state of financing is then explored, as well as the related barriers to deploying advanced infrastructure. Approaches to surmounting these barriers are proposed in the final chapter, including a series of practical considerations for public- and private-sector stakeholders and multilateral organizations.

Consistent with United Nations Sustainable Development Goal 17 (to revitalize the global partnership for sustainable development[7]), all participants in all sectors of the digital ecosystem must cooperate to improve the state of ICT financing and to further global investment in high-quality broadband infrastructure. The Internet for All project hopes that this paper can contribute to the development of this goal by promoting more such cooperation.

The case for forward-looking internet access

The economic impact on gross domestic product (GDP) of increasing broadband penetration is well documented. Empirical studies have shown that each 10% increase in internet penetration correlates with an increase of up to 2.8 percentage points in the rate of GDP growth,[8,9] with the specific amount depending on contextual factors relating to a country's existing stage of economic development. Less discussed are the growth benefits from faster download speeds which, when doubled, result in a 0.3 percentage-point increase in per-capita GDP growth.[10]

Underpinning this GDP growth are individuals, businesses, institutions and societies that derive more economic benefit at higher internet maturity levels, with such effects compounding over time. Many institutions, including the World Economic Forum and the European Commission, have recognized the link between the level of digitalization and economic development, and have published indices such as the Networked Readiness Index and the Digital Economy and Society Index to track the progress of nations on their path to full connectivity.[11]

Digital maturity raises the bar

For developed and developing economies alike, inclusive growth depends not simply on providing connectivity, but on providing what is termed "forward-looking access", or internet provision through networks with sufficient capacity, quality and speed to support more advanced usage. Consider the construction of road infrastructure in the United States and Europe. When highway systems were being developed in the middle of the last century, planners and engineers anticipated economic and population growth that was decades away, and typically constructed road systems that could accommodate significant increases in vehicular traffic.

For ICT infrastructure, it helps to think in terms of the rising levels of digital engagement embraced by all types of users – individuals, businesses and the public sector. An individual's use of the internet can encompass many characteristics depending on the user's skills, preferences, spending power and proximity to high-speed access. Current usage can be categorized into five distinct maturity levels, each characterized by what people do online and the skills their activities require, as well as by the minimum quality of service that allows them to carry out the activities (see Figure 1). While such levels can (and should) be distinguished by user type – i.e. individual, industrial, institutional and others – the focus, for the sake of simplicity, is on individual levels. Importantly, the boundaries, definitions and number of maturity levels are likely to shift as additional uses of the internet emerge over time.

Level One involves internet use in its most basic form and comprises the sorts of interactions most typically experienced by resource- or skill-constrained individuals. Online activities are usually limited to basic activity, such as simple web browsing, the use of social media and text-based communication. Internet interactions are generally short and often limited, owing to poor connections, problems of affordability, inadequate basic or technical skills, or lack of interest. Level One usage tends to be more prevalent in lower-income countries due to economic and infrastructural factors. However, it also exists worldwide in all regions and at all income levels, especially among new internet users and those not relying significantly on connectivity in their personal or professional lives.

While they still live primarily offline, **Level Two** users engage online in a manner that provides significant enrichment to their daily lives. Users typically have the means and skills to appreciate many of the internet's benefits, but they can also face some cost-, skill- or connectivity-related constraints. They have useful ways of incorporating the internet into their lives, including as entertainment, streaming media consumption, online shopping, app usage, and some professional applications such as online research and the routine use of simple web tools. Level Two is usually the minimum level at which individuals can use the internet for "supply-side" activities, for example selling online, renting out equipment or participating in the sharing economy.

Level Three usage applies to those relying on the internet for major aspects of their lives and careers. Usage patterns are characterized by near-constant and unconstrained connectivity, which users typically consider essential for both personal and professional reasons. These users are more likely to own multiple internet-enabled devices and use the web liberally for information, communication, entertainment and commerce. They embrace new internet-enabled technologies quickly, are likely to rely significantly on cloud storage, and can interact and collaborate online using a variety of platforms.

Still in its infancy, **Level Four** maturity involves a widening range of applications. Encompassing all the typical behaviours of Level Three, it also involves more advanced internet-based technologies (machine-to-machine connectivity, for example) and requires higher minimum bandwidth. It is characterized by an increased breadth of technologies and interconnected devices, including those associated with smart agriculture, smart transportation, smart homes and other technologies of the Fourth Industrial Revolution.[12] As of 2018, Level Four connectivity is mostly (though not exclusively) associated with businesses, but individual consumers in many regions are entering this maturity level rapidly as IoT connectivity becomes more widespread.

Figure 1: Overview of maturity levels

Note: D/L speed=download speed; U/L speed=upload speed; Gbps=gigabits per second; Kbps=kilobits per second; Mbps=megabits per second; ms=millisecond; MB=megabyte; GB=gigabyte; TB=terabyte; TVWS=TV white space
Source: The Boston Consulting Group estimates

	Level 1	Level 2	Level 3	Level 4	Level 5
D/L speed	512 Kbps	2-3 Mbps	25 Mbps	100 Mbps	1 Gbps
U/L speed	64 Kbps	512 Kbps	10 Mbps	100 Mbps	1 Gbps
Latency	1,000 ms	400 ms	100 ms	20 ms	10 ms (1 ms for select applications)
Monthly use	10-100 MB	500 MB	50 GB	200 GB	1 TB

Given the pace of internet-based technological innovation and the growth in intensity of data use, Level Four usage will soon give way to a new, as-yet-unrealized maturity level. As the Fourth Industrial Revolution advances, **Level Five** usage is expected to encompass a rapidly evolving set of applications that blur the lines between the physical, digital and biological worlds. The technologies driving Level Five maturity could include applications such as artificial intelligence, full-sensory virtual reality, holographic video conferencing and internet-enabled medical implants. At this maturity level, extremely high monthly data usage can be anticipated, for example 1 terabyte or more for an individual, as well as a host of activities requiring very high bandwidth.

Network ubiquity and reliability are critical factors for Levels Four and Five; any variation in service quality could have significant and sometimes dangerous consequences. In addition, the sheer volume of data carried by advanced networks, as well as the mission-critical nature of the applications they enable, raises significant issues of network security and data safety. A network outage or security breach in an era of autonomous cars, smart infrastructure, remote robotic medical instruments and internet-enabled medical implants could have disastrous and far-reaching effects (see the sidebar, "Rising internet security concerns").

Digital inequalities …

While the maturity model's more advanced levels anticipate emerging needs, the pace of change in technology and ICT connectivity clearly indicates that a future of more ubiquitous advanced maturity levels – and others beyond – is not far off. This emerging usage and its corresponding socio-economic impact are likely to disproportionately benefit societies that have the infrastructure in place to embrace it fully.

Not surprisingly, current disparities in ICT infrastructure correspond with broader economic inequalities. For example, in 2016, the penetration of fixed broadband was 30% in developed regions but only 8.2% and 0.8% in developing regions and least developed countries (LDCs), respectively.[13] While mobile coverage is better, similar disparities exist: 82% of the world's population lived within range of a 3G signal in 2015, but approximately 60% of the people in LDCs did.[14] Networks providing 4G connectivity reach 62% of the world's population, but only 24% of the population in LDCs (see Figure 2).[15]

Disparities in network coverage also support the divide in internet use;[16] the compounding impact on GDP growth further exacerbates existing economic inequalities between developed and developing nations. As the recent work by the World Economic Forum on the Fourth Industrial Revolution divide has made clear, populations and businesses that lack advanced connectivity will be increasingly disadvantaged as new internet-based technologies become more widespread in developed countries.[17] As Level Five access and usage increases over time, the public, private and civic sectors must work to ensure that the right infrastructure is implemented as a critical matter of economic development, international justice and even human rights.

… And high costs

Currently, the problem is that advanced connectivity means high infrastructure costs, which can vary widely depending on multiple factors such as the type of network selected for implementation, labour, regulation, population density and topology. The cost of fibre-to-the-home (FTTH) architecture, for example, varies widely in different contexts. The Organisation for Economic Co-operation and Development (OECD) found recently that high urban density in South Korea leads to a relatively low installation cost of $110 to $170 per home, whereas worldwide averages exceed $1,000 per home.[18] Though costs have been declining and some new, more cost-efficient technologies have emerged – network virtualization of radio access networks, the use of open-source interfaces, among others[19] – these have not yet been widely embraced by most network operators.

Figure 2: Proportion of population covered by a mobile network, by technology and region (2015)

Source: ITU. "Indicator 9.c.1: Proportion of population covered by a mobile network, by technology". Accessed via UN Statistics, https://unstats.un.org/sdgs/

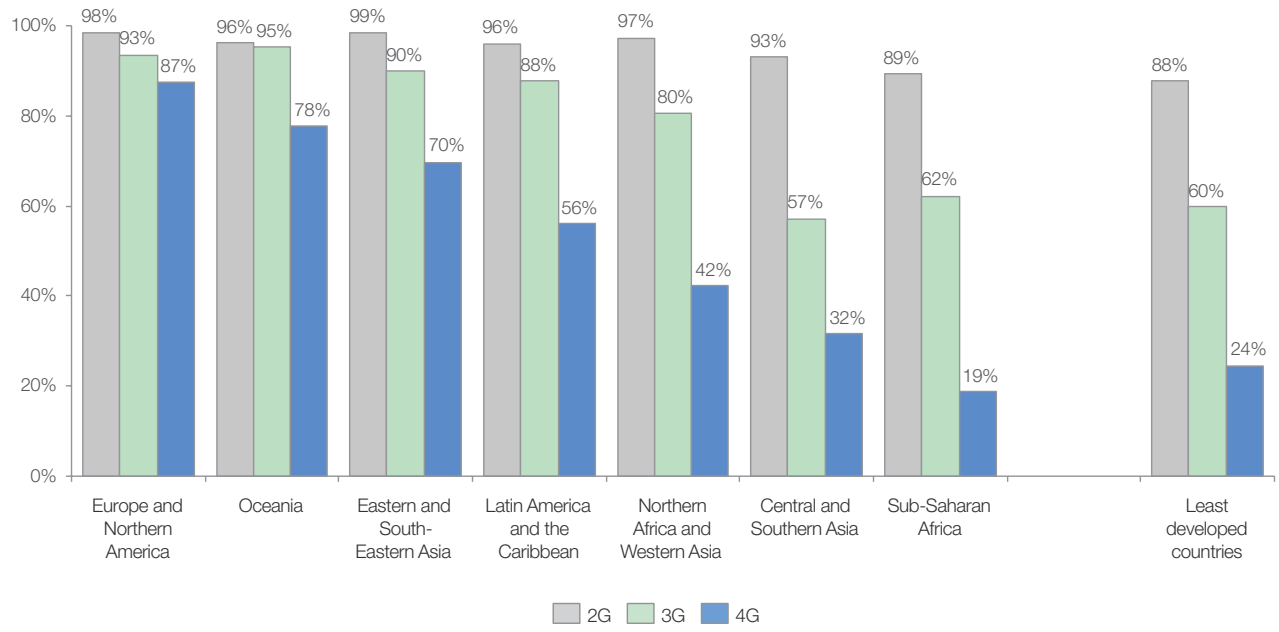
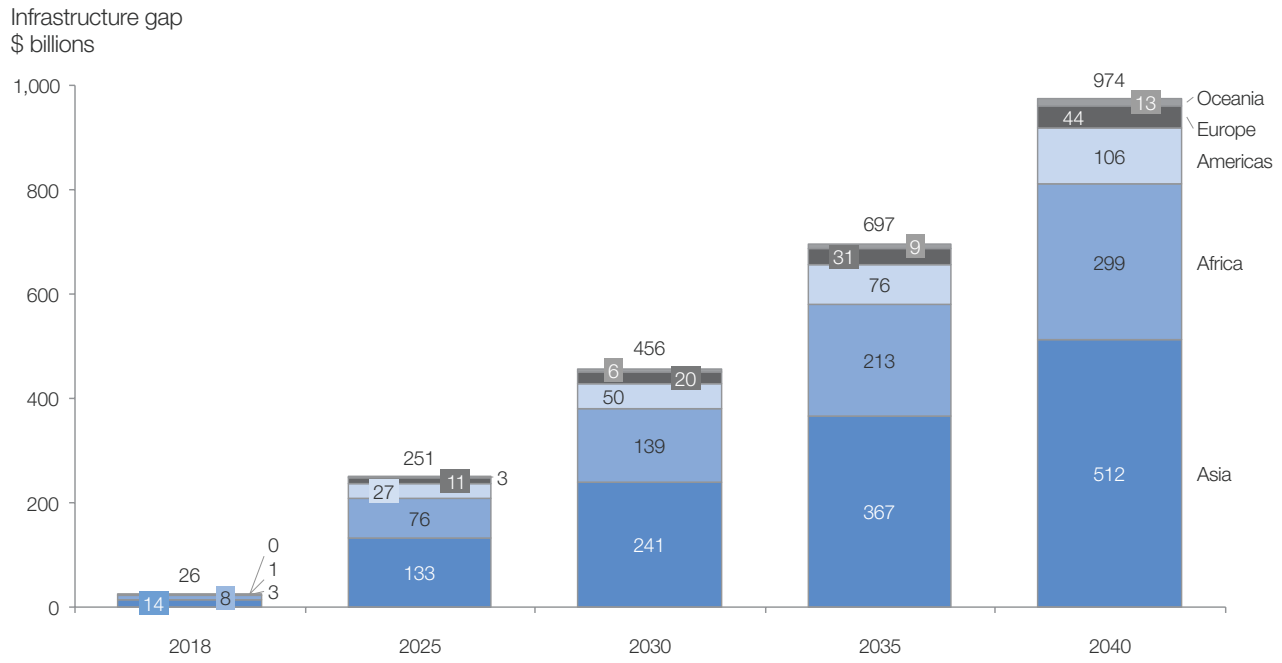


Figure 3: ICT infrastructure gap to reach nearly $1 trillion by 2040, with biggest divides in Africa and Asia

Note: The infrastructure gap is defined as the difference between projected ICT infrastructure stock and projected ICT infrastructure need. Projected ICT infrastructure stock is developed by first calculating current ICT infrastructure stock at the national level through a perpetual inventory approach using data on gross fixed capital formation (GFCF) in ICT, then projecting future GFCF based on a model that includes economic growth, population growth and stated government commitments. Projected ICT infrastructure need is defined as the level of infrastructure that would bring a country's infrastructure stock equal with its best performing peer. Peer groups are defined by GDP/capita, and "best performing" is defined as 75th percentile of countries in the peer group. More detail on the methodology can be found at https://s3-ap-southeast-2.amazonaws.com/global-infrastructure-outlook/Global+Infrastructure+Outlook+-+24+July+2017.pdf.

Sources: Global Infrastructure Outlook (G20 Initiative); Oxford Economics



Take the European Union (EU) as an example. The Boston Consulting Group (BCG) estimates that closing the infrastructure gap and bringing the EU's existing ICT infrastructure to a level that supports forward-looking maturity usage (i.e. minimum bandwidth of 100 megabits per second [Mbps]) would require an investment of approximately $320 billion.[20] On a global level, the G20's Global Infrastructure Hub estimates a funding shortfall of nearly $1 trillion for ICT infrastructure by 2040 (see Figure 3).[21] The GSM Association (GSMA) has estimated that meeting fast-rising mobile traffic demand in the world's major cities by 2025 will require network operators to at least double, and in some cases triple, their capital and operating expenditures,[22] a level of investment that is not financially feasible.

As quoted in GSMA and BCG (2018):

> While data traffic growth soars, the business case for network operators to invest in upgrading mobile networks is weak because operators have only a small share in the value of the projected traffic growth. Revenues for network operators depend on multiple factors, for example, consumer purchasing power, competition intensity, the quality of mobile networks and regulatory frameworks. In terms of new unique users, developed markets are mostly saturated. Subscriber numbers in emerging markets are still growing, but at low average revenue per user (ARPU) levels.[23]

Ovum research indicates that mobile ARPU has declined worldwide in all regions for years, even with the exponential growth in data volumes.[24,25]

However, taking a broader view of the return on investment and considering the associated socio-economic benefits derived from increased high-quality internet access reveals that the economic growth resulting from forward-looking infrastructure improvement exceeds the required investment in a surprisingly short period (see Figure 4). The analysis of 28 countries currently in the EU[26] shows that the returns to society in the form of GDP growth exceed any infrastructure-related capital expense in a period of 7-18 months, so long as the full economic benefits to society are considered. Moreover, the magnitude of the payback can be dramatic. An investment of $2.7 billion in Ireland to enable Level Three usage nationally would lead to an uplift in GDP of between $3.9 billion and $10.2 billion, with a theoretical payback in less than one year. In Germany, the GDP increase from a $47.3 billion investment in ICT infrastructure would be between $47.5 billion and $86.5 billion, and would theoretically be realized in six months to one year.[27]
The massive potential for economic growth and development all but demands a rethinking of the financing model for ICT infrastructure investment. New projects, such as upgrading existing infrastructure, might be hard to justify based on the business case for a network operator. But the broader economic and social benefit – and short payback period – should encourage other types of players to get involved. This idea is explored in the rest of this paper.

Figure 4: Sizing the benefits of expanded and upgraded ICT infrastructure in the EU

Note: B=billion
Source: The Boston Consulting Group calculations, based on a proprietary methodology using proprietary, subscription and publicly available data from Eurostat, International Telecommunication Union, United Nations, World Bank and Gartner, among others

Country	Population split by maturity level (%)	Approx. infrastructure investment required [1]	GDP uplift from infra. investment	Time for GDP uplift to exceed infra. investment
Luxembourg		$0.2 B	$0.3 B - $0.6 B	0.4 - 0.8 years
Denmark		$2.5 B	$1.8 B - $3.4 B	0.7 - 1.4 years
UK		$41.9 B	$32.1 B - $49.8 B	0.8 - 1.3 years
Netherlands		$1.4 B	$9.5 B - $13.6 B	0.1 - 0.2 years
Sweden		$5.6 B	$6.9 B - $10.0 B	0.6 - 0.8 years
Estonia		$0.8 B	$0.3 B - $0.5 B	1.6 - 2.7 years
Germany		$47.3 B	$47.5 B - $86.5 B	0.5 - 1 years
Finland		$3.9 B	$3.2 B - $6.2 B	0.6 - 1.2 years
Belgium		$1.7 B	$6.3 B - $12.7 B	0.1 - 0.3 years
France		$55.5 B	$33.7 B - $71.7 B	0.8 - 1.6 years
Austria		$6.2 B	$5.2 B - $11.3 B	0.6 - 1.2 years
Ireland		$2.7 B	$3.9 B - $10.2 B	0.3 - 0.7 years
Latvia		$0.6 B	$0.4 B - $1.0 B	0.6 - 1.6 years
Spain		$28.8 B	$16.3 B - $44.7 B	0.6 - 1.8 years

Non-user Level 1 Level 2 Level 3 Level 4

1. Estimated infrastructure investment required to enable nationwide Level 4 use.

Country	Population split by maturity level (%)	Approx. infrastructure investment required [1]	GDP uplift from infra. investment	Time for GDP uplift to exceed infra. investment
Luxembourg		$0.2 B	$0.3 B - $0.6 B	0.4 - 0.8 years
Denmark		$2.5 B	$1.8 B - $3.4 B	0.7 - 1.4 years
UK		$41.9 B	$32.1 B - $49.8 B	0.8 - 1.3 years
Netherlands		$1.4 B	$9.5 B - $13.6 B	0.1 - 0.2 years
Sweden		$5.6 B	$6.9 B - $10.0 B	0.6 - 0.8 years
Estonia		$0.8 B	$0.3 B - $0.5 B	1.6 - 2.7 years
Germany		$47.3 B	$47.5 B - $86.5 B	0.5 - 1 years
Finland		$3.9 B	$3.2 B - $6.2 B	0.6 - 1.2 years
Belgium		$1.7 B	$6.3 B - $12.7 B	0.1 - 0.3 years
France		$55.5 B	$33.7 B - $71.7 B	0.8 - 1.6 years
Austria		$6.2 B	$5.2 B - $11.3 B	0.6 - 1.2 years
Ireland		$2.7 B	$3.9 B - $10.2 B	0.3 - 0.7 years
Latvia		$0.6 B	$0.4 B - $1.0 B	0.6 - 1.6 years
Spain		$28.8 B	$16.3 B - $44.7 B	0.6 - 1.8 years

Non-user Level 1 Level 2 Level 3 Level 4

1. Estimated infrastructure investment required to enable nationwide Level 4 use.

Sidebar: Connectivity technologies for a New Age

As consumer and business internet usage climbs the maturity curve, the importance of network capacity and quality rises as well. Though emerging technologies can leverage other types of infrastructure to obtain superfast speeds (e.g. G.fast targets speeds of up to 1 GB per second on copper cable over short loops),[28] fibre-optic cable remains the only practical option accounting for uses of the internet that will emerge in Level 5.

Wireless infrastructure is in a similar situation. While current fourth-generation long-term evolution (4G LTE) connections can reach download speeds of up to 50 Mbps,[29] this is insufficient for technologies that require high bandwidth and extremely low latency, such as self-driving cars. These applications require next-generation connectivity (commonly known as 5G) – namely, technology not yet rolled out in any mass market.

The technological requirements for each maturity level are summarized as follows:

- **Level 5**: This maturity level is for the future. Currently, only fibre (wireline) and 5G (wireless) infrastructure will provide the speed, bandwidth, and low latencies required for advanced technologies, such as Industry 4.0 and the IoT.

- **Level 4**: While fibre is still the optimal wireline technology, hybrid fibre-coaxial cables will substantially suffice for Level 4. For mobile, 4.5G connectivity is sufficient. While some technologies (e.g. G.fast) may provide the required last-mile bandwidth in copper cables, such solutions have inherent limitations and should not be considered for greenfield projects involving new infrastructure. They are liable to reach their limits under the demands of more advanced usage.

- **Level 3 and below**: Older technologies, such as copper for wireline and 3G and 4G technology for wireless, can support usage at these maturity levels. However, such technologies limit usage's ability to advance to Levels 4 and 5.

Unfortunately, the more capable a technology, the more expensive it is to deploy, generally speaking. While upgrading mobile technology from 2G and 3G to 4G is relatively inexpensive (making use of the same network of cell towers, for instance), advancing to 5G will require a massive deployment of small cells to handle the exponential volume of data traffic and meet the quality and reliability standards of advanced applications.

For last-mile wireline technology, the deployment costs of copper and fibre cable at greenfield sites – for example, premises that as yet have no connectivity infrastructure – are largely equivalent. However, significant cost differences emerge at brownfield sites, which already have some variety of infrastructure and in most instances either copper or coaxial cables. In such circumstances, it may be cost-effective to pursue fibre-to-the-node (FTTN) solutions, in which fibre infrastructure extends to neighbourhood distribution points, and individual premises are thereafter connected using slight upgrades to existing cable. While these solutions may leverage G.fast technology to achieve ultrafast connection speeds, they likely will not support Level 5 technologies. This raises the question of whether it makes more sense financially to upgrade directly to fibre-to-the-premises (FTTP) solutions. In the United Kingdom, the relative costs and benefits of such questions are explored in some detail in a 2015 paper by British charity Nesta,[30] which cites a WIK-Consult estimate that 40% of UK internet usage will rely on 1 Gbps+ connectivity by 2025.[31]

Regardless, the implication is clear: To the extent possible, greenfield connections should prioritize the highest possible level of connectivity. As shown elsewhere in this paper, an investment in high-quality infrastructure will quickly generate more than sufficient paybacks to justify added expense. Replacing existing copper connections, particularly in the last 100 metres, may not be achievable given cost constraints. In these situations, stakeholders should investigate the best possible technologies to maximize existing infrastructure (e.g. G.fast on copper) and look to upgrade existing last-100-metre infrastructure over time, as permitted by rising maturity usage demands and economic considerations.

Sidebar: Rising internet security concerns[32]

The rapid rise in digital connectivity and usage brings with it a corresponding rise in digital security concerns. As people become increasingly dependent on digital data, any risk to that data poses a corresponding risk to society. As new services and applications are developed, the threats become more diverse and more sophisticated. Moreover, they can lead to more damage in both the virtual realm and the physical world.

Most discussions of cybersecurity focus on "data at rest" – namely, data stored on computers and servers. Much of the media coverage of cyberattacks to date has focused on data breaches and identity theft. For instance, the Equifax credit bureau breach in the United States compromised the personal and financial data of 150 million Americans, and the North Korean attack, exposing sensitive corporate email at a leading Hollywood film studio, rightly attracted much attention.

But just as critical from an overall perspective on threat is the security of "data in motion". Protecting data as it travels over networks requires a consideration of three aspects of cybersecurity: data confidentiality, data integrity, and network and device security. If all three aspects are not addressed, trust in online services – whether social media, cloud services, online banking, videoconferencing or ordinary email – will be undermined, discouraging investment in new infrastructure and new services.

The best basis for data confidentiality is strong, widely-deployed encryption. Fortunately, progress is being made in this area. According to Mozilla, by the start of 2017, more than half of all data transmitted over the internet used hypertext transfer protocol secure (HTTPS) encryption.[33] Protecting the integrity of data in transit and ensuring that every email and every bit sent is delivered to its intended recipient are bigger challenges. In recent years, both accidental and malicious diversions of traffic have increased. Here again, progress is being made, though only slowly. More secure routing protocols are needed to prevent the hijacking of data.

Network and device security, the third part of the cybersecurity triad, has received more attention thanks to some well-documented attacks. One was the October 2016 Mirai botnet attacks, in which more than 100,000 closed-circuit TV cameras were used to overwhelm critical internet services depended upon by hundreds of websites.[34] A few weeks later, a similar attack almost forced the entire country of Liberia offline.[35] These attacks highlight the growing threats posed by the IoT. Fortunately, internet service providers (ISPs) and web security firms are developing powerful and easy-to-use services for identifying and blocking traffic from botnets. Until recently this filtering function required expensive hardware, but more and more is being done by software running in the cloud.

Solution providers and enterprises face important trade-offs in cost, speed, ease-of-use and access restrictions as they try to manage a complex landscape of legal, corporate and governmental stakeholders. Collaboration is paramount to ensure practical and up-to-date solutions are in place.

The financing landscape for information and communications technology[36]

From a financing perspective, ICT infrastructure differs in important ways from other types of infrastructure, such as transport or water and sewage. The most significant is the relative extent of private- and public-sector involvement. Most ICT infrastructure financing has traditionally come from private-sector companies, namely network operators, ISPs and tower builders, who are motivated to make often substantial investments based on the prospect of commercial return. Governments and multilateral players, such as development banks, have played a relatively minor role, especially compared to the scale of their investment in other infrastructure sectors. This is due in part to a persistent perception that providing internet connectivity is the private sector's responsibility.[37]

A second significant reason, which is closely related to the first, is that investors consider other types of infrastructure as "asset classes". In other words, well-established markets and vehicles for capital look to support (and earn a return from) multiple types of infrastructure projects. Similar markets and vehicles have not developed in the ICT sector because of the dominant role of industry players.

That said, several types of potential funders are at work (see Figure 5).

Private-sector capital providers

Industrial private-sector capital providers include network operators, ISPs, tower builders and others, such as satellite companies. Network operators in particular face big challenges. To keep up with growing traffic demand, they need to replace their legacy 2G and 3G technology with at least 4G capability in emerging markets and to manage the transition to developing and deploying next-generation, high-quality broadband infrastructure in developed countries. Deploying new technologies is costly and includes not only the costs of infrastructure materials and labour, but also a range of additional costs, from regulatory expenses (e.g. spectrum licences) to operating expenses (e.g. power). While a formal analysis of such costs is beyond the scope of this paper, their magnitude limits the degree to which operators can reconfigure their networks. At the same time, current policies and regulations undermine the incentive to invest. Developed markets, where saturation rates are high, have very few unconnected regions. While subscriber numbers in emerging markets are still growing, and while data use per person continues to grow worldwide, ARPU levels are declining.[38] The result is a lack of incentive to invest beyond the markets with the most promising business cases, in both developed and developing regions.

Figure 5: Entities providing ICT financing

Note: MNO=mobile network operator; ISP=internet service provider; VC=venture capital; PE=private equity; NGO=non-governmental organization; USF=universal service fund; IRR=internal rate of return.
Source: The Boston Consulting Group trend analysis

A wide variety of funding sources currently operate** within the ICT infrastructure funding space, underscoring a baseline interest in funding connectivity and, broadly, a general availability of funds. However, the **vast majority of ICT connectivity infrastructure funding has traditionally come from private-sector ICT companies.

	Actors	Examples	Notes	Objectives	Risk appetite
Private sector	Industry	MNOs/ISPs/Tower companies	• **Vast majority of funding** & "front line" of profitable investment	• Provide connectivity for profit	Low
Private sector	Financial sector	Investment & commercial banks	• **Willingness to invest is often complicated** by concerns over competing infrastructure networks, uncertainty around technological developments, and the belief that investment is the responsibility of MNOs and ISPs	• Provide financing and capital for profit	Low
Private sector	Financial sector	Private investment firms (pensions, VC, PE, etc.)		• Grow capital for profitability • Diversify portfolio	Low
Private sector	Other private sector	Technology firms Other sectorial firms		• Expand customer base • Invest for business sustainability	Low-Medium
Private sector	Non-profit	Foundation/NGOs	• **Longer-term investment horizons**, enabling investment in lower-IRR projects that do not meet objectives of other investors	• Develop philanthropy by addressing inequalities	Medium-High
Public sector	Multilateral	Multilateral development bank/Fund	• Investment usually **motivated by national interest**, with social and development outcomes prioritized alongside (or above) economic profitability • Funds can be **combined with private-sector** money to mitigate some kinds of investment risk and improve investment climate	• Provide financing to foster long-term economic development	High
Public sector	Public sector	Sovereign wealth fund		• Create long-term value for investors by driving sustained economic development	Medium
Public sector	Public sector	USFs		• Expand connectivity in underserved areas through subsidies and fees	High
Public sector	Public sector	National development bank/Fund		• Provide financing to foster national long-term economic development	High

As one of many examples, the World Bank has estimated that 40% of Moroccans do not have high-speed internet access because the cost of extending infrastructure to remote or sparsely populated areas is unprofitable to mobile network operators without significant cost reductions or government interventions.[39]

Other private-sector investors, such as banks, private investment firms and technology companies looking to expanding their customer bases, can have longer-term investment horizons supporting their investment in lower-return projects that do not meet the financial objectives of network operators. However, their willingness to finance ICT infrastructure is often complicated by concerns over competing networks and uncertainty regarding technological developments that may threaten their investments' long-term relevance. Many private-sector investors in infrastructure exclude ICT infrastructure from their portfolios, considering it overly complex and largely the domain of network operators and ISPs. Even those that do make infrastructure investments will often not invest in expanding infrastructure beyond core population centres, unless they see significant support from public-sector or international funds.

Public-sector and international capital providers

Public-sector capital providers include governments, sovereign wealth funds, universal service funds (USFs), and multilateral development banks and funds such as the World Bank. Some foundations and non-governmental organizations (NGOs) are also active but often have a more limited mandate because of donor restrictions or impact objectives. They also typically lack the wherewithal to invest at the same scale represented by public and multilateral actors. Many sources of public-sector capital are not required to be paid back.

Governments and sovereign wealth funds in developed countries typically have low or no involvement in ICT infrastructure investment. The reasons for this notably include a tendency to view internet access and provision as a strictly private-sector activity rather than a public right. Some public-sector entities have also noted that their procurement requirements, which can add months or even years to project timelines, are at odds with the rapid speed of progress among ICT technologies and, therefore, undermine the suitability of public investment processes for ICT infrastructure projects.

In the United States, for example, the public sector's share of ICT infrastructure investments is nearly zero, while the share of public investment in transportation and water and sewage infrastructure is about 90%.[40] Governments in some emerging markets are more open to using public money to further national ICT goals, which affect economic and social development. They look for opportunities to collaborate with private-sector capital providers to mitigate investment risk and improve the investment climate. The World Economic Forum 2017 White Paper, "Internet for All: An Investment Framework for Digital Adoption", describes a variety of approaches that the public and private sectors can use to help finance ICT infrastructure investment in Africa's Northern Corridor countries.[41]

USFs, set up by governments to address gaps in coverage that cannot be served by the private sector alone, serve a valuable function in theory. Under their arrangements, government subsidies and operator fees (which are typically passed on to consumers) are aggregated over time to pay for infrastructure expansion and other internet access requirements in areas that are sparsely populated, topologically challenging or difficult to serve. In practice, however, studies by the GSMA,[42] the International Telecommunication Union[43] and others have shown that the application of USFs has been remarkably incongruous with their stated intentions. For example, more than half of global funds collected by USFs have not been used, and fully one-third of all funds worldwide have not distributed any of their assets. Despite some notable success stories (e.g. Colombia), many more USFs suffer from inadequate underlying legal frameworks or ineffective administration, problems that hinder the application of their principles and purpose.

Multilateral development banks frequently provide financing to foster long-term economic development, but recent analysis by Xalam Analytics, prepared for the Alliance for Affordable Internet and the World Wide Web Foundation, indicates that their investments in the ICT sector in low- to middle-income countries represented only 1% of their total investments between 2012 and 2016. The analysis also presents recent survey data indicating that these organizations view ICT sector capital requirements to be adequately covered by private sources of capital – an attitude that also resonates with many public-sector officials.

NGOs tend to view connectivity as less of a financial investment and more of a social need, enabling the funding of lower-return projects that do not meet the objectives of other investors. Furthering connectivity is also consistent with their goals of using philanthropy to address inequalities. But project-by-project funding by NGOs tends to be relatively small compared to that of public and private actors.

Other factors

Despite multiple potential sources of funds, the flow of capital towards infrastructure projects has been limited. The lack of development of ICT infrastructure as an asset class plays a role, but other factors also conspire to limit investment (see Figure 6).

While each constraining factor affects financing categories in some way, the private sector is disproportionately hamstrung, with market, risk mitigation and partnership factors posing the most far-reaching disincentives to broader investment.

Figure 6: Six factors constraining the flow of capital towards infrastructure projects

Source: The Boston Consulting Group analysis

Market factors	Risk mitigation factors	Partnership factors	Project factors	Regulatory factors	Sourcing factors
Elements of **competition from operators and infrastructure providers**, as well as concerns over **consumer adoption and willingness to pay**	Concerns that existing means of **mitigation are inadequate and complex**, and are often derived from a lack of available market and investment research	Perception that partnership models of infrastructure finance are **overly complex and of limited financial benefit**	**Inadequate project preparation, small project size and lack of comfort** with alternative technologies	Areas of **spectrum policies, pricing barriers and regulatory uncertainty**	**Project obscurity and the lack of a conventional pipeline** for surfacing ICT infrastructure projects

A broadened perspective

Like most companies, network operators focus on the returns they generate for their owners, and they evaluate projects based on this standard. For understandable reasons, this calculation has typically taken into account relatively narrow financial criteria and has not considered broader public returns (GDP growth, job creation and improvements in social outcomes).

However, corporate leaders are re-evaluating business's role in society. As quoted in Beal, Douglas, et al. (2017):

> Several trends are behind [this] shift. First, stakeholders, including employees, customers, and governments, are pressuring companies to play a more prominent role in addressing critical challenges such as economic inclusion and climate change. In particular, achieving the UN's Sustainable Development Goals (SDGs) will not be possible without the private sector's involvement. Second, investors are also increasingly focusing on companies' social and environmental practices as evidence mounts that performance in these areas affects returns over the long term. Third, standards are being developed for which environmental, social, and governance (commonly referred to as ESG) topics are financially material by industry, and data on company performance in these areas is becoming more available and reliable, increasing transparency and drawing more scrutiny from investors and others.[45]
>
> As these trends gain momentum, companies need to add a lens to strategy setting, one that considers what we call total societal impact. [See box, "Total societal impact".] TSI is the total benefit to society from a company's products, services, operations, core capabilities, and activities … The most powerful – and most challenging – way to enhance TSI is to leverage the core business, an approach that yields scalable and sustainable initiatives. If well executed, this approach enhances TSR [total shareholder return] over the long term by reducing the risk of negative events and opening up new opportunities.[46]

For network operators and other private-sector investors, this approach points to the potential for increased long-term profit in conjunction with investment in broader socio-economic gains.

Box: Total societal impact

Recent work by BCG on corporate performance and companies' total societal impact (TSI) finds that increasing a company's focus on nonfinancial factors, such as ESG metrics, has a statistically significant impact on valuations and margins, two key drivers of TSR.

The increased focus on TSI, and the link between TSI and TSR, result from several converging trends. First, multiple stakeholders increasingly expect companies to play a more active role in addressing social and environmental issues. Second, the investment community is ever more focused on companies' social and environmental performance with socially responsible investing on the rise. This shift represents an opportunity for network operators and other private-sector investors to consider a project's broader societal impact when conducting the investment analysis. The potential benefits include:

- **Strengthening the brand and increasing customer attraction**. Companies known for their commitment to positive social impact can inspire costumers' loyalty and trust in their markets. This can translate to increased sales, reduced costs for customer acquisition and reduced customer attrition, which in turn result in improved profitability.
- **Gaining an advantage in attracting and retaining talent**. A strong track record in TSI can energize the workforce and give a company an edge in the ongoing need to attract, engage and retain talent.
- **Spurring innovation**. Companies that adopt a TSI lens often identify new and innovative solutions to challenges they might have otherwise ignored. These innovations, such as new technology needed to reach underserved communities, can affect existing markets and result in future competitive advantages in core markets.

The key implication of BCG's findings for network operators and other private-sector investors is that they should not base decisions on whether to participate in projects solely on traditional measures of profitability. Instead, they should aim to participate where the core business can be leveraged to achieve maximum societal impact, knowing that such a strategy could potentially increase long-term TSR in conjunction with investment in broader socio-economic gains.

Expanding the case for ICT infrastructure financing

Meeting the global need for advanced network infrastructure requires collaboration among the sources of financing and development of new financing models that account for returns on investment beyond simple business cases. In most developed and emerging markets, the public sector must improve the attractiveness of ICT investments. The public and private sectors also can work together to increase the use of blended financing and attract additional types of investors (see Figure 7).

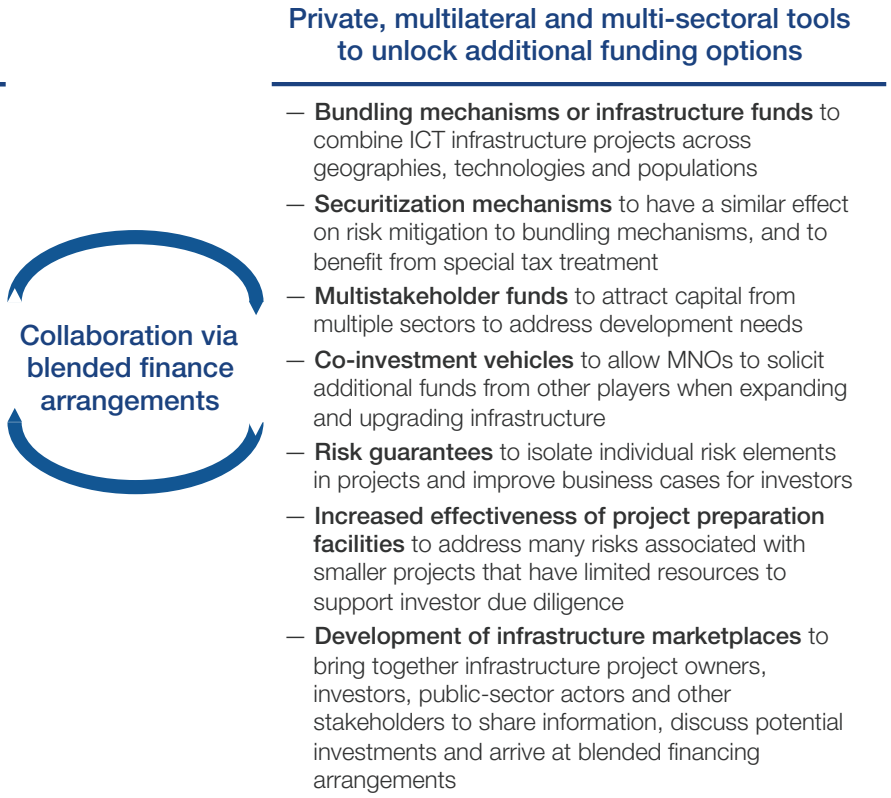
Public-sector actions

In addition to actions to stimulate demand for more bandwidth (the subject of previous Internet for All reports,[47] such as reducing taxes on smartphones, increasing relevant content online, investing in skill building and prioritizing infrastructure access to schools and clinics), governments can also implement policies and regulatory reform that create more favourable environments for infrastructure project owners and investors.

- Implementing "dig once" policies that apply to all types of network infrastructure reduces overall costs per connection and allows funders to bundle investments across different types of infrastructure. World Bank research shows that laying ducts for future installation of cables along another infrastructure project adds less than 1% to a project's cost and eliminates the need to dig new trenches, one of the biggest costs of new fixed-line infrastructure.[48]
- Reworking tax policies to incentivize investment and reduce financial burdens for those willing to invest in infrastructure expansion and improvement can help attract new capital. For example, Rwanda revised its tax code in 2015 to provide investors with a seven-year tax holiday if they invest more than $50 million in projects in ICT and other sectors.[49] As with spectrum sales, governments need to balance revenue considerations with providing incentives to private-sector players.
- Providing anchor tenancies to infrastructure expansion, such as a commitment to use a minimum amount of data capacity in schools, government offices and other public facilities, can help incentivize infrastructure investment and improve the business case for private investors.
- Releasing new spectrum in a timely and affordable manner, rather than trying to maximize short-term government revenues from high-priced spectrum auctions, enables MNOs to expand network capacity without constructing new infrastructure. Repurposing unused or underused spectrum for mobile use and allowing spectrum sharing can also help alleviate capacity bottlenecks.

Figure 7: Summary of recommendations

Source: The Boston Consulting Group analysis



- Incentivizing increasingly important small cell deployment can help expand network capacity in urban areas where traffic is growing fast. However, small cell deployment is also subject to many constraints, a number of them regulatory. Governments can facilitate and incentivize small cell installation by, for example, providing access to site locations (such as on municipal property, including bus shelters and lamp posts) at low or no cost, speeding bureaucratic approval processes and allowing mobile operators to pursue small cell sharing agreements. The GSMA has estimated that a package of reforms including timely spectrum release and steps to facilitate small cell deployment, among other things, could reduce infrastructure costs for network operators in urban areas by 30-50%.[50]

- Promoting the establishment of internet exchange points (IXPs) – the infrastructure through which ISPs and content providers exchange traffic – can further affordable and fair internet interconnections. For customers in many developing markets who use networks of different companies, the lack of IXPs means that traffic between locations 50 or 100 km apart might have to be routed through countries thousands of miles away. This drastically increases both latency and costs.

Other initiatives

Public- and private-sector players can attract more financing to ICT infrastructure projects in a number of ways. Some require public-private collaboration, while others use vehicles that have demonstrated success in other industries or in targeting new types of funders.

Blended financing

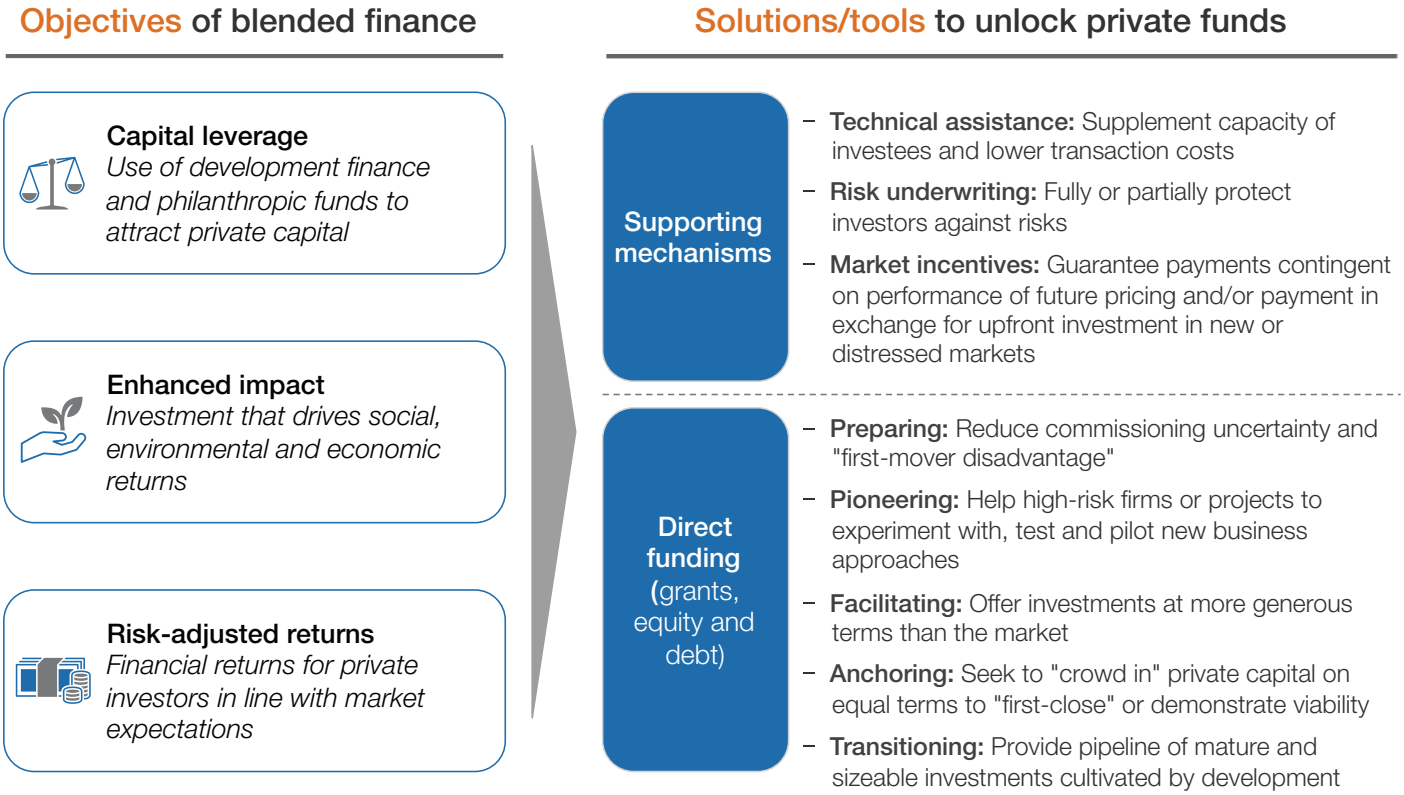
Foremost among the opportunities for public- and private-sector collaboration is the increased use of blended financing arrangements to reduce private investment risks and attract more capital to infrastructure investments that serve a public need. These arrangements help investors overcome many of the barriers to financing rural development projects, including low returns relative to risk (real or perceived); inadequate or inefficient local markets; and lack of knowledge, experience and investment scope among private investors.

The World Economic Forum and the OECD describe blended finance as "the strategic use of development finance and philanthropic funds to mobilize private capital flows to emerging and frontier markets".[51] It typically tries to do three things:

- Use development finance and philanthropic funds to attract private capital

Figure 8: Blended finance – The strategic use of development finance and philanthropic funds to attract private capital flow

Source: Information from World Economic Forum and OECD. *A How-To Guide for Blended Finance: A practical guide for Development Finance and Philanthropic Funders to integrate Blended Finance best practices into their organizations*, September 2016



- Direct money to investments that drive social, environmental and economic returns
- Provide financial returns for private investors that are in line with market expectations (see Figure 8)

Such blended financing can be used to advance infrastructure development and address investment barriers across multiple stages of project and/or market maturity:[52]

- Preparing: Reducing investment uncertainty for pre-commissioned projects owing to unclear market conditions, an uncertain regulatory environment or questions over project viability
- Pioneering initiatives: Reducing project risks and investor uncertainty when a project experiments with new business models or technologies
- Facilitating growth: Providing growth capital on more generous terms than private-sector markets to projects operating in conditions that do not provide attractive business cases for private investors
- Anchoring for expansion: Completing financing needs for established enterprises by providing growth capital at market rates to fill gaps not met by other funders or investors
- Transitioning: Providing a pipeline of mature investment opportunities to investors and other funders looking to deploy capital at scale

Project bundling

ICT infrastructure projects can be bundled into dedicated investment vehicles or funds that reduce exposure to individual risks of geography or technology and enable smaller projects to attract capital from larger investors. The use of dedicated infrastructure funds has been increasing since their creation in the 1990s, when they were often publicly listed. However, their use in ICT has been limited. For example, only 3% of all deals undertaken by infrastructure funds in Asia from 2010 through 2015 involved telecommunications, compared with 44% involving energy, 22% utilities and 16% transportation.[53]

Securitization mechanisms

Securitization mechanisms, such as social bonds, have a similar risk mitigation effect as bundling mechanisms, and are often given advantageous tax treatment by governments because of their positive social impact. The International Finance Corporation's (IFC) Social Bond Program is one example. The IFC, part of the World Bank Group, collects money from investors through the bond issue and invests in eligible projects through financial intermediaries. Over its fiscal years 2015 and 2016, the IFC invested $255 million in the telecommunications, media and technology sector, accounting for 12% of programme commitments.[54] ICT projects received two-thirds of this money, or more than $200 million. Representative projects have included a $30 million loan commitment to Indigo Tajik in Tajikistan, where the operator is seeking to upgrade its network to increase accessibility and affordability in remote populated regions, and a $66 million loan commitment to Robi Axiata in Bangladesh, where the company aims to upgrade its 3G network and support expansion in rural areas.[55]

Multistakeholder funds

Infrastructure investment can also come from financing vehicles involving multiple parties across sectors. The European Commission, together with the European Investment Bank, has launched a project bond initiative to raise capital for large infrastructure projects in the ICT, transportation and energy sectors. The goal is to help infrastructure projects attract institutional investors, such as insurance companies and pension funds, by providing the projects with credit enhancement in the form of senior debt. The first ICT-related issue, which received €189 million, was managed by Natixis for Axione Infrastructures in France and involved extending superfast broadband coverage in the country's rural areas.[56] Other examples include the Global Fund, an international financing organization started with seed capital from the Bill & Melinda Gates Foundation and originally targeting global health needs, which is being considered as a model for addressing other Sustainable Development Goals.[57]

Co-investment vehicles

These mechanisms allow network operators to solicit funds from other players when expanding and upgrading infrastructure, which attracts financing and diversifies risk. For instance, the Mobile Solutions Technical Assistance and Research project, funded by the U.S. Agency for International Development (USAID), offers a service that helps network operators attract project-based co-investment from other entities without regard to sector, but specifically favouring private-sector investment.[58]

Risk guarantees

Another model involves risk guarantees (also known as loss guarantee schemes), either on their own or as part of broader blended finance arrangements. Risk guarantees have been shown to address major risk elements that inhibit private investors, enabling capital to flow more directly to underserved regions and populations.

The use of risk guarantees in blended financing arrangements can be facilitated by making benchmarks on costs associated with infrastructure projects publicly available and thus demystifying the process for capital providers, and by sharing success stories to promote best practices and models for cooperation (see the sidebar, "Using demographic and technical analyses to encourage investment in rural areas"). The ICT Financing Partners Platform, currently being developed by the World Economic Forum in partnership with USAID, aims at building such mechanisms. Further details are available in the appendix.

Infrastructure marketplaces

Infrastructure marketplaces, such as the Sustainable Development Investment Partnership (SDIP) run by the World Economic Forum and the OECD, bring together infrastructure project owners, investors, public-sector actors and other stakeholders to share information, discuss potential investments and arrive at blended financing arrangements for projects that have a demonstrated impact.[59] Though such marketplaces have gained traction for transportation and energy infrastructure projects, they have yet to expand into ICT.

The role of project preparation

Increasing the effectiveness of project preparation facilities, which are supported by a variety of multilateral, public, non-profit and/or private capital, can address many risks linked to smaller projects with limited resources. Standardizing contractual terms, risk assessment and documentation across and within countries can ease the due-diligence process, which can constrain private investors because of limited access to information and high costs.

Project preparation consists of developing feasibility studies (e.g. demand analysis, viability, financial modelling, site suitability) and building the business case for an infrastructure project before it solicits financing. These activities are typically funded and carried out by external entities, such as development finance institutions, public-sector development agencies and NGOs. Project preparation improves the ability of project owners to attract funding and potential funders to evaluate projects.

While interest-free loans or full or partial grants sometimes constitute the financial support for project preparation, most support is provided with an expectation of repayment, typically with interest. Some project preparation funds and facilities are currently at work providing technical and financial support to infrastructure projects.

Project owners must demonstrate their projects' attributes in a way that is easily understood. By building a solid pipeline of bankable projects and focusing on solving the aforementioned limitations, project preparation facilities can increase the flow of investments, especially from the private sector. That could lead to a greater number of projects being undertaken and a surge in high-quality connectivity.

Sidebar: Using demographic and technical analyses to encourage investment in rural areas

Rural areas have a strong need for infrastructure, given the significant gaps between urban and rural connectivity in many countries, as well as the large opportunity for public returns from greater internet use. Take the example of India: BCG has projected that rural internet use will grow by more than 30% a year to more than 300 million users in 2020, but at the same time there is wide state-by-state disparity in penetration and use. Two southern states (Kerala and Tamil Nadu) and four northern states (Himachal Pradesh, Haryana, Punjab, and Jammu and Kashmir) have the highest penetration, including Kerala (37%), Himachal Pradesh (28%) and Punjab (27%). Many eastern states, such as Bihar (9%), Odisha (10%), West Bengal (11%) and Assam (12%), are at the lower end of the spectrum.[60]

Investments from the private sector are essential to extending infrastructure in rural areas, but strong business cases, and therefore financing, have been hard to come by. One reason is that operators have tended to follow a "one solution for all" approach in the type of connectivity and expected financial return, which has set the bar very high for most projects.

Better and more in-depth project planning can also help attract financing for rural projects. Investors need the ability to differentiate between solving each business scenario and choosing the projects they want to back, even in rural areas. Working with operators, governments and investors, GSMA has developed tools to help investors evaluate ICT infrastructure projects, including the ability to better map the unserved. These maps enable investors and others to see merged technical data from all operators in a country, such as for technologies currently in use, population density and coverage. The maps show:

- The size and location of each rural settlement
- The distance of each settlement from existing coverage
- The local landscape and topography (mountain, plain, forest, etc.)

The purpose of such tools is to identify opportunities within the unserved population and support decision-making for the best solution for each area. Mapping provides operators and investors with the potential for higher returns through better information. The first country to be analysed was the Democratic Republic of Congo, where the mapping exercise found more than 100 settlements comprising over 50,000 people with no coverage, and that these potential customers were all less than 25 kilometres from a coverage source, a distance from which a direct microwave link can be sent and activated.

The mapping initiative will expand to more countries (currently the Democratic Republic of Congo, Nigeria and Tanzania are under way) and is expected to lead to more financing and higher connectivity in rural areas.

Sidebar: Case studies on innovative financing models

Three case studies of projects in various stages of completion are outlined in this section. The featured projects were selected because of their thought-provoking elements in the context of the global community's development of solutions to the financing challenge.

Case study: Vive Digital (Colombia)

In 2010, the Government of Colombia announced the creation of Vive Digital, an ambitious plan to expand internet access and adoption, grow the ICT sector, reduce poverty and increase employment. It seeks to address both supply-side (infrastructure, services) and demand-side (education, adoption) factors to grow the internet ecosystem and is organized across four main pillars:[61]

- Expand connectivity infrastructure across the country
- Increase access to internet-based services at an affordable price
- Develop applications and digital content to appeal to end users
- Foster ICT adoption by educating users and spurring demand

The infrastructure pillar took shape following what appeared to be a market failure: though internet-based services, such as those for e-commerce and e-government, were becoming more widely available by 2010, and though the economy was growing, the growth of broadband connections remained sluggish. To address this failure, the Colombian Ministry of Information and Communication Technologies formulated a goal to connect 95% of the country's towns to a fibre backbone within four years, a feat the government estimated would cost approximately $600 million.

To achieve this plan, the infrastructure expansion was conceived as a public-private partnership and opened to bidders. The winner, Azteca Comunicaciones, would be responsible for approximately two-thirds of the total construction costs and for managing, operating and maintaining the network upon completion. It would also be responsible for supplying broadband access to 5,000 government offices over five years.[62]

Simultaneously, the government encouraged competition in the mobile economy by allocating additional spectrum. Its auction process included three provisions: first, any successful bidder would need to open its network to other operators to reach more consumers; second, they would need to allow national roaming; and third, they would need to demonstrate a commitment to the country's unconnected population by offering low-price plans that included tablets and mobile devices for low-income school districts.[63]

By 2014, the project had increased the number of internet users from 2.2 million to 9.9 million, substantially exceeding its 8.8 million target. The number of connected municipalities grew from 200 to 1,078; submarine cables for international connectivity increased from five to nine; and the percentage of connected households as well as small and medium-sized enterprises grew from 7% to 61% and 17% to 50%, respectively.[64]

Following the completion of the programme's original four-year plan, Vive Digital has been extended for another four years. This time its goals include converting Colombia into a global leader in developing internet applications for the world's poorest, and making Colombian government services the most efficient in the world thanks to a consolidated online system.

Case study: Red Compartida (Mexico)

An example of an innovative financing model based on public-private partnerships, Red Compartida is an ambitious telecom project aiming to roll out 4G-LTE to more than 90% of Mexico's population by 2023, with a special focus on rural areas. It is expected to require more than $7 billion in investment over its life cycle.

Mexico's telecom market was traditionally dominated by one player. It controlled access to large parts of the telecommunications infrastructure and was at times accused of anti-competitive behaviour, such as prohibitive connection fees charged to competitors who required access to its infrastructure. In 2014, the Mexican government passed wide-ranging telecommunications reforms, which included a request for the Mexican telecommunications regulator to establish a wholesale-only wireless network. Thus, the Red Compartida initiative was created. Private telecom operators will rent network capacity at a wholesale price and in turn be able to provide quality and cost-efficient telecom services across Mexico.

Altan Redes, a newly established operating entity initiated by the Spanish telecom company, Grupo Multitel, was awarded the Red Compartida project with a network concession for a term of 20 years (and an option to extend it another 20 years). The public-private partnership agreement was signed in January 2017. Existing telecom operators in Mexico were barred from participating in the bidding for the project. The first development milestone is 30% coverage, to be achieved by March 2018, with a ramp-up to 92.2% over the next five years. Current reports expect Altan Redes to exceed the first milestone and achieve coverage of 33-35% of the country by March 2018.

The project has financing from both the private and public sector and will see the Mexican government put the spectrum and fibre-optic links in place. Altan Redes, meanwhile, will develop and manage the infrastructure. The company is backed by a wide range of investors, with a Morgan Stanley-managed infrastructure fund and the IFC (largely through its China-Mexico Fund)

holding approximately 33% and 27%, respectively, and the remainder split between industrial and private stakeholders as well as a Canadian pension fund. In addition to paying an annual fee for spectrum, Altan Redes will contribute 1% of its income from network rentals to the Mexican government's Secretariat of Finance and Public Credit.

Due to its wholesale infrastructure model and its use of highly efficient 700 megahertz bandwidth, the network offers significant savings. With delivery costs of $0.85 per gigabyte, the network is anticipated to provide service at between one-third and one-tenth the cost of incumbents.

Case study: Digital Malawi[65]

Malawi has faced critical obstacles to internet connectivity: with only 32% of the country covered by 3G infrastructure, a GDP per capita of $300 and an uncompetitive mobile services duopoly that has persisted for 15 years, the country's base of internet users is only about 10% of the population.

In 2016, a promising set of telecommunications regulations was passed, leading to the development of SimbaNet, a fibre-optic network linking Malawi to Zambia and Tanzania that has been set to significantly increase connection speeds nationwide. Further capitalizing on this achievement, the Government of Malawi, with the support of the World Bank, passed the Digital Malawi programme. The initiative has a three-pronged approach: to make Malawi a more attractive and competitive place for private-sector digital investment; to unlock more public funds for internet connectivity initiatives; and to build capacity and infrastructure to deliver public services to the Malawian population.

Supported by a $72.4 million credit from the International Development Association, the programme uses a "cascade" approach to provide the best-possible allocation of private- and public-sector financing. Namely, it draws on the private sector to invest in cases where market conditions are encouraging and reserves public funds to correct market failures or to provide funding, though only in cases where private finance is impractical or unavailable. The programme heavily emphasizes addressing demand factors, including $9.5 million to support policy changes and digital skill building. It envisions creating a national internet backbone to link public and higher education institutions, thereby providing an anchor tenancy of essential use; this can serve additional populations as demand for internet use rises. The programme also earmarks approximately 7% of its total budget to project preparation, a nod to its commitment to develop private-sector project owners.

Digital Malawi's implementation, foreseen to be active through 2022, will be led by Malawi's Public-Private Partnership Commission, with key partnership from the Ministry of Information and Communications Technology and the Malawi Communications Regulatory Authority. If successful, the Digital Malawi programme stands to rapidly accelerate the country's relationship with the internet, both improving the state of internet access and adoption internally and accelerating Malawi's accession to a more digital future internationally.

Conclusion

Digital connectivity is one of humanity's greatest technological advances. Taking full social and economic advantage of it requires not only that everyone be able to use the internet, but that they use it to the degree they wish. Developing national internet ecosystems to higher levels of maturity – defined in terms of data throughput and network performance – can both drive economic growth and help ensure that countries are full participants in the Fourth Industrial Revolution.

A more mature internet ecosystem requires a more robust internet infrastructure. While the price tags on such investments are often high, the investments pay for themselves very quickly when the social benefits they convey are taken into account. The current dominant model of financing connectivity infrastructure, however, generally does not allow this; it sees connectivity infrastructure as a purely private investment.

This perspective needs to change, if countries wish to drive internet maturity to higher levels. A number of alternative financing models exist, both established and emerging, that could be employed to allow multistakeholder participation in financing connectivity infrastructure. These models help to socialize the costs of connectivity infrastructure to match the ways in which the benefits they convey accrue to society as a whole rather than to a single investor.

The World Economic Forum is working with a community of stakeholders through the Internet for All project to find effective modalities of employing such alternative financing models. Others should also take up the challenge and ensure that one of our greatest shared technological advances does not become an exclusive luxury enjoyed only by half the world.

Appendix 1: ICT Financing Partners Platform

Overview

The socio-economic benefits of internet access are well documented. However, the pace of growth in internet users has slowed to 9% annually over the last 5 years, compared to 14% in the preceding five-year period. Much of this slowing is due to challenges in financing infrastructure expansion and improvement, which often arise because of such issues as information opacity, difficulties in forming investment partnerships and the relatively small ticket size of many connectivity infrastructure projects.

The ICT Financing Partners Platform was conceived to address these issues and unlock additional flows of capital to connectivity infrastructure. Developed as part of the World Economic Forum Internet for All project and with the support of over 20 organizations drawn from the Internet for All Global Steering Committee, the platform aims to bring together stakeholders from across the public, private and civic sectors to facilitate ICT connectivity investment transactions, foster investment partnerships and promote dialogue.

The platform's concept builds on the broader conversations that have occurred globally – including via the World Economic Forum/OECD Sustainable Development Investment Partnership – on how new sources of private capital can be mobilized for infrastructure investment.

The platform's initial target area geographically will focus on the region covered by the Southern African Development Community and will benefit from local project preparation and technical support from the Development Bank of Southern Africa. The Inter-American Development Bank has expressed a similar interest in providing support for a Latin America-focused platform.

Core activities

The platform's overarching mission is to increase investment in connectivity through the following activities:

- **Facilitate transactions**: Present projects for potential investment among the platform's members
- **Build pipeline**: Enable deal pipeline sharing among various providers of capital
- **Overcome partnership challenges**: Facilitate multistakeholder funding arrangements, especially as blended finance, through increased communication, cooperation and transparency
- **Understand the capital landscape**: Enable a better understanding of the universe of capital providers and their corresponding objectives, preferences, risk tolerance and more
- **Maintain databases and benchmarks**: Collect and distribute information on coverage, willingness to pay, past deal structures and more, for relevant regions, populations and technologies
- **Ease dialogue**: Provide a space for cross-sectoral conversation on projects, priorities and potential deals
- **Further advocacy**: Facilitate the process for better ICT-related policy and regulatory environments

Appendix 2: Calculation methodology for Figure 4, "Sizing the benefits of expanded and upgraded ICT infrastructure in the EU"

Figure 4 comprises four separate calculations and relies on a combination of publicly available, paid and proprietary data sets. All figures are approximate and are not meant to form the basis for any policy or investment decision.

Population split by maturity level

This column shows a rough estimate of the population in each country that occupies a given maturity level. The population thresholds rely on proxy data sourced primarily from Eurostat, which approximate certain use scenarios outlined in the maturity levels framework as described in this White Paper.

- **"Non-users"** are calculated by multiplying the total population of each country in 2015 by the proportion of that country not defined as an internet user.
- **"Level 1"** users are calculated as the maximum of (1) the population of internet users living outside of 3G coverage, or (2) the population of internet users who do not shop online.
- **"Level 2"** users are calculated as the total population of internet users, minus the sum of internet users in levels 1, 3, 4 and 5.
- **"Level 3"** users are calculated as the minimum of (1) the population of internet users living in a 4G coverage area, or (2) the population of internet users using cloud storage to save or share texts, minus the population of internet users in level 4.
- **"Level 4"** users are the estimated population living in a smart home.
- **"Level 5"** users are assumed to be zero, as this maturity level refers to as yet unrealized future use scenarios.

Approximate infrastructure investment required

This column provides a rough estimate of the total investment required to connect the entirety of each country's population to high-speed (defined as 100 mbps) internet via fixed infrastructure, plus coverage from LTE mobile infrastructure.

The calculation first takes into account the existing stock of fixed and mobile infrastructure by technology type, and calculates the proportion of the population not covered by 100 mbps (or higher) fixed infrastructure or LTE (or higher) mobile infrastructure. The resulting population figures are referred to as the "fixed gap" and "mobile gap".

Using a combination of proprietary coverage data and demographic data, the fixed and mobile gaps are then divided into three component figures, respectively: those populations in areas with a high population density, those in areas with a medium population density and those in areas with a low population density.

The segmented population gap figures are then combined with proprietary cost data by population density to determine the cost of FTTx and/or cable upgrades (for the fixed gap), and the cost of LTE infrastructure (for the mobile gap).

The final infrastructure investment required is the sum of these fixed and mobile investment figures.

GDP uplift from infrastructure investment

GDP uplift figures assume an increase in penetration and movement between maturity levels as a result of enhanced infrastructure. The minimum figures listed assume economic impact generated by (1) an increase in internet penetration of 10%, up to a maximum of 100%, and (2) a maximum of 10% of the population in a given maturity level migrating upwards to the next maturity level. The maximum figures listed assume economic impact generated by (1) an increase in internet penetration to 100% across all countries, and (2) a maximum of 50% of the population in a given maturity level migrating upwards to the next maturity level.

The economic impact of migrating between maturity levels relies on two figures: a 1.2 percentage point increase in GDP from increasing internet penetration rates by 10%, and a 0.3 percentage point increase applied to those populations who double the speed of their internet use. The proportion of economic growth from increased penetration is applied logarithmically, in accordance with the number of 10% increases required to achieve full penetration, to the entire population. The proportion of economic growth from doubling speed is applied only to those portions of the population witnessing an increase in their actual speed (as described in the two scenarios in the previous paragraph). Such calculations rely on the following average speed assumptions associated with each maturity level: Level 1 assumes 0.512 mbps, level 2 assumes 2.5 mbps, level 3 assumes 25 mbps and level 4 assumes 100 mbps.

Time for GDP uplift to exceed infrastructure investment

The theoretical time for GDP uplift to exceed infrastructure investment is calculated as follows:

[2016 GDP including uplift from infrastructure – 2016 projected GDP at constant growth rates] / approximate infrastructure investment required.

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Endnotes

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