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# WORKING PAPER

## INNOVATION, INVESTMENT, AND COMPETITION IN BROADBAND AND THE IMPACT ON AMERICA'S DIGITAL ECONOMY

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## Abstract

In recent years various media have claimed that America is falling behind in high-speed broadband Internet, that Americans pay more for broadband of lower quality than people in other countries, and that American broadband providers don't compete, innovate, or invest. The EU, Japan, and South Korea, not the United States, are said to be leading in these areas. This paper investigates a variety of datasets to see whether there is evidence for these claims. The paper demonstrates not only that the United States performs well on many broadband measures, but that claims about the United States falling behind are inconsistent with American leadership in the digital economy where broadband networks are an essential, though not the only, input. Based on these conclusions, the paper provides policy analysis on broadband network deployment and suggestions on adoption, the arguably more important—but frequently overlooked—component of broadband.

*JEL* codes: L1, L2, L4, L5, L8, O1, O2, O3, O4, O5

Keywords: broadband, broadband innovation, broadband investment, broadband competition, digital economy, broadband comparisons, international broadband comparisons, broadband adoption, broadband policy, broadband regulation, fixed broadband, mobile broadband

**Innovation, Investment, and Competition in Broadband and the Impact on America's Digital Economy**

Roslyn Layton and Michael Horney

It is hard to overstate the impact of the Internet on the lives of Americans. Some 20 years ago, the Internet was not something most Americans used. Today a majority of Americans access the Internet from a smart phone from almost anywhere. The Internet has transformed communication, commerce, and entertainment, and will continue to drive changes in health care, transportation, education, government, and other areas.

Broadband, or high-speed Internet, has proliferated in the United States because of innovation, investment, and competition. America's digital transformation is the result of robust innovation and competition across the Internet value chain, from broadband technologies to Internet services, and to heavy capital investment by broadband providers. Meanwhile, Americans have widely adopted broadband technologies, as evidenced by growth in broadband subscriptions, data consumption, connected devices, and digital goods and services. Furthermore, the United States has leveraged broadband to turn itself into perhaps the world's leading digital economy as measured by the level of broadband-enabled economic activity, the number of Internet-based companies, the level of digital exports, and the level of Internet-enabled employment. By 2009, the gross domestic product (GDP) of *just the Internet* of the United States was already greater than the total GDP of Sweden, Ireland, Switzerland, or Israel.[1]

[1] Matthieu Pélissié du Rausas et al., "Internet Matters: The Net's Sweeping Impact on Growth, Jobs, and Prosperity" (report, McKinsey Global Institute, McKinsey & Company, May 2011), http://www.mckinsey.com/insights/high_tech_telecoms_internet/internet_matters.

This paper reviews data on broadband investment, innovation, and competition to examine their relationship to the larger broadband-based digital economy. Measuring the digital economy is a nascent area of economics, but examining the broadband metrics can provide a helpful background to understanding the digital economy. In any event, a review of the relevant measures shows that the United States is a leader in broadband innovation, investment, and competition. The paper concludes by highlighting the policy measures to ensure continued growth and investment in broadband as well as to encourage adoption.

**An Overview of Broadband in America**

Broadband is synonymous with high-speed Internet. In contrast to traditional dial-up, also called "narrowband," broadband connections allow more data to be transmitted faster. Broadband is also characterized by the feature of being "always on"; there is no waiting time for connectivity.[2] The Organisation for Economic Co-operation and Development (OECD) defines broadband as connections with a minimum speed of 256 kilobits per second (Kbps) download. The Federal Communications Commission (FCC) defines broadband at 4 megabits per second (Mbps) download.[3] This speed threshold defined by the FCC can deliver most Internet applications, including a video call on Skype (128 Kbps)[4] and standard-definition streaming of a video on Netflix (0.5 Mbps—the minimum, though not preferred, speed).[5]

It is important to mention that broadband speed, bandwidth, and throughput are not the same things. Speed—for example, 5 Mbps—is the theoretical maximum speed that the line can

[2] "What Is Broadband," Broadband.gov, accessed March 5, 2014, http://www.broadband.gov/about_broadband.html.
[3] "Sixth Broadband Progress Report," Federal Communications Commission, July 2010, http://www.fcc.gov/reports/sixth-broadband-progress-report.
[4] "How Much Bandwidth Does Skype Need?," Skype, accessed March 14, 2014, https://support.skype.com/en/faq/FA1417/how-much-bandwidth-does-skype-need.
[5] "Internet Connection Speed Recommendations," Netflix, accessed March 14, 2014, https://help.netflix.com/en/node/306.

support. Many factors affect speed, including the type of device, the connection quality, the proximity to the local exchange, and connected premises equipment (e.g., a modem). Throughput is the download speed, or the speed experienced in practice. It can change in different intervals or even during the same session. It depends on other Internet traffic and the websites that the user visits—one may have a 50 Mbps connection and access Netflix, but Netflix will run on the speed it needs, 0.5–5.0 Mbps depending the user's selected subscription quality.[6] So achieving an optimal Netflix experience is less about the last-mile line speed (that part of a connection from the broadband provider to the user directly) and more about the bandwidth or throughput Netflix creates *before* it gets to the last mile.

According to Cisco's Visual Networking Index, an annual report of global Internet traffic, the rate of Internet consumption per capita in the United States is on the rise and growing faster than in most countries.[7] The United States is in second place and on track to surpass South Korea. Internet consumption has been growing exponetially around the globe but has picked up considerable speed in the United States since 2010, acounting for over 30 percent of all global traffic in 2012. Consumer video over fixed networks generates the largest share of Internet traffic.[8] America's existing broadband networks, through a combination of innovation, investment, and competition, have enabled the growing traffic, which is itself a measure of success. That is to say, if the current networks were not already up to speed, the United States could not handle the growing level of traffic, let alone exhibit the high level of Internet-enabled GDP it does today.

