EXECUTIVE OFFICE OF THE PRESIDENT
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THE ECONOMIC BENEFITS OF NEW SPECTRUM FOR WIRELESS BROADBAND

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EXECUTIVE SUMMARY

The surge in wireless data traffic has caused a "spectrum crunch."
With the proliferation of smartphones, tablets, and other mobile devices with internet access, wireless data traffic has grown tremendously, increasing by more than 100% between 2009 and 2010. Industry forecasters expect that a rapid pace of growth in data traffic will continue for at least the next few years. For example, one industry forecaster projects that mobile data traffic will increase by a factor of 20 between 2010 and 2015. It is unlikely that wireless carriers will be able to accommodate this surging demand without additional spectrum. Other approaches to expanding the capacity of wireless networks, including improvements in spectral efficiency, increases in network density through cell site construction, and offloading traffic to wireline networks via Wi-Fi or other antenna systems, will likely be insufficient to allow capacity to keep up with demand. In short, the projected growth in data traffic can be achieved only by making more spectrum available for wireless use. In response to this "spectrum crunch," the Obama Administration has proposed making an additional 500 MHz of spectrum available for wireless broadband.

Wireless broadband can serve as a platform for innovation.
Wireless broadband has the potential to transform many different areas of the American economy by providing a platform for new innovation. Areas where the innovations will likely have significant impact include consumer products and services, such as media-rich mobile apps and high definition streaming video; products to enhance business productivity, such as mobile video conferencing solutions and access to web-based business applications; health care, where the quality of care will be enhanced and costs reduced through products like patient-physician video conferencing and remote transmission of diagnostic information and images; and education, where digital classroom materials and educational applications are already enhancing learning.

Wireless broadband will have significant benefits for public safety.
Wireless broadband has a vital role to play in improving the ability of emergency personnel to communicate efficiently and to obtain necessary information quickly, including real-time videos, images, and other data. The creation of a state-of-the-art nationwide wireless broadband network for public safety communications will ensure that the public safety benefits of wireless broadband are available throughout the nation, and will also enable interoperability at the national level, making first responders more effective when they are called on to cross jurisdictional lines. With sufficient dedicated spectrum for public safety use, public safety personnel will have access to critical information even in emergency situations when commercial wireless networks are congested.

Wireless broadband is likely to have a substantial impact on jobs, growth, and investment.
Like other information and communication technologies that have transformed the economy in the past, the spread of wireless broadband is likely to increase the rate of growth in per capita income; spur economic activity through new business investment; and support many new high-quality jobs. Because these effects are difficult to quantify precisely, CEA does not endorse any

specific numeric prediction. Nonetheless, the evidence is clear that the wireless industry is an important source of investment and employment, and that supporting the growth of this industry through new spectrum allocation is likely to generate substantial economic benefits.

Other countries recognize the importance of wireless broadband.
Japan and South Korea have been world leaders in rolling out high-speed broadband services, and enjoy high levels of wireless broadband adoption. Europe, too, is moving forward with efforts to improve wireless broadband.

Voluntary incentive auctions and new unlicensed spectrum will promote economic benefits.
For commercially held spectrum, voluntary incentive auctions will ensure that spectrum is repurposed from the lowest value uses to the highest; and that the economic benefits are widely shared among stakeholders, including broadcasters, wireless carriers, consumers, and taxpayers. The White House has projected that voluntary incentive auctions, along with other measures to enable more efficient spectrum management, could generate nearly $28 billion in revenue over ten years. Allocating spectrum with a mix of licensed and unlicensed use has the greatest potential to support future innovation.

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I. Introduction

Over the past twenty years, the growth of information and communication technology has transformed the global economy. Access to the internet has introduced new ways of searching for and sharing information, buying and selling goods and services, consuming media and entertainment, communicating with each other, and more. Wireless telecommunications have made instantaneous communications possible, allowing people to stay increasingly connected while enjoying unprecedented mobility. There is little doubt that these transformations have brought enormous economic and social benefits to people in the U.S. and around the world.

Today, the latest transformative technology is the combination of wireless mobility with the interconnectedness of the web: wireless broadband. Already, the emergence of smartphones and tablet computers has begun to change the ways that we use mobile devices. Soon, a cellphone that does not allow web-browsing will seem as outdated as a phone booth is today. The hundreds of thousands of smartphone apps have only scratched the surface of potential innovation using wireless broadband as a platform.

Thanks to the proliferation of mobile devices with wireless internet access, along with the growth of media-rich consumer applications, the volume of data traffic traveling over the wireless networks has been exploding. With the pace of innovation accelerating, this demand for wireless data services will undoubtedly continue to grow exponentially. And as the volume of wireless data traffic increases, the risk of congestion in the airwaves is increasing as well. Wireless broadband needs radio spectrum to function, and the spectrum currently allocated to wireless is not sufficient to handle the projected growth in demand, even with technological improvements allowing for more efficient use of existing spectrum and significant investment in new facilities.

The only feasible way to realize the full potential of wireless broadband is to make new spectrum available for wireless services. Fortunately, there is considerable spectrum that is currently underused or used in less economically valuable ways, and that could be repurposed for use in wireless broadband. The public challenge is to bring about a dramatic change in the way we use spectrum as rapidly and as efficiently as possible, with widely shared economic benefits.

In early 2011, President Obama introduced a National Wireless Initiative. An important element of this proposal is the President's goal of nearly doubling the amount of spectrum available for wireless broadband in the next ten years, by freeing up 500 Megahertz (MHz) of spectrum currently allocated for other uses. Some of this spectrum will be repurposed from federal government uses. The National Telecommunications and Information Administration (NTIA) has been working to identify portions of federal spectrum, and shared federal/commercial spectrum, that can usefully be repurposed, in part by finding ways to make more efficient use of the remaining federal and shared spectrum. In October 2010, NTIA recommended that 115 MHz of spectrum used by federal agencies be made available for wireless broadband use within five years. Since then, NTIA has continued to evaluate possible opportunities for repurposing federal spectrum. When necessary, repurposing of federal spectrum will be subject to conditions to ensure that there is no harmful interference with public safety needs or other critical public uses of the spectrum. For example, the federal spectrum that NTIA identified for repurposing in

October 2010, whose prior uses include satellite-based meteorological services and naval radar systems, would be shared between commercial broadband and federal uses by requiring geographic limitations on the wireless broadband operations using the spectrum.

In addition to making portions of federal spectrum available for wireless broadband, meeting the President's goal will require a substantial amount of commercially licensed spectrum to be repurposed. In particular, a portion of the spectrum that is currently licensed for over-the-air television broadcasting would yield substantially greater economic value if used for wireless broadband. With the passage of the Middle Class Tax Relief and Job Creation Act of 2012, Congress has now authorized the Federal Communications Commission (FCC) to use "voluntary incentive auctions" to reallocate commercially licensed spectrum. These auctions will be an innovative addition to the tools available to the FCC, and will promote widely shared economic benefits by allowing existing licensees to receive a portion of the auction proceeds in exchange for voluntarily making their spectrum available for wireless broadband. Moreover, the auctions are expected to generate substantial revenues for the U.S. Treasury, providing support for important public goals, including deficit reduction, research and development on emerging wireless technologies to advance public safety communications, and investment in a nationwide, interoperable wireless network for public safety.

This report describes the substantial economic benefits that will result from making new spectrum available for wireless broadband. Section II summarizes the compelling evidence that the surging demand for wireless data traffic is unlikely to be accommodated without additional spectrum for wireless broadband – the "Spectrum Crunch." Section III discusses the potential for wireless broadband to play a transformative role as a platform for innovation in many areas of the economy, ranging from consumer products to business applications, from health care to education. Section IV describes the critical role that wireless broadband plays in improving public safety communications. Section V summarizes the existing economic literature that seeks to quantify the overall economic impact of innovative information and communication technologies, including wireless broadband. Section VI discusses wireless broadband policies in other countries. Finally, Section VII turns to a brief discussion of two key issues: the benefits of voluntary incentive auctions as a mechanism for repurposing commercially licensed spectrum; and the benefits of allocating spectrum for a mix of licensed and unlicensed uses.

II. The Spectrum Crunch

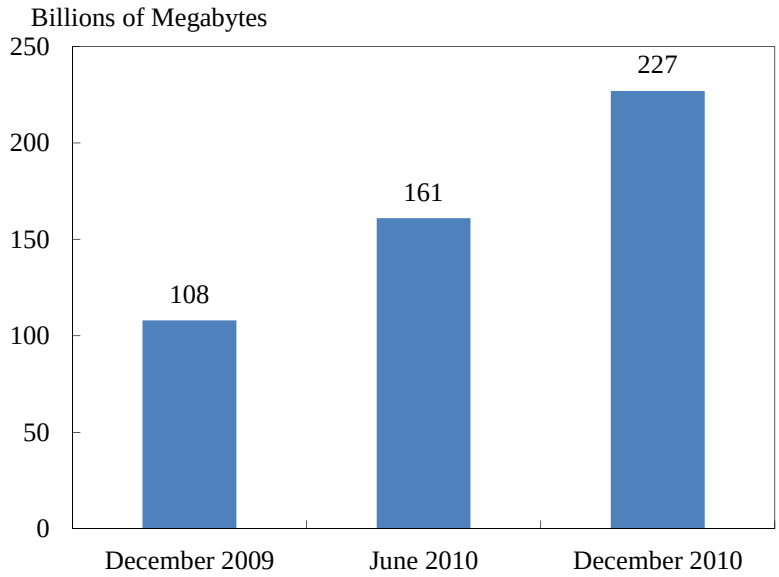
Wireless data traffic has increased dramatically in recent years

Smartphones, tablets, and other mobile devices with wireless internet access have surged in popularity in recent years. A June 2011 survey reports that more than half of the Americans who purchased a new wireless handset in a three-month period chose a smartphone instead of a traditional "feature phone" with no web access.[1] The proliferation of these mobile devices has led to tremendous growth in wireless data traffic. According to a 2011 report, overall U.S. mobile data traffic was 110% higher in the last half of 2010, compared to one year earlier. (see

[1] "In US, Smartphones Now Majority of New Cellphone Purchases," *NielsenWire,* June 30, 2011. http://blog.nielsen.com/nielsenwire/online_mobile/in-us-smartphones-now-majority-of-new-cellphone-purchases/

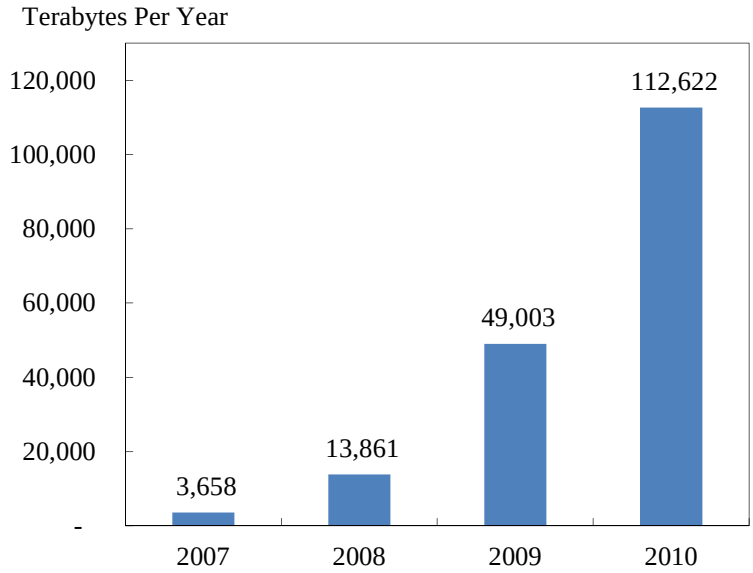
Figure 1). Similarly, AT&T has reported that its mobile data volumes have increased 30-fold since the introduction of the iPhone in 2007, as illustrated in Figure 2.

Figure 1: Total Reported U.S. Data Traffic: 6-month Measures



Source: CTIA Semi-Annual Wireless Survey

Figure 2: AT&T Mobile Data Volumes

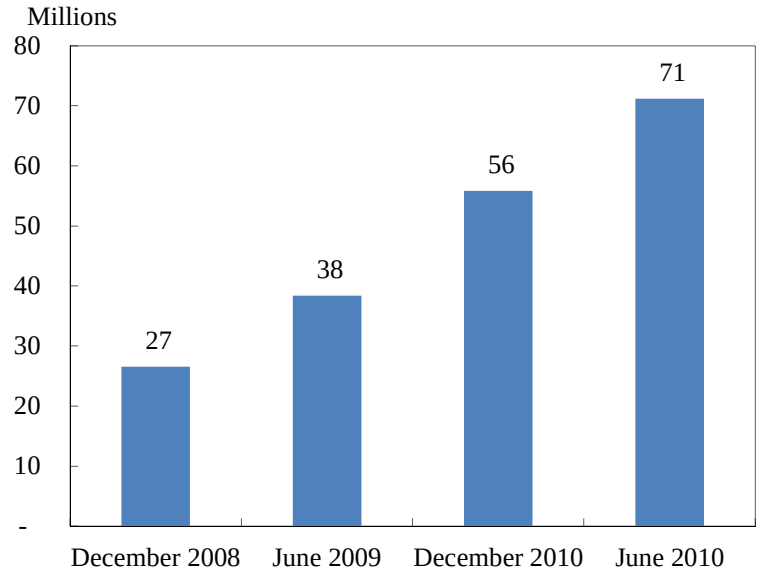


Source: "Acquisition of T-Mobile USA, Inc. by AT&T Inc.: Description of Transaction, Public Interest Showing and Related Demonstrations," filed with the Federal Communications Commission, April 21, 2011.

This growth in data traffic can be partially attributed to growth in the number of wireless subscriptions, but primarily stems from the dramatic growth in data usage by the average user. The number of mobile wireless connections in the U.S. (with speeds over 200 kilobits per second) grew by over 160% from the end of 2008 through June 2010 (see Figure 3), while the

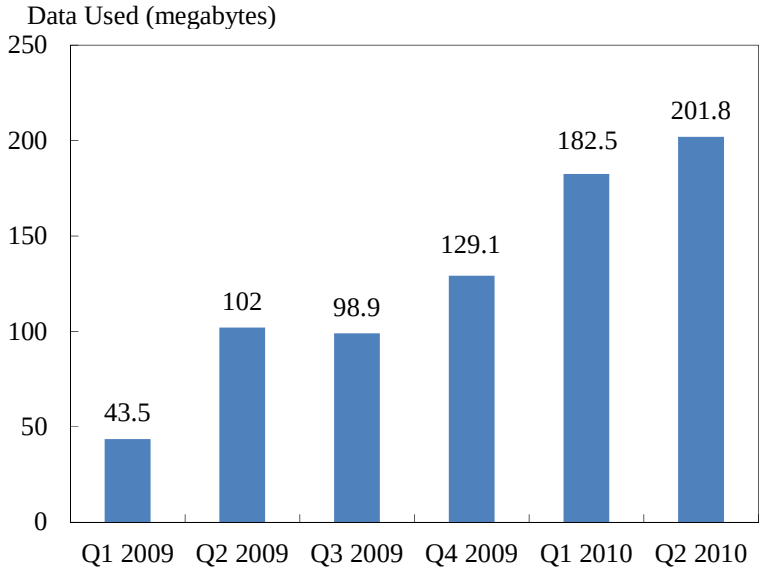
average data used per line increased almost fivefold from the first quarter of 2009 through the second quarter of 2010 (see Figure 4).

Figure 3: The Number of U.S. Mobile Wireless Connections



Source: "Internet Access Services: Status as of June 30, 2010," FCC Wireline Competition Bureau, March 2011.
Note: Figures are for wireless connections with speeds over 200 kilobits per second in at least one direction.

Figure 4: Average Data Used Per Line

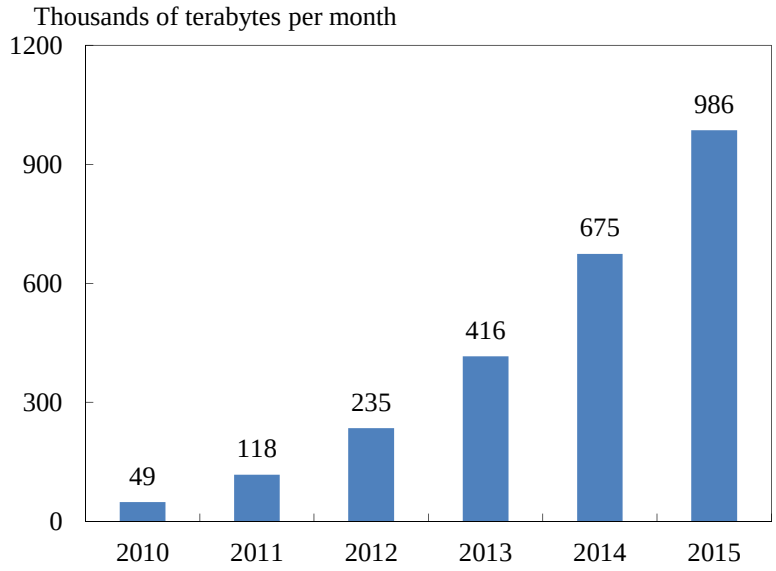


Source: "Mobile Broadband: The Benefits of Additional Spectrum," FCC OBI Technical Paper No. 6, October 2010, citing data from Validas, LLC.

The rapid growth in wireless data traffic shows no sign of slowing

Industry forecasters expect that this rapid pace of growth in data traffic will continue. For example, Cisco projects that mobile data traffic in the U.S. will increase by a factor of 20 between 2010 and 2015 (see Figure 5).

Figure 5: Mobile Data Traffic Forecast for North America, 2010 - 2015



Source: Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2010-2015.
Note: The U.S. accounts for over 90% of North American mobile data traffic throughout this period.

The surging demand for wireless services cannot be met without additional spectrum

Spectrum is an essential input into wireless services, the "invisible infrastructure" that makes wireless communication possible, as FCC Chairman Julius Genachowski has described it.[2] Spectrum is also a critical constraint on a wireless network's capacity. As the volume of data flowing over a wireless network increases relative to the amount of spectrum available, the network can become increasingly congested, leading to dropped calls, delayed connections, and slower flows of data to mobile devices. The need to expand network capacity to accommodate growing demand for data services is the primary reason that wireless carriers were collectively willing to invest over $19 billion to purchase new spectrum during the FCC's 2008 auction of spectrum made available by the transition to digital over-the-air television broadcasting.[3]

Adding spectrum is not the only way to expand the capacity of a wireless network. One alternative is to transition to new technologies that improve "spectral efficiency," the amount of data that can be transmitted on a given band of spectrum (measured in bits per second per Hertz of spectrum). Most recently, this kind of technological progress is occurring as wireless carriers

[2] Remarks of Chairman Julius Genachowski, FCC Spectrum Summit, October 21, 2010. http://transition.fcc.gov/Daily_Releases/Daily_Business/2010/db1021/DOC-302331A1.pdf

[3] For example, Verizon's 2008 Annual Report states, "Our purchase of spectrum in the FCC auction expanded our inventory by 60 percent, which gives us additional capacity to accommodate the rapid growth of wireless data services such as text messaging, e-mail, and Internet access."

roll out more spectrally efficient "fourth generation" ("4G") wireless technologies to replace older, less efficient technologies. However, the network capacity improvements from the migration to 4G technologies are not expected to keep pace with the surging demand for wireless data services. For example, the FCC has made projections based on the reasonable assumption that the gradually improving mix of technologies as 4G networks are rolled out would effectively double the average spectral efficiency of wireless networks between 2009 and 2014.[4] With data traffic volumes potentially increasing by a factor of 35 over the same period,[5] it is clear that the spectral efficiency improvements achieved through the transition to 4G technology will not be sufficient to avoid a shortage of spectrum. Moreover, the potential for spectral efficiency to increase beyond the level provided by current 4G technologies may be limited, as it is widely believed that current levels of efficiency are approaching the theoretical physical limits of spectrum.[6]

Another way to expand capacity on a wireless network is to increase the "spatial reuse" of the spectrum, by increasing the density of the network. In other words, when the nodes of the network (cell towers and antennas) are closer together, the same band of spectrum can be used more intensively. Because increasing network density is one of the key ways to alleviate network congestion, wireless carriers have been making substantial investments in new cell sites. Overall, the number of cell sites in the U.S. increased by roughly 40% over the five year period ending in 2009, to roughly 246,000 sites.[7] Wireless carriers will undoubtedly continue to look for opportunities to add new cell sites, but even if investment in new cell sites were sustained at the same pace as in recent years, it would likely be insufficient to fully address the looming shortage of wireless capacity. The FCC has estimated that if no additional spectrum is allocated to mobile broadband, wireless carriers would need to invest over $170 billion to build enough capacity to accommodate the anticipated demand for mobile data traffic by 2014.[8] A capacity expansion of that magnitude would require adding more than 300,000 new cell sites over the next five years,[9] more than doubling the total number of sites in the U.S. Such a large increase in the number of cell sites is unlikely to be achieved, not only because of the large capital expenditures required, but also because it may become increasingly difficult to find suitable locations for new cell sites that accommodate local zoning restrictions and other constraints.[10]

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[4] "Mobile Broadband: The Benefits of Additional Spectrum," FCC Omnibus Broadband Initiative Technical Paper No. 6, October 2010.

[5] According to the Cisco Visual Networking Index Global Mobile Data Traffic Forecast.

[6] For example, "Efficient Use of Spectrum," Rysavy Research, May 4, 2011, states that today's advanced wireless technologies are nearing the "fundamental constraints of physics," indicating that the past growth rates in spectral efficiency will not be able to continue.

[7] "Mobile Broadband: The Benefits of Additional Spectrum," FCC Omnibus Broadband Initiative Technical Paper No. 6, October 2010.

[8] *Id.*

[9] The FCC study estimates the average cost of a cell site is $550,000.

[10] In addition to constructing new cell sites, carriers often address network congestion by offloading data traffic from their wireless networks via Wi-Fi hotspots and "distributed antenna systems." These solutions are important ways of making more efficient use of spectrum, and will undoubtedly play an increasingly important role in network capacity management as wireless data usage increases, especially in urban centers and other areas with a high density of wireless device users, such as sports arenas and convention centers. In many areas, however, these options may not be cost effective solutions to the growing congestion on wireless networks.

In short, unless additional spectrum is made available, wireless networks will have inadequate capacity to accommodate the demand for mobile data services. These capacity limitations will put increasing pressure on wireless carriers to ration mobile data usage through higher prices. The first signs of this pressure have already emerged, as three of the four largest U.S. wireless carriers have announced that they will be eliminating their unlimited data plans in favor of tiered usage-based pricing.[11] Moreover, if wireless data traffic is constrained by shortages of available spectrum, the potential for wireless broadband to generate substantial economic benefits by serving as a platform for innovation will be severely limited.

III. Wireless Broadband: A Platform for Innovation

With access to sufficient spectrum, wireless broadband has the potential to transform many different areas of the American economy, as new wireless technologies give new capabilities to consumers, businesses, and the public sector. Devices and applications that take advantage of high-speed mobile data services are already appearing, giving an early preview of the endless possibilities for innovation that lie ahead. This section of the report describes some of the innovative products and services that are likely to emerge in various sectors of the economy as a result of the growth in wireless broadband.

Consumer applications

More than anything else, the explosion in wireless data usage is driven by the surging consumer demand for full internet browsing, media-rich applications, and streaming video content on mobile devices. To date, there have been over 18 billion downloads of "apps" for Apple's iPhone and other mobile devices, as well as more than 10 billion downloads for devices using the Android operating system, with each total increasing by around one billion each month.[12] These mobile app downloads will account for an estimated $7.3 billion in annual revenue in 2011, with that figure projected to increase to over $14 billion in 2012.[13] There are over 120,000 companies publishing apps for Apple's platform alone,[14] and many have been actively increasing employment. For example, a *Wall Street Journal* article in April 2011 cited evidence that in early 2011 there were more than 5,000 online job postings for mobile app developers and other positions requiring smartphone expertise, for each of the three primary smartphone platforms.[15] Recent research indicates that more than 88% of the 500 most popular mobile apps were developed by small businesses, most with fewer than ten employees.[16]

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[11] "Verizon to Drop Its Unlimited Mobile-Data Plan," *New York Times* Gadgetwise blog, July 5, 2011. http://gadgetwise.blogs.nytimes.com/2011/07/05/verizon-to-drop-its-unlimited-mobile-data-plan-july-7/

[12] http://news.businessweek.com/article.asp?documentKey=1377-aZexK83DlR8E-7LHAMSL2GJ1L94BEL37Q9IPT42 and http://www.forbes.com/sites/greatspeculations/2011/12/09/googles-android-market-celebrates-10-billion-downloads-but-still-lags-apple-where-it-counts/

[13] Canalys Mobile App Store Analysis forecast, June 2011. http://canalys.com/pr/2011/r2011064.html

[14] As of December 5, 2011, there were 122,478 active publishers in Apple's U.S. app store. http://148apps.biz/app-store-metrics/?mpage=appcount

[15] "Mobile App Talent Pool Is Shallow: Companies Scramble for Engineers Who Can Write Software for Smartphones," *Wall Street Journal*, April 5, 2011. http://online.wsj.com/article/SB10001424052748704547604576263200170918660.html

[16] "The Surprise Behind the Mobile App Numbers," *Huffington Post*, July 12, 2011. http://www.huffingtonpost.com/morgan-reed/the-surprise-behind-the-m_b_895397.html

Today's mobile apps offer diverse new ways for consumers to communicate with one another, to find and share information, and to enjoy media content. Recent surveys show that the most popular categories of mobile apps include weather and news; mapping, navigation, and search; social networking; and music, games, and other entertainment.[17] A particularly promising area for innovation may be "location-based services," such as those that assist consumers in finding local businesses or services (e.g., restaurants, ATMs, or car rentals), or those that provide real-time information on local traffic conditions to enable drivers to avoid congested roadways. Also, the combination of widespread access to wireless broadband with the development of cloud-based computing services has the potential to transform consumers' uses of technology in many ways. For example, the introduction of cloud-based music storage services by Amazon and Apple could change the ways that consumers access their personal media collections. Another way that wireless broadband will have a dramatic impact on consumers' lives is by enabling remote interaction with appliances and other electronic products. For example, consumers can already use smartphones from any location to control their air conditioning and lighting, creating opportunities for energy conservation and greater convenience.

As connection speeds improve with the rollout of 4G networks, consumers will be able to access increasingly high quality media content. Video content, in particular, already accounts for between 40 and 60 percent of all mobile data traffic today,[18] and that figure is projected to grow,[19] as new content becomes available on wireless devices and that content attracts a growing number of consumers. For example, within two months after HBO introduced an app to allow subscribers to view video content on mobile devices, 3 million consumers had downloaded the app, representing more than 10% of HBO's subscriber base.[20] Overall, the number of consumers who view video content on a mobile phone has more than doubled in the past two years, reaching more than 28 million in the first quarter of 2011, and that trend shows no sign of slowing (see Figure 6). Streaming video, which now suffers from interruption or stalling up to 40% of the time,[21] will undoubtedly become more reliable, and will increasingly be available in high definition and even 3D. Increased use of multi-way video chat services on mobile devices will enable friends and families to communicate with one another in new ways, and will also allow real-time face-to-face collaboration and interaction on both work and leisure activities.

[17] http://blog.nielsen.com/nielsenwire/online_mobile/games-most-popular-mobile-app-category/

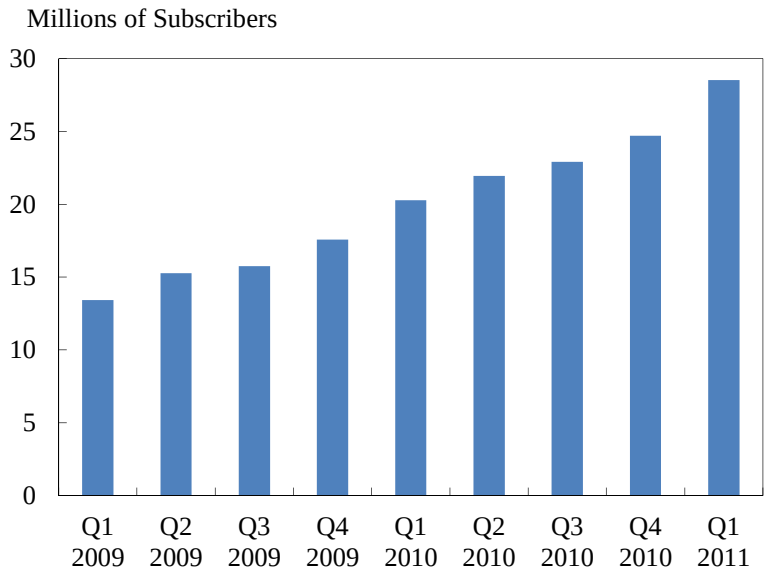
[18] "Bytemobile Gives Update on Mobile Video Traffic Trends," *Wireless Week*, June 21, 2011. http://www.wirelessweek.com/News/2011/06/Technolgy-Bytemobile-Update-Traffic-Trends-Mobile-Video/

[19] According to Cisco, mobile video has the highest data traffic growth rate of any application category measured by Cisco's Visual Networking Index. http://www.cisco.com/en/US/solutions/collateral/ns341/ns525/ns537/ns705/ns827/white_paper_c11-520862.html

[20] http://news.cnet.com/8301-31001_3-20074484-261/take-that-netflix-hbo-go-app-sees-big-growth/

[21] *Wireless Week*, *supra* note 19.

Figure 6: Number of U.S. Mobile Subscribers Watching Video on a Mobile Phone



Source: Nielsen

Business Productivity

Wireless broadband also has the potential to facilitate significant productivity improvements in American businesses. Wireless carriers and other technology firms offer mobile products designed to enable businesses to operate more efficiently. Examples include mobile videoconferencing products that enable real-time video collaboration with offsite field workers; applications in transportation logistics, allowing remote management of fleets and inventories; and real-time remote access by sales personnel to customer-relationship software, the latest inventory and sales data, and other back-office information. In most cases, these services rely on commercial wireless broadband networks. For example, Librestream, a provider of mobile business videoconferencing solutions, announced in January that it had begun using Verizon's newly deployed 4G wireless network.[22]

Many mobile business applications take advantage of the growing use of smartphones and tablets in commercial settings. A recent report projected that by 2016 there will be 830 million users of business-to-employee and business-to-customer applications for mobile devices.[23] Low-cost mobile devices can be a cost-effective way for businesses to access web-based services, taking advantage of the high processing power and large data storage capabilities of remote servers. Because these "cloud-based" solutions do not require the high fixed costs of information technology infrastructure, they can be cost-effective even for small businesses. An AT&T survey of small businesses found that about one-third of small businesses currently use cloud-based software services, while nearly three-fourths use mobile apps for their business.[24] As smartphones and tablets continue to grow in popularity and as wireless broadband access

[22] http://www.librestream.com/news/jan-5-2011.html
[23] http://dhdeans.blogspot.com/2011/07/mobile-enterprise-apps-for-smartphones.html
[24] "AT&T Survey Shows Mobile Apps Integral to Small Business Operations," March 15, 2011. http://www.att.com/gen/press-room?pid=19326&cdvn=news&newsarticleid=31689&mapcode=enterprise

becomes widespread, new business-oriented applications for mobile devices will likely emerge, promoting greater increases in productivity.

Health Care

The health care industry now comprises roughly one-sixth of the U.S. economy, and improving the efficiency of the sector is an important public goal. One of the most promising public benefits of increasing access to wireless broadband is the potential for mobile technologies to have a positive impact on the quality of patient care and to slow the growth of health care costs. The use of mobile technologies in health care is also an important opportunity for economic growth and innovation, with the potential consumer demand for mobile health services worth an estimated $20 billion in the U.S., according to a 2010 McKinsey study.[25]

An important role for wireless technology in health care is the use of videoconferencing to enable direct interaction between a patient and a health care provider, or between two or more providers, who are in different locations. This can be particularly valuable for aging patients and others with limited mobility, and in rural and underserved areas where access to specialists may be limited. A number of studies have shown that the quality of care achieved via videoconferencing can sometimes be equivalent to traditional face-to-face care. For example, the AHA issued a statement in 2009 that, for stroke patients, a remote exam with high-quality videoconferencing is as effective as a bedside evaluation.[26] While medical videoconferencing often occurs today over wired broadband connections, the availability of wireless options can be important to enable communications even when a patient or physician is unable to be at a fixed workstation. For example, in August 2011 the TriStar Health System announced that it is rolling out a videoconferencing system at five Nashville area hospitals to enable neurologists to evaluate stroke patients from a wireless-enabled laptop in any location.[27]

With the widespread adoption of smartphones (some estimate that more than 80 percent of physicians now have one),[28] a key emerging area of innovation is the development of technologies that enable health care providers to access electronic health records and diagnostic information, such as lab results and medical images, from their personal mobile devices. One of the pioneering firms in this area is AirStrip Technologies, which offers the first FDA-approved mobile applications that can send real-time waveform data directly from hospital monitoring systems to mobile devices, allowing physicians to monitor fetal heartbeats, maternal contractions, and other vital signs from their smartphones or tablets.[29] Another key milestone passed in February 2011, when the FDA approved Mobile MIM, the first diagnostic medical imaging app for iPhones and iPads. This app gives physicians access to diagnostic images like

[25] "Global Mobile Healthcare Opportunity," McKinsey and Company, February 18, 2010. http://www.mckinsey.it/idee/practice_news/global-mobile-healthcare-opportunity.view.
[26] AHA news release, May 7, 2009. http://newsroom.heart.org/pr/aha/733.aspx
[27] "TriStar Goes Live with Tennessee's First TeleMedicine Network for Stroke Care," August 8, 2011. http://tristarhealth.com/about/newsroom/tristar-goes-live-with-tennessee-s-first-telemedicine
[28] "Doctors using smartphones, tablets to access medical data," *Star Telegram*, July 5, 2011. http://www.star-telegram.com/2011/07/05/3201630/doctors-using-smartphones-tablets.html
[29] "InformationWeek Selects AirStrip OB as a Vital Healthcare App," *Business Wire*, July 6, 2011. http://www.businesswire.com/news/home/20110706005283/en/InformationWeek-Selects-AirStrip-OB-Vital-Healthcare-App

MRIs on their own mobile device, allowing for accurate and timely medical decisions to be made from any location.[30] In September 2011, the FDA cleared Calgary Scientific's ResolutionMD Mobile, an application that allows physicians to view high-resolution scans and patient data on both Apple and Android devices.[31] These kinds of applications have the potential to improve access to scarce specialists and enable rapid decision-making in time-sensitive medical emergencies. Moreover, web-based services delivered over commercial broadband networks can help to reduce hospital information technology infrastructure costs, by shifting the computationally intensive image-rendering functions away from hospital-based hardware to centralized servers.

Another category of emerging wireless health technologies includes devices that allow remote monitoring of patients with chronic conditions. For example, Corventis, Inc., a developer of wireless cardiovascular solutions, distributes a wearable sensor that continuously monitors a patient's heart rate, respiratory rate, and other vital signs, automatically captures an electrocardiogram if an irregular heart rhythm is detected, and transmits the data wirelessly to a remote server that can be accessed over the internet by the patient's physician.[32] Another innovator, Asthmapolis, developed an inhaler for asthmatics that wirelessly transmits the time and location to a central server each time the patient uses it. The patient and her physician receive weekly summary reports that may assist them in identifying and preventing conditions that trigger asthma attacks.[33] Wireless monitors for blood pressure, glucose level, and bone density have also been introduced. As patients with multiple chronic conditions account for an increasing proportion of overall health expenditures, effective round-the-clock monitoring is an important way to identify problems early, keep patients out of the hospital, and reduce unnecessary costs. Mobile patient monitoring with wireless technologies has been projected to reduce healthcare costs by between $2 billion to $6 billion by 2014.[34]

Education

Access to wireless broadband can also have important benefits for education. In February 2011, President Obama introduced his Wireless Innovation and Infrastructure Initiative in a speech on the campus of Northern Michigan University, in part to highlight the university's decision to invest in a local wireless broadband network. This investment aims to ensure that all students and faculty have access to high-speed internet, even if they live off-campus, and hence to "expand the learning environment," as the University described it.[35]

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[30] "Mobile MIM, First FDA-Cleared Diagnostic Medical Imaging App, Now Available on the U.S. App Store," MIM Software press release, February 15, 2011. http://www.mimsoftware.com/about/mobilemimpr

[31] "Using Smartphones for Medical Diagnosis," *Cellular News*, May 9, 2011. http://www.cellular-news.com/story/49088.php. See also "Calgary Scientific's ResolutionMD Mobile Receives FDA Clearance for Diagnostic Image Viewing on iPhones and iPads," Sept. 26, 2011. http://www.prnewswire.com/news-releases/calgary-scientifics-resolutionmd-mobile-receives-fda-clearance-for-diagnostic-image-viewing-on-iphones-and-ipads-130581658.html

[32] http://www.corventis.com

[33] "Inhaling information: How to collect data on asthma while, at the same time, treating it," *Economist*, April 7, 2011. http://www.economist.com/node/18526861

[34] http://mobihealthnews.com/7564/cost-savings-from-mobile-health-monitoring-to-reach-1-9-billion-to-5-8-billion-globally-by-2014-says-juniper-research/

[35] http://webb.nmu.edu/SiteSections/WiMAX.shtml

Wireless educational technologies have also been effectively deployed in primary and secondary education settings. For example, Maine's Learning Technology Initiative equipped all of the state's middle schools with wireless access, and provided laptops for every seventh- and eighth-grade student and teacher. Studies conducted after the implementation of the project showed improvements in writing proficiency and in math and science retention.[36] Another example is Project K-Nect, a funded pilot program that began in North Carolina in 2007. The project provided smartphones to at-risk poorly performing high school and middle school students, giving them access to digital instructional content aligned with in-class lessons and enabling them to collaborate with one another on assignments and to communicate electronically with after-school tutors. Teachers reported that students enrolled in the program were more engaged academically, and in 2009, the program was extended to schools in Virginia and Ohio.[37] More generally, the academic literature on the impact of information technology in the classroom has yielded mixed evidence, with some studies finding evidence of positive effects on student achievement, while other studies do not.[38] This highlights the importance of efforts to identify the most promising opportunities for innovation and to rapidly evaluate the effectiveness of new technologies. As the White House and the Department of Education announced on September 16, 2011, such efforts are among the primary goals for "Digital Promise," the new national center created to advance educational technologies.[39]

Even outside of the classroom, wireless broadband has the potential to enhance educational outcomes, through the availability of educational applications for smartphones and tablets. For example, the app store for iPhones and iPads currently offers over 40,000 apps in the education category.[40] The most popular categories of educational apps include foreign language, literacy, math, and test prep.[41] Some research suggests that educational apps can be promising ways to facilitate learning in children. For example, a study released by PBS Kids in 2010 found evidence of improvements in vocabulary and other reading skills for children aged three to seven who played with popular reading apps.[42] Much remains to be learned about how to most effectively harness the potential of wireless technology for educational purposes, but it is already evident that this is a promising area for innovation as wireless broadband usage continues to grow.

IV. Wireless Broadband and Public Safety

Wireless broadband has a vital role to play in improving the ability of emergency personnel to communicate efficiently and to obtain necessary information quickly, including real-time videos,

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[36] See references cited at fn. 684 of the FCC's "Annual Report and Analysis of Competitive Market Conditions With Respect to Mobile Wireless, Including Commercial Mobile Services," released June 27, 2011.

[37] "Project K-Nect, 24/7 Wireless Collaboration Enhances Student Engagement and Math Development," Qualcomm. http://www.qualcomm.com/documents/files/project-k-nect-case-study-education-technology-digital-inclusion.pdf

[38] See, for example, Barrow, L., L. Markman, and C. E. Rouse, "Technology's Edge: The Educational Benefits of Computer-Aided Instruction," *American Economic Journal: Economic Policy*. Vol. 1, No.1 (February 2009), pp. 52-74, and the references therein.

[39] http://www.whitehouse.gov/the-press-office/2011/09/15/fact-sheet-digital-promise-initiative.

[40] http://148apps.biz/app-store-metrics/?mpage=catcount

[41] "iLearn: A Content Analysis of the iTunes App Store's Education Section," Carly Shuler, November 2009. http://www.joanganzcooneycenter.org/upload_kits/ilearn_1_.pdf

[42] http://pbskids.org/read/files/iPod_Report_ExecSum.pdf

images, and other data. Historically, emergency personnel have relied on land mobile radio systems to communicate. In recent years, with the growing capabilities of mobile information and communication technologies, public safety agencies have also begun to invest in wireless broadband systems to support their missions. Access to wireless broadband will enhance the ability of first responders to send and receive vital information in real time, including live video transmitted from security cameras or from a helicopter monitoring a scene from the air. Ambulances will be equipped to remotely access patient medical records and to transmit images and data that will aid in rapid evaluation and delivery of needed medical care. The parent of a missing child will be able to email a photo to a police dispatcher, and have it instantly viewed by officers in the field.[43] And as the President described in his 2011 State of the Union Address, a firefighter will be able to "download the design of a burning building onto a hand-held device."[44]

The new legislation that Congress has now passed provides for the creation of a state-of-the-art nationwide wireless broadband network for public safety communications. Developing and deploying such a system will help ensure that the public safety benefits of wireless broadband are available throughout the nation, and will also enable interoperability at the national level, making first responders more effective when they are called on to cross jurisdictional lines. An interoperable network will also reduce the costs of the assorted interoperability measures now being used, ranging from swapping radios to using Internet-based gateways to patch together different systems. Moreover, deploying a single nationwide network will realize important scale economies, eliminating duplicative operating and maintenance costs and enabling public safety entities to obtain commercially supplied devices and equipment at substantially lower cost than they can today. Finally, with clear, nationwide standards that help make public safety communication systems interoperable across jurisdictions and vendors, software and hardware developers will find it more economical to invest in innovative public safety devices and applications, further enhancing the effectiveness of first responders.[45]

Another important public safety benefit of the new legislation is that it designates the band of spectrum known as the D-block for public safety use. A critical challenge in public safety communications is the risk that, during a large-scale emergency such as an earthquake or hurricane, wireless networks will become highly congested, due to the sudden spike in cellphone usage as many individuals simultaneously try to communicate with family members and colleagues. If public safety communications rely on the same wireless infrastructure as everyone else, this congestion has the potential to limit the effectiveness of public safety personnel precisely when their services are most needed. By contrast, with dedicated spectrum for public safety use, as provided for in the new legislation, the public safety wireless broadband network will have sufficient spectrum to operate effectively in emergency situations, ensuring that first responders will have access to critical information even when commercial wireless networks are congested.

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[43] "Ventura Police Department Saves Seconds and Lives," 2010, Motorola Case Study, http://www.motorola.com/web/FileScan/Business/US-EN/NGPS/Ventura_Police_Department_Case_Study.pdf

[44] State of the Union Address, January 25, 2011.

[45] For more detail on the benefits of a public safety wireless broadband network, see "The Benefits of Transitioning to a Nationwide Wireless Broadband Network for Public Safety." The White House, June 16, 2011. http://www.whitehouse.gov/sites/default/files/uploads/publicsafetyreport.pdf

The new legislation also provides vital funding to support research and development in standards, technologies, and applications to advance wireless public safety communications. This funding will accelerate the development of wireless technologies that will enhance the communication capabilities of public safety entities. Moreover, just as defense-related research into networking technologies played an important role in the early development of the internet, research directed towards wireless public safety communications is likely to generate innovations that spill over into other important areas.

In addition to the benefits of a nationwide network for public safety communications, wireless broadband promises to enhance public safety through the emergence of smartphone and tablet apps developed by or for public safety entities. For example, in August 2011, the FBI released a Child ID app, the first mobile application created by the FBI. The app allows parents to electronically store photos and vital information about their children on a smartphone, so that the information can be easily accessed and shared with law enforcement officials in an emergency.[46] Apps designed for use by public safety personnel include technologies that allow police to quickly identify criminal suspects and accident victims. For example, a number of police agencies are planning to adopt a new technology that uses a smartphone to perform facial recognition, iris scanning, and fingerprint identification.[47] Other innovations in development include plans to equip smartphones with small air sensors, to automatically alert public safety entities if dangerous chemicals are detected in the air.[48] In short, wireless broadband offers a tremendous potential for life-saving public safety innovations.

V. The Overall Economic Impact of Wireless Broadband

As the examples in the previous section illustrate, growth in wireless broadband is likely to drive substantial economic benefits, by serving as a platform for new innovation in many areas of public and commercial importance. In aggregate, these benefits will likely lead to increased investment, faster economic growth, and new jobs. While it is difficult to quantify these aggregate effects precisely, a number of studies have examined the economic effects of past growth in information and communication technology, including broadband, while other studies have made projections on the likely impact of expanding wireless broadband.

Evidence on the economic impact of information and communication technology

A large body of literature has linked macroeconomic performance with the growth in information and communication technology. For example, Roller and Waverman (2001) estimate that one-third of the growth in per capita income in 21 developed economies from 1970 to 1990 can be attributed to telecommunications infrastructure investments.[49] Looking at more recent evidence, Jorgenson et al. (2008) estimate that information and communication technology accounted for 59% of productivity growth from 1995 to 2000, and 38% of

[46] "The FBI's Child ID App." http://www.fbi.gov/news/stories/2011/august/child_080511/child_080511
[47] "How a New Police Tool for Face Recognition Works." *Wall Street Journal* "Digits" blog, July 13, 2011. http://blogs.wsj.com/digits/2011/07/13/how-a-new-police-tool-for-face-recognition-works/
[48] "Cell-All: Super Smartphones Sniff Out Suspicious Substances," http://www.dhs.gov/files/programs/gc_1268073038372.shtm
[49] Röller, Lars-Hendrik, and Leonard Waverman, "Telecommunications Infrastructure and Economic Development: A Simultaneous Approach," *The American Economic Review*, Vol. 91, No. 4 (Sep., 2001), pp. 909-923.

productivity growth from 2000 to 2006.[50] Similarly, Brynjolfsson and Saunders (2010) conclude that most of the growth in productivity in the U.S. since 1995 can be attributed to information technology.[51]

Evidence on the economic impact of broadband

A number of economic studies have examined the impact of broadband on measures of economic performance, including economic growth, employment, and consumer welfare. For example, Gillett et al. (2006) find that U.S. communities where mass-market broadband was available by December 1999 experienced more rapid growth in employment and in the number of businesses, relative to comparable communities without broadband at that time, between 1998 and 2002. Based on these findings, the authors estimate that broadband added about 1-1.4% to the growth rate in employment, and about 0.5-1.2% to the growth rate in the number of business establishments.[52] Goolsbee and Klenow (2006) estimate the consumer welfare from internet use, finding that, as of January 2005, the value to the average user was on the order of several thousand dollars per year.[53] Czernich et al. (2011) estimate the effect of broadband infrastructure on economic growth in a panel of developed economies from 1996-2007, finding that the introduction of broadband causes per capita income to increase by 2.7 to 3.9 percent, on average. Moreover, they find that higher levels of broadband penetration result in faster growth in per capita income. In particular, a 10 percentage point increase in broadband penetration raises the growth rate of per capita income by 0.9 to 1.5 percentage points.[54] Similarly, Koutroumpis (2009) investigates the economic impact of broadband on growth in 22 OECD countries based on data collected for the period 2002-2007, also finding a significant causal link between broadband infrastructure and economic growth.[55] In a study commissioned by the Internet Innovation Alliance, Dutz, Orszag, and Willig (2009) estimate that access to broadband at home generates about $32 billion per year in net value to consumers.[56] Finally, while there is still only limited empirical evidence quantifying the effect of broadband on innovation activity, a recent paper by Bertschek et al. (2011) studies the expansion of broadband service in Germany from 2001 to 2003, finding that access to broadband increases the likelihood that a firm will introduce a new innovation by about 40 percentage points.[57]

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[50] Jorgenson, Dale W., Mun S. Ho and Kevin J. Stiroh, "A Retrospective Look at the U.S. Productivity Growth Resurgence," *The Journal of Economic Perspectives*, Vol. 22, No. 1 (Winter, 2008), pp. 3-24.

[51] Brynjolfsson, Erik, and Adam Saunders, *Wired for innovation: how information technology is reshaping the economy*, MIT Press, 2010.

[52] Gillett, Sharon , William Lehr, Carlos O'sorio, and Marvin Sirbu, "Measuring Broadband's Economic Impact," *Broadband Properties*, vol. 24, no. 12 (2006) 12-24.

[53] Goolsbee, Austan and Peter J. Klenow. "Valuing Consumer Products By The Time Spent Using Them: An Application To The Internet," *American Economic Review*, 2006, Vol. 96, No. 2, (May 2006), 108-113.

[54] Czernich, Nina, Oliver Falck, Tobias Kretschmer, and Ludger Woessmann, "Broadband Infrastructure and Economic Growth," *The Economic Journal*, vol. 121, issue 552, (May 2011), 505-532.

[55] Koutroumpis, Pantelis. "The economic impact of broadband on growth: A simultaneous approach," *Telecommunications Policy*, vol. 3, no. 9, (2009) 471-485.

[56] Dutz, M., J. Orszag, and R. Willig, "The Substantial Consumer Benefits of Broadband Connectivity for U.S. Households," Internet Innovation Alliance, 2009. http://internetinnovation.org/files/special-reports/CONSUMER_BENEFITS_OF_BROADBAND.pdf

[57] Bertschek, Irene, Daniel Cerqueray, Gordon J. Kleinz, "More bits - more bucks? Measuring the Impact of Broadband Internet on Firm Performance," University of Mannheim working paper, March 2011. https://community.oecd.org/servlet/JiveServlet/previewBody/24346-102-1-46419/bertschek_cerquera_klein_2011.pdf

Projections on the economic impact of wireless broadband

Although it is too soon for the empirical data to yield reliable estimates of the economic impact of wireless broadband, a few studies have estimated economic effects with the available evidence. For example, in a study for CTIA (the wireless industry trade association), Entner (2008) estimates that the productivity gains from wireless broadband adoption resulted in $33 billion in annual cost savings in 2005, with that figure projected to grow to $127 billion by 2016.[58] Pearce and Pagano (2009) project that an additional $17.4 billion in investment in new wireless broadband networks would increase national income by $126 to $184 billion within 2 years.[59] In a study released by the Broadband for America Coalition, Crandall and Singer (2010) estimate that, from 2003 to 2009, 3G wireless and satellite technologies accounted for $11.6 billion in annualized investment and about 168,300 new jobs; and project that annual investment in wireless technologies from 2010 to 2015 will average $14.3 billion, creating 205,000 new jobs.[60] A Deloitte report projected that U.S. investment in 4G networks could fall in the range of $25 – $53 billion over the period 2012 to 2016, accounting for $73 – $151 billion in GDP growth, and 371,000 – 771,000 new jobs.[61] Lastly, Sosa and Van Audenrode (2011) estimate that the reassignment of 300 MHz of spectrum to mobile broadband will lead to $75 billion in new investment, 300,000 new jobs, and $230 billion in additional GDP, within five years.[62] Given the wide range of uncertainty as to the incremental impact of new spectrum assignment on industry investment levels, CEA does not endorse any specific numeric prediction. Nonetheless, the evidence is clear that the wireless industry is an important source of investment and employment in the U.S. economy, and that supporting the growth of this industry through new spectrum allocation is likely to generate substantial economic benefits.

VI. Wireless Broadband in Other Countries

The U.S. is not alone in recognizing the large potential benefits of wireless broadband, and the need to ensure that there is sufficient spectrum for these benefits to be realized. Other countries are also moving forward with their own mobile broadband spectrum policies.

Japan and South Korea are often recognized as the world leaders in both wired and wireless broadband deployment. As early as 2005, commentators were expressing concern about how far the U.S. had fallen behind those countries in broadband technology.[63] A Morgan Stanley analysis in late 2009 concluded that Japan has outpaced the rest of the world in most mobile internet areas by about five to ten years, affecting such areas as online commerce and the

[58] Entner, Roger, "The Increasingly Important Impact of Wireless Broadband Technology and Services on the U.S. Economy," 2008. http://files.ctia.org/pdf/Final_OvumEconomicImpact_Report_5_21_08.pdf
[59] Pearce, Alan and Michael Pagano, "Accelerated Wireless Broadband Infrastructure Deployment: The Impact on GDP and Employment," *Media Law and Policy*, Spring 2009.
[60] Crandall, R. and H. Singer, "The Economic Impact of Broadband Investment," Feb. 23, 2010, released by the Broadband for America coalition. http://www.ncta.com/DocumentBinary.aspx?id=880
[61] "The impact of 4G technology on commercial interactions, economic growth, and U.S. competitiveness," August 2011, Deloitte Development, LLC.
[62] Sosa, D. and M. Van Audenrode, "Private Sector Investment and Employment Impacts of Reassigning Spectrum to Mobile Broadband in the United States," August 2011, Analysis Group, Inc.
[63] See, e.g., Bleha, Thomas, "Down to the Wire," *Foreign Affairs*, Vol. 84, No. 3 (May - Jun., 2005), pp. 111-124.

provision of digital consumer content.[64] Press reports early in 2011 described South Korea's plans to increase broadband speeds for every household in the country to a level more than 200 times as fast as the average broadband speed in the U.S.[65] South Korea later announced plans to transition all paper textbooks to digital versions accessible on tablets and other mobile devices by 2015, as well as shifting nationwide testing and after-school educational programs online, so that South Korea may be among the first countries to realize the potential for wireless broadband to transform education.[66]

Europe is also moving forward with plans to accelerate the growth of wireless broadband. The world's first commercial network using the most advanced 4G technology (known as "LTE" technology) was rolled out in Scandinavia in late 2009 by TeliaSonera, a full year before Verizon rolled out the first commercial LTE services in the U.S. Moreover, download speeds on TeliaSonera's network are substantially faster than available in the U.S., with speeds expected to range from 20 to 80 megabits per second, compared with 5 to 12 megabits per second on Verizon's network. According to an executive at telecom equipment supplier Ericsson, the reason for the dramatic difference in speed and capacity is that TeliaSonera has twice as much spectrum available for each channel.[67] European advances in adopting wireless broadband are reflected in OECD statistics on wireless broadband penetration rates. As illustrated in Figure 7, in December 2010, the U.S. ranked 9th, with penetration rates significantly lower than Japan, Korea and a number of Scandinavian countries. As a result of Europe's success in rolling out LTE technology, a Vice-President of the European Commission remarked in June 2011, "One year ago, we thought that companies in the U.S. would be alone in pioneering the 4th generation systems; now we can say that Europe is in the lead."[68]

Even in countries that rank below the U.S. in wireless broadband penetration, there are efforts to allocate substantial amounts of additional spectrum for wireless broadband. For example, a 2010 report noted that, even though European countries already have somewhat more spectrum allocated to wireless broadband than the U.S., Germany is auctioning an additional 340 MHz, and the United Kingdom an additional 262 MHz.[69]

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[64] "The Mobile Internet Report: Ramping Faster than Desktop Internet, the Mobile Internet Will Be Bigger than Most Think," Morgan Stanley, December 15, 2009.
http://www.morganstanley.com/institutional/techresearch/pdfs/mobile_internet_report.pdf

[65] "Home Internet May Get Even Faster in South Korea," *New York Times*, Feb. 21, 2011.
http://www.nytimes.com/2011/02/22/technology/22iht-broadband22.html

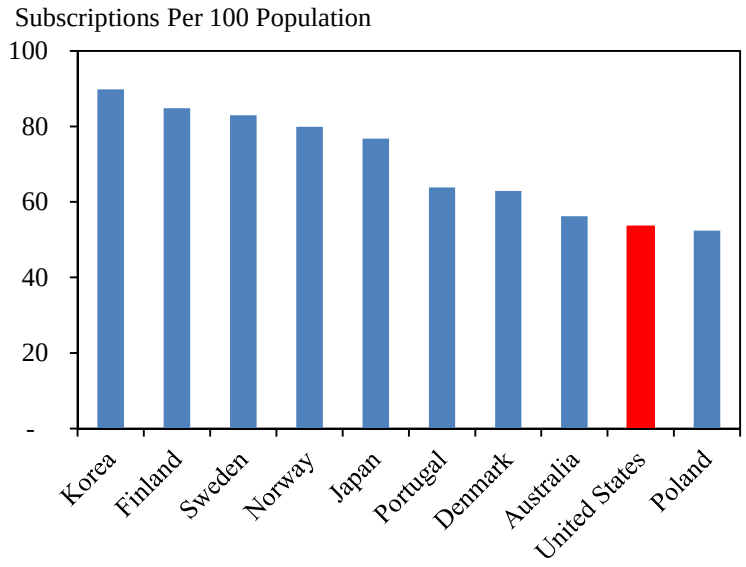
[66] "All Korean Textbooks to Go Digital By 2015," *eSchool News*, July 1, 2011.
http://www.eschoolnews.com/2011/07/01/all-korean-textbooks-to-go-digital-by-2015/

[67] "TeliaSonera launches first commercial LTE services," *ComputerWorld*, December 14, 2009.
http://www.computerworld.com/s/article/9142222/TeliaSonera_launches_first_commercial_LTE_services

[68] "Spectrum must be backbone of internet revolution, not the bottleneck," Neelie Kroes remarks at the 6th Annual European Spectrum Management Conference, Brussels, June 14, 2011.
http://europa.eu/rapid/pressReleasesAction.do?reference=SPEECH/11/433

[69] Bennett, R. "Going Mobile: Technology and Policy Issues in the Mobile Internet," Information Technology and Innovation Foundation, 2010. http://www.itif.org/files/100302_GoingMobile.pdf

Figure 7: Wireless Broadband Penetration Rates for Selected Countries, December 2010



Source: OECD

VII. The Benefits of Voluntary Incentive Auctions and Unlicensed Spectrum

Voluntary incentive auctions are the most efficient way to repurpose licensed spectrum

Since the FCC first started to use auctions to assign spectrum to commercial carriers in 1994, the success of the program has led to similar auctions around the world.[70] Despite wide acceptance that these auctions have been a highly efficient way to allocate spectrum, the FCC did not have the authority to use auctions to allow existing licensees to bid for the right to receive compensation in exchange for voluntarily relinquishing their spectrum holdings. The goal of passing legislation permitting voluntary incentive auctions was highlighted in the President's Wireless Initiative, endorsed in April 2011 by 112 economists in a letter to President Obama,[71] and has now become a reality with the passage of the new spectrum legislation. By authorizing the FCC to use voluntary incentive auctions to reallocate spectrum, the new legislation will ensure that spectrum is transferred from relatively low value uses to higher value uses, generating net economic benefits that will be widely shared among all of the key stakeholders.

Wireless carriers will benefit from increased wireless broadband capacity, as the additional capacity will enable them to profitably serve the growing demands of their customers. Consumers will benefit from the growth of new services, reduced constraints on data usage, and lower prices, relative to levels the market could support in the absence of new spectrum. Broadcasters who choose to participate in the auction will benefit from the ability to share in auction proceeds in exchange for releasing underused spectrum assets. The use of voluntary incentive auctions will ensure that market forces will drive reallocations, so that spectrum will

[70] See, e.g., Cramton, P. "Spectrum Auctions," in *Handbook of Telecommunications Economics*, Martin Cave, Sumit Majumdar, and Ingo Vogelsang, eds., Amsterdam: Elsevier Science B.V., Chapter 14, 605-639, 2002.
[71] Economists' letter to President Obama regarding incentive auctions, April 6, 2011.
http://www.politico.com/static/PPM41_april6_economists_letter_to_obama_regarding_incentive_auctions.html

only be repurposed if both new and existing licensees are made better off by the transaction. In particular, if a broadcaster believes that it can most profitably make use of its spectrum holdings by continuing to broadcast to households that rely on over-the-air television or by investing in innovative services such as mobile DTV, it is under no obligation to participate in the auction.[72] This approach allows market forces to guide spectrum towards its highest value uses. For example, if a broadcaster has a promising opportunity to introduce mobile DTV, and if that opportunity offers greater value than repurposing the spectrum for wireless broadband, the broadcaster will likely choose to retain the spectrum and invest in the innovative new service. In other instances, when wireless broadband offers the highest value, broadcasters will likely find it profitable to relinquish some or all of their spectrum holdings in exchange for financial compensation.

Taxpayers will benefit from a valuable source of new revenue. Even after providing a reasonable return on wireless carriers' investment and a profitable sale for broadcasters that choose to participate, the transfer of spectrum is expected to generate substantial economic gains. In a well-designed auction, a significant portion of that surplus is likely to be retained by the U.S. Treasury. While it is impossible to know in advance precisely how much revenue the auctions will yield, it is possible to make reasonable inferences from evidence on prior FCC spectrum auctions, along with financial information about the likely value of spectrum to broadcasters. For example, the White House has projected that voluntary incentive auctions, along with other measures to enable more efficient spectrum management, could generate nearly $28 billion in revenue over ten years.[73] These revenues will provide substantial public benefits through a number of different uses, including deficit reduction and critical investments in public safety. Finally, as described in greater detail above, the American economy will enjoy broad benefits, from greater economic efficiency, new innovations, and increases in employment, productivity, and economic growth. The use of voluntary incentive auctions is a significant innovation in the area of spectrum allocation, much like the FCC's pioneering use of spectrum auctions in the mid-1990's, and the spectrum auction provisions of the new legislation have the potential to generate significant economic benefits.

An important feature of the new legislation is that it preserves the FCC's authority to adopt and enforce rules that are generally applicable to all auction participants. These rules may include limits on spectrum aggregation, preventing any single entity from licensing an unduly large share of the spectrum in a market. The legislation includes safeguards to ensure that the FCC cannot "pick winners" by excluding individual entities from participating in auctions, but the FCC will still be able to adopt broadly applicable rules that may be necessary to prevent the accumulation of market power and to preserve competition in the market for wireless services.

[72] Broadcasters that retain spectrum may need to have their spectrum relocated to new frequencies, in order to allow for the formation of contiguous bands of spectrum for new uses. The FCC has proposed that "broadcasters should be fully compensated for any costs of any channel changes, and that any moves from UHF to VHF should be voluntary." (FCC Chairman Julius Genachowski, prepared remarks at NAB Show 2011, April 12, 2011.)

[73] "Winning the Future through Innovation," White House fact sheet.
http://www.whitehouse.gov/omb/factsheet/winning-the-future-through-innovation

Unlicensed spectrum is a valuable complement to licensed spectrum

The new legislation also promotes innovation by authorizing the FCC to make certain spectrum available for unlicensed use, including portions of the spectrum released by broadcasters. Allocating a portion of the released spectrum for unlicensed use has the potential to generate greater economic benefits than a regime based solely on exclusive licenses. In order to access exclusively licensed spectrum, a user must enter into a service agreement with the license holder. Although licensees may offer service agreements that, in some instances, efficiently facilitate user access to licensed spectrum, in other circumstances the transactions costs associated with negotiating this access may prove to be a barrier to efficient use of the spectrum. For example, innovative firms may find it prohibitive to enter into the necessary licensing agreements each time they wish to introduce a new experimental wireless technology. By contrast, when unlicensed spectrum is available, the low barriers to entry can promote widespread experimentation and the development of innovative new technologies.

The emergence of Wi-Fi as an essential part of today's wireless infrastructure illustrates the way that unlicensed access can facilitate innovation. In 1985, when the FCC released for unlicensed use the spectrum that Wi-Fi currently relies on, that portion of the spectrum was dismissed as "junk."[74] Few could have anticipated that, two decades later, unlicensed spectrum would support routine wireless internet access in "hotspots" like coffee shops and airports. Today, households with fixed broadband access routinely use Wi-Fi routers to enable wireless broadband access in the home. A comScore report found that, in May 2011, Wi-Fi accounted for over 47% of web page views on the iPhone, and almost 92% of iPad page views.[75] Hospitals and other health care facilities frequently deploy local Wi-Fi networks to facilitate wireless communications and access to electronic medical records. Even major wireless carriers, with their large portfolios of exclusive-use spectrum, often rely on Wi-Fi infrastructure to offload traffic from their networks in congested areas. According to a Cisco report, 21% of U.S. smartphone and tablet data traffic in 2010 was offloaded to fixed line networks through Wi-Fi or femtocells.[76] In April 2011, Wi-Fi accounted for over 98% of all offloaded traffic.[77]

Moreover, economically important uses of unlicensed spectrum extend beyond Wi-Fi: For example, Bluetooth technology has proliferated in numerous devices, ranging from wireless headsets and mobile phones to video game consoles and other consumer electronics. Also, the use of "radio-frequency identification" (RFID) tags has led to improvements in inventory management in retail and other sectors, increasing labor productivity and reducing losses due to stock-out events.[78]

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[74] See, e.g., Statement of FCC Chairman Julius Genachowski, Sept. 23, 2010. http://transition.fcc.gov/Daily_Releases/Daily_Business/2010/db0923/FCC-10-174A1.pdf

[75] http://www.prnewswire.com/news-releases/comscore-introduces-device-essentials-for-measuring-digital-traffic-from-all-devices-enabling-optimization-of-marketing-strategies-and-customer-experience-124418053.html

[76] Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2010–2015, Table 7. http://www.cisco.com/en/US/solutions/collateral/ns341/ns525/ns537/ns705/ns827/white_paper_c11-520862.pdf

[77] Juniper Research press release, April 19, 2011. http://www.juniperresearch.com/viewpressrelease.php?id=303&pr=240

[78] "The economic value generated by current and future allocations of unlicensed spectrum," R. Thanki, 2009. http://fjallfoss.fcc.gov/ecfs/document/view?id=7020039036

Just as it was hard to imagine the explosive growth of Wi-Fi technology when the FCC first released unlicensed spectrum, it is difficult today to anticipate the variety of future technologies that may emerge if new spectrum is made available for unlicensed use. Different bands of spectrum have different propagation characteristics, affecting the ease of transmitting signals over long distances or through walls. As a result, technologies that are not feasible today may become technically feasible and widely adopted if a portion of the newly released spectrum is made available for unlicensed use. In short, a diverse mix of licensed and unlicensed spectrum offers the most fertile environment for future innovation.