MODULE 1. Building Broadband

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1.1 Introduction

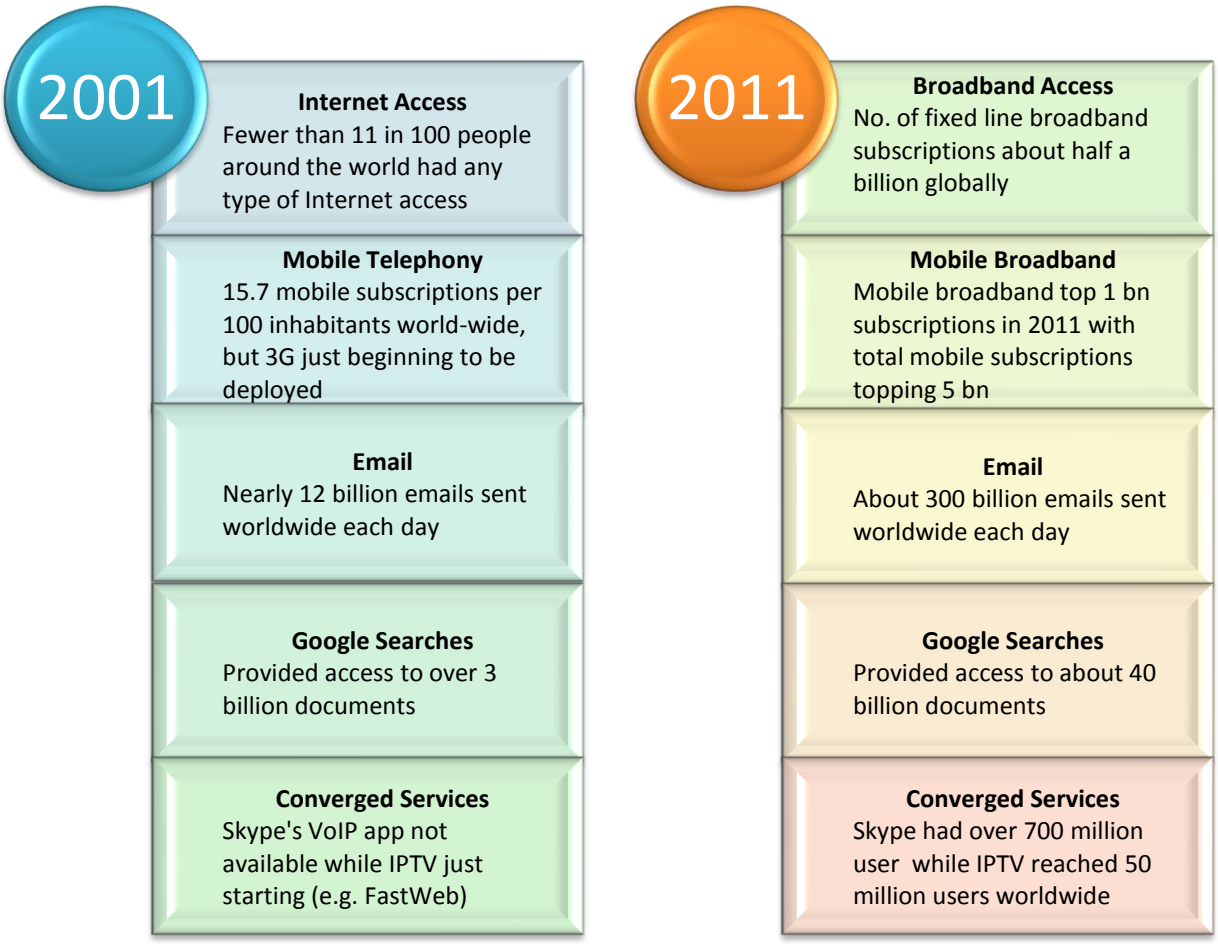
In just one decade, the world of information and communications technologies (ICT) has changed dramatically. The Internet has become an integral part of people's personal and business lives; critical for a wide range of information, communication and entertainment services. With broadband networks, consumers can now access the Internet at speeds up to or exceeding 100 megabits per second (Mbit/s) and they can use their mobile phones for a wide range of activities, including surfing the Internet, purchasing goods and services online, streaming video or music and conducting financial transactions.

A look at the state of broadband some 10 years back, however, presents a much different picture. In 2001, fewer than 11 in 100 people around the world had any type of Internet access, the majority of which was through a dial-up connection.[1] Korea (Rep.) was the only country with a wireline broadband penetration rate in the double digits;[2] the other top five countries in the Organisation for Economic Co-operation and Development (OECD) had just over three subscribers per 100 people by the end of 2001.[3] Wireless broadband was still in its infancy. Although there were 15.7 mobile cellular subscriptions per 100 people worldwide in 2001, third generation (3G) networks capable of mobile broadband services and applications were just beginning to be deployed.

Despite relatively low speeds and penetration, by 2001 the Internet was already beginning to provide a rich and dynamic source of content and communications. Email was in common use—in 2001 nearly 12 billion email messages zipped around the world every day. Blogs had become a popular form of social media, with sites such as LiveJournal and Blogger.com leading the way. Entering the search engine business in 1998, Google had quickly expanded and provided access to over three billion documents by December 2001. Due to limited bandwidth, however, many websites were text-heavy, with few images and virtually no video. Social networking sites were merely looming on the horizon; it would be another two years before the launch of Myspace, three years for Facebook and four years for YouTube. Other bandwidth-intensive online applications, including Skype, YouTube and Apple's iTunes store, were also years away from commercial launch. Converged services, such as Internet Protocol television (IPTV), were just being introduced.

Fast-forward a decade and we find that much of what was popular in 2001 is still in high demand today. Google has continued its rise and now processes over one billion search requests every day (see Figure 1.1). The number of email accounts worldwide exceeded three billion in 2011, while the number of emails sent averaged about 300 billion per day and is expected to reach over 500 billion per day by 2013.[4] With over 150 million blogs in 2011, blogging has evolved from a simple online diary to a type of new media, which is used by "citizen journalists" as an alternative to traditional journalism, as well as by governments and corporations to communicate less formally with the public. In addition, a multitude of new services and applications has emerged that were not even conceived of a decade ago. YouTube has surpassed three billion views a day,[5] while Skype has over 700 million user accounts[6] and Facebook over 845 million active monthly users at the end of 2011.[7] The growth of today's most popular services and applications would not have been possible without broadband access. In turn, for those currently without such access, many of these tools are still not available.

Figure 1.1. Comparison of Availability of Networks, Services and Applications in 2001 and 2011



Source: TMG, Inc.

Improvements to users' online experience and the rise of digital media are largely attributable to more widespread deployment of wireline broadband, along with significant improvements to mobile technologies and services. As of December 2010, the OECD found that the average wireline broadband penetration rate in the top five countries was over 36 subscribers per 100 people, more than a ten-fold increase in less than a decade.[8] Additionally, among all OECD countries, the average advertised wireline broadband speed had surpassed 37 Mbit/s by September 2010, which allows users to download a feature-length movie in a matter of minutes.[9] Despite these advances, a digital divide remains between developed and developing countries. Although wireline broadband has grown considerably in terms of the global average, penetration levels in developing countries remain low. By the end of 2010, the number of fixed line subscriptions reached about half a billion globally, with just 4.4 subscriptions per 100 people in developing countries compared to 24.6 in developed countries.[10] In effect, wireline broadband deployments in many developing countries are a decade behind those in developed countries.

But broadband is not just about high-speed access to the Internet to allow users to surf the web, play video games and engage in social networking (although these are useful drivers of demand and provide their own benefits to users). Broadband is an enabling platform for advanced services and applications. The benefits of broadband can reverberate throughout the economy and act as an essential input in all

other sectors, including education, health, transportation, energy and finance; similar to the impact that electricity has had on productivity, growth and innovation. However, in order to achieve this potential, governments must put in place effective policies that spur supply and demand, as well as encourage uptake of broadband in all sectors of the economy.

The roll-out of broadband requires significant investment from the private sector, as well as support from the public sector. It will also require a long-term perspective because its benefits will not occur overnight. For developing countries with limited resources, it may be difficult to focus on broadband when many of their communities do not have schools for children, safe drinking water or access to hospitals and health care. However, broadband offers countries a platform to provide other sectors of the economy with new tools to enhance businesses, improve the economy and benefit its people. This will require resources and the benefits will not be immediate, but making this high priority and part of a country's development agenda will be necessary to ensure that developing countries do not further extend the digital divide between developed and developing countries.

This module of the Broadband Strategies Toolkit expands on the significance of broadband to both developing and developed countries, first by identifying what broadband means in various contexts, including speed and functionality, identifying broadband as an enabling platform and broadband in terms of network infrastructure. Secondly, this module examines why broadband is important, particularly the potential positive impact that broadband can have on the productivity, employment and throughout every sector of the economy. The main market trends regarding the supply and demand of broadband networks, services and applications are addressed, as well as an overview of how policymakers and stakeholders can take advantage of these trends to implement deployment and adoption strategies that maximize the benefits of broadband.

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[1] ITU, *ICT-Eye Database: Estimated Internet users per 100 inhabitants 2001*, *available at* http://www.itu.int/ITU-D/ICTEYE/Reports.aspx.

[2] ITU, *ICT-Eye Database: Estimated fixed broadband subscriptions 2001*, *available at* http://www.itu.int/ITU-D/ICTEYE/Reports.aspx#.

[3] OECD, 1h. Historical Penetration Rates, Top 5 (June 2010), *available at* http://www.oecd.org/sti/ict/broadband.

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[6] Skype Journal, "Attention: Skype is Half-a-Facebook in user activity, a Quarter of all International Phone Calls," January 10, 2012, http://skypejournal.com/blog/2012/01/10/attention-skype-is-half-a-facebook-in-user-activity-a-quarter-of-all-international-phone-calls/.

[7] Facebook, "Fact Sheet," http://newsroom.fb.com/content/default.aspx?NewsAreaId=22.

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[9] OECD, 5a. Average advertised download speeds, by country (Sept. 2010), *available at* http://www.oecd.org/sti/ict/broadband.

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1.2 What is Broadband?

Despite its worldwide growth and promotion by policymakers, network operators, content providers and other stakeholders, broadband does not have a single, standardized definition. The term "broadband" may refer to multiple aspects of the network and services, including: 1) the infrastructure or "pipes" used to deliver services to users; 2) high-speed access to the Internet; and/or 3) the services and applications available via broadband networks, such as Internet protocol television (IPTV) and voice services that may be bundled in a "triple play" package with broadband Internet access. Further, many countries have established definitions of broadband based on speed, typically in Mbit/s or kilobits per second (kbit/s), or based on the types of services and applications that can be used over a broadband network (i.e., functionality). Due to each country's unique needs and history, including economic, geographic and regulatory factors, definitions of broadband vary widely.

Traditionally, broadband has often been defined in terms of data transmission speed (i.e., the amount of data that can be transmitted across a network connection in a given period of time, typically one second, also known as the data transfer rate or throughput). Defining broadband in terms of speed has been an important element in understanding broadband, particularly since the data transfer rate determines whether users are able to access basic or more advanced types of content, services and applications over the Internet. However, attempts to define broadband in terms of speed present certain limitations. To address these limitations, some countries (e.g., Brazil)[1] and international organizations (e.g., OECD)[2] have decided or proposed not to categorize broadband in terms of speed, but are instead looking at broadband in terms of functionality—focusing on what can and cannot be done with a certain type of connection.

1.2.1 Broadband as an Enabling Platform

The Broadband Strategies Toolkit and Handbook view broadband more holistically as a high-capacity ICT platform that improves the variety, utility and value of services and applications offered by a wide range of providers, to the benefit of users, society, and multiple sectors of the economy.

From a policy perspective, broadband should not be viewed simply as a certain speed or functionality, but as an enabling ICT platform that can potentially influence the entire economy. As noted by the OECD and the World Bank, the true benefits of broadband are expected to arise less from any direct impact but instead from the applications that broadband enables and the associated gains in productivity.[3] While there are direct effects from investments in broadband technology and deployment of the infrastructure, the indirect effects arise from factors that drive growth, including innovation, efficiency and competition, as well as the facilitation of new and useful products, services, processes and business models that could not exist without broadband.[4] According to the OECD, as broadband technology continues to improve and bandwidth increases, the capacity for broadband to act as an enabler of structural change in the economy expands due to its impact on an increasing number of sectors and activities.[5] Viewing broadband as an enabling platform and key input across sectors is the basis of identifying the role that broadband can play as a general purpose technology (GPT), which is further addressed in the section 1.3.4.

In order to capture the full range of these potential benefits, it may be useful for policymakers to consider broadband through an ecosystem framework, as outlined in section 1.5.1. This perspective comprises both supply-side considerations (network platforms) and demand-side considerations, such as e-government initiatives, development of services and applications). To encourage the diffusion of

broadband-enabled innovations throughout the economy, policymakers should also consider the absorptive capacity of various sectors, including health, education, energy and transportation. Unless all these elements—supply, demand, and absorptive capacity—are coordinated, the impact of broadband on the economy as a whole will be constrained.

1.2.2 Broadband in Terms of Speed, Functionality and Technology

Seeing broadband as an enabling ICT platform does not contradict or exclude common understandings that define broadband in terms of speed, functionality, or technology. This section will give an overview of more specific elements of broadband, usually used to narrow the term down.

In the most practical sense, the term broadband is generally understood to mean a dedicated or "always-on" connection to the Internet with speeds faster than dial-up. The concept of broadband also involves being able to do things that are virtually impossible to do over dial-up given its limited bandwidth—videoconferencing, online gaming and watching videos, to name a few. Broadband has commonly been defined in terms of a minimum data transmission speed, usually referring to the amount a user can download. Defining broadband in terms of speed refers to the amount of data (generally in bits) that can be transmitted across a network connection in a given period of time, typically one second. Also known as the data transfer rate or throughput, speed has been an important element in understanding broadband, particularly since the data transfer rate determines the types and range of content, services and applications that a user may access.

Speed matters for users: An increasing number of Internet applications, such as those that display high-quality video content, require high speeds to work. These applications often cannot be downloaded or viewed unless the Internet connection is of a certain speed and quality. When a user tries to access an application hosted on a remote server, the speed and quality of the user's connection is measured by the server, and an error message is displayed if the connection does not meet the minimum requirements to provide the service. Even if an Internet application or website does not impose these requirements, there are other consequences to users on slower connections. Usability suffers when an application or website meant to be used over broadband is accessed over dial-up, often to the point of futility. A website or application that is accessible but effectively unusable over slower connections will lead only to frustrated users and, for commercial websites, higher expenses for customer support. In addition, as broadband connections have become faster and more widespread, website designers have taken advantage of the added bandwidth to offer richer and more complex websites. Consumers on slower connections, and especially those on dial-up, may find that their experience on the Internet worsens with each website redesign.

Box 1.1. Understanding Broadband Speeds

1 kbit/s = 1,000 bits per second

1 Mbit/s = 1,000,000 bits per second (1,000 kbit/s)

1 Gbit/s = 1,000,000,000 bits per second (1,000 Mbit/s)

However, definitions of the precise threshold of transmission rates that determines whether Internet access is considered broadband vary. At the low end, broadband is often defined as download speeds of at least 256 kilobits per second (kbit/s). A 2009 ITU document, for example, defines broadband as at least 256 kbit/s.[6] This is the definition used by other organizations, including the OECD, the United Nations Conference on Trade and Development, and the Partnership for Measuring ICT for Development, a consortium of international organizations and agencies. However, Recommendation

I.113 of the ITU Standardization Sector, defines broadband as "transmission capacity that is faster than [...] at 1.5 or 2.0" Mbit/s, and in reality, broadband services are increasingly being offered at 100 megabits per second (Mbit/s), with the goal of reaching 1 Gigabit per second (Gbit/s) and beyond.[7] The higher the data transfer rate, the faster that files can be transmitted and, in this way, broadband speed is linked with functionality.

Attempts to define broadband more specifically in terms of speed can be challenging. As a 2008 study on behalf of the European Union (EU) noted:

> Definitions based on data transfer speed are not able to take into account the very fast evolution in technologies and uses. Is a bandwidth of 256 kbit/s a broadband connection? Should the lower limit be set to 1 Mbit/s? There is no definitive answer as the bandwidth required to run internet applications is continuously increasing and infrastructure standards are also continuously improving to face the growing demand. Such a definition can only be relative to a particular moment in time in a particular country.[8]

Defining broadband in terms of speed presents several difficulties. First, broadband speed definitions vary widely among countries and international organizations from at least 256 kbit/s on the low end (such as in India)[9] to faster than 1.5 Mbit/s on the high end (such as in Canada). Second, as referenced in the above-mentioned EU study, definitions based on speed may not keep pace with technology advances or with the speeds services and applications require to function properly. In other words, what is considered "broadband" today may be seen as too slow in the future as more advanced applications technologies develop. Thus, any speed-based definition of broadband will need to be updated over time. Third, such definitions may not reflect the speeds realized by end users such that the speeds advertised by commercial broadband providers may be much higher than the speeds set by the government as broadband or vice versa. For example, while Colombia's broadband speed definition is 1 Mbit/s, its average broadband connection speed is already 1.8 Mbit/s.

Policymakers and regulators are struggling to develop definitions of broadband that are appropriate to the time and that reflect rapidly improving technological capabilities. In July 2009, for example, India's telecommunications regulator suggested that the government redefine broadband as connectivity of 2 Mbit/s or faster, up from the 256 kbit/s defined in the Broadband Policy of 2004.[10] Some countries have developed different categories in addressing broadband. The Canadian Radio-television and Telecommunications Commission, for example, distinguishes between "high-speed Internet service," defined as at least 128 kbit/s, and "broadband service," which must be at least 1.5 Mbit/s.

In addition to or in place of these definitions, a number of countries have minimized or avoided the issue of defining broadband in terms of speed and have focused instead on setting ambitious minimum speed goals. Broadband speed goals in these countries include:

- Australia's goal is to make connections with speeds of 100 Mbit/s available to 93 percent of homes, schools, and businesses by 2018.
- Finland has the goal of making 100 Mbit/s connections available to every household by 2016.
- Germany's goal is 50 Mbit/s connections for 75 percent of households by 2014.[11]
- The EU's "Digital Agenda for Europe" calls for all Europeans to have access to connections with speeds of at least 30 Mbit/s by 2020, with 50 percent or more of households having access to speeds in excess of 100 Mbit/s.
- Korea, a country where broadband connection speeds already average almost 50 Mbit/s, has set the lofty goal of 1 Gbit/s connections by 2013.[12]

- Sweden aims for 40 percent of households and businesses having access to 100 Mbit/s connections by 2015, and 90 percent by 2020.[13]
- The United Kingdom has relatively modest goals. Its "Digital Britain" plan aims for universal connections of at least 2 Mbit/s by 2012.[14]
- The United States set a goal of providing 100 million households with access to actual (not advertised) speeds of 100 Mbit/sMbit/s and all households with access to actual speeds of at least 4 Mbit/s downlink and 1 Mbit/s uplink by 2020.[15] Given the speed and unpredictability of technological progress, the FCC plans to "review and revise" these goals every four years.[16]

Some countries are moving away completely from understanding broadband in terms of speed and instead seek to define it in terms of functionality. This is because minimum upload and download numbers do not always paint the whole picture, and definitions based on bandwidth run the risk of always being a step behind. Defining broadband in terms of functionality cuts to the chase: what can and cannot be done with a certain connection. As with many information technologies, broadband has demonstrated that it is quick-to-market, continually changing and unpredictable. Customer expectations are continually ramping up as the need for more bandwidth and faster connections is driven by more advanced services and applications.

For example, Brazil's broadband plan avoids attaching a minimum speed to its definition of broadband. Instead, broadband is defined as "the provision of telecommunications infrastructure that enables information traffic in a continuous and uninterrupted manner, with sufficient capacity to provide access to data, voice and video applications that are common or socially relevant to users as determined by the federal government from time to time."[17] This definition identifies those Internet applications that must be accessible over an Internet connection in order for that connection to be considered broadband. At the same time, it allows for the government to adjust the set of Internet applications that serve as the benchmark.

However, for some purposes, defining broadband in terms of functionality can be problematic as meeting the definition becomes more subjective. A definition based on speed is easy to apply: if broadband is defined as at least 1.5 Mbit/s, a 2 Mbit/s connection is broadband while a 1 Mbit/s connection is not. But when broadband is defined in terms of functionality, the distinction between what is and is not broadband becomes fuzzy. Admittedly, this can lead to positive outcomes, for example, if citizens of a country can appeal to operators and regulators for speeds that meet actual current usage criteria. Yet, the questions that need to be answered also become more equivocal: Is being able to watch a YouTube video equal to a broadband connection? What if it takes minutes to buffer and starts and stops throughout?

For several contexts, being able to universally quantify broadband can be useful. If a country wants to compare itself to its peers in terms of broadband penetration, for example, it needs to follow a common metric. If it wants to be able to track its growth in broadband availability from year to year, it needs to set a standard that can be easily and reliably measured over time. Likewise, if it wants to hold accountable telecommunications providers to their broadband deployment plans it must provide a clear definition or set of expectations for providers to meet.

To allay some of the aforementioned shortcomings, some countries seem to be embracing a "hybrid" approach to defining broadband. On one hand, they specify the minimum speed that will qualify as broadband. On the other hand, they list the Internet applications that a broadband connection should support. For example, the Canadian National Broadband Task Force has defined broadband as "a high-capacity, two-way link between end users and access network suppliers capable of supporting full-

motion interactive video applications to all Canadians on terms comparable to those available in urban markets." Nonetheless, the CRTC defines broadband as at least 1.5 Mbit/s (with anything faster than 128 kbit/s being defined as "high-speed"). The U.S. Federal Communications Commission divides broadband into tiers as described above, but also describes broadband as an "advanced communications systems capable of providing high-speed transmission of services such as data, voice, and video over the Internet and other networks."[18]

Next to speed and functionality, in addressing "what is broadband," it is also useful to identify the various wireline and wireless technologies that deliver connectivity to users. Generally, the three main wireline technologies currently in use to deliver broadband to end user locations are: 1) digital subscriber line (DSL); 2) hybrid fiber coaxial cable (HFC) or cable modem; and 3) fiber optic cable. Fiber networks generally offer the fastest speeds. Particularly if fiber network access reaches directly to the end user's home or business, referred to as fiber-to-the-premises (FTTP), then download speeds can reach 100 Mbit/s or more.[19] Maximum download speeds ranging from 40 Mbit/s to over 100 Mbit/s can be achieved through fiber-to-the-curb or -cabinet (FTTC), which carries the fiber network to within a few hundred meters of the end user location with the remaining distance covered by DSL or HFC.[20] Fiber, as well as cable modem and the more advanced versions of DSL (such as Very-High-Speed DSL), can support the latest business services, such as videoconferencing 'or triple play' services for households (Voice over Internet Protocol (VoIP), television services and video-on-demand, and high-speed Internet access).

Third generation (3G) networks are the main mobile broadband technologies available today. In 2011, there were nearly three billion 3G subscriptions,[21] of which over 70 percent had peak download speeds of 7.2 Mbit/s or higher.[22] As the number of Long-Term Evolution (LTE) deployments grows, mobile users will be able to take advantage of the wide array of services available with fourth generation (4G) networks offering download speeds of up to 100 Mbit/s. Notably, LTE deployments are occurring at the fastest rate of any mobile technology ever, faster than both second generation (2G) and 3G networks.[23] For greater detail on the evolution of mobile broadband, as well as greater technical specifications of wireline broadband, see Chapter 5 of the Broadband Handbook and Module 2 of the Broadband Toolkit.

[1] Brazil's broadband plan defines broadband as "the provision of telecommunications infrastructure that enables information traffic in a continuous and uninterrupted manner, with sufficient capacity to provide access to data, voice and video applications that are common or socially relevant to users as determined by the federal government from time to time." Ministério das Comunicações, *Um Plano Nacional Para Banda Larga: O Brasil Em Alta Velocidade* (BrazilianNational Broadband Plan) at 24 (2009) (translated by Telecommunications Management Group, Inc.)

[2] OECD, *Broadband Growth and Policies in OECD Countries* at 134 (2008).

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[4] OECD, *Broadband and the Economy*, DSTI/ICCP/IE(2007)3/FINAL, OECD Ministerial on The Future of the Internet Economy, p. 11 (June 17-18, 2008), *available at* http://www.oecd.org/dataoecd/62/7/40781696.pdf.

[5] OECD, *Broadband and the Economy*, DSTI/ICCP/IE(2007)3/FINAL at 11 (2008).

[6] ITU, Manual for Measuring ICT Access and Use by Households and Individuals at 22(2009).

[7] ITU, ITU and Its Activities Related to Internet-Protocol (IP) Networks at 55 (2004).

[8] Martin Fornefeld, Gilles Delaunay, and Dieter Elixmann, *The Impact of Broadband on Growth and Productivity*, A study on behalf of the European Commission, p 9 (2008), *available at* http://ec.europa.eu/information_society/eeurope/i2010/docs/benchmarking/broadband_impact_2008.pdf.

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[10] The Hindu Business Line, TRAI for 'redefining' floor broadband speed at 2Mbps, July 24, 2009, available at http://www.thehindubusinessline.com/2009/07/24/stories/2009072451070400.htm

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[13] Government Offices of Sweden, *Broadband strategy for Sweden* at 14 (2009).

[14] U.K. Department of Business Innovation & Skills, *Digital Britain Report* at 12 (2009).

[15] U.S. FCC, *Connecting America: The National Broadband Plan* at 25, 135 (2010).

[16] U.S. FCC, *Connecting America: The National Broadband Plan* at 135 (2010).

[17] Brazil Ministério das Comunicações, *Um Plano Nacional Para Banda Larga: O Brasil Em Alta Velocidade* (Brazilian National Broadband Plan) at 24 (2009) (translation ours).

[18] U.S. FCC, *Federal Communications Commission Strategic Goals – Broadband*, available at http://www.fcc.gov/broadband/ (last visited Jan. 31, 2011).

[19] Ray Le Maistre, "BT Ramps up Its FTTX Speeds," *Light Reading*, October 5, 2011, http://www.lightreading.com/document.asp?doc_id=213082.

[20] Rupert Wood, "Extending the Speed and Reach of Copper NGA," Analysys Mason Knowledge Centre, May 19, 2011, http://www.analysysmason.com/about-us/news/insight/Insight_extending_copper_May2011/.

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[22] Global mobile Suppliers Association, "Mobile Broadband Wallchart: 3GPP Systems," November 7, 2011, http://www.gsacom.com//downloads/charts/WCDMA_Networks_Wallchart.php4.

[23] Global mobile Suppliers Association, "GSM/3G Market/Technology Update," Evolution to LTE Report, January 5, 2012, http://www.gsacom.com/gsm_3g/info_papers.php4.

1.3 Why is Broadband Important?

1.3.1 Positive Impacts of Broadband

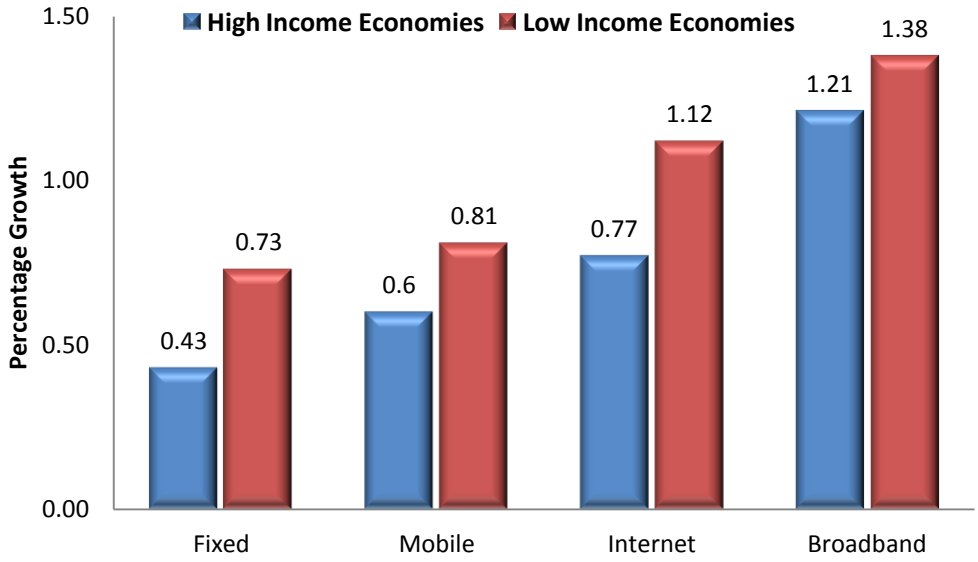
With the appropriate policies in place, broadband is a transformative platform that impacts the ICT sector as well as other sectors of the economy. While some may disagree on the precise economic and social benefits that can be attributed specifically to broadband, and may challenge the studies that have suggested a large impact, few argue against the fact that broadband has dramatically changed our personal lives, our businesses and our economies. Moreover, as an enabling ICT platform and potential GPT, broadband can facilitate growth and innovation in the ICT sector and throughout the economy, serving as a vital input for each sector that strengthens the economy as a whole. Broadband has the capacity to "contribute to virtually every sector in the economy through productivity gains."[1]

Even beyond productivity increases, broadband affects the economy in multiple ways, for instance, through job growth and improved quality of life. It is capable of facilitating micro- and macroeconomic growth by "accelerat[ing] the distribution of ideas and information and foster[ing] competition for and development of new products, processes, and business models."[2] Broadband impacts a country's economic output and GDP in multiple ways by: 1) enhancing the role of human capital through easier acquisition of knowledge and technical skills; 2) improving the efficiency and productivity of enterprises; 3) increasing community competitiveness by attracting knowledge-based businesses; and 4) sparking new and innovative technologies, services, applications and business models.[3] The multiplier effect of broadband can drive GDP, productivity, and employment growth. However, policies that support the supply and demand elements of the ecosystem, as well as the absorptive capacity to develop broadband capabilities in other sectors, must all be in place in order to fully realize such benefits.

1.3.2 Impact of Broadband on Gross Domestic Product

Due to the potentially wide-ranging impacts of broadband, and its ability to provide easier access to information that increases efficiencies and productivity in the economy, it is unsurprising that increased use of broadband networks and services has been found to produce positive outcomes that reverberate throughout a country, particularly involving GDP. A frequently cited World Bank study found that low-income and middle-income countries experienced "about a 1.38 percentage point increase in GDP for each 10 percent increase in [broadband] penetration" between 2000 and 2006.[4] The World Bank further found that the development impact of broadband on emerging economies is greater than for high-income countries, which "enjoyed a 1.21 percentage point increase in per capita GDP growth" per 10 percent increase in broadband penetration.[5] The study also demonstrates that broadband has a potentially higher growth effect than other ICTs, including wireline telephony, mobile telephony and the Internet, as shown in Figure 1.2. The predominance of broadband may be unexpected considering that, over the last decade, mobile telephony has been the fastest growing ICT worldwide, with a 2010 global penetration rate of 76.2 out of 100 persons.[6]

Figure 1.2. Growth Effects of Various ICTs on GDP

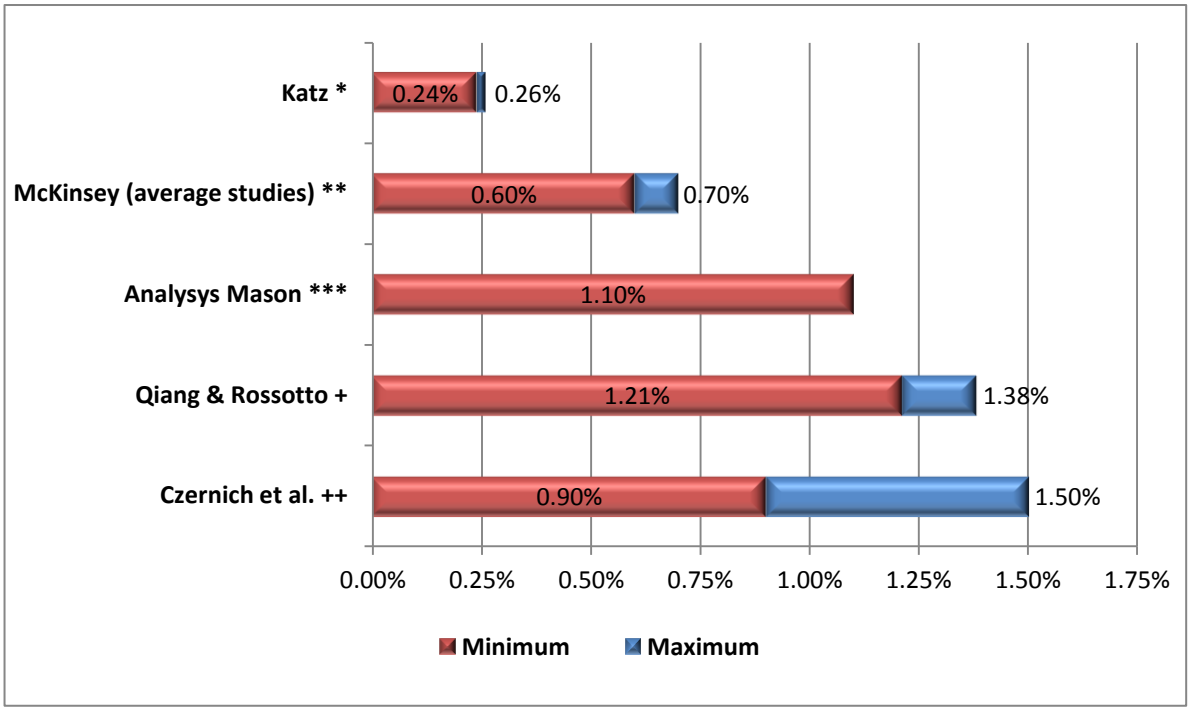


Source: Adapted from Qiang and Rossotto, Extending Reach and Increasing Impact, Chapter 3: Economic Impacts of Broadband, p. 45.

The World Bank's findings of broadband's growth effects are supported by other independent studies. In a study noting the extensive benefits of broadband for emerging markets, management consulting firm McKinsey & Company estimated that "a 10 percent increase in broadband household penetration delivers a boost to a country's GDP that ranges from 0.1 percent to 1.4 percent."[7] Additionally, a study of OECD countries by global consulting firm Booz & Company found that among high-income countries, there is a strong correlation between average annual GDP growth and broadband penetration wherein "[c]ountries in the top tier of broadband penetration have also exhibited 2 percent higher GDP growth than countries in the bottom tier of broadband penetration."[8]

Although numerous studies have found a positive impact on economic growth, the estimate of its actual magnitude varies. For example, a ten percent increase in broadband penetration has been found to increase economic growth from a low of range of 0.24 percent to a high of 1.50 percent (Figure 1.3).

Figure 1.3. Impact on GDP of an Increase of 10 Percent in Broadband Penetration



Sources: Katz 2010;[9] Analysys Mason 2010;[10] McKinsey 2010;[11] Qiang&Rossotto 2009;[12] and Czernich et al. 2009.[13]
*Notes: * Only includes Germany; ** Average of five country studies, including United Kingdom, Australia, New Zealand, Malaysia and a Middle Eastern country, from various sources 2003 and 2004, and Qiang and Rossotto 2009 study; *** Limited to mobile broadband impact in India; + Various countries, upper range applies to developing countries and lower range to developed countries; ++ Sample of 20 OECD countries.*

While these studies provide important insight into the growth effects of broadband, data collection and further systematic research and analysis in this area are needed, particularly for developing countries. Currently, there is ample anecdotal evidence of the effects of broadband on economic growth, with some cases highlighted below. However, these cases provide only limited evidence of the impact that broadband has on the economy as a whole. It is also important to note that investment in broadband or policies fostering its deployment or adoption are unlikely to produce significant GDP gains without complementary investments or policies in other sectors, notably education, innovation, civic participation and health care. However, even with the implementation of appropriate policies, the impacts of broadband on growth in certain areas may be limited. For example, developing countries may be in less need of telemedicine to improve health outcomes and more in need of low-tech and inexpensive solutions, such as mosquito nets and de-worming pills.[14] Additionally, despite providing a new educational resource, broadband can also create a new distraction if careful controls are not in place that limit Internet access to non-academic sites such as Facebook, YouTube and file-sharing websites.[15]

Examples of the impact of broadband on economic growth around the world

Australia

The Australian Government is in the process of deploying the country's largest-ever infrastructure project, the National Broadband Network (NBN). At a cost of up to AUD 43 billion (USD 41 billion) over eight years, the NBN is set to rollout a fiber network delivering broadband speeds of up to 100 Mbit/s

to at least 93 percent of the population and wireless networks delivering speeds of 12 Mbit/s or more to those living in remote areas.[16] As the NBN is implemented, both the public and private sectors are researching the impact that the NBN is expected to have on economic growth.

One such study, completed in November 2010, reviewed the anticipated effects of the NBN up to the year 2020 based on the NBN's rollout plan.[17] The results revealed that for 18 industries, the NBN's impact would improve economic outcomes between 0.17 percent and 0.54 percent with an average of 0.43 percent across all industries.[18] As Table 1.1 below shows, four industries—transportation, electricity, water and government services—will have more than 0.5 percent growth due to broadband. Interestingly, the communications industry is expected to gain 0.46 percent in output from broadband, which is less than the expected gain in the top six sectors. Despite these estimated gains, the authors of the study believed "they most likely underestimate the full impacts of applications, processes and business models that are only available with a high speed and quality service."[19] Overall, the benefits across all sectors help to demonstrate the significant network effects of broadband.

Table 1.1. Expected Impacts of the NBN on Output of Major Industries at 2020

Industry	% Change (most to least)
Transport	0.54
Water	0.54
Electricity	0.53
Government services	0.51
Finance and insurance	0.49
Construction	0.49
Gas	0.48
Communications	**0.46**
Trade	0.44
Other business services	0.43
Oil	0.42
Recreation and other services	0.38
Coal	0.34
Manufacturing	0.33
Forestry and fishing	0.27
Other minerals	0.25
Processed foods	0.23
Primary agriculture	0.17

Source: Simes, et al., Australian Business Expectations for the National Broadband Network, p. 6.

The study also surveyed 540 businesses across the 17 industry groups with annual revenues ranging from less than AUD 5 million to over AUD 1 billion, finding that 57 percent expected that the NBN will change the way they communicate with suppliers and customers while 55 percent believed that their online capabilities will definitely or likely be enhanced by the NBN.[20]

Canada

Over the last several years, broadband access studies in Canada have focused on the importance of broadband for economic growth and development, particularly in rural areas. In 2005, for example, Industry Canada commissioned a survey to be conducted in the rural areas of British Columbia regarding subscribers' views of the significance of broadband access. More than 80 percent of all business respondents "reported that absence of broadband would affect their businesses negatively" and over 18 percent stated "they could not operate their businesses without broadband."[21] Additionally, according to business owners' self-reported figures, broadband increased productivity by 62 percent and there was "a majority indicating an increase in productivity of more than 10 percent."[22] Overall, the study showed that, even prior to 2005, broadband had become a significant competitive factor for businesses in rural British Columbia.[23]

An earlier study on broadband investment, conducted in the township of Dundas, Ontario in 2003, showed that investment in fiber optic network infrastructure of CAD 1.3 million resulted in CAD 25.22 million "increase in GDP for Dundas County and CAD 7.87 million increase for the Province of Ontario," as well as the creation of 207 new jobs.[24] The researchers also found that the new fiber lines directly contributed to an additional CAD 3.5 million in provincial tax revenues and CAD 4.5 million in federal tax revenues.[25]

China

Between 2010 and 2013, China's network operators, China Unicom, China Telecom and China Mobile, are expected to invest an estimated CNY 62.billion (USD 9 billion) in the creation of a single fixed broadband access network providing speeds of 1 Mbit/s or more.[26] These investments seem justified given the fast growth of the number of fixed broadband subscribers: it is expected to reach 182 million by 2013, which represents growth of nearly 77 percent between 2010 and 2013.[27]

Set against these figures, the impact of broadband on China's GDP is anticipated to be substantial. As such, China's "dial-up and broadband Internet together may contribute a combined 2.5 percent to GDP growth for every 10 percent increase in penetration."[28]

Germany

Under Germany's National Broadband Strategy, 75 percent of households are expected to have broadband access of at least 50 Mbit/s by 2014. By 2020, 50 percent of German households will have 100 Mbit/s access while another 30 percent will have 50 Mbit/s broadband access. A 2009 study on the economic impact of the National Broadband Strategy found that investments in the network are expected to result in a contribution of EUR 18.8 billion to Germany's GDP between 2010 and 2014.[29] By 2020, Germany's ultra-fast broadband network will contribute an additional EUR 14.6 billion in GDP.

The study further found that from an "incremental economic growth standpoint, network construction would yield additional value added of 33.4 billion Euros, while network externalities will result in additional 137.5 billion Euros."[30]

India

A study released by Analysys Mason in December 2010 on the deployment of wireless broadband in India found that each percentage point increase in mobile broadband penetration in India could increase India's GDP by INR 162 billion (USD 3.8 billion), or 0.11 percent, by 2015.[31] The study further indicated that if the Indian Government allocates an additional 5 MHz of 3G spectrum to each licensee, the broadband penetration rate would likely increase 3.3 percent.[32] This could result in an increase of

INR 538 billion (USD 12.7 billion) of GDP, in addition to the case that no additional allocation is made, translating into an additional 3.3 percent growth in GDP by 2015.[33]

The study also estimated significant improvements to other sectors within the wireless broadband ecosystem by 2015 regarding content, applications, service models and device categories:[34]

- 82 percent increase in the consumer/retail sector, including mobile advertising, entertainment and commerce.
- 67 percent increase in the financial services sector, including mobile banking.
- 101 percent increase in social services, including mobile learning, health and government.

Latin America and the Caribbean

A study of 24 countries in Latin America and the Caribbean found that, controlling for educational and developmental starting levels, a "1 percentage point in broadband penetration can generate 0.0178 percentage points in GDP growth" (i.e., 10 percent increase in broadband penetration results in 1.78 percent increase in GDP).[35] Based on this figure, it was estimated that the contribution of broadband to GDP growth throughout Latin America and the Caribbean was 3.4 percent between 2009 and 2010.[36] The study also found that from 2007 to 2008, the growth of broadband access in Latin America and the Caribbean contributed between USD 6.7 billion and USD 14.3 billion to the economies, taking into account both direct and indirect effects.[37]

South Africa

In July 2010, the South African Government issued the Broadband Policy for South Africa, which aims to provide 256 kbps download speed to 15 percent of the country's households with broadband being within 2 km of the remaining households by 2019.[38] A 2010 study by Analysys Mason reviewed the likely direct and indirect effects the broadband policy might have on South Africa's economy, finding that wireless broadband is expected to increase the country's GDP by 1.8 percent, or over ZAR 72 billion (USD 9.4 billion) by 2015.[39] In addition, wireless broadband is expected to create about 28,000 new jobs directly, not including further jobs outside the communications industry.[40]

Thailand

A 2010 study of broadband in Thailand noted that even without a formal broadband plan or policy—the "business as usual" (BAU) path to broadband access (considering fixed and wireless connections with speeds of at least 256 kbit/s) would result in a broadband penetration rate of 17 out of 100 households.[41] This is expected to add nearly 1 percent to the country's GDP growth by 2015.[42] The study notes that while "this increase will contribute marginally to Thailand's economy, it represents a 50 percent to 60 percent lower broadband penetration rate than what we can expect from most other Asian peer nations by 2015," which is likely to leave Thailand at a competitive disadvantage vis-à-vis its neighbors.[43]

The study noted that if a broadband plan is implemented that provides "meaningful broadband," the penetration rate in Thailand may nearly double by 2015, with 80 percent of this penetration based on wireless broadband technologies.[44] Based on this broadband projection, mobile broadband "would drive new investments, expand the domestic economy, and bring a rise to GDP of as much as 2.4 percent per year, all other things being equal."[45] As such, broadband has the potential to be a "meta-driver" of "overall macroeconomic growth, rather than merely a driver of ICT industries alone."[46]

1.3.3 Broadband, Employment and Job Creation

Broadband enables job creation through three main channels: 1) direct jobs created to deploy the broadband infrastructure; 2) indirect and induced jobs created from this activity; and 3) additional jobs created as a result of broadband network externalities and spillovers.[47] Each of these channels includes the employment of unskilled, skilled and highly skilled workers. Direct jobs relate primarily to civil works and construction of broadband infrastructure, which involves more low-tech positions. Indirect and induced jobs require various levels of skilled workers. However, network-effects (i.e., spillover) jobs are mainly high-skill jobs requiring specific technical knowledge and education. Indeed, broadband spillover employment effects are not uniform. Instead, they tend to concentrate in service industries, such as financial services, health care, etc. It can also produce some effects in middle-skills jobs, such as in manufacturing, but usually related to the use of ICT, requiring ICT-skills.

Numerous studies have estimated the impact on broadband in each of these job creation categories for specific countries by calculating employment multipliers for each of the categories (Table 1.2). While these studies are country-specific and cannot be applied directly to other nations, they provide an estimate of the potential employment gains that could result from effective broadband development. A simple average of these estimates indicates that potential broadband job creation results in 2.78 indirect and induced jobs per direct broadband construction job created and 1.17 spill-over additional jobs created per direct job. This means that broadband can create between 2.5 and 3 additional jobs per direct broadband employment. Some studies have estimated the impact of broadband on the employment creation rate. For instance, Katz estimated that an increase of about 8 percentage points of broadband penetration in 12 Latin American countries could result in almost 8 percent increase on average over their employment rate.[48]

Table 1.2. Estimated Broadband Employment Creation Multipliers

Study	Year	Scope	Type I	Type II	Network Effects
Crandall et al.	2003	US	…	2.17	…
Katz et al.	2008	Switzerland	1.4	…	…
Atkinson et al.	2009	US	…	3.60	1.17
Katz et al.	2009a	US	1.83	3.43	…
Libenau et al.	2009	UK	…	2.76	…
Katz et al.	2009b	Germany	1.45	1.93	…
Average			**1.56**	**2.78**	**1.17**
Note: Type I (Direct + Indirect)/Direct; Type II (Direct + Indirect + Induced)/Direct					

Sources: Katz 2009, citing Crandall el al. (2003),[49] Katz et al. (2008),[50] Atkinson et al. (2009),[51] Katz et al. (2009a),[52] Libenau et al. (2009)[53] and Katz et al. (2009b).[54]

It should be noted that although broadband is likely to have overall positive effects on job growth, short-term job losses may result from broadband-enabled improvements in productivity due to process optimization and capital-labor substitution. Various studies have confirmed that broadband creates many more jobs than it displaces in the longer term. For example, the OECD has found that increased broadband penetration rates can significantly affect labor productivity; raising broadband penetration five percentage points has yielded an estimated 0.07 percent increase in labor productivity.[55] Similarly,

Booz & Company found that "10 percent higher broadband penetration in a specific year is correlated to 1.5 percent greater labor productivity growth over the following five years."[56] By simultaneously lowering the costs of doing business and increasing productivity, broadband can be instrumental in promoting the growth of enterprises.[57]

As with broadband's effects on GDP, further data collection and analysis are needed to confirm the positive impact that broadband has on employment growth. Yet, aside from the studies identified above, researchers focusing on various regions and outcome measures have reported more evidence of how broadband development has stimulated the job market.

A European Commission study found that broadband had a positive impact on employment in 2006 with a net creation of 105,000 jobs throughout Europe due to broadband deployment.[58] A nationwide study in the United States examined how broadband deployment affects job creation, determining that the availability of broadband at a community level increased employment growth by more than 1 percent.[59] Another study focusing just on the state of Kentucky in the southern United States found that a 1 percentage point increase in broadband penetration increased employment by 0.18 points, with the increase ranging from 0.14 percent to 5.32 percent depending on the industry sector.[60]

In Malaysia, the Malaysian Communications and Multimedia Commission (MCMC) estimated in 2008 that achieving 50 percent broadband penetration by 2010 could increase the country's GDP by 1 percent, as well as create 135,000 new jobs. The regulator further projected that by 2022, the number of jobs created would reach 329,000, again based on 50 percent broadband penetration rate.[61] An evaluation of multiple studies showed that for "every 1000 additional broadband users, roughly 80 new jobs are created."[62]

1.3.4 Broadband as a General Purpose Technology

The importance of broadband might only be fully realized once it is understood as a general purpose technology (GPT). While the notion of broadband as a GPT has been addressed only in recent discussions of broadband and development, as well as in government-funded stimulus plans, the concept of GPTs was introduced on a more general basis already in the 1990s. It includes three key characteristics:

- Pervasive use in a wide range of sectors;
- Technological dynamism (inherent potential for technical improvements); and
- As GPTs evolve and improve, they spread throughout the economy, bringing about general productivity gains.[63]

In broad terms, GPTs are technologies that enable new and different opportunities across an entire economy, rather than simply addressing one problem or one sector. According to the OECD, GPTs "fundamentally change how and where economic activity is organized."[64] Common examples of GPTs include electricity, the internal combustion engine and railways.

Although the initial conception of GPTs did not include the ICT sector, later research has considered ICTs (with broadband as the enabling platform) through the lens of the GPT concept. This view of broadband as a potential GPT has also been embraced in publications from, or on behalf of, the World Bank, *info*Dev and the European Commission, as well as in academia.[65]

When taken holistically, broadband as a platform—coupled with services, applications, content and devices—has the potential to satisfy the three criteria mentioned above, so that it can be considered a GPT. First, broadband can be used as a key input in nearly all industries. Second, broadband has the

potential for technological dynamism through the development of new technologies, as well as improvements to the capacity and speed of broadband systems. For example, the average global broadband (wireline and wireless) speed in mid-2011 was 2.6 Mbit/s, with the top 20 countries having average speeds of over 7.6 Mbit/s, which allows services and applications requiring higher bandwidth, such as streaming video, to develop and become accessible to users.[66] Third, broadband has the potential to enable and engender new organizational methods that result in more general increases in productivity. Global architecture firms, for example, may have offices around the globe, but team members working on a new building design no longer have to be in the same place or even the same time zone. By using broadband connections to share work products, the team can be completely decentralized.

As broadband's potential as a GPT is realized, it becomes an enabler of technology-based innovation and growth throughout the economy by businesses and individuals, as well as by academic, governmental and other institutions. Businesses and individuals are able to use currently available broadband technologies and services to create entirely new applications and services in areas such as advertising, e-commerce, online video, social networking and financial services, including online banking and loans.[67] Innovation in these areas is important for the growth of new markets in developed economies and for the transfer of technology to emerging economies, which can benefit from e-services, such as mobile health and mobile banking.[68] Broadband-enabled services also allow the public sector to access new communities and regions, as well as deliver higher quality services more efficiently, including online education, telemedicine and civic participation. In the following several specific examples of how broadband can enable growth in and beyond the ICT sector in both developed and developing countries are provided. Five common themes are discussed: improved research and development efforts, reduction in business costs through cloud computing, improved productivity in the retail, services and manufacturing sectors, and improved outcomes in education and health care.

Research and Development throughout Economic Sectors

Broadband can have a particularly strong impact on research and development (R&D) leading to innovative technologies, as well as enabling new ICTs to lead to further innovations. Additionally, broadband may allow businesses to move more rapidly in the product development cycle from the idea stage to final product.[69] For example, a company could have teams in various locations around the world working on related portions of the same project, using broadband connectivity to provide seamless communication and information sharing (see Box 1.2).

Box 1.2. Examples of the Potential Impacts of Broadband on Innovation in R&D

- Enable instant sharing of knowledge and ideas
- Lower barriers to product and process innovation via faster and less expensive communications
- Accelerate start-ups
- Improve business collaboration
- Enable small business to expand their R&D and collaborate in larger R&D consortia
- Reduce time from idea to final product
- Foster greater networking
- Promote "user-led innovation"

Source: OECD, Broadband and the Economy (2008).

Increasing broadband penetration may also enable more than just large firms, governments and academic research institutions to develop innovative products. For example, Apple's iPhone App Store has over 100,000 registered application developers, most of which are small companies.[70] Since the App Store opened in 2008, Apple has paid app developers over USD 2.5 billion.[71]

Cloud Computing: Reducing Costs for Businesses

For enterprises of all sizes, the costs of IT infrastructure, including hardware, software, and technical support, can be significantly reduced with the adoption of cloud computing technologies. Cloud computing generally allows for instant access to and storage of applications and data via broadband connectivity. Currently, almost every traditional business application has an equivalent application in the cloud, which means that cloud services can effectively replace the more conventional, and typically more expensive, method of accessing and storing applications and data through software installed locally on one's own computer or in-house server.[72] Additionally, cloud computing reduces or eliminates the need for on-site IT staff since these data processes are handled remotely. Other potential benefits of cloud computing for businesses include:[73]

- Reduced need for up-front investment since cloud-computing is typically based on a pay-as-you-go pricing model;
- Lower operating costs since the service provider does not need to provision capacities according to the peak load;
- Easy access through a variety of broadband-enabled devices; and
- Reduced business risks and maintenance expenses, as business risks (such as hardware failures) and maintenance costs are shifted to infrastructure providers, who often have better expertise and are better equipped for managing these costs and risks.

In 2011, Harvard Business Review Analytic Services conducted a global survey of nearly 1,500 businesses and other organizations on their current and planned use of cloud computing, as well as the perceived benefits and risks associated with cloud computing services.[74] About 85 percent of respondents stated that their organizations will be using cloud computing tools on a moderate or extensive basis over the next three years in order to take advantage of the benefits of cloud computing, including improved speed and flexibility of doing business, lower costs and new avenues for growth, innovation and collaboration. Only seven percent of respondents stated that their businesses had been using cloud computing for over five years; however, these early adopters reported that real business value had already been created, including faster time to market, lower operation costs and easier integration of new operations.

In addition, cloud computing itself can provide for new business models and avenues for revenue. For example, Amazon, the largest U.S. online retailer, began offering cloud computing services to businesses and individuals in 2002 because the company had excess computing and storage capacity.[75] In order to accommodate the busiest shopping week of the year in the United States, Amazon had to purchase a much larger amount of capacity than was required for the rest of the year. Rather than let the extra capacity go unutilized, Amazon began renting out its system to others, thereby becoming a "utility" for computing services.

Despite the promise of cloud computing as a source of substantial cost savings for enterprises, there are various issues that may limit its impact, particularly lack of access to broadband services. Cloud computing requires access to fast, reliable and affordable broadband in order to achieve its maximum functionality. In addition, cloud computing raises several network and data security concerns.[76] Other

significant concerns include reliability of the technology, lack of interoperability with existing IT systems and lack of control over the system.

Retail and Services Sectors

Particularly for the retail and services sectors (that is, customer relations averages 50 percent or more of a company's activities), broadband can improve the ability to reach new customers and maintain contact with existing customers.[77] As such, the ability to send multimedia email or use targeted online advertising to keep and attract customers can increase a company's sales while using less capital and labor inputs than would be required for postal mailings or door-to-door sales calls. Broadband also enables self-service websites, such as online airline reservations or e-government services, as well as remote services such as online technical support and video conferencing.[78] For example, broadband is essential for developing countries, particularly India, Mauritius, and China, which are the main off-shoring destinations for IT technical support and business process outsourcing.[79]

In addition, sophisticated services, enabled by broadband and the development of ICTs, have become not just a traded input for goods, but a final export for direct consumption.[80] Success stories such as call centers in Kenya, business consulting and knowledge-processing offices in Singapore, accountancy services in Sri Lanka, and human resources processing firms in Abu Dhabi are different forms of this phenomenon. Recent research has found that sophisticated service exports are becoming an economic driver of growing importance in developing countries and may be an additional channel for sustained high growth.[81] The deployment and adoption of broadband also has the potential to provide an additional conduit for economic growth through service exports.

Manufacturing and Industrial Sectors: Supply-Chain Management

Broadband allows businesses to more efficiently manage their supply chains by automatically transferring and managing purchase orders, invoices, financial transactions and other activities.[82] As with any information-based business activity, broadband can enable faster, more secure and more reliable processing than previously possible. Broadband connectivity saves processing and transfer time along the supply chain, and it can also substantially increase competitiveness by helping businesses reduce stock levels, optimize the flow of goods and improve the quality of final products.[83] Since manufacturing and industrial sectors have been the main driver of overall economic growth in developing countries for the last 15 years, broadband is expected to play a vital role for them in improving productivity in these sectors and in ensuring the ability for companies to effectively compete in a global market.[84]

Education: Building Human Capital

In order to fully realize broadband's potential for economic growth, it is necessary to have an educated workforce trained in the use of ICTs. Additionally, there is a self-reinforcing effect between education (and technological literacy in particular) and broadband adoption, since broadband can help improve fundamental educational outcomes, including learning how to better use broadband. For example, the services and applications available over broadband networks have been shown to improve basic educational performance in a review of 17 impact studies and surveys carried out at national, European and international levels by the European Commission.[85] These studies found that broadband and ICTs positively impacted learning outcomes in math, science and language skills.[86] In addition to facilitating basic skills, broadband improves the opportunities for those with ICT training; they generally have a higher chance of finding employment, as well as higher earning potentials.[87] Bridging the connectivity divide is critical to ensuring that today's students—and tomorrow's high-tech workforce—can take advantage of these benefits.

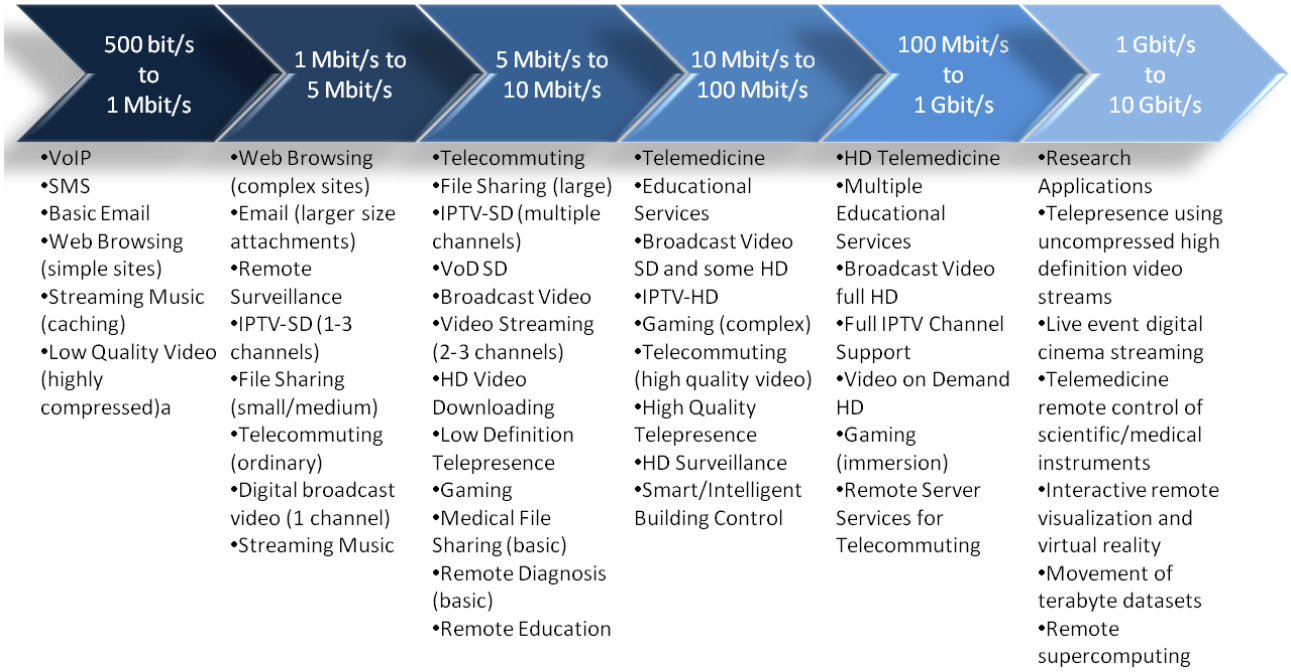
One way to expand access to broadband and ICTs in rural and remote areas is through the deployment of mobile education labs: vehicles fitted with broadband connectivity, computer equipment and learning facilities.[88] They allow educators to drive to various schools throughout the week. In addition, these mobile labs can provide ICT training for adults to improve digital literacy. As opposed to transporting children in rural areas to where broadband facilities exist or waiting until the network is built out to them, mobile facilities offer a more cost-effective way to reach rural populations.[89] The United Nations has noted the success of mobile schools in Mongolia, where 100 mobile "tent" schools have been introduced in 21 provinces, as well as in Bolivia.[90] Bolivia has implemented a bilingual education program for three of the most widely used indigenous languages, which has been expanded to include indigenous children in remote areas.[91] In Morocco, the government implemented a program called NAFID@ to help over 100,000 teachers afford wireline or mobile broadband connections, which has allowed the teachers to receive training in the use of ICTs in the classroom, as well as to use e-learning programs and online libraries to improve class lessons.[92]

Health Care Sector

Health-based broadband applications and services are significantly improving health and medical outcomes around the world, particularly for patients in remote areas and those with limited mobility through e-health and mobile health (m-health) initiatives.[93] Considering that there are fewer than 27 million doctors and nurses for the more than six billion people in the world—and only 1.2 million doctors and nurses in the lowest income countries—harnessing mobile technologies will be a valuable tool for healthcare practitioners to reach patients. As mobile broadband develops and spreads in developing countries, examples of the benefits are already becoming clear.[94]

Although basic voice and data connections can be useful in improving health and medical care, broadband connectivity is necessary to capture the full potential of e-health services, including telemedicine that enables real-time audio and video communications between patients and doctors, as well as between healthcare providers. Improvements in telemedicine and other e-health initiatives rely on increasing bandwidth capacity, more storage and processing capabilities and higher levels of security to protect patient information.[95] As noted in Table 1.3, the U.S.-based California Broadband Task Force estimated that telemedicine will require speeds between 10 and 100 Mbit/s and high definition telemedicine will require broadband speeds of over 100 Mbit/s.[96] The current wireline and wireless infrastructure in most countries is insufficient to take advantage of the e-health opportunities in the digital economy. This is particularly important for developing countries where ensuring access to and adoption of wireline and wireless broadband networks would be particularly useful for including those who have been left out of more traditional healthcare models.

Table 1.3. Necessary Upstream and Downstream Speeds for Various Services and Applications



Source: California Broadband Task Force, The State of Connectivity, Building Innovation through Broadband, Final Report (2008).

This was the case in Rwanda where a three-phase e-health project was delayed due to lack of high-speed broadband connectivity.[97] The first phase of the initiative, which established an electronic data storage system that permitted sharing of patient information among three hospitals, was completed without delay. However, the final two phases involving video conferencing and a real-time telemedicine system were put on hold for a year until a broadband Internet connection could be established to connect the three hospitals with a fiber optic cable network.[98]

Box 1.3. Mobile Health Services in Nigeria

In Nigeria, the government lacked sufficient public health information to efficiently allocate health care services to over 800 villages that lacked primary health care. A public-private partnership, Project Mailafia, was established to alleviate this situation. Project Mailafia sends teams of mobile health care providers to remote villages, where they treat patients and collect health data that support better public health decision-making and resource allocation. The mobile health workers collect the data on ruggedized netbooks, and transfer the data to area clinics. The clinics then upload the data to a central database using Worldwide Interoperability for Microwave Access (WiMAX) and Wi-Fi technologies.

Source: Intel, Realizing the Benefits of Broadband (2010).E-government applications

E-government covers a broad range of applications that transform government processes and ways that it connects and interacts with businesses and citizens. This allows citizens to better participate in society and improves the efficiency, accountability and effectiveness of government programs and processes.[99] Broadband is important for e-government as it provides the foundation for public administration networks that allow processes to flow more smoothly.[100] E-government can also help to drive demand for broadband.

Countries around the world are providing increasing access to online services, including the provision of basic services, the use of multimedia technology to promote two-way exchanges and consultation with citizens on public policy issues.[101] Although the Republic of Korea, the United States, and Canada take the top three places in terms of number of online government services available, the UN found that several countries have made significant progress over the last two years, including Bahrain, Chile, Colombia and Singapore.[102] The UN also found that the use of mobile phones for e-government services, such as alert messages, applications or fee payments, are almost as popular in developing countries as they are in developed countries.[103]

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[4] Christine Zhen-Wei Qiang and Carlo M. Rossotto, *IC4D: Extending Reach and Increasing Impact*, *Chapter 3: Economic Impacts of Broadband*, GICT Dept. World Bank, p. 45 (2009). *See also* Yongsoo Kim, Tim Kelly and Siddhartha Raja, *Building Broadband: Strategies and Policies for the Developing World*, GICT Dept. World Bank (Jan. 2010), *available at* http://siteresources.worldbank.org/EXTINFORMATIONANDCOMMUNICATIONANDTECHNOLOGIES/Resources/282822-1208273252769/Building_broadband.pdf.

[5] Qiang and Rossotto, *IC4D: Extending Reach and Increasing Impact*, *Chapter 3: Economic Impacts of Broadband* (2010), p. 45.

[6] Qiang and Rossotto, *IC4D: Extending Reach and Increasing Impact*, *Chapter 3: Economic Impacts of Broadband* (2009), p. 45.

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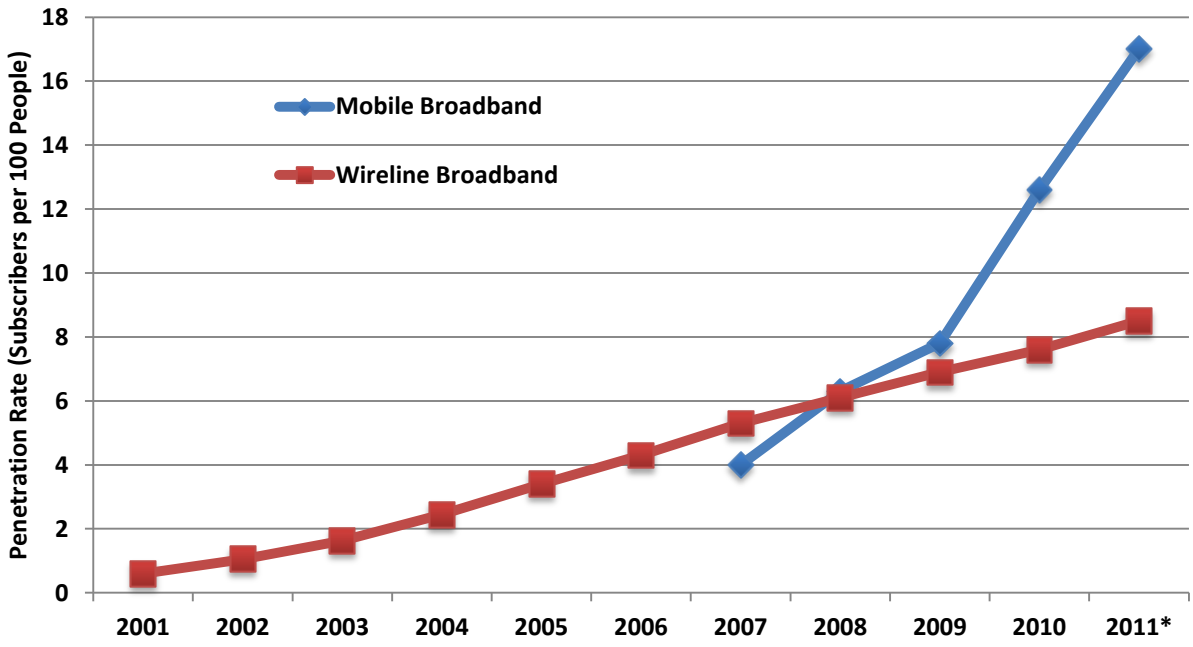
1.4 What Market Trends are Fostering Broadband Deployment and Adoption?

Broadband connectivity is expanding globally. Between 2005 and 2010, the average wireline broadband penetration rate grew over 60 percent—from 3.3 to 8.8 subscribers per 100 people.[1] As a result of such growth, the estimated number of wireline broadband subscriptions surpassed 550 million by mid-2011, up from 471 million in 2009.[2] A sizable number of these new subscriptions come from Brazil, Russia, India, and China (known as the BRIC countries), which have collectively doubled their subscriber base in the last several years.[3] The number of active mobile broadband subscriptions reached nearly 1.2 billion by mid-2011, representing a 45 percent increase annually since 2007, with total mobile subscriptions topping five billion.[4] By the end of 2010, there were over twice as many mobile broadband as wireline broadband subscriptions (see Figure 1.4).[5]

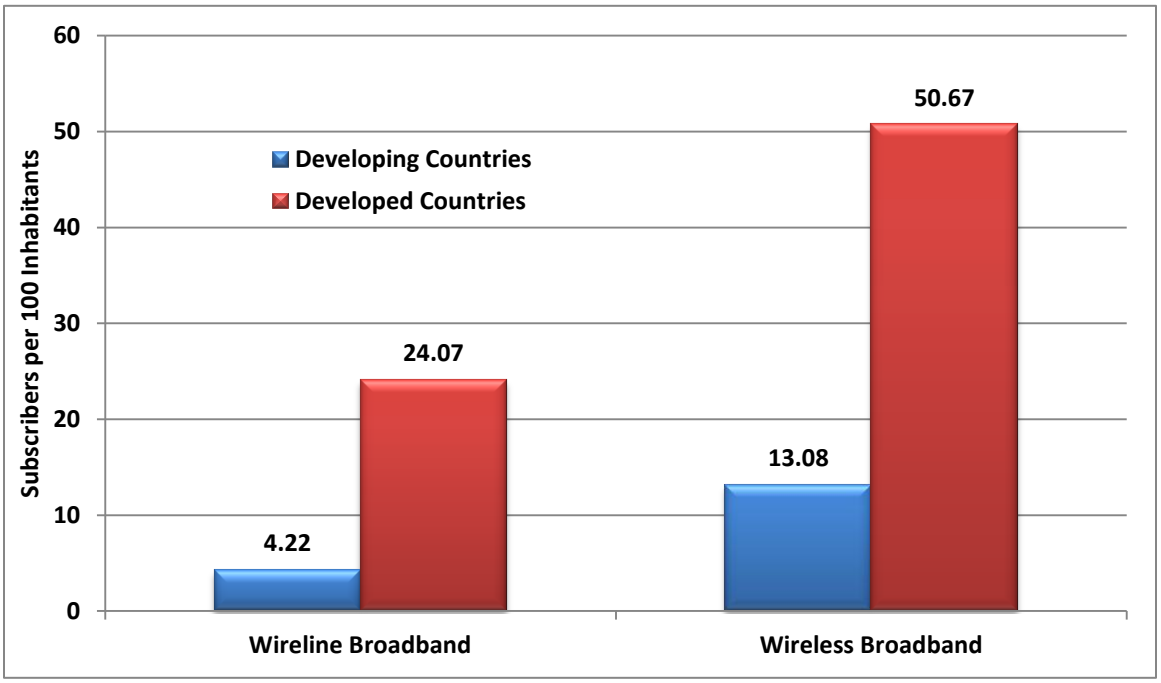
Figure 1.4. Global Fixed and Mobile Broadband Penetration Rate per 100 People (2000-2010)



Source: ITU, World Telecommunications/ICT Indicators Database, Global ICT Trends, www.itu.int/ITU-D/ict/statistics/material/excel/2011/Global_ICT_Dev_01-11.xls (2011).

Despite these advances, a "digital divide" remains between developed and developing countries. Technology fitting the needs of users is critical, but broadband deployment also depends on structural market characteristics, such as competitiveness and purchasing power, as well as the evolution of relevant (localized) content, international connectivity, geography, and several other factors. As shown in Figure 1.5, there are nearly six times more wireline broadband subscribers in developed countries than in developing countries and nearly four times more mobile broadband subscribers.[6] In effect, wireline broadband deployments in many developing countries are a decade behind those in developed countries. Given the cost and resources required for the deployment of wireline broadband, wireless broadband is more likely to be the broadband solution for users in developing countries, particularly in rural and remote areas.

Figure 1.5. Digital Divide for Wireline and Wireless Broadband, 2010



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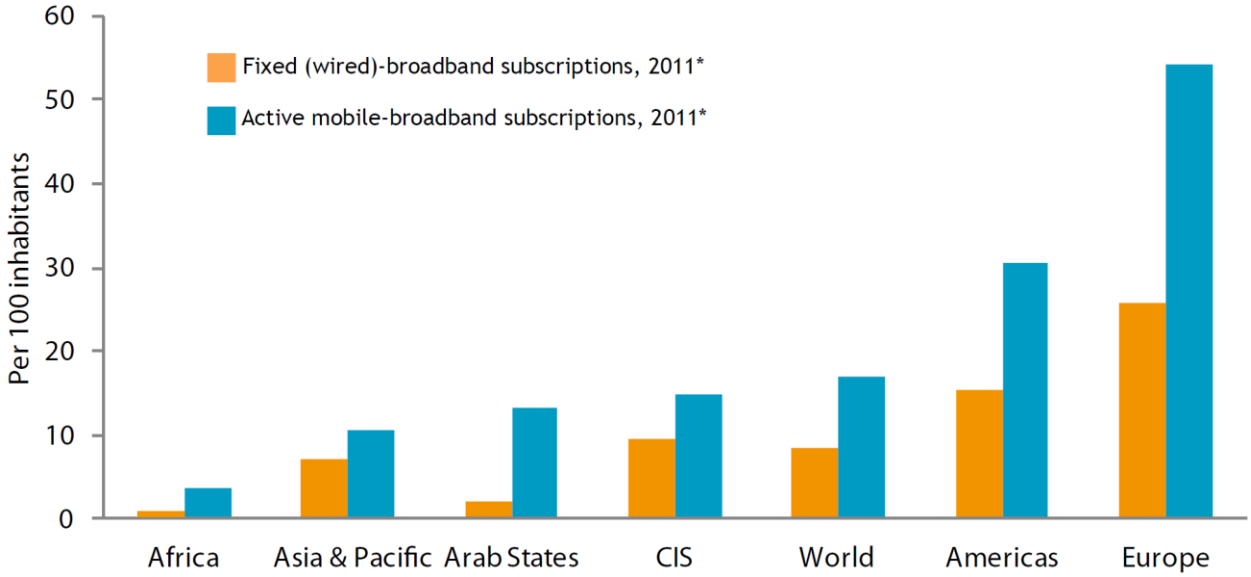
1.4.1 Trends in Supply

Developments in the types of technologies and business models used to deploy broadband network infrastructure are allowing operators to supply more people at lower costs. In developed countries, network operators are installing fiber optic cables closer to end users, reaching directly into their neighborhoods, offices and homes. In developing countries, the spread of high-speed wireless networks promises to gain momentum over the next few years. Wireless broadband is already more prevalent than wireline broadband in many developed and developing countries. As noted in Figure 1.6, the number of wireless broadband subscriptions in Africa, for example, is more than four times that of wireline.[7] In comparison, Europe's wireless broadband penetration is nearly double the wireline penetration rate at 26 percent and 54 percent, respectively.[8] This suggests the potential for wireless broadband in areas where traditional wireline infrastructure may be absent, as well as in areas with substantial wireline build-out.

With the number of wireless broadband subscriptions worldwide surpassing the one billion mark in 2011, developing countries, particularly India and China, are often leading the way.[9] Together, India and China have the top five mobile operators in terms of total number of subscriptions, which is expected to continue as mobile broadband grows.[10]

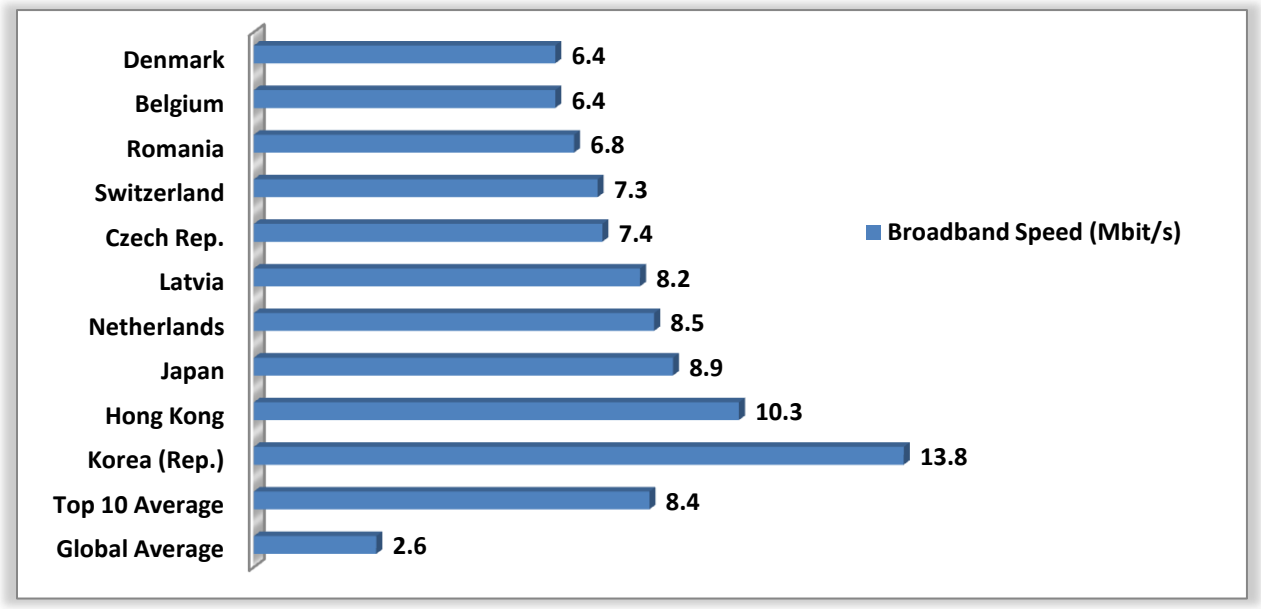
Figure 1.6. Wireline and Wireless Broadband Subscriptions by Region, 2011*



Source: ITU, The World in 2011: ICT facts and Figures (2011).
**Estimates*

Another important trend affecting broadband networks is their ever-increasing speed. In 2011, Akamai, a major Internet traffic manager, noted a global shift away from narrowband to broadband connectivity.[11] As shown in the figure below, the global average Internet connection speeds (for users who pass through the company's servers) rose 43 percent year-over-year to 2.6 Mbit/s, and all of the top ten countries achieved average connection speeds well above the "high broadband" threshold of 5 Mbit/s.

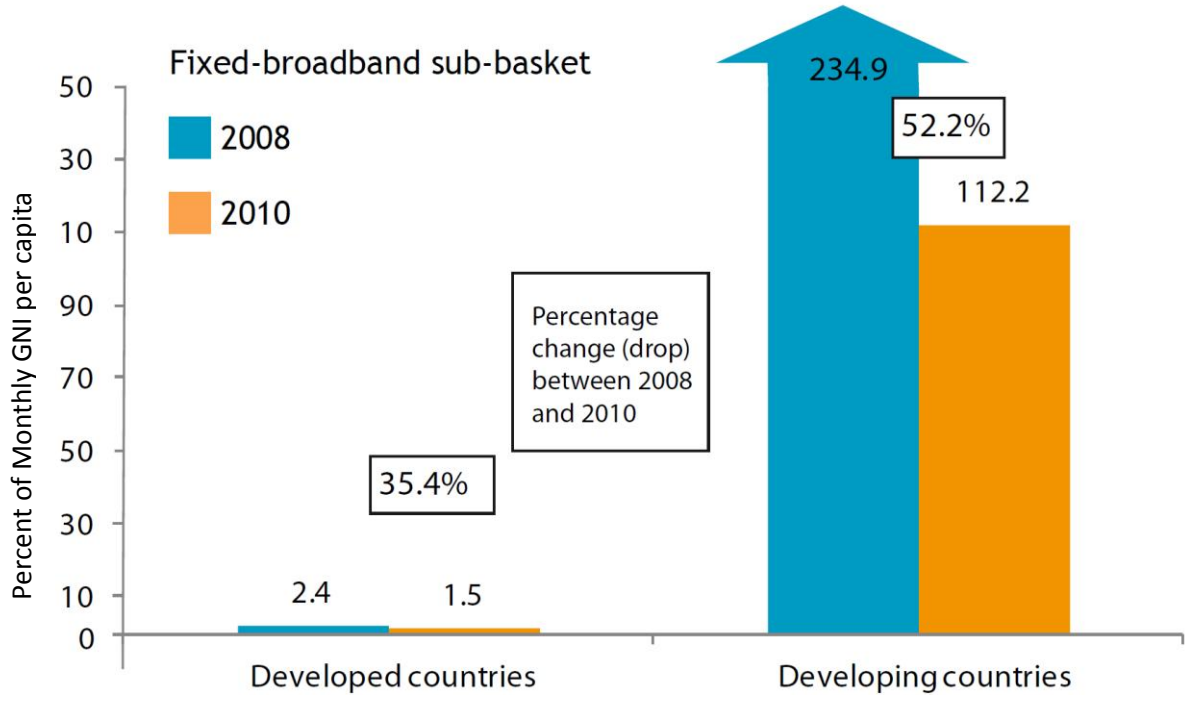
Figure 1.7. Average Broadband Speed: Top 10 Countries, Q2 2011



Source: Akamai, The State of the Internet, 2nd Quarter, 2011 Report.

A result of greater supply of broadband and improved technologies is the steady decrease in broadband prices, generally for equal or faster broadband speed. In its report, *Measuring the Information Society 2011*, the ITU reported that among 165 countries studied, the retail price of "entry level" (i.e., 256 kbit/s) wireline broadband access halved between 2008 and 2010.[12] In developed countries, these monthly broadband subscriptions represented just 1.5 percent of income—for 31 developed countries, a basic broadband subscription costs on average the equivalent of 1 percent or less of average monthly gross national income (GNI) per capita. Comparatively, in 19 countries, most of which are least developed countries, a broadband subscription costs on average more than 100 percent of monthly GNI per capita. For example, the monthly price for a wireline broadband connection in Ethiopia, Guinea, Malawi and Zimbabwe is over ten times the average monthly income. As such, the price of wireline broadband Internet access in developing countries is substantially more expensive relative to developed countries, which demonstrates that despite falling prices, broadband Internet access remains too expensive for many around the world. While wireline broadband prices may be prohibitively high, they are declining most rapidly in developing countries. The ITU found that the steepest reduction in retail broadband prices has taken place in developing countries with wireline broadband prices dropping by over 50 percent between 2008 and 2010, as compared to a drop of 35.4 percent in developed countries (Figure 1.8).

Figure 1.8. Wireline Broadband Prices in Developed and Developing Countries between 2008 and 2010



Source: ITU, The World in 2011: ICT Facts and Figures.

In addition to overall increased availability, faster speeds and declining prices in broadband network access, the release of new broadband-enabled devices may also be viewed as a supply-side input. The overall trend for broadband devices is improved capabilities, mobility and portability. According to research firm IDC, in the second quarter of 2011, global smartphone shipments grew 11.3 percent year-on-year while the feature phone market shrank 4 percent over the same period.[13] In Western Europe, the number of smartphone shipments surpassed feature phone shipments for the first time.[14] By the end of 2011, over 450 million smartphones will be shipped, leading to the worldwide smartphone

market growing nearly 50 percent since 2010 as users upgrade to smartphones with more advanced features.[15] These devices are designed to take advantage of broadband connectivity, whether provided by a mobile network or by Wi-Fi distribution of the wired broadband connection in a home, workplace, or Wi-Fi "hotspot."

Mobile Broadband for Developing Countries

While developing economies often do not have the type of infrastructure that is usually associated with broadband deployment (that is, wireline access), the significant deployment and availability of mobile services is proving to be an easier way for the developing world to shrink the digital divide. Access to 2G mobile networks is now available to 90 percent of the world population and 80 percent of the population living in rural areas. By mid-2011, 3G networks reached 45 percent of people worldwide.[16] According to the ITU, people are moving rapidly from 2G to 3G platforms, in both developed and developing countries, with 159 countries offering 3G services commercially by mid-2011, compared to 95 countries in 2007.[17]

Globally, there has been steady growth in the number of advanced mobile wireless broadband networks. As of October 2011, 424 HSPA systems had been launched commercially in 165 countries, including 152 commercial HSPA+ networks launched in 79 countries.[18] By mid-2011, nearly 600 WiMAX networks had been planned or launched commercially worldwide.[19] Most of these WiMAX networks are being deployed in developing countries and Africa regions. For example, there have been 120 commercial or planned WiMAX deployments in 33 Latin American and Caribbean countries and 117 deployments in 43 African countries.[20]

As mobile broadband subscriptions have overtaken fixed broadband subscribers, the continued accessibility to mobile services has spurred the growth and deployment of broadband in the developing world. Indeed, because of high penetration of mobile in the developing world, as the broadband market matures, the majority of growth is likely to occur there.[21]

The immense commercial success of mobile telephone service attests to the attractiveness of untethered access to users around the world. In the developing world, it is important to note that mobile services are in many cases the first widely available two-way telecommunications technologies. As such, while the appeal of mobility is certainly a factor, the choice for many users is not between mobile and fixed service, but rather between mobile broadband and no broadband. In addition, in many countries, particularly developing countries, the deployment of new access lines is time consuming, costly, and yields unattractive returns. As noted in the case of India (see Table 1.4), there are substantial cost differentials when comparing the costs of deploying broadband technologies.

Table 1.4. Comparative Evaluation of Deploying Broadband Technologies in India

Technology	Time to Deploy	Capex per Subscriber
DSL (FttN) Existing Line	Low	USD 799
DSL(FttN) New Line	High	USD 2,200
FttH	High	USD 2,540
FttB	Medium	USD 1,390
WiMAX	Low	USD 133

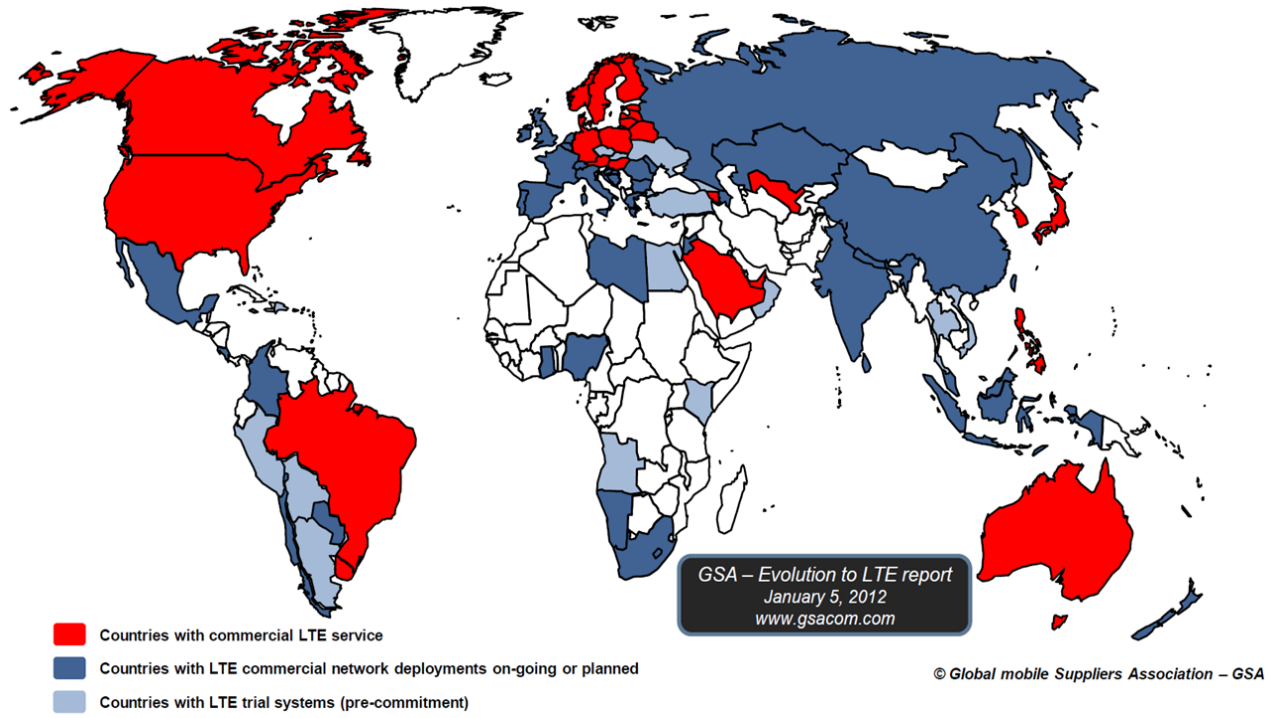
HSPA	Low	USD 125

Source: Analysys Mason, Assessment of Economic Impact of Wireless Broadband in India, December 2010, available at http://www.gsmamobilebroadband.com/upload/resources/files/AM_India_Exec_Summary_Final.pdf.

Deployment of mobile broadband technologies is beginning to advance beyond 3G in both developed and developing countries. In particular, LTE systems are capable of providing broadband speeds faster than DSL and comparable to fiber optic networks. Regulators are assisting these developments by increasingly permitting mobile operators to upgrade existing network infrastructure, as well as releasing new spectrum bands for mobile services.

As of January 2012, 285 network operators in 93 countries were investing in LTE systems, including 49 commercial LTE networks launched in 29 countries (Figure 1.9).[22] Although current commercial deployments of LTE are focused in developed countries, there have been a few commercial LTE launches in emerging economies, including Saudi Arabia, the Philippines and the United Arab Emirates.[23] LTE is in the trial stages in many other developing countries throughout Latin America (e.g., Argentina, Bolivia, Brazil, Chile, Colombia, Dominican Republic, Mexico, Peru and Uruguay); the Asia-Pacific region (e.g., China, India, Indonesia, Malaysia, Sri Lanka, Thailand and Vietnam); and the Middle East and Africa region (e.g., Angola, Bahrain, Egypt, Kenya, Namibia, Oman and South Africa).

Figure 1.9. Worldwide LTE Network Commitments, Launches and Trials as of January 2012



Global mobile Suppliers Association, Map: Worldwide LTE Network Commitments, Launches and Trials, January 5, 2012.

Towards Ubiquitous/Seamless Broadband Access

Perhaps the ultimate trend in advanced wireline and wireless broadband technologies is the ability for users to access networks seamlessly, whether at work or at home, in shops or restaurants, on planes, trains, at sea and in the most remote areas. Beyond the current and emerging terrestrial wireless and

wireline technologies being used for provision of broadband services addressed above, satellites are also capable of providing Internet access, reaching the most remote locations. A new generation of satellites was launched in the beginning of 2010 that are capable of providing true broadband speeds to end users. The advantage of satellite broadband access is that it can extend broadband to those areas that neither wireline nor terrestrial wireless providers can go. Collectively, terrestrial and satellite broadband deployments will help to provide ubiquitous access and ensure that anyone has the option to subscribe to a broadband service, as well as maintain connectivity regardless of where they travel. In addition to ubiquitous broadband access, cloud computing services, which help to drive demand for broadband, will enable a seamless broadband experience from any device, as addressed below.

1.4.2 Trends in Demand

The development of novel or enhanced applications, services and devices enabled with broadband connectivity has served as a key driver of demand for broadband access over the past several years. The availability of broadband networks has allowed at least a partial migration of existing services away from more traditional models requiring consumers to conduct in-person transactions and/or abide by pre-scheduled services (such as banking, education, healthcare, shopping and entertainment) towards broadband digital networks that allow consumers to conduct a wide variety of activities online and on their own time, regardless of standard business hours or scheduled programming. While many of these same services saw an initial online presence with dial-up and other narrowband services, the rise of broadband connectivity has facilitated the development of more robust applications and services. Today, broadband networks allow consumers near-instantaneous access to on-demand entertainment content; permit professionals to better communicate and collaborate with far-flung colleagues; and create opportunities for students to access richer, more interactive educational materials. From the perspective of organizations leveraging broadband-enabled services to better reach consumers, clients, members and citizens, the efficiency of electronic communications has led to an increasing interest in bringing traditionally offline or non-electronic services to the Internet, or at least augmenting traditional means with online alternatives.

Innovative Applications and Services

Demand for more and higher-quality video and other rich content will be a major factor in driving the demand for higher-capacity broadband access. In addition, applications are also increasingly driving broadband use and development. Applications consist of function-specific software that delivers content to users or allows them to perform certain tasks.[24] Social media applications, which connect users and allow for creative, collaborative, user-centered and interoperable environments in real time, are also helping to drive demand for broadband.[25] These applications include social networking, a wide variety of Web 2.0 applications and cloud computing services, as addressed below.

Social Media and Web 2.0

Social media, which include YouTube and Facebook, are applications that facilitate social interaction, using web and mobile technology. For example, YouTube, which allows users to generate video content, upload it and share it with others, is one of the most widely used social media applications and requires broadband capabilities to be effective. In 2011, some 48 hours of video was uploaded to YouTube every minute, resulting in nearly eight years of content uploaded each day—equivalent to 240,000 feature films every week.[26] Web 2.0 is closely related to social media and is a term generally associated with applications that feature user-generated content and facilitate collaboration among users.[27] Web 2.0 applications—including web-based communities, hosted services, web applications, social networking sites, photo and video sharing sites, wikis, blogs, mashups and folksonomies—are

interoperable, user-centered, and collaborative. Unlike the "traditional web," they allow users to generate, distribute and share content in real time and typically require broadband connectivity. The availability of social media and Web 2.0 applications is stimulating demand and is an important factor to bear in mind in developing demand creation or facilitation strategies.

Social Networking

Social networking applications allow people to initiate and maintain connections, communicate with one another via various media, including text, voice and video, interact through social games and share user-generated and traditional media content. The highly personalized, easy, and flexible nature of social networking applications makes them some of the most-used online tools and one of the main drivers of broadband demand. Since these websites tend to offer only limited functionality with low bandwidth Internet connections, they help to drive broadband demand among users seeking to take full advantage of them. Non-adopters who may not have found broadband to be relevant in the past may seek out broadband services in order to interact with family and friends, as well as discover and create other engaging user-generated content.

Mobility is an important part of social networking. In December 2011, of the over 845 million active Facebook users, more than 425 million accessed Facebook through their mobile devices and use Facebook twice as much as their non-mobile device counterparts.[28] Indeed, evidence already exists that social networking applications are driving mobile broadband use in many countries. In the United Kingdom, mobile operator Hutchison 3G released traffic statistics showing the amount of data customers use when browsing social networking sites.[29] The operator found that social networking accounts for most mobile broadband usage in the country, with Facebook being the most popular application. With the number of mobile broadband users surpassing the one billion mark in 2011, the value of social networking driving demand for ever-increasing amounts `of data is substantial.[30]

Box 1.4. Impact of Facebook—Some Key Statistics

- Facebook has more than 845 million active users around the world.
- About 80 percent of Facebook users are located outside of the United States and Canada.
- Over 70 languages are available on the site.
- Over 700 billion minutes a month are spent on Facebook.
- Over 425 million people access Facebook via their mobile phone per month.
- 48 percent of young people said they now get their news through Facebook.
- The average user is connected to 80 community pages, groups and events.
- On average, more than 250 million photos are uploaded per day.
- In just 20 minutes on Facebook over 1 million links are shared, 2 million friend requests are accepted and almost 3 million messages are sent.

Source: http://www.facebook.com/press/info.php?statistics; as of January 2012

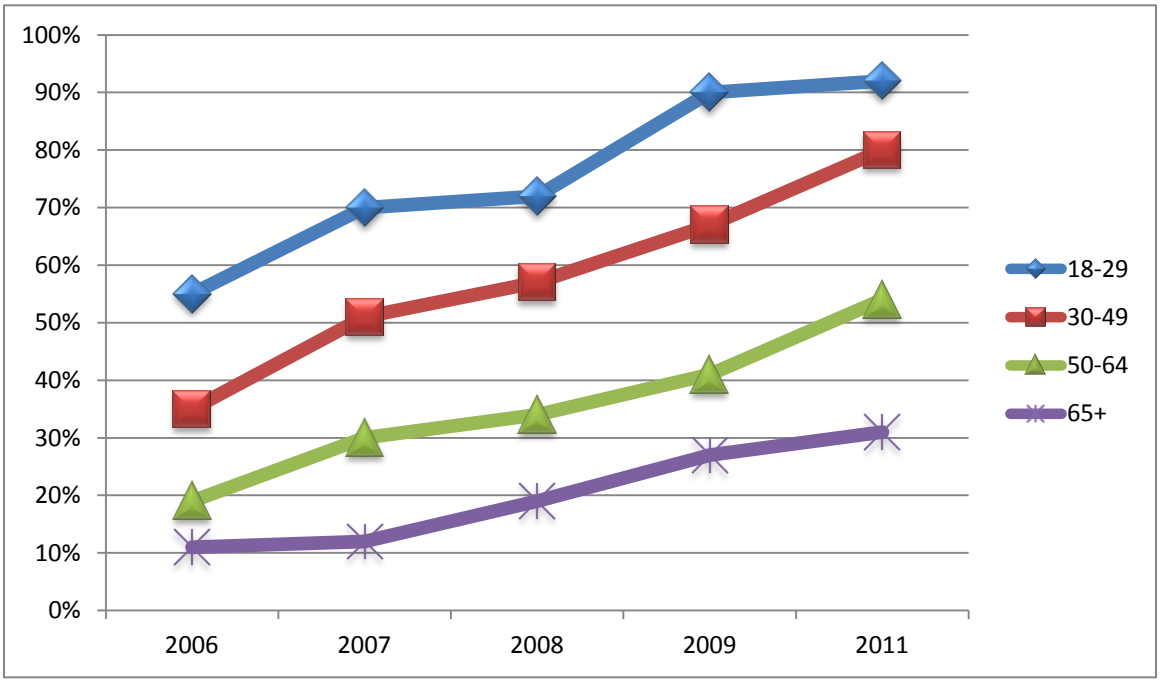
Particularly in developing countries where mobile broadband is likely to be more accessible than wireline broadband, social networking applications accessed through mobile devices are likely to be a major driver of demand for broadband access. Facebook is actively reaching out to users without advanced phones or networks, in the expectation that it will entice more advanced usage in time.[31] India is now number two (after the United States) in terms of active Facebook users with nearly 43.5 million users as of February 2012, with Indonesia a close third with over 43 million users.[32] One of the reasons for Facebook's popularity in Indonesia is that it is "a way to establish social status, success and a platform for self-promotion."[33] This resonates with many people in developing countries where Facebook has emerged as the leading application.[34] Indonesia's interest in social networking extends to

Twitter: around one-fifth of Indonesian Internet users access the microblogging application, equaling the world's highest penetration.[35] All of this has spurred a demand for faster connectivity, with available mobile broadband speeds rising to 40 Mbit/s.[36]

In general, the exchange of user-generated content, particularly through video-sharing sites, also helps to drive broadband. Since social media focus on user-generated content, they are often quite localized, meaning they are available in local languages and character sets and deal with topics that are locally relevant. As noted in a 2011 survey by Pew Research Center, 71 percent of online adults in the United States use video-sharing sites, which is a 38-point increase from 2006.[37] For example, with more than three billion videos viewed every day, YouTube has become the most popular online video sharing site in the world.[38] As *Forbes* magazine noted, the site is likely the "biggest television station on the planet."[39] Not only does broadband access facilitate use of these social networking applications, but the applications are major drivers of broadband demand.

Perhaps most indicative of future trends is that younger users report more frequent usage of video-sharing sites, implying that, as younger users get older, the popularity of video-sharing sites among all age groups will continue to rise. This trend is visible in data from the last five years, as shown in Figure 1.10. In each of these cases, broadband connectivity enables access to the media, information, conversations or services that users are sharing. While some of these services may function over a narrowband connection, most are intended for the always-on, high-speed connectivity of broadband.

Figure 1.10. Percentage of Internet Users Watching Videos on Video-Sharing Sites by Age, 2006-2011*



Source: Pew Internet & American Life Project, The Audience for Online Video-Sharing Sites Shoots Up
**2010 data broken down by age range are not available.*

As another important social networking application, Twitter, an application that allows users to broadcast short text messages, had over 100 million registered users worldwide in 2011.[40] Formed in 2006, it is already a powerful tool for the organization of social and political activities across the world.[41] In particular, Twitter and other social media helped play a pivotal role in the 2011 so-called "Arab Spring" uprisings. Protest organizers used Twitter, Facebook and YouTube, in addition to texting and

similar narrowband technologies, to coordinate protest activities. Social media facilitated the spread of information about citizens' grievances through YouTube videos and conversations on social networking websites when official or traditional media sources may not have given those grievances much or any coverage. These online tools are now firmly embedded within a more expansive media ecology that includes traditional sources such as radio, as well as popular satellite television stations.

Indeed, there is much interest in user-created content created outside of professional routines and practices. The OECD predicts that the popularity of user-created content will likely continue to grow, with new drivers furthering its creation and use. Specifically, consumers will increasingly use mobile devices to watch and create user-created content, with higher uplink data transmission speeds and other consumer devices allowing easier content upload.[42] All this means that the demand for mobile broadband devices capable of video capture and sharing will only grow.

Social Collaboration: Wikis, Mashups, and Crowdsourcing

Web 2.0 applications allow for more than simply connecting with others—they also allow for people anywhere in the world to collaborate: they can create content through blogs and podcasts; co-create content, for example, through wikis; link different types of content from different sources together to create new media (e.g., mashups); or use social tags to identify folksonomies. Additionally, Web 2.0 applications often have strong network effects in which websites become more useful as more people participate (e.g., Wikipedia entries or reviews of products on Amazon).

Although perhaps to a lesser extent than social networking applications, these social collaboration tools help to increase the demand for broadband services by engaging users and making the online experience more personalized and flexible. Often, they draw on the idea of the "wisdom of the crowd," which refers to practices where opinions and information are collectively created rather than arrived at by the views of a single or small group of experts.

- Wikipedia is a well-known example of such social collaboration. The popular collaborative encyclopedia is multilingual, web-based, free to access and written by Internet volunteers, most of whom are anonymous. Anyone with Internet access can write and make changes to Wikipedia articles, and there are currently more than 82,000 active contributors around the world who are creating and editing over 19 million articles in 270 languages.[43] Launched in 2001, Wikipedia is now available in over 280 languages—the English Wikipedia contains nearly 3.9 million distinct articles, followed by German with 1.36 million and French with 1.21 million[44], though many languages native to developing countries remain under-represented. .[45]

- Users can also create mashups, which are interactive Web applications that integrate content (e.g., video, text, audio or images) retrieved from third party data sources in order to create new and innovative services and applications.[46] Mashup websites tend to rely on external websites that use open source application programming interfaces (APIs), which expose all of the instructions and operations in an application to facilitate the interaction between different software programs. Mashups may be as simple as a restaurant's website embedded with a single API, such as a Google map to make it easier for customers to find it. Other mashups combine multiple APIs. For example, a web-based interactive restaurant guide could use APIs from sites with online reviews, photos, and maps to tell you the best places to eat in a given city and where to find them.

- Crowdsourcing is a type of web collaboration referring to the outsourcing of tasks to a large, undefined group or community (the "crowd") through an open call for assistance, such as via Twitter, Facebook or a dedicated webpage. Following the 2010 earthquake in Haiti, the Crisis Map of Haiti used crowdsourcing to coordinate relief efforts on the island. Those in need could submit

incident reports via the organization's website, phone, SMS, email, Facebook, Twitter, etc., and thus request aid or even report missing persons. After being reviewed by volunteers, the reports were mapped with Global Positioning System (GPS) coordinates in near real-time on a map also showing shelter sites and hospitals. These tools helped speed search-and-rescue efforts and provide vital supplies to those most needing them. The events in Haiti provide a model for how to deal with future disasters, both natural and man-made, as well as demonstrating a practical application of Web 2.0 technologies.

Collaborative Working Tools for Businesses and Institutions

Businesses and institutions are taking advantage of Web 2.0 applications (often referred to as "Enterprise 2.0") to improve productivity and efficiency, as well as lower costs. Generally, Web 2.0 applications are not only less expensive, faster to deploy and more flexible than commercial or customized software packages, but also offer built-in collaborative workspace tools that enable people to interact across differences in time and space.[47] These tools often center around "groupware" that allows multiple people to work together on projects and share documents, calendars and other data and to participate in video and audio conferences. Since Web 2.0 apps require large amounts of bandwidth to download and upload the various types of digital media, a broadband connection is essential.

Education and Web 2.0

Support for school connectivity programs can be strengthened through the use of Web 2.0 applications in education. Even where virtual classrooms or other e-learning tools are in use, Web 2.0 tools can replace or complement expensive Virtual Learning Environment (VLE) software to provide a more flexible approach through the use of blogs, wikis, and other collaborative applications. For example, a classic VLE involves the teacher sharing slides and resources with students through an enabling software program. Web 2.0 applications, such as Slideshare for presentations, Google Docs for documents, Flickr for images, and YouTube for videos, however, are capable of replicating the core functions of the VLE software at no cost to educators or students.[48] Open source and cloud technologies also allow for more educational opportunities where fewer resources are available. For example, students without personal computers can complete assignments at a university computer lab or Internet café via Google Docs. Other services, such as Flat World Knowledge's open source textbooks, allow professors to review, adopt, and even customize textbooks for their classes, which students can then purchase in print format or view online for free, further reducing the cost of education. Additionally, teachers can incorporate blogging and wikis to encourage student participation and interaction.

A 2009 study by the Joint Research Centre of the European Commission on e-learning initiatives in Europe found that student and teacher participation in Web 2.0 applications supports technological innovation in education and training by providing new formats for knowledge dissemination, acquisition, and management.[49] These tools increase the accessibility and availability of learning content through a range of platforms that offer a large variety of educational material. Further, Web 2.0 tools support new strategies for studying a subject matter by making available a host of dynamic tools for transforming content and displaying information in different formats, as well as contribute to diversifying and enhancing teaching methods. Students are able to have more personalized and flexible lessons targeting their specific needs and are able to learn valuable networking and community-building skills. Additionally, these tools allow collaboration among geographically dispersed groups and can facilitate intercultural, cross-border, and cross-institutional exchange, while reduced costs allow for institutions in developing countries to compete with those in other areas.

Cloud Computing

While applications have traditionally resided on the user's computer or other device, there is increasing interest in hosting applications on remote servers, or in "the cloud." Some cloud-based applications, such as web-based email (or webmail), have been in use for several years, even predating widespread broadband deployment. However, the rise of broadband has enabled more robust applications, including productivity applications, such as the office suites offered by companies including Google[50] and Microsoft.[51] Some of the benefits of cloud-based applications include access to information and documents from multiple locations, decreased processing power requirements for end-user devices, and decreased responsibility for users to update and maintain applications. In particular, cloud computing allows users to use any device from any network location to access uploaded files while keeping the costs of software and data distribution very low.

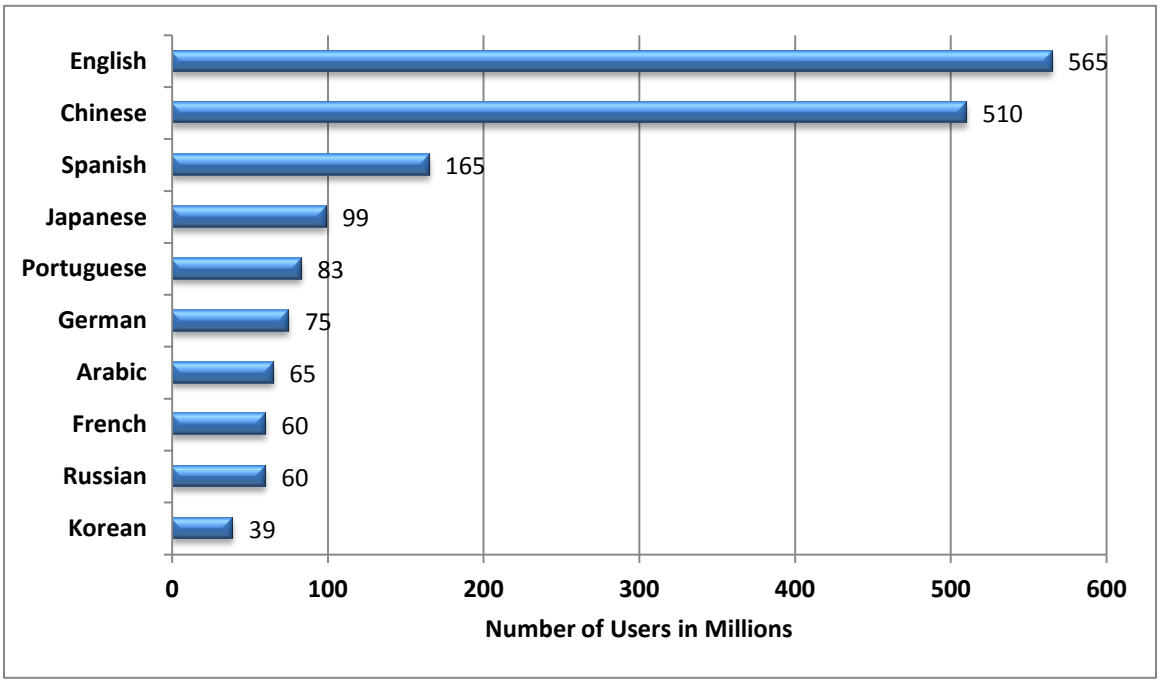
Other cloud computing applications focus on file storage, independently of format. For example, Dropbox is a digital storage service with over 50 million subscribers who can upload, access and share documents, photos and videos from any location—up to 2 MB of storage is free while 50 MB is USD 10 and 100 MB is USD 20.[52] Online retailer Amazon also offers cloud services to consumers and businesses, allowing users to create a "personal hard drive in the cloud."[53] By January 2012, Amazon had hundreds of thousands of customers in 190 countries storing 762 billion objects, which was nearly triple the number of stored objects at the end of 2010.[54] The rising popularity of cloud computing services can help drive consumer demand for broadband since access to fast and reliable broadband is needed in order to maximize the value of the cloud.

Compelling and Local Content

Ultimately, what motivates people to buy broadband services and devices is that they believe broadband will enrich their lives, offer convenience, provide entertainment and improve their businesses. The network infrastructures or policies in place to expand broadband access are less important to end users on a day-to-day basis than the availability of relevant and useful online services and applications that allow users to access, create and share content. What Bill Gates said about the Internet in 1996 remains true today: "Content is King."[55] Attractive and useful content, as well as context (with the development of location based services, which require broadband access), are perhaps the most important underlying elements of broadband adoption.

The English language currently used for the majority of websites around the world;an estimated 56.4 percent of all websites are in English followed by German at 6.6 percent and Japanese and Russian at 4.7 percent each.[56] Interestingly, when looking at the number of Internet users by first language, Chinese was a close second to English in May 2011 (Figure 1.11) and is likely to overtake in the near future. However, Chinese is ranked number six in terms of number of websites with about 4.5 percent of all websites in Chinese. This discrepancy helps highlight how there can be a significant obstacle to Internet and broadband use by non-English speakers due to the scarcity of content in their own languages.

Figure 1.11. Number of Internet Users by Language, May 2011



Source: Internet World Stats, Top 10 Languages Worldwide in Millions of Users (May 2011), available at http://www.internetworldstats.com/stats7.htm.

Efforts to create content that is relevant and interesting, using the local language and character sets, is expected to increase the demand for broadband services in local areas. For example, the Kenya ICT Board in 2010 launched a grant of KES 320 million (USD 3.7 million) to promote the development of relevant, local digital content and software by targeting entrepreneurs in the film, education, entertainment and advertising industries. The goal of the project is to increase Internet penetration and promote local content, which is viewed as a potential area for new revenues in the country.

In addition to direct grants for the production of local content, governments can support the development of local content and applications in other ways, such as the development of standardized keyboards, character sets and character encoding. This type of indirect intervention would have an impact on the content available by enabling users to create content in their own languages.[57] Additionally, translation and standardization of operating systems into local languages can help to facilitate the development of local applications that are relevant and comprehensible to local users.[58] Governments can also play an important role in developing local content and local applications by directly creating local content and local applications in the form of e-government applications as described above.

Some forms of user-generated content, such as YouTube videos, face fewer barriers to expression as the speaker is recorded in his or her own language directly. YouTube is localized in 25 countries and is available in 43 languages.[59] This helps to overcome some of the barriers in content reaching a possible community of interest, but not entirely, as content generated in languages other than those used in the 43 local versions or the worldwide version may encounter barriers in reaching an audience.

It is likely that greater amounts of local content will continue to become available in the near term. For example, a website called d1g.com is a platform in Arabic for sharing videos, photos, audio, a forum, and a question and answer facility. Launched in 2007, d1g.com is one of the Arab world's fastest-growing

social-media and content-sharing websites, with more than 13 million users and 5.3 million unique monthly visitors in mid-2011.[60] It has 15 million videos, and streams an extensive amount of Arabic videos—600 terabytes of data per month. Notably, nearly 100 percent of d1g's content is user-generated, with a small amount produced in-house. d1g.com became the most popular Arab social-media site (after Facebook and Twitter) when a user created the "Egyptstreet" diwan during the Egyptian revolution. During that time, unique visitors rose from three million to five million per month, and visits per month grew from six million to 13 million.

Broadband-Enabled Devices

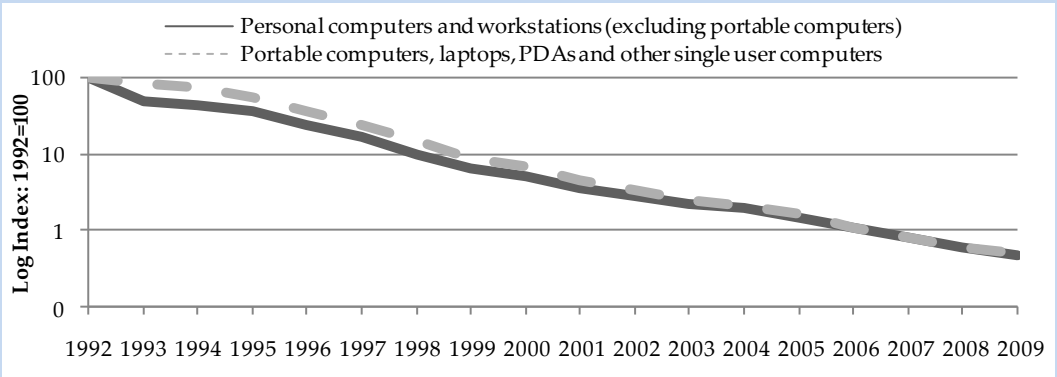
In addition to services and applications, the continual development and evolution of devices and device use cases has been and will continue to be a key driver of broadband demand. The trends in device development are to make them smaller, faster, less expensive and more useful with a wider range of capabilities.

Portable Internet access devices, including laptops, smartphones, netbooks and tablets, can leverage broadband connections to access services and applications in much the same ways as traditional desktop PCs. Further, there is a growing trend toward connecting devices not traditionally used for Internet access to online services and to connect devices to each other directly – an idea known as the "Internet of Things." A wide spectrum of services and applications are used by a variety of devices, each enabled by broadband connectivity. As more devices are able to take advantage of broadband to provide information, services or functionality in a more effective or efficient manner, they drive demand for broadband service. Box 1.5 describes three trends in user devices that promise to alter the terrain of the computing and communications industries, bringing them closer to converging.

Box 1.5. Three Trends in User Devices

Three trends in user devices have implications for broadband. First, traditional computers such as desktops and laptops are becoming cheaper. A computer capable of multimedia functions and Internet connectivity is much cheaper today, with prices dropping over 90 percent over the last decade. Indeed, producer price indices for the computer manufacturing industry have plummeted since 1992 (see figure below).

Prices of computer hardware in the United States, log scale, 1992–2009



Second, mobile telephones are becoming smarter. Popular smartphones include handsets powered by Windows or Linux derivatives. They both host applications and allow users to connect to applications over wireless connections. A survey of business technology professionals found that more than a third of smartphone users "occasionally or frequently leave their laptops at home in favor of their

smartphones." Over 700 million smartphones were shipped worldwide in the first half of 2011 with double-digit growth expected in 2012.

A third development is the netbook—inexpensive portable computers that support simple applications and Internet connectivity. Netbooks are increasingly being bundled with mobile broadband connectivity. In the United States telecommunications service provider Sprint has bundled a netbook for USD 1 for subscribers who sign a two-year mobile broadband service contract.

Pyramid Research predicts that netbooks will accelerate mobile broadband adoption among low-income customers, estimating that mobile broadband subscriptions will rise by 25 percent after services go below USD 20 a month and include ultralow-price netbooks. A growing demand for netbooks has led microprocessor maker Intel to see rapidly increasing sales of its Atom microprocessor, designed for the netbook market.

Sources: U.S. Bureau of Labor Statistics; Information Week Oct 2008, Your next computer; Budde Global - Mobile - Handset Market 10/06/2009; http://news.cnet.com/8301-1035_3-10280886-94.html; Pyramid Research, Mobile broadband for the masses: The case for bundled netbooks, May 2009, p. 8; http://www.marketwatch.com/story/intel-margins-soar-as-manufacturing-might-kicks-in-2009-10-13; *International Data Corporation,* Worldwide Mobile Phone Market Grew More Than 11% in the Second Quarter; Feature Phones Decline for First Time in Almost 2 Years, According to IDC *(July 28, 2011),* available at *http://www.idc.com/getdoc.jsp?containerId=prUS22962811*.

Portable Devices

With respect to the expanding universe of Internet access devices, the rise of portable devices is generating significant new demand for broadband services, especially mobile broadband. While feature phones continue to outsell smartphones, the latter are enjoying significant growth. Research firm IDC has also found that the nascent tablet computing market is growing rapidly. For example, nearly 18.1 million tablets were shipped worldwide in Q3 2011 alone, representing a 265 percent increase over the previous year.[61] In a separate forecast, IDC predicted that combined shipments of smartphones, tablets, and other application-enabled devices would overtake traditional PC shipments by mid-2011 as complementary devices to PCs.[62] By October 2011, however, it appeared that tablets had not yet displaced PCs in terms of sales.[63]

It is important to note that the majority of tablet shipments in 2010 and 2011 were Apple's popular iPad and iPad2, which now have a 61.5 percent worldwide market share, while the first competing product from a major vendor did not enter the market until the last quarter of 2010.[64] The expected growth in 2011 tablet shipments reflects continued interest in the iPad, as well as further introductions of competing products, many based on the Android operating system. However, IDC believes that the non-PC devices are not necessarily replacing PCs, but rather are expanding the market for Internet access devices. All of these devices are designed to take advantage of broadband connectivity, whether provided by a mobile network or by Wi-Fi distribution of the wired broadband connection in a home or workplace.

The explosive growth of wireless telephony services in the developing world has been one of the great ICT success stories in recent years, and has brought about significant change in the way the world's population communicates and conducts business. With the low level of fixed telephony or broadband connections in the developing world, it is expected that advanced mobile devices will provide a primary means by which those in developing countries gain access to broadband. Thus, while broadband services in much of the developed world began with PCs and laptops and expanded to mobile devices, the pattern in the developing world is more likely to be the reverse, or may not even include a significant role for traditional PCs and laptops.

Internet of Things

The Internet of Things can be characterized as the networked interconnection of objects, including those that are not traditionally considered as Internet access devices. It includes the idea of machine-to-machine (M2M) communications, in which machines or devices exchange information without the need for human intervention. Beyond connecting consumer devices, such as household appliances or cameras, the Internet of Things can also encompass connections to, for example, a wide range of sensors, utility networks (the "smart grid") and healthcare devices. The connection of everyday devices and objects could enable a number of activities, including remote monitoring or activation of household devices; automated reporting from networks of weather, geologic, or other sensors; improved vehicle traffic management; and alerts to individuals or doctors regarding medical needs.

As stated in the U.S. National Broadband Plan, "the Internet of Things will likely create whole new classes of devices that connect to broadband, and has the potential to generate fundamentally different requirements on the fixed and mobile networks: they will require more IP addresses, will create new traffic patterns possibly demanding changes in Internet routing algorithms, and potentially driving demand for more spectrum for wireless communications."[65] As shown in Box 1.6, a number of countries are deploying smart city initiatives around the world.

Box 1.6. Examples of Smart City Initiatives around the World

The concept of an Internet of Things may be extended to encapsulate all of the major systems of a city. In such a "smart city," transportation, public services, utilities, and other systems are interconnected and constantly updated to create a type of "living, breathing" organism. Businesses, residents, tourists, and government can all tap into this network to communicate with each other, glean information, identify trends, and even provide corrective action as needed.

As advanced, Internet-connected devices become available and more ubiquitous, a number of smart city initiatives have appeared. In Barcelona, a municipal fiber-optic network complemented by a Wi-Fi mesh network facilitates smart city functions. Traffic lights, parking meters, surveillance and traffic cameras, and public lighting are all connected to the network. In addition, sensors throughout the city monitor traffic flow, parking availability, pollution, and noise and report to the network. Police officers, city planners, and even social workers can tap into this network for real-time information. Even trash containers are tracked using RFID tags; a pilot program measures the amount of trash produced per household to enable a "pay as you throw" program and optimize collection routes.

In Venice, 10,000 kilometers of fiber optics and 120 Wi-Fi hotspots combine to enable a smart city platform that connects residents, businesses, schools, universities, museums, and city management. An RFID-enabled card allows citizens to access municipal buildings (including libraries, museums, and sports venues), use municipal transportation services, and even pay for items and services such as parking, tickets, and food. A similar service is available for tourists, allowing them to plan their visit and pre-pay for tours and services online. ARGOS, the Automatic & Remote Grand Canal Observation System, provides city managers real-time information of canal traffic and automatically detects and highlights illicit behavior.

In India, a number of smart cities are being developed. For example, the Rajasthan government is collaborating with the Japanese government to develop Bhiwadi-Neemrana town in Alwar district as a smart city—part of a smart community development project. The aim is to integrate water supply, solid waste management, power production, and transportation systems to create an efficient city with a low carbon footprint. The project is being financed largely by Japan's Ministry of Economy, Trade and Industry (METI) would finance the ambitious project, with additional support from India's Delhi-Mumbai

Industrial Corridor project.

Source: http://ec.europa.eu/information_society/policy/rfid/index_en.htm

Although the concept of the Internet of Things has been discussed for several years, and some devices are deployed, it is fair to say that a global Internet of Things is still in the early stages of development. A variety of stakeholders are taking steps to guide and advance development of multiple aspects of a world where most humans are surrounded by perhaps hundreds or thousands of networked objects at any given time. For example, the European Commission in 2009 adopted an Internet of Things Action Plan[66] intended to promote the evolution of the Internet of Things through technology standardization and research funding, as well as protection of privacy, data and security. In June 2010, the European Parliament followed with a resolution encouraging the development of the Internet of Things in Europe.[67] In July 2010, China's vice minister of industry and information technology announced that his ministry was developing a national Internet of Things plan. Further, the European Union and China in May 2010 inaugurated a joint Internet of Things expert group.[68]

Beyond government plans to guide and promote the Internet of Things, private-sector companies are also moving forward with technologies and solutions to develop and expand the Internet of Things. For example, Hewlett-Packard's CeNSE ("Central Nervous System for the Earth")[69] and IBM's Smarter Planet campaign[70] both work to create networks of Internet-connected sensors that enable a feedback loop for objects and people, and thus the monitoring and analysis of a wide range of environmental conditions and data. The volume of data transmitted to or from an individual device may be miniscule, but if billions or trillions of objects around the world are connected to the Internet, the result will be significant data flows best that can only be handled by broadband connectivity. One Hewlett-Packard estimate, for example, states that one million sensors, running continuously would generate 20 petabytes of data over a six-month period.[71]

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1.5 How Can Broadband Development Be Supported?

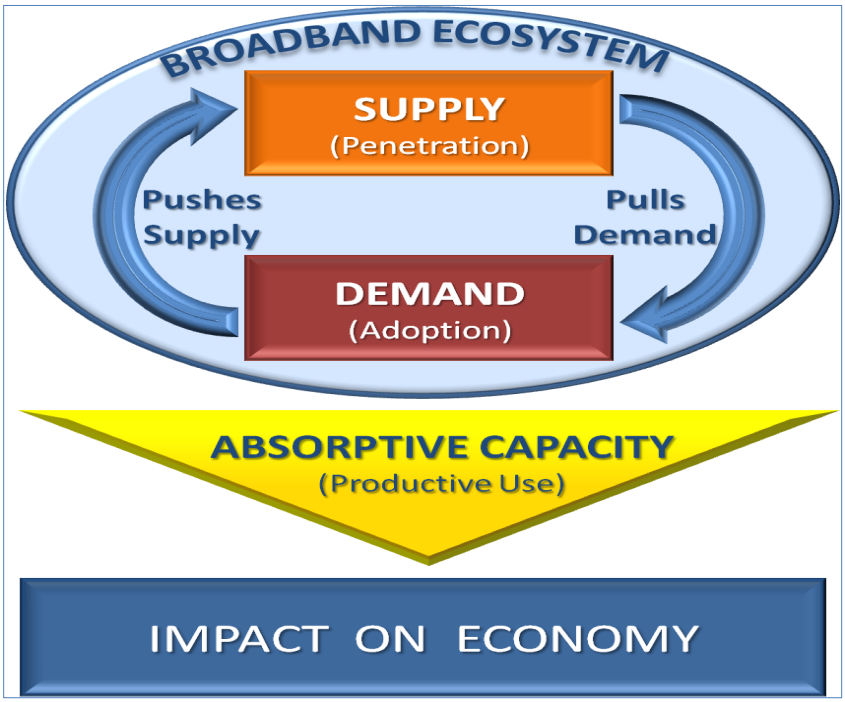
Despite the rapid growth in broadband supply and the development of broadband-enabled applications, services, and devices, there are also notable challenges. Whether within a particular economy or when comparing nations or even regions, the more affluent and better-educated populations generally have earlier and better access to broadband networks and services than the less-affluent and less-educated populations. With the rise of broadband-enabled services and applications, and the increasing migration of many aspects of modern life online, a lack of broadband connectivity can increasingly have a negative impact on social and economic development by excluding those who lack broadband access or do not see the relevance of broadband services.

Governments can employ a wide range of strategies and policies to support the development of broadband, such as through market liberalization efforts including opening international gateways to competition and the allocation of new spectrum for wireless broadband, including the release of the "digital dividend" spectrum for commercial wireless use once a country's digital television transition is completed. To help government policymakers and private sector investors better understand the various ways in which broadband networks and services can best be supported, it is useful to have an overarching concept of how to think about broadband from a policy point of view. This Toolkit proposes to view broadband as an ecosystem of mutually dependent and reinforcing components of supply and demand. Viewing broadband as an ecosystem helps to encourage the development of coherent, integrated policies that maximize the benefits of broadband across all sectors of the economy and aspects of society.

1.5.1 Broadband Ecosystem: Framework for Deployment and Adoption

Under the ecosystem model (Figure 1.12), the supply of broadband network platforms is the first necessary condition—broadband infrastructure must be available. However, demand for broadband is just as important in order to make substantial network investments worthwhile. Additionally, the ability for non-ICT sectors to use and create broadband-enabled services and applications boosts demand and encourages further network deployments. Developing these synergies will largely determine the extent to which broadband impacts the economy and serves as an enabling platform, and ultimately, as a GPT that can act as an essential input in driving innovation and growth in all sectors.

Figure 1.12. The Broadband Ecosystem and Its Impact on the Economy



Source: Adapted from Kim, et al, Building Broadband, World Bank, 2010.

Viewing broadband as an ecosystem helps define the likely roles that governments will need to play in using broadband as a tool in ICT for development (ICT4D). Broadband is more than the supply of access to networks and services, and thus represents a significant shift away from the models used with telephones. To foster broadband markets, governments will have to move beyond their traditional "push" role focused on supply-side growth in ICT infrastructure and development of the ICT sector.

A broader conceptual framework helps because it encourages a rethinking of the areas of focus for broadband policies and strategies. It suggests that, in order to expand the ecosystem, governments will have to design various policies and programs focused on different components of the ecosystem. Countries might overlook the "demand facilitation" aspect of broadband strategies if they consider only the supply of broadband connectivity. For instance, failing to consider the demand side, such as promotion of useful applications and services, could lead to an incomplete policy or strategy.

There are various interdependencies among the components of the broadband ecosystem, and hence a holistic approach to broadband development will tend to produce better results. These interdependencies link the various components in multiple ways. Investments in high-speed networks improve the quality of service and promote the creation of even more complex or bandwidth-intensive applications. Similarly, the availability of various applications attracts more users by increasing the value of broadband and supports wider investments in networks and quality of services. Widespread access to services has also allowed users to create their own content, again driving the demand for high quality services that can do more than simply 'download' content, but also allow sharing among users. Building a high-speed telecommunications network is only the necessary first step in developing a broadband system. A range of policies and programs are needed to promote and universalize the use of this network by supporting the development of services and applications, encouraging users to go online and taking steps towards wider inclusiveness.

Viewing broadband as an ecosystem fits with the growing recognition that government strategies need to develop "push" measures that promote broadband supply, as well as "pull" measures focused on building demand. Such pull measures can promote digital literacy, establish an enabling environment (including an appropriate legal framework), and foster the development of applications (including local content).

Broadband Ecosystem: Supply-Side Constraints

The basic elements of supply in the broadband ecosystem consist of four levels: 1) international connectivity; 2) domestic backbones; 3) metropolitan and backhaul connectivity and 4) local connectivity (see Module 2 for more on the broadband supply chain).[1] At all levels, broadband connectivity is expanding globally. The estimated number of wireline broadband subscriptions surpassed half a billion in 2010, up from 471 million in 2009 with Brazil, Russia, India and China (referred to as the BRIC) countries doubling their subscribers in the last four years.[2] The number of wireless broadband users has also expanded rapidly with over 1 billion mobile broadband subscriptions in 2011. Between 2002 and 2008 demand for international submarine cable bandwidth grew 54 percent a year. And supply is rising to meet this demand: more submarine cables will be built between 2009 and 2011 than between 1999-2001, at the height of the telecommunications boom.[3] Capacity will grow even faster because technologies are able to squeeze more data into the same bandwidth.

In considering policies and strategies to promote broadband development, one important goal is to ensure that access is available to the widest possible user base. This means that networks need to be built out to reach as many people as possible. But facilitating broadband supply presents at least two significant issues. First, there are areas in virtually every country that have no meaningful access to broadband services at all. This problem is most pronounced in developing countries, which have seen less investment in the construction of networks outside metropolitan areas. This situation has improved in recent years with the spread of wireless networks, but there are still areas without network coverage. Second, some areas have networks in place, but these networks are not capable of supporting broadband speeds and services. These areas will need to be upgraded to provide broadband through the construction of high-speed wireline networks and/or through advanced wireless networks (3G or 4G services). In many developing countries, where wireless penetration can far exceed wireline penetration, upgraded wireless networks capable of providing true broadband speeds are expected to be the main supplier of broadband services.

On the supply side, the problem is not as simple as just building more networks; as operators roll-out their broadband business plans, issues of cost, service quality (bandwidth/data speeds), and technology choice will also play important roles in deciding how best to bring access to a nation's citizens. Even then, simply building more networks or providing access to all is not a guarantee of success—governments may need to support broadband development by encouraging demand for broadband in those limited instances where the private sector does not generate useful and relevant applications, services and content.

Broadband Ecosystem: Demand-Side Constraints

For the demand side of the ecosystem, relevant, useful and innovative advancements in services, applications, and content are important for encouraging adoption and use of broadband. As such, the many demand-side components—including services, applications and content—are essential to promoting a vibrant broadband ecosystem. While generally a distinction is made between services and applications, as technology evolves there is likely to be overlap between them. For example, mobile banking may be treated as a service or an application (and maybe even as both), depending on how and what features are offered. In addition, electronic government (e-government) covers an entire range of

services and applications that transform government processes and modes of interacting with businesses and citizens.[4] The distinction, at least in terms of the ecosystem, may be irrelevant—what is important is that these services/applications drive demand.

In order to improve access to broadband, stakeholders will need to consider approaches that can alleviate cost concerns, improve digital literacy across societies and ensure the availability and awareness of relevant content. There has long been discussion of a "digital divide," the gap between the "haves" and the "have-nots." With the rise of broadband-enabled services and applications, and the increasing migration of many aspects of modern life online, a lack of broadband connectivity can increasingly have a negative impact on relative social and economic development.

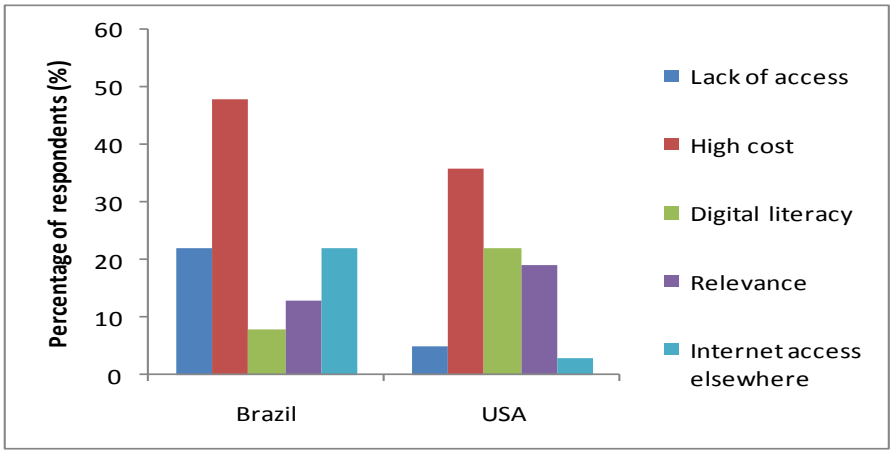
Improving the availability of broadband networks only addresses one impediment linked to broadband development. Even with networks in place and accessible, there are likely to be barriers due to lack of demand and skills. This problem involves people who have access to broadband networks, but are unable or unwilling to obtain service. Addressing lack of demand is important because low adoption rates will leave networks underutilized. This has at least two implications.

First, from a network externalities standpoint, fewer users reduce the economic and social utility of the networks. Where relatively few people can communicate online, the network externalities will be reduced since there is a smaller number of potential customers for businesses to serve. This further means that there may be fewer local businesses and consumers to offer broadband-enabled services and applications, such as video streaming services (e.g., Hulu+), voice and video communications (e.g., Skype) and download services for a variety of applications like software, e-books, etc.

Second, low adoption and use will undermine the business case of any network—even those built with public funds. Fewer users means that the cost of networks is spread over a smaller user base, making them relatively more expensive to build and maintain/operate. Thus, it is important from the overall goal of improving broadband development for governments to focus their attention on developing policies that not only facilitate and encourage the building of broadband networks, but ensure that as many people as possible can and do use them. Barriers to adoption vary and will likely not be the same in all countries, but some broad categories are identifiable.

In studies conducted to identify barriers to Internet and broadband adoption, the primary reasons respondents cite for not subscribing to broadband services can be grouped into four main categories: 1) broadband is not relevant; 2) equipment or service is too expensive; 3) lack of training or comfort with using broadband Internet services; and 4) broadband is not supplied.[5] This is not to say that demand inhibitors are exactly the same in all countries. The factors seen as impediments to adoption in some countries may be less of a factor than in other countries, due to different social and cultural histories and experiences, as well as different socio-economic conditions.[6] Figure 1.13, which reflects survey data collected from non-adopters of Internet services in Brazil and the United States, shows how some factors vary in their importance in these two countries.[7] Respondents in the United States, for example, see digital literacy as a much bigger problem than respondents from Brazil who consider high cost to be a larger issue. Therefore, each country must analyze and address the demand-reducing factors on a case-by-case basis and tailor solutions to the individual problems.

Figure 1.13. Reasons for Non-Adoption of Internet in Brazil and Broadband in the United States



Sources: NIC Brasil, Análise dos Resultados da TIC Domicílios and FCC, Broadband Adoption and Use in America.

With respect to social and political development, broadband can serve as an enabler of more effective and efficient delivery of services and information. As an increasingly large percentage of customers (or citizens, in the case of government services) take advantage of online services, the resulting savings or revenues encourage an increasing number of private and public service providers to shift more services online. However, an increasing reliance on online services will result in the exclusion of those populations who lack broadband access or do not see the relevance of broadband-enabled services. There are, of course, multiple levels and arenas in which broadband access enables social and political interaction, whether casual communication on social networks, familiarity with the news or entertainment of the day on a video-sharing website, or access to current government information and services. However, as these online platforms become increasingly integrated into social and political lives, it becomes more important for broadband to be widely available and accessible so as to ensure the possibility of participating for all sectors of society. As Dr. Nicholas Gruen, former chair of Australia's Government 2.0 Taskforce stated in September 2010, a new facet of the digital divide is what he termed the "participation partition," in which citizens who are more active in online discourse have more influence in their communities.[8]

Given the social and economic benefits of broadband access, the countries, communities, organizations and populations that lack broadband have a greater likelihood of being excluded from important economic and social developments. It is incumbent upon all stakeholders to pursue strategies to expand broadband access in order to enhance the social development of citizens and organizations as well as the economic development opportunities of communities and countries.

Absorptive Capacity

Addressing supply and demand are necessary conditions for the promotion of broadband network and services, but by themselves they are still not sufficient to guarantee that broadband can reach its full potential in the economy. For that to happen, broadband users (citizens, businesses and government) must also have the capacity to understand, learn and apply the lessons learned about broadband's benefits and capabilities across the economy and society.

Absorptive capacity generally refers to the ability of an organization to recognize the value of new, external information, to assimilate that information and then apply it to the organization's benefit. This ability is critical to an organization's innovative capabilities, as new technologies are assimilated by organizations to create, improve and transform business processes, products and services.[9] As users

have the ability to become co-creators of content[10] and as broadband user-led innovation is enabled[11] this same concept can be extended to include other users of the broadband platform, including citizens. Thus, to fully realize the benefits of broadband, the various sectors of the economy and society must have the capacity to acquire, assimilate, transform and exploit the capabilities enabled by this platform. Under the ecosystem model, absorptive capacity is the mechanism by which the benefits obtained from broadband feed into the greater economy, allowing this technology to unleash its potential as a GPT.

Policymakers can facilitate the capacity to understand and incorporate the many benefits of broadband through the development and implementation of policies that are complementary to broadband build-out. In addition, the private sector should be encouraged to adopt broadband as an input to drive productivity, growth, innovation, and welfare throughout the economy and society.

Broadband alone has limited direct impact as a technological platform, but instead acts as an enabler. As such, broadband holds the potential to significantly impact economic and social progress and transform the economy. However, for this potential impact to materialize, broadband must be used by businesses, government and citizens in ways that increase productivity in the economy.[12] This requires: 1) that the creation and availability of broadband-enabled services and applications that increase efficiency and productivity and 2) that businesses, government and citizens have the capacity to use broadband-enabled services and applications in a productive and efficient way. These two requirements are critical for achieving the potential economic impact that broadband can produce.

The economy's capacity to absorb broadband depends on how the two requirements described above are fulfilled in the economy. In a nutshell, a country's absorptive capacity can be thought as determined by:

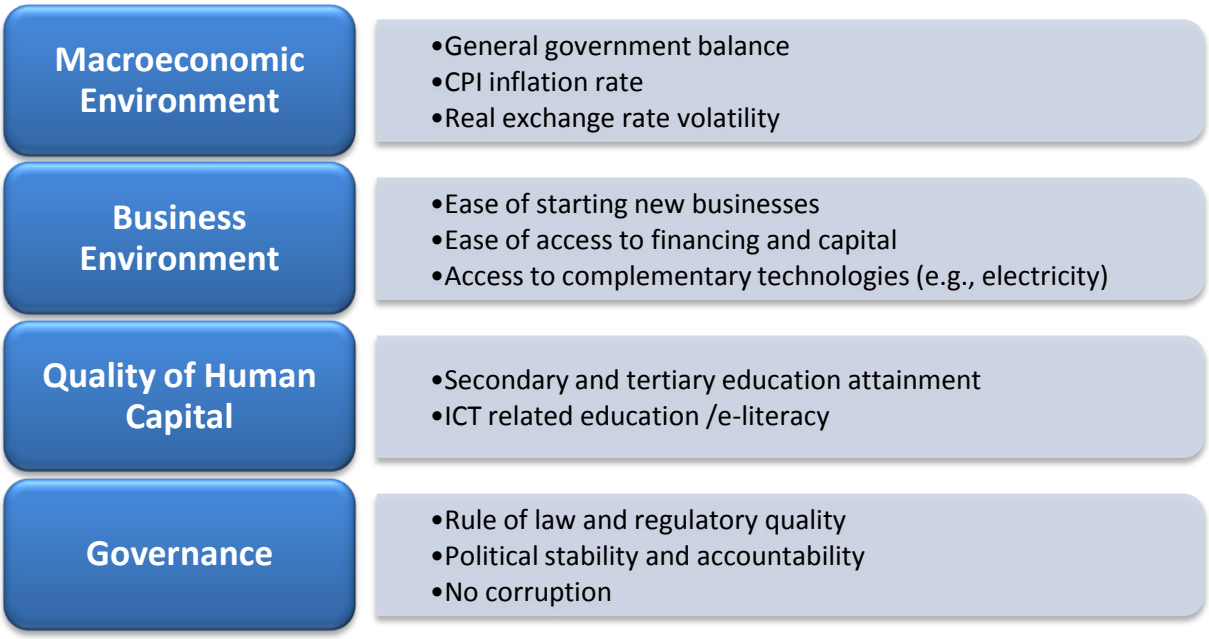
1. The capacity of business to create broadband-enabled services and applications and use these applications and services to transform their business processes to be more productive and efficient;
2. The capacity of citizens to create and use broadband-enabled services and applications to increase their welfare; and
3. The capacity of the government and other institutions (e.g., schools) to introduce and accommodate broadband-enabled services to deliver public services more efficiently and transparently to the public.

Components of Broadband Absorptive Capacity

Four components determine the degree to which a country's economy is able to absorb broadband and translate it into economic and social development. These components are: 1) the economy's macroeconomic environment; 2) the business environment; 3) the quality of human capital; and 4) the governance structure (Figure 1.14). The macroeconomic environment determines the "broadband-friendliness" of the economy and whether the economy and its main actors (i.e., businesses, government and citizens) are open to using ICTs. The business environment, which includes access to financing and diffusion of previous technologies, determines the ability of businesses and entrepreneurs to create new broadband-enabled innovations, modify business processes based on these innovations and update existing products, services and strategies using broadband and the broadband-enabled environment. The quality of human capital depends on the ability of the labor force, businesses and academic institutions to understand the potential of broadband and adapt their mindsets to the broadband-enabled environment. Finally, the governance structure determines the degree to which businesses and citizens are permitted to share and access information openly, as well as to share broadband-based ideas and innovations. Additionally, governance addresses the security of investment

and the cost of creating new broadband-enabled business, services and products. Governance that promotes the absorptive capacity of broadband generally requires free, open access to information and abidance by the rule of law to protect investments. Although there are a wide range of elements for each of the components of absorptive capacity, the following figure provides some important examples.

Figure 1.14. Illustrative Examples of Elements of Absorptive Capacity



Source: Partially based on World Bank, Global Economic Prospects 2008: Technology Diffusion in the Developing World (2008).

Degree of Broadband Absorptive Capacity

The degree of absorptive capacity in a given economy will determine the amount of broadband-enabled economic development. Without strong absorptive capacity, the impact of broadband on economic development will be limited or even non-existent (see Box 1.7 below). A country can have nationwide broadband coverage and widespread adoption, but will obtain very little overall economic and social benefit if absorptive capacity is limited. Conversely, in a country with relatively limited broadband coverage or adoption, broadband can have a targeted impact on the economy if there is sufficient absorptive capacity. Moreover, absorptive capacity can be targeted to specific sectors of the economy, which has been the case with the IT and business process outsourcing (BPO) industry in countries like India. This targeted absorptive capacity can then expand throughout the economy.

Box 1.7. Technological Absorptive Capacity

An economy with a flexible facilitating structure that has an entrepreneurial business environment; few technological regulatory restrictions; an ICT-educated workforce; high penetration of previous complementary technologies (e.g., electricity); a business-friendly financing structure; and a responsive public policy structure will experience faster diffusion of broadband-enabled applications and services and larger economic and social impact. The impact of broadband-enabled ICTs on economic growth will be slower and smaller in an economy that lacks some of these elements or that delays the needed changes to adapt the facilitating structure to broadband-enabled ICTs (e.g., by not modifying the regulatory framework to eliminate technological restrictions or to facilitate their diffusion).

In relative terms it can be put as follows: assuming that the maximum and fastest effect on the structure of the economy that a country can obtain from broadband-enabled ICTs is 100 (i.e., potential positive impact from broadband), the degree of absorptive capacity of the economy will determine how much and how fast that 100 value can be actually realized.

Sweden and Italy provide a good illustrative example of how this mechanism works. Both countries have relatively similar levels of GDP per capita and an in-depth penetration of previous complementary technologies, such as electricity and telephone lines. However, the absorptive capacity in both countries was different. Sweden performed better in business environment and human capital. In addition, Sweden took a very active role in modifying the facilitating structure of its economy to allow for faster diffusion of broadband (e.g., by establishing a public policy to enable the diffusion of broadband and implementing e-literacy programs).

Figure 1.15. Sweden and Italy: Internet Adoption Proxies

	Sweden	Italy
Percent of population with no Internet skills (2007)	22 percent	58 percent
Percent of enterprises receiving Internet orders (2007)	26 percent	4 percent
Percent of enterprises purchasing on Internet (2007)	72 percent	29 percent

Source: LECG (2009) citing Commission of the European Communities (2008).

There are many other factors in place that explain the better performance of Sweden's economy in the diffusion of broadband-enabled ICTs, but what it is important to highlight is that Sweden actively adapted the facilitating structure of its economy to allow broadband to diffuse faster and broader than Italy did. As a result, the economic effects of broadband-enabled ICTs in Sweden have been larger and surfaced faster. For instance, from 1998 to 2007, average annual productivity growth has been much faster in Sweden than in other peer countries (2.32 percent vis-à-vis 0.39 percent in Italy and an average of 1.66 percent among OECD countries). Even though the source of this growth is not exclusively due to broadband, Sweden's policy has transformed the country into a broadband leader, which has played an important role in its economic growth.

Source: LECG, Economic Impact of Broadband: An Empirical Study (2009), available at http://www.connectivityscorecard.org/images/uploads/media/Report_BroadbandStudy_LECG_March6.pdf.

1.5.2 Lessons and Principles from Broadband Experience

There is no "one-size-fits-all" approach that will guarantee greater broadband deployment and adoption in every country. Political and economic conditions vary, and each country is endowed with different technological resources. Some countries have a relatively well-developed wireline telephone network that could support broadband deployment, while others have widely deployed cable TV networks that might be able to provide a measure of facilities-based competition from the start. In yet other countries, there may be various regulatory, political, economic or other barriers to entry that prevent potential competitors from offering broadband services or building broadband networks.

This variance makes it unwise to propose a uniform solution to promote broadband development. In some cases, the challenge will be to create incentives so that widespread networks can be used to offer broadband services. In other countries, the main challenge may be to find ways to educate potential users about the benefits of broadband and train them to use broadband applications and services. As a result, each country will face its own unique circumstances that will drive policy and investment

decisions. However, the key objective for governments is to pursue policies that will create an enabling environment that will foster broadband development.

Development of Country-Specific Solutions

Important lessons can be learned from those countries that have pursued broadband development policies (see Box 1.8Box 1.8).[13] First, the focus in these countries has been on improving the incentives and climate for private investment—a policy that even highly resource-constrained countries might be able to follow (and many have successfully attained with mobile telephony). Many of the policies and programs that have been developed support private sector investments and call for specific, limited and well-justified public funding interventions only in exceptional circumstances. In particular, where governments are trying to promote growth of underdeveloped markets, policies and regulations that may reduce private sector investment should be avoided.

Government funding or policy should generally avoid having the effect of "crowding out" private sector investment. For example, governments can encourage private investments in many cases without direct subsidies, such as by developing passive infrastructure—ducting, towers, cable conduits, and opening rights of way—which can significantly cut costs and create minimal market distortions.[14] Public investments should be considered only when no or insufficient private investments are expected for a significant period. Furthermore, to maintain a level playing field for competition even with public investments, governments should seek to avoid favoring one company (or access technology, e.g., telephony vs. cable) over another. For example, if and when governments intervene to increase network availability, it may be necessary to ensure that subsidized networks are open access—meaning that network operators offer capacity or access to all market participants in a nondiscriminatory way.[15] This is the case in some countries, particularly Australia and South Africa, which have opted to create publicly financed, state-owned enterprises to deploy nationwide broadband networks on a wholesale, open access basis.[16] Additionally, it is recognized that there may be cases where a dominant provider may need to be appropriately regulated to avoid market concentration or other adverse impacts on overall market competition.

Box 1.8. Public Sector's Role in Fostering Broadband Development—Key Lessons

- Government should focus on maximizing competition, including removal of entry barriers and improving the incentives and climate for private investment.
- Government should provide for specific, limited, and well-justified public funding interventions only in exceptional circumstances (e.g., where governments are trying to promote growth of underdeveloped markets).
- Government funding or policy should not compete with or displace private sector investment.
- Government should maintain a level playing field for competition even with public investments by avoiding favoring one company (or access technology, e.g., telephony vs. cable) over another.
- Subsidized networks should be open access (i.e., offering capacity or access to all market participants in a nondiscriminatory way).
- Government may need to regulate dominant providers to avoid market concentration or other adverse impacts on overall market competition.
- Government should eliminate barriers to content creation and refrain from blocking access to content, including social networking sites, or restricting local content creation.

Source: Telecommunications Management Group, Inc.

Developing countries in particular will also need to identify ways to leverage limited resources to maximize impact, prioritizing programs based on demand and market evolution, rather than shying away from policy reform altogether. For most developing countries, the most effective approach to promoting broadband development is likely to involve a mix of approaches and policies that rely on private sector investment, coupled with regulatory reform that will promote efficient and competitive markets (which will also increase private sector investment). Direct government intervention should be limited to those cases where markets do not function efficiently (such as providing service to high-cost areas) or where larger social goals are clearly identified (such as digital literacy training). The basic principle remains the same: governments should only intervene based on sound economic principles, where the benefits of intervention outweigh the costs. For example, particularly at the initial stage of broadband market development, there may be a need for aggressive government policies to generate demand, expand networks, and reach underserved areas and communities.

Factors and Policies Common in Countries with High Broadband Penetration

Some of the main factors common to all countries with high broadband penetration rates—particularly levels of urbanization and wealth—cannot be addressed through broadband policy alone. Achieving high broadband penetration in countries with large rural populations and low levels of urbanization is generally more difficult than in highly urbanized countries due to substantially increased network build-out costs. A country's wealth also significantly impacts broadband penetration since wealthy countries are better positioned to financially support the supply-side initiatives while consumers in those countries are better able to afford broadband services, applications and devices. These non-policy factors especially challenge many developing countries, which tend to have low levels of urbanization and low income levels. For example, Sub-Saharan Africa not only has the lowest broadband penetration rate of any region in the world,[17] but it also has low urbanization and income levels—only 26 percent of the population lives in an urban area while the GDP per capita is just USD 1,286.[18] Urbanization, income and other non-policy factors, such as education levels and degree of income equality, also impact broadband penetration in developed countries. According to an analysis of 30 OECD countries, such non-policy factors can account for roughly three-fourths of a nation's broadband performance."[19]

Regardless of a country's non-policy factors, there are certain policy-related elements common among countries with high broadband penetration rates that may be adopted in developing and developed countries alike.[20] The creation and implementation of comprehensive, national broadband strategies are one the main common features among countries with high broadband diffusion. Market liberalization and regulatory frameworks that promote competition are also a key hallmark of high broadband penetration. Many countries have also supported broadband infrastructure deployment through some degree of public financing. Additionally, policymakers in these countries have developed broadband strategies, regulatory frameworks and public-funded initiatives in three main stages: 1) focus on encouraging market growth by creating an enabling regulatory environment, such as by reducing barriers to entry and supporting large infrastructure projects; 2) encourage competition among private sector actors in order to drive growth, using a competition-based (ex post) regulatory framework to provide market oversight and; 3) focus on ensuring universal access to broadband services as the broadband market matures.[21] Module 2 further addresses these and other policy approaches to promoting the development of broadband.

[1] Adapted from Yongsoo Kim, Tim Kelly and Siddhartha Raja, *Building Broadband: Strategies and Policies for the Developing World*, GICT Dept. World Bank (2010), http://siteresources.worldbank.org/INFORMATIONANDCOMMUNICATIONANDTECHNOLOGIES/Resources/Building Broadband_cover.pdf

[2] ITU, "Fixed Broadband Subscriptions," ITU World Telecommunication /ICT Indicators Database (updated Dec. 2011), http://www.itu.int/ITU-D/ict/statistics/. .

[3] TeleGeography Global Bandwidth Research Service, 2009.

[4] Nagy K. Hanna, Christine Zhen-Wei Qiang, Kaoru Kimura & Siou Chew Kuek, *IC4D Report*: National E-Government Institutions: Functions, Models, and Trends, World Bank, 2009, available at http://siteresources.worldbank.org/EXTIC4D/Resources/5870635-1242066347456/IC4D_2009_Chapter6.pdf.

[5] See Pew Internet and American Life Project, *Home Broadband Survey* (2010), *available at* http://www.pewinternet.org/Reports/2010/Home-Broadband-2010/Summary-of-Findings.aspx; Eurostat, *Information Society Statistics at Regional Level* (Mar. 2009), *available at* http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Information_society_statistics_at_regional_level#Publications.

[6] Janet Hernandez, Daniel Leza and Kari Ballot-Lena, *ICT Regulation in the Digital Economy*, GSR Discussion Paper, Telecommunications Management Group, Inc., p. 4 (2010), *available at* http://www.itu.int/ITU-D/treg/Events/Seminars/GSR/GSR10/documents/GSR10-ppt2.pdf.

[7] Núcleo de Informação e Coordenação, *Análise dos Resultados da TIC Domicílios*, Gráfico 8, p. 14 (2009). The total percentage of respondents is more than 100 because some respondents provided more than one reason for non-adoption. FCC, *Broadband Adoption and Use in America*, p. 30 (November 2009). The total percentage of respondents is less than 100 because, for purposes of comparison, not all factors addressed in the study are included in this figure.

[8] Alex Howard, *"Participation partition" the newest facet of the digital divide, warns Gruen* (Sept. 16, 2010), gov20.govfresh, *available at* http://gov20.govfresh.com/participation-partition-the-newest-facet-of-the-digital-divide-warns-gruen.

[9] Wesley Cohen and Daniel A. Levinthal, *Absorptive Capacity: A New Perspective on Learning and Innovation*, Administrative Science Quarterly (1990), pp. 128-152.

[10] http://www.oecd.org/dataoecd/57/14/38393115.pdf

[11] von Hippel, Eric (2005), Democratizing Innovation, MIT Press

[12] In particular, the World Bank defined absorptive capacity in the context of innovation as the quality of its labor force and the business environment (including access to finance) in which firms operate and are able (or unable) to start up, expand, and reap the financial rewards of their new-to-market innovations. See World Bank, *Global Economic Prospects 2008: Technology Diffusion in the Developing World*, Washington, DC, 2008, *available at* http://econ.worldbank.org/WBSITE/EXTERNAL/EXTDEC/EXTDECPROSPECTS/GEPEXT/EXTGEP2008/0,,menuPK:4503385~pagePK:64167702~piPK:64167676~theSitePK:4503324,00.html. Applied to broadband, this will focus on broadband-enabled services and applications and would also expand to the use of and creation by businesses, citizens and the government of these services and applications to modify transform their behavior and processes to be more productive and efficient.

[13] The experiences of the countries surveyed in the World Bank's report, *Building Broadband: Strategies and Policies for the Developing World*, for example, may provide good approaches that could be adapted for use in many countries. Yongsoo Kim, Tim Kelly, and Siddhartha Raja, *Building Broadband: Strategies and Policies for the Developing World,* World Bank, (June 2010), *available at* http://www.infodev.org/en/Publication.1045.html.

[14] OECD, *Broadband Growth and Policies in OECD countries* (July 2008), *available at* http://www.oecd.org/document/1/0,3343,en_2649_34223_40931201_1_1_1_1,00.html. Also see Christine Qiang, *Broadband infrastructure investment in stimulus packages: relevance for developing countries,* World Bank (2009)*, available at* *http://siteresources.worldbank.org/EXTINFORMATIONANDCOMMUNICATIONANDTECHNOLOGIES/Resources/282822-1208273252769/Broadband_Investment_in_Stimulus_Packages.pdf*

[15] Christine Qiang, *Broadband infrastructure investment in stimulus packages: relevance for developing countries,* World Bank (2009).

[16] See NBN Co, "Our Purpose," http://www.nbnco.com.au/about-us/our-purpose.html for information on the state-owned enterprise building out Australia's national broadband network and Dept. of Public Enterprises South Africa, "Broadband Infraco," http://www.dpe.gov.za/state-2_broadbandinfraco for information on that country's state-owned enterprise responsible for deploying a nationwide broadband network.

[17] ITU, "The World in 2011," ICT Facts and Figures, 2011, http://www.itu.int/ITU-D/ict/facts/2011/material/ICTFactsFigures2011.pdf.

[18] World Bank, Data: Sub-Saharan Africa, http://data.worldbank.org/region/SSA.

[19] Robert D. Atkinson, Daniel K. Correa and Julie A. Hedlund, *Explaining International Broadband Leadership*, Information Technology and Innovation Foundation, p. 18 (May 2008), *available at* http://www.itif.org/files/ExplainingBBLeadership.pdf.

[20] Kim, et al., *Building Broadband: Strategies and Policies for the Developing World*, GICT Dept. World Bank (2010), 82.

[21] Kim, et al., *Building Broadband: Strategies and Policies for the Developing World*, GICT Dept. World Bank (2010), 83.