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[6] Ibid.
[7] "Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2013–2018," Cisco, February 5, 2014, http://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/white_paper_c11-520862.html.
[8] Patrick Brogan, "Internet Usage Data Show U.S. Expanding International Leadership" (USTelecom, Washington, DC, November 7, 2013), http://www.ustelecom.org/sites/default/files/documents/110613-usage-research-brief.pdf.

***Broadband Subscriptions***

The OECD is a leading intergovernmental organization that comprises 34 democratic and capitalist countries, including the United States, Canada, Mexico, South Korea, Japan, and a number of European countries. Its Broadband Portal is perhaps the most comprehensive publicly available database on broadband statistics. The OECD collects and collates a variety of broadband measures from member governments and then prepares them in a standardized fashion. Although some measures may be dated, the data as a whole provide a valuable set of broadband measures for price, performance, adoption, and deployment. The OECD discusses broadband within the context of fixed connections (DSL, cable, and fiber-optic connections of at least 256 Kbps) and wireless connections (satellite, mobile, or Wi-Fi connections of at least 256 Kbps).[9]

The United States is the OECD's largest broadband market by number of subscriptions and turnover. It contains more than one-quarter (27 percent) of the OECD's fixed broadband subscriptions and more than one-third (35 percent) of all its wireless broadband subscriptions. The OECD reports that in June 2013 the United States had over 91 million fixed connections, more than a quarter of the total (332 million) for the 34 nations in the study. Americans have three times as many wireless broadband subscriptions as fixed, some 300 million mobile broadband subscriptions compared with a total of 851 million in the OECD.[10]

Just as broadband speed, bandwidth, and throughput are different things, so are broadband deployment and adoption. Deployment is the physical construction of the broadband network: the wires, towers, and so on. Deployment is frequently measured in number of households passed or percentage of population covered by a given broadband technology.

[9] "Broadband and Telecom," Organisation for Economic Co-Operation and Development, 2010, http://www.oecd.org/sti/broadband/oecdbroadbandsubscribercriteria2010.htm.
[10] "Total Fixed and Wireless Broadband Subscriptions by Country—1c," Organisation for Economic Co-Operation and Development, June 2013, http://www.oecd.org/sti/broadband/oecdbroadbandportal.htm.

Adoption, on the other hand, is the act of a person using the Internet, such as purchasing a subscription or using a computer in a library. The mere deployment of broadband in a region does not mean people will adopt it. Countries can have high deployment and low adoption. Penetration describes the number or ratio of dedicated lines from a network to a household or subscriber, frequently expressed as subscriptions.

The OECD countries comprise more than 1.2 billion of the world's 7 billion people.[11] The organization reflects largely the experience of developed countries. The International Telecommunications Union (ITU), a United Nations organization for telecommunications, provides another picture, that of both developing and developed countries.

The ITU reports on global Internet use by individuals in each country. The average for the world, both developed and developing countries, was 41.8 percent in 2012. The countries with the highest adoption rates are the Nordic countries (Iceland, Norway, Sweden, and Denmark), the Falkland Islands, and Luxembourg, in all of which at least 90 percent of the population uses the Internet. According to the report, 81 percent of the population of the United States uses the Internet.[12] The United States scores at twice the world average for adoption. While adoption can be improved with certain groups, particularly the elderly, it should be recognized that, by and large, most Americans are already on the Internet.

### *US and EU Broadband Comparisons*

Although the OECD data are helpful, it can be misleading to compare any one nation to another without the proper context. If such comparisons are made, it is important to compare

[11] "Population," Organisation for Economic Co-Operation and Development, accessed June 12, 2014, http://stats.oecd.org/Index.aspx?DataSetCode=POP_FIVE_HIST.
[12] "Percentage of Individuals Using the Internet," International Telecommunications Union, 2013, http://www.itu.int/en/ITU-D/Statistics/Pages/stat/default.aspx.

countries with relative similarities, such as geographic area and population size. While comparing the Netherlands to Belgium makes sense (two neighboring lowland countries of roughly similar size and population), comparing the United States to South Korea or Denmark is less meaningful. South Korea is the size of Minnesota but with nine times the population. Denmark (excluding Greenland) is slightly bigger than Maryland but smaller than West Virginia. Thus, it is more realistic to compare the United States and its 50 states to the European Union and its 28 states. The geographic area, population size, and regional diversities between the two areas are more similar.

The OECD does not compare the United States to the EU, but meaningful measures of the two regions can be prepared using other datasets. In 2013, the EU government commissioned an in-depth study of broadband for its Digital Agenda Scoreboard. Table 1 displays those data. For the United States, the National Broadband Map contains the most detailed public information about America's broadband facilities and subscriptions as of 2013. Table 1 also includes those data, with three notations of the newest information. These authoritative data clearly show the United States leading on the availability of key broadband technologies and competition between broadband facilities. Christopher Yoo, a professor at the University of Pennsylvania Law School and founder of the Center for Technology, Innovation and Competition, comes to similar conclusions about broadband coverage and competition in a new report titled "US vs. European Broadband Deployment: What Do the Data Say?"[13]

[13] Christopher S. Yoo, "U.S. vs. European Broadband Deployment: What Do the Data Say?" (Philadelphia: Penn Law, Center for Technology, Innovation and Competition, June 2014), https://www.law.upenn.edu/live/files/3352-us-vs-european-broadband-deployment.

**Table 1. United States and EU Broadband Comparisons, 2013**

| | United States (%) | EU (%) |
|---|---|---|
| Availability of broadband with a download speed of 100 Mbps or higher to population | 57* | 30 |
| Availability of cable broadband to population | 88 | 42 |
| Availability of 4G/LTE to population | 94** | 26 |
| Availability of FTTH to population | 25 | 12 |
| Percentage of population that subscribes to broadband by DSL | 34 | 74 |
| Percentage of households that subscribe to broadband by cable | 36*** | 17 |

* The National Cable Telecommunications Association suggests speeds of 100 Mbps are available to 85 percent of Americans. See "America's Internet Leadership," National Cable Telecommunications Association, 2013, http://www.ncta.com/positions/americas-Internet-leadership.
** Verizon's most recent report notes that it reaches 97 percent of America's population with 4G/LTE networks. See "Overview," Verizon, News Center: LTE Information Center, accessed June 12, 2014, http://www.verizonwireless.com/news/LTE/Overview.html.
*** This table is based on 49,310,131 cable subscribers at the end of 2013, noted by Leichtman Research (http://www.leichtmanresearch.com/press/031714release.html) compared with a total of 138,505,691 households noted by the National Broadband Map.

Source: US data from National Broadband Map; see "Access to Broadband Technology by Speed," Broadband Statistics Report, July 2013, http://www.broadbandmap.gov/download/Technology%20by%20Speed.pdf and http://www.broadbandmap.gov/summarize/nationwide. EU data from European Commission; see "Chapter 2: Broadband Markets," Digital Agenda Scoreboard 2013, working document, December 6, 2013, http://ec.europa.eu/digital-agenda/sites/digital-agenda/files/DAE%20SCOREBOARD%202013%20-%202-BROADBAND%20MARKETS%20_0.pdf.

Notes: LTE = long-term evolution, FTTH = fiber to the home, DSL = digital subscriber line.

### *Broadband Prices*

Some Americans believe that broadband prices are too high. They claim that Europeans pay less for faster speeds. Frequently, these assertions fail to standardize the comparisons—for example, to compare similar networks and speeds. A higher-speed, next-generation network connection delivering more data generally costs more than a slower one. The challenge for measuring European and American prices is that networks are not uniform across the regions. The OECD comparisons are based on availability in at least one major city in each country, not in the country as a whole. This means that OECD data may overstate the availability of broadband and

understate its price in many European countries. Therefore it is necessary to look at different datasets to get a more balanced picture.

The EU's Digital Agenda Scoreboard data attest that next-generation networks exist only in pockets of the EU. For example, just 26 percent of Europeans have access to 4G/LTE (long-term evolution) wireless networks, but 97 percent of Americans can access these networks. Thus, it is difficult to prepare a fair assessment of mobile wireless prices when Americans use five times as much voice and twice as much data as Europeans. Furthermore, American networks are 75 percent faster than those in the EU. The overall price may be higher in the United States, but the unit cost is lower, and the quality is higher. This means Americans get more value for their money.[14]

Another item rarely mentioned in international broadband comparisons is mandatory media license fees. These fees can add as much as $44 to the monthly cost of broadband. When these fees are included in comparisons, American prices are frequently an even better value. In two-thirds of European countries and half of Asian countries, households pay a media license fee on top of the subscription fees to use devices such as connected computers and TVs. Historically, nations needed a way to fund broadcasting, so they levied fees on citizens. Because the United States took the route of funding broadcasting through advertising, these fees are rare in the United States.

Government-funded broadcasting has moved to the Internet, and the state-funded TV channels have their own websites with video. Thus, media license fees are now applied to fixed-line broadband subscriptions, and even mobile broadband in some places. In general in such countries, all households that subscribe to information services (e.g., broadband) must register with the national broadcasting corporation, and they receive an invoice once or twice a year. The media fees are compulsory, and in some countries it is a criminal offense not to pay.

[14] Roslyn Layton, "The European Union's Broadband Challenge" (American Enterprise Institute, Washington, DC, February 2014), http://www.aei.org/files/2014/02/18/-the-european-unions-broadband-challenge_175900142730.pdf.

Defenders of media license fees say that they are an important way of providing commercial-free broadcasting, and in countries that see the state as responsible for preserving national culture and language, media license fees make this possible. Many countries maintain their commitment to such fees to deter what they consider American cultural imperialism and to support local-language content.

Media license fees may seem foreign to Americans because there is not a tradition for receiving an annual bill for monthly broadcasting. Historically, television and radio were considered "free" because they were supported by advertising. Moreover, the US content industry is global in scale and makes up a large part of America's third-largest category of exports, that of digital goods and services, which totaled more than $350 billion in 2011.[15]

When calculating the real cost of international broadband prices, one needs to take into account media license fees, taxation, and subsidies. Neither the OECD Broadband Portal[16] nor the ITU's statistical database[17] provides this information. However, these inputs can materially affect the cost of broadband, especially in countries where broadband is subject to value-added taxes as high as 27 percent, not to mention media license fees of hundreds of dollars per year.

We collected information on media license fees for the OECD countries, and where applicable, added them to the prevailing broadband price comparisons. Table 2 gives an overview of media license fees in the OECD.

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[15] "Digital Trade in the U.S. and Global Economies, Part 1," United States International Trade Commission, July 2013, http://www.usitc.gov/publications/332/pub4415.pdf.
[16] "Broadband and Telecom," Organisation for Economic Co-Operation and Development, January 9, 2014, http://www.oecd.org/sti/broadband/oecdbroadbandportal.htm.
[17] "Statistics," International Telecommunications Union, 2014, http://www.itu.int/en/ITU-D/Statistics/Pages/stat/default.aspx?utm_source=twitterfeed&utm_medium=twitter.

**Table 2. Media License Fees by Country**

| Country | Yearly (US$) | Monthly (US$) | Country | Yearly (US$) | Monthly (US$) |
|---|---|---|---|---|---|
| Australia[(a)] | 0.00 | 0.00 | Japan[(h)] | 197.66 | 16.47 |
| Austria | 459.10 | 38.26 | Luxembourg | 0.00 | 0.00 |
| Belgium | 236.15 | 19.68 | Mexico | 0.00 | 0.00 |
| Canada | 0.00 | 0.00 | Netherlands | 0.00 | 0.00 |
| Chile | 0.00 | 0.00 | New Zealand | 0.00 | 0.00 |
| Czech Republic | 90.33 | 7.53 | Norway[(i)] | 447.51 | 37.29 |
| Denmark[(b)] | 443.75 | 36.98 | Poland | 72.01 | 6.00 |
| Estonia | 0.00 | 0.00 | Portugal | 0.00 | 0.00 |
| Finland | 0.00 | 0.00 | Slovenia[(j)] | 180.82 | 15.07 |
| France[(c)] | 179.45 | 14.95 | South Korea[(k)] | 28.32 | 2.36 |
| Germany[(d)] | 295.56 | 24.63 | Spain | 0.00 | 0.00 |
| Greece | 70.68 | 5.89 | Sweden[(l)] | 318.45 | 26.54 |
| Hungary | 0.00 | 0.00 | Switzerland[(m)] | 527.40 | 43.95 |
| Iceland | 0.00 | 0.00 | Turkey | 0.00 | 0.00 |
| Ireland[(e)] | 219.18 | 18.26 | United Kingdom[(n)] | 242.50 | 20.21 |
| Israel[(f)] | 128.77 | 10.73 | United States | 0.00 | 0.00 |
| Italy[(g)] | 155.48 | 12.96 | | | |

Sources:
(a) "RTR—Television Fund," Australian Regulatory Authority, accessed May 2, 2014, https://www.rtr.at/en/ffat/Fernsehfonds.
(b) "About DR," Denmark, accessed May 2, 2014, https://www.dr.dk/om_dr/licens.
(c) "Contribution to Public Service Broadcasting (TV Fee)," Service-Public.fr, accessed May 2, 2014, http://vosdroits.service-public.fr/particuliers/F88.xhtml.
(d) "The Radio Talk," The Radio Talk, accessed May 2, 2014, http://www.rundfunkbeitrag.de/.
(e) "TV Licence—Homepage," TV Licence, accessed May 2, 2014, https://www.tvlicence.ie/Homepage.aspx.
(f) "Israel Broadcasting Authority," Israel Ministry of Foreign Affairs, accessed May 2, 2014, http://mfa.gov.il/MFA/MFA-Archive/2003/Pages/Israel%20Broadcasting%20Authority.aspx.
(g) "Information on Subscription to the Italian Television," Rai.it, accessed May 2, 2014, http://www.abbonamenti.rai.it/Ordinari/Inglese.aspx.
(h) "NHK Subscription Fees," NHK Online, accessed May 2, 2014, http://pid.nhk.or.jp/jushinryo/multilingual/english/.
(i) "About NRK—License," Norway, accessed May 2, 2014, http://www.nrk.no/lisens/.
(j) "Radio and Television Corporation of Slovenia Act (ZRTVS-1)," RTVSLO, accessed May 2, 2014, http://www.rtvslo.si/files/RTV_Slovenija/zrtvs_1.pdf.
(k) "How to Read Your Electric Bill," KEPCO, accessed May 2, 2014, http://cyber.kepco.co.kr/kepco/EN/F/htmlView/ENFBHP003.do?menuCd=EN060203.
(l) "Radio and TV Fee," Radiotjanst, accessed May 2, 2014, http://www.radiotjanst.se/en/Radio-and-TV-fee/.
(m) "SR 784.40 Federal Act of 24 March 2006 on Radio and Television Act (RTA)," Federal Authorities of the Swiss Confederation, accessed May 2, 2014, http://www.admin.ch/opc/de/classified-compilation/20001794/index.html.
(n) "TV Licensing—Home," TV Licensing, accessed May 2, 2014, http://www.tvlicensing.co.uk/.

Figure 1 shows an example of a media license fee invoice from Denmark, where it is levied semiannually. The fee of 1,218 Danish crowns ($225.79) includes tax.

**Figure 1. Example of Media License Fee from Denmark, February 2014**

3. FEBRUAR BETALES DETTE BELØB VEDR. AFTALENR 821797294 1.218,00
DR LICENS, LICENSNUMMER 40010826
LICENSINDEHAVER: CASPER LUNDGREEN
FAKTURANUMMER 1051166915, FORFALD: 03.02.2014
MEDIELICENS 01.02.2014-31.07.2014 1.218,00
HERAF MOMS 25 % 243,60 KR.

Source: Roslyn Layton, "How Media License Fees Impact the Real Price of Broadband," *Technology Liberation Front*, April 25, 2014, http://techliberation.com/2014/04/25/how-media-license-fees-impact-the-real-price-of-broadband/.

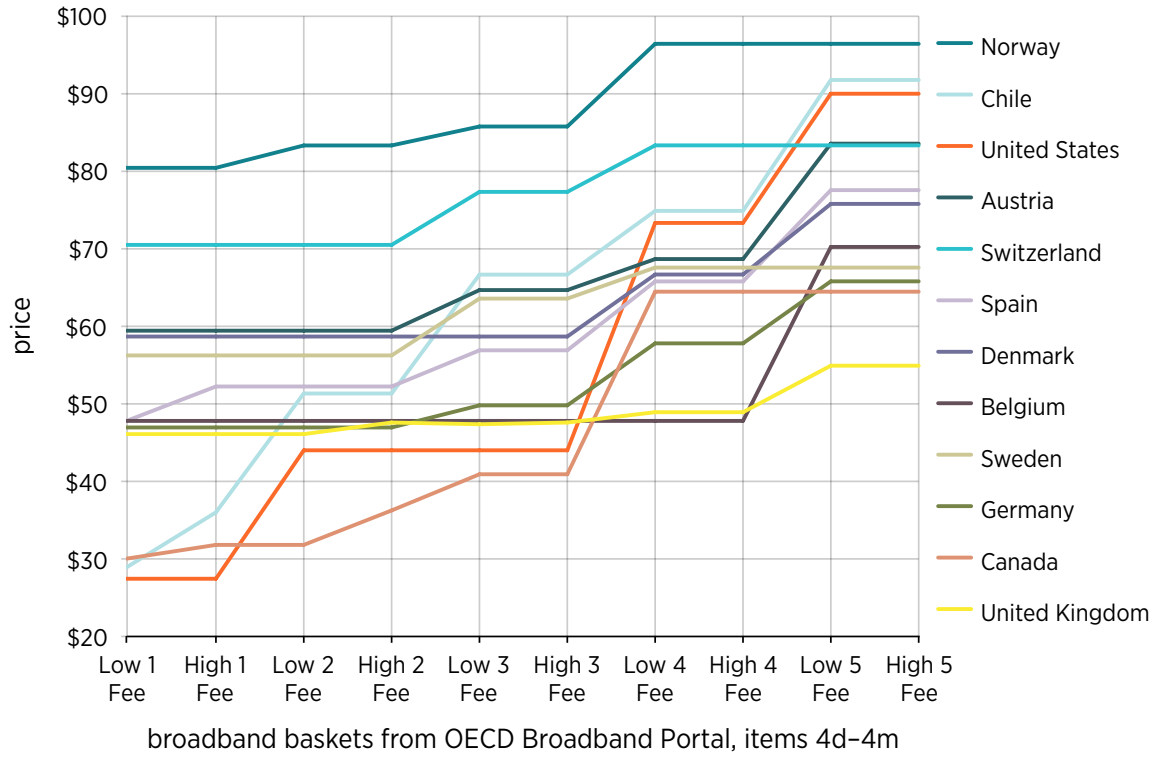
For each country, we added the price of the media license to the price from the OECD's broadband report (section 4c-4m of the OECD broadband database). The OECD compiles prices for a set of 10 broadband baskets of different speeds ranging from 2 GB at 0.25 Mbps to more than 54 GB at 45 Mbps in at least one major city in each country. The prices are current as of September 2012.

Figure 2 displays a subset of countries to show the fluctuation of prices depending on the speed and data of each package. The data show that when compulsory media fees are added, US prices are commensurate with, if not less than, those of other OECD countries.

We also calculated the average broadband price for each basket for all of the OECD countries, adjusted for media license fees. Here we find that the US price is lower than the OECD average in four out of ten baskets. In nine baskets, the US price is within one standard deviation of the OECD average, and in two cases just $2–$3 more. The US price falls outside one standard deviation of the OECD average in only one case—the penultimate basket of highest speed and data.

These data call into question assertions that US broadband prices are out of line. Not only are US prices within a normal range, but entry-level prices for broadband are below those in many other countries.

**Figure 2. Broadband Prices with Media License Fees, 2012**




Source: "Fixed Broadband Basket 4d–4m," OECD Broadband Portal, September 2012, http://cloudfront-assets.techliberation.com/wp-content/uploads/2014/04/Broadband-prices-with-media-license-fees.png; national governments.

Note:
Low 1: 2 GB / 10 hours per month, 0.25 Mbps and above; High 1: 6 GB / 30 hours per month, 0.25 Mbps and above; Low 2: 6 GB / 15 hours per month, 2.5 Mbps and above; High 2: 18 GB / 45 hours per month, 2.5 Mbps and above; Low 3: 11 GB / 20 hours per month, 15 Mbps and above; High 3: 33 GB / 60 hours per month, 15 Mbps and above; Low 4: 14 GB / 25 hours per month, 30 Mbps and above; High 4: 42 GB / 75 hours per month, 30 Mbps and above; Low 5: 18 GB / 30 hours per month, 45 Mbps and above; High 5: 54 GB / 90 hours per month, 45 Mbps and above.

The ITU has also recognized that American prices are reasonable. According to its 2013 report "Measuring the Information Society," broadband prices should be no more than 5 percent of income. The United States scored third in the world in 2012 for entry-level affordability of fixed-line broadband. It is tied with Kuwait, with fixed-line broadband prices at just 0.4 percent of gross national income per capita. This means that for as little as $15 per

month, Americans could get a basic broadband package at purchasing power parity in 2011 ($48,450 annual income).[18]

The figures are higher for mobile broadband (based on a postpaid handset with 500 MB of data): 2.1 percent of gross national income per capita, equating to $85 per month. However, the cost of mobile broadband for a computer with 1 GB of data equates to just 0.5 percent of gross national income per capita per month, about $20 in 2011. The United States scores in the top 10 in the world for entry-level affordability for both prepaid and postpaid mobile broadband for use with a computer.[19]

Taking the highly digital nation of Denmark as an example, 80 percent of fixed and wireless broadband subscriptions are under 30 Mbps.[20] That corresponds to baskets 1–4 in figure 2. If we assume that most American households subscribe to 30 Mbps or less, then American prices are in line with the rest of the OECD countries. Only subscribers who demand more than 30 Mbps pay more than the OECD norm.

The assertion that Americans pay more for broadband than people in other countries is frequently supported by incomplete and inappropriate data. To have a more complete picture of the real price of broadband across countries, media license fees need to be included.

[18] "Measuring the Information Society," International Telecommunications Union, 2013, 82, http://www.itu.int/en/ITU-D/Statistics/Documents/publications/mis2013/MIS2013_without_Annex_4.pdf.
[19] "Measuring the Information Society."
[20] "Broadband Survey 2013," Business Authority, January 21, 2014, http://erhvervsstyrelsen.dk/bredbaandskortlaegning-2013/0/7.

***How Much Broadband Does a Household Need?***

The Center for Communication Media and Information Studies at Aalborg University in Copenhagen made an in-depth report on broadband expectations for 2020.[21] It includes scenarios for a family of four, providing projections for extreme and normal usage. In the "extreme" example, each family member is in the midst of a bandwidth-heavy activity. Three of the family members must be able to receive three different television services in 3D HDTV (three-dimensional, high-definition television) quality and the fourth family member must be able to use an e-health/home office application. The bandwidth needs for this scenario are 40–130 Mbps download and 10 Mbps upload. The "normal" scenario assumes lower-quality video and less bandwidth for cloud and download services. Three of the family members receive three different television services, but in different qualities (an 720p HDTV and 1080p HDTV and 3D HDTV 1080p[22]) while the fourth family member uses a cloud game service. Here the capacity recommendation is 30–70 Mbps download and 10 Mbps upload. Although these scenarios are interesting, they fall well under the 1,000 Mbps (1 gigabit) threshold that fiber to the home (FTTH) offers, and current networks could support these scenarios.[23]

The Norwegian Centre for Integrated Care and Telemedicine, the world's oldest and leading institute for telemedicine, notes that most telemedicine applications (e.g., video consultation) run acceptably on average broadband levels, and even the most advanced application requires no more than 10 Mbps.[24] Indeed, the limiting factor for telemedicine is not broadband deployment but humans. Health care providers can be resistant to change, and

[21] Knud Erik Skouby et al., "Broadband Bandwidths in a 2020 Perspective," Aalborg University Center for Communication, Media and Information Technologies, May 8, 2013, http://www.cmi.aau.dk/News/Show+news/broadband-bandwidths-in-a-2020-perspective.cid87641.
[22] These refer to different types of television sets, each larger with an increasing number of vertical pixels.
[23] Skouby et al., "Broadband Bandwidths in a 2020 Perspective."
[24] Sture Pettersen (Department Leader for Innovation and Implementation, Norwegian Center for Telemedicine), interview conducted by Roslyn Layton, February 21, 2013.

patients may be reluctant to adopt health-related Internet technologies. The other requirements for telemedicine are wireless networks and devices, so investing exclusively in wireline networks will not necessarily enable telemedicine.

Some argue that FTTH must be deployed in order to meet demand for bandwidth arising from consumption of real-time entertainment, considering that Netflix and YouTube account for more than half of all downstream traffic in North America.[25] But deploying FTTH bears a high cost, and may disproportionately reward video content providers. Not all consumers want to pay for these upgrades. Although this paper does not address the topic, it is worth considering whether video providers, whose services take the lion's share of network capacity, should play an expanded role in network investment. Even Mark Cooper, head of research of the Consumer Federation of America, suggests that Netflix should participate in such an endeavor.[26]

Using taxpayer money to fund FTTH essentially subsidizes profitable video content providers and Hollywood content owners. As recent agreements between network providers and Netflix show, many capacity problems can be resolved with interconnection solutions that do not require any new networks.[27] If anything, Netflix is making its service more efficient all the time so that it can be consumed on lower and lower bandwidths as well as on mobile networks. Furthermore, Netflix has indicated that it will experiment with tiered pricing for different qualities of video definition.[28] It follows then that broadband prices should scale with quality as well.

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[25] "Global Internet Phenomena Report: 2H 2013," Sandvine, 2013, 2, https://www.sandvine.com/downloads/general/global-internet-phenomena/2013/2h-2013-global-internet-phenomena-report.pdf.
[26] Sara Jerome, "Consumer Group Wants to Tax Netflix to Pay for Rural Broadband," *The Hill*, February 24, 2011, http://thehill.com/policy/technology/145915-consumer-group-tax-netflix-to-pay-for-rural-broadband.
[27] Charlie Douglas, "Comcast and Netflix Team Up to Provide Customers Excellent User Experience," Comcast, February 23, 2014, http://corporate.comcast.com/news-information/news-feed/comcast-and-netflix.
[28] Reed Hastings (Netflix CEO) and David Wells (Netflix CFO) to Netflix shareholders, January 22, 2014, http://files.shareholder.com/downloads/NFLX/2501256210x0x720306/119321bc-89c3-4306-93ac-93c02da2354f/Q4%2013%20Letter%20to%20shareholders.pdf.

## Broadband Technologies and Innovations

An overview of leading broadband technologies gives a sense of the competition and technology in the marketplace. This includes the evolution of DSL, cable, FTTH, mobile, Wi-Fi, and satellite. Additionally, many of the technologies both compete with and complement each other. WiMAX and other broadband technologies exist, but are not discussed here. The key takeaway is that each broadband technology has advantages for a given set of users; however, policymakers should avoid favoring one technology over another. It is the interplay between the technologies that creates a dynamic broadband marketplace.

### *DSL*

Beginning in the 1980s, the telephone industry explored ways to compete with cable television by offering video over its copper wires. The telephone industry's research institutes had been working on a number of innovations. Over the years, their researchers, including seven Nobel Prize winners, developed many technologies for radio astronomy, transistors, lasers, charge-coupled devices, the UNIX operating system, and the C, S, and C++ programming languages.[29]

In 1987, Bell Labs' Joseph Lechleider presented a way to repurpose the existing copper wire phone network into high-speed broadband infrastructure. His invention allowed data to travel in both directions at the same rate. To enable video, it was necessary to change the symmetry of the data flow so that more data flowed downstream (e.g., to facilitate video transfer) while less data flowed upstream. The invention was thus called asymmetric digital subscriber line (ADSL) and has become a global standard.[30]

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[29] "Bell Labs Awards," Alcatel Lucent, accessed January 17, 2014, http://www.alcatel-lucent.com/bell-labs/awards.
[30] Anton A. Huurdeman, *The Worldwide History of Telecommunications*, 1st ed. (New York: Wiley-IEEE Press, 2003).

With ADSL (or DSL, as it is commonly called) broadband providers now had the ability to change the symmetry of their networks according to their customers' needs. For example, transmission for traditional voice calls is symmetrical; voice signals go back and forth equally. A video conference would also require some kind of symmetry, but to enable other kinds of applications such as streaming video, an ASDL connection is more appropriate on copper infrastructure.

In any case, the ASDL technologies introduced TV over the Internet, or Internet protocol television (IPTV). This offered the user an important advantage over cable: the ability to control when to watch video content without having to follow a linear television schedule.[31] To be sure, video recorded on reels and VHS/Beta allowed users to control when they watched, unlike traditional television, but IPTV's digital and "on demand" qualities are a next-generation improvement.

Telephone providers had key advantages over cable providers: telephone *and* Internet protocol television. However, the early idea of Internet TV didn't catch on as planned. Subscribers used their DSL connections to access the Internet, with its own smorgasbord of content and applications.

Innovations have continued within the family of DSL technologies, including VDSL (very high data rate DSL), which can offer high-definition television. Vectoring coordinates transmission and reception of DSL signals to mitigate crosstalk (the biggest challenge to DSL broadband), allowing data to move more quickly and smoothly along wires. Vectoring over DSL allows speeds of up to 100 Mbps, while even higher speeds over DSL will be available using G.fast technologies. G.fast is the deployment of fiber optics to a distribution point up to a couple

[31] Ibid.

of miles away from the subscriber while relying on the existing copper lines to the subscriber's premises. The advantage of this approach is cost-effectiveness; subscribers can experience an increase in throughput at a minimal cost that is borne by a larger share of subscribers.[32]

The high costs of the last-mile infrastructure frequently inhibit next-generation broadband deployment all the way to homes. These costs include not just labor and deployment, but also regulatory obstacles. In many cities, DSL providers would like to offer their customers fiber but underground conduits are full of copper wires for traditional telephone services, which by law have to be maintained and cannot be removed. Not only is there not room for fiber in the conduits, but municipal leaders are reluctant to allow disruption to streets and buildings.

Additionally, many subscribers who have been offered fiber will not pay the higher fees to cover the cost of deployment to their homes because substitute technologies cost less, and the bandwidth requirements of current applications can be met by other technologies.

As table 1 shows, just over one-third of Americans choose DSL for broadband, compared to a whopping 74 percent of Europeans, largely because there are not competing networks available in Europe. DSL does not serve a majority of Americans for broadband, but the United States is still a market with tens of millions of subscribers, and providers have incentives to continue improving the technology, especially because of competition from other facilities. For example, in 2012 AT&T announced a $14 billion investment program, a portion of which goes to update its copper wireline facilities.[33] Competition from cable and other technologies, as well as a desire to reduce churn, can encourage such investment decisions.

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[32] Jeff Heynen et al., "Extending Copper Access Networks with Vectoring and G.Fast: Why Fiber Isn't a Must" (Webinar, March 11, 2014), http://event.on24.com/eventRegistration/EventLobbyServlet?target=lobby.jsp&eventid=748757&sessionid=1&key=3FA95A7E80E9811BBC75D27914898B02&eventuserid=95430341.

[33] AT&T, "AT&T to Invest $14 Billion to Significantly Expand Wireless and Wireline Broadband Networks, Support Future IP Data Growth and New Services," news release, November 7, 2012, http://www.att.com/gen/press-room?pid=23506&cdvn=news&newsarticleid=35661&mapcode=.

***Cable***

Cable was a project undertaken to overcome distance and connect America beginning in the late 1940s. Some remote parts of the country could not be reached by terrestrial TV signals, so cable lines were brought to many homes.

The game changer for cable was Data over Cable Service Interface Specification, or DOCSIS, in 1997, a standard for data delivery across coaxial cable. This, along with the cable modem, which provides bidirectional communication, allowed cable providers to turn themselves into broadband providers. The cable industry has developed a hybrid fiber coaxial (HFC) cable network, making it a full-fledged broadband provider, offering high-speed data as well as voice in addition to television.[34]

Cable's strategy in its competition with Internet television has been to make the cable experience richer, better, and more diverse. The cable industry has innovated its offering so that television appears in high definition, not standard definition. It also provides a number of tools and devices to improve the viewing experience, such as content discovery. Finally, cable also offers TV everywhere, through the ability to stream cable and broadband content to connected devices.

Subscribers use cable technology not just for television and Internet access, but also for telephony. Some 26 million Americans selected cable as their voice provider as of 2012. Cable operators now make up five of the top ten residential phone companies in the country.[35] Users can purchase services a la carte, but many opt for a bundle of cable television, broadband Internet, and voice in a single subscription, also called triple play.

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[34] "Evolution of Cable Television," Federal Communications Commission, March 14, 2012, http://www.fcc.gov/encyclopedia/evolution-cable-television.

[35] "Impact of Cable," National Cable and Telecommunications Association, accessed January 15, 2014, http://www.ncta.com/impact-of-cable.

Like modern DSL technologies, cable networks also include fiber. The HFC network platform will continue to yield bandwidth increases for the foreseeable future. In 2011, Comcast unveiled an HFC network that can reach gigabit speeds.[36] With node splitting, spectrum utilization, better modulation, 24-channel bonding, and DOCSIS upgrades, cable coaxial networks can continue to meet consumer demand for many years. This means that as long as consumers demand it, there is an incentive to improve the speed and throughput of the existing wires in the ground.

The scale of cable provider Comcast has allowed it to invest in another broadband technology, neighborhood Wi-Fi. Comcast is turning the homes and neighborhoods of its subscribers into millions of Wi-Fi hot spots around the country. To enable this, Comcast offers customers an all-in-one device that combines a customer's wireless router, cable modem, and voice adapter. This device broadcasts two Wi-Fi signals, one securely configured for the subscriber and the other for the neighborhood, which can be accessed by anyone in the vicinity. Using unlicensed spectrum, Comcast's neighborhood Wi-Fi program is an important innovation and creates competition for mobile broadband providers.[37]

### *Fiber to the Home*

Optical fiber is a type of broadband network technology. Fiber has the property of low attenuation, meaning that it can maintain the intensity of the transmitted signals. It is ideally suited for long distances, and thus is used in Internet backhaul and undersea cables. Made of

[36] Tony Werner, "Comcast CEO Brian Roberts Demonstrates 1Gbps Speed Broadband Connection and Next Generation Video Product," Comcast, June 16, 2011, http://corporate.comcast.com/comcast-voices/comcast-ceo-brian-robert-demonstrates-1gbps-speed-broadband-connection-and-next-generation-video-pro.
[37] "Comcast Unveils Plans for Millions of Xfinity WiFi Hotspots through Its Home-Based Neighborhood Hotspot Initiative," Comcast, June 10, 2013, http://corporate.comcast.com/news-information/news-feed/comcast-unveils-plans-for-millions-of-xfinity-wifi-hotspots-through-its-home-based-neighborhood-hotspot-initiative-2.

glass (silica) or plastic and slightly thicker than a human hair, a strand of fiber has greater bandwidth than coax or copper. In fact, fiber is extant in all modern broadband technologies in some way. The broadband debate centers on to what degree fiber optics should be deployed to every residence, given the cost of deployment and the fact that other broadband technologies continue to improve speed and price.

Fiber is said to be "future proof" because its speeds and bandwidth are so high, reportedly 25 terabits per second (or 25,000 gigabits per second), meaning that fiber installed today can accommodate theoretically any bandwidth needs in the future. The challenge to deploy more FTTH comes down to the high up-front investment cost versus relatively slow overall adoption. For example, the EU Digital Scoreboard reports that although some areas have a higher adoption rate of FTTH (e.g., Stockholm, where government subsidies have been used to lower the subscription price), the overall adoption rate is just 2 percent for the EU areas that have FTTH networks.[38] This demonstrates that consumer demand is not yet at the level to justify greater investment in fiber.

In 2005, after a windfall from the sale of corporate assets and internal revenue projections based on the false assumption that the economics of electricity utilities could be applied to broadband, 14 private utility companies in Denmark invested $2 billion in FTTH, particularly in rural regions. The companies invested between $10,000 and $18,000 per home to deploy fiber, including backhaul costs.[39] Today, 70 percent of Denmark's households and businesses have access to ultra-fast broadband of 100 Mbps or higher from FTTH and cable networks, but just

[38] European Commission, chapter 2 in "Digital Agenda Scoreboard 2013" (European Commission Working Document, European Commission, Brussels, December 6, 2013), 43, http://ec.europa.eu/digital-agenda/sites/digital-agenda/files/DAE%20SCOREBOARD%202013%20-%202-BROADBAND%20MARKETS%20_0.pdf.
[39] John Strand, "FTTH Investors Day" (presentation, Fibre to the Home Council Europe, Brussels, October 2, 2013), http://ftthcouncil.eu/documents/Investors/FTTH_Investors_Day_Brussels.pdf.

1.85 percent subscribe to the fastest speed tier.[40] The utility companies today have only 250,000 broadband customers combined, and most of them subscribe to the tiers below 100 Mbps to satisfy their needs and budget. About 80 percent of Danish homes and businesses subscribe to 30 Mbps or less, but more than two-thirds subscribe to just 10 Mbps or less.[41]

There is no doubt that FTTH is a valuable infrastructure, but the time horizon investors should expect for return on investment can be uncertain, whether it is 5, 25, or some other number of years. Public companies generally have to report on a quarterly basis. Investors, which include pension funds, retirees, and so on, want consistent returns to their portfolios. This creates additional pressure for FTTH providers to be profitable quickly, not to mention the presence of competing technologies that also create risk for the uptake of FTTH.

In Japan, FTTH was facilitated by a number of government actions, including allowing companies to write down investment costs immediately (rather than amortize them over many years) and providing tax breaks and subsidies.[42] Moreover, there may be a cultural or business acceptance that companies can make investments and operate with lower profits for a longer period of time than would be acceptable in the United States. The 250-year business plan is not unheard of in Japan. It is also interesting to note that in a number of countries with national fiber projects, particularly South Korea, subsidies were needed to get people to adopt FTTH.[43]

Before deploying costly FTTH networks, the feasibility to improve existing DSL and cable networks as well as to deploy wireless broadband markets should be considered. Canada

[40] Skouby et al., "Broadband Bandwidths."
[41] "Broadband Survey 2013."
[42] Saul Hansell, "The Broadband Gap: Why Do They Have More Fiber?," *New York Times*, March 12, 2009, http://bits.blogs.nytimes.com/2009/03/12/the-broadband-gap-why-do-they-have-more-fiber/?_php=true&_type=blogs&_php=true&_type=blogs&_r=1.
[43] Irene Wu, "Broadband in Canada, South Korea and Japan: How Policy Objectives Influence Development" (presentation, "The Future of Broadband: Wireline and Wireless," Gainsville, FL, February 24, 2005), http://bear.warrington.ufl.edu/centers/purc/DOCS/PRESENTATIONS/events/0205%20LBS/P0205_Wu_Broadband_in_Canada.pdf.

provides a case in point. The OECD reports that both Canada and South Korea have essentially the same advertised speeds, 68.33 and 66.83 Mbps respectively.[44] Canada's fixed broadband subscriptions are shared almost equally between DSL and cable, with very little FTTH. Meanwhile, South Korea has the highest rate of FTTH per capita of any country in the world. This shows that fast speeds are possible on different kinds of networks.

One conclusion might be that the government needs to invest in FTTH because it is not profitable for the private sector to do so. However, as this paper will show, demand is weak for ultrafast broadband. For the most part, consumers have access to high speeds but subscribe to lower tiers because the applications they desire do not require the fastest speeds. Furthermore, cash flow in the broadband industry is sufficient to fund broadband investments, and the investments that are made are the result of consumer demand.

If the government is to play a role in broadband, a better use of public funds is not deployment, but rather adoption. Those who have not yet adopted the Internet because they do not like computers will not change their minds because they have an FTTH connection. Once people have digital skills, they are empowered not just to adopt broadband but to seek employment where digital skills are required and to take advantage of digital services.

Moreover, as the list of failing government-funded fiber projects grows, there is increasing evidence that the government-led broadband as utility model is not sound. Chattanooga, Tennessee, is one city where hundreds of millions of dollars of federal money was spent on a gigabit network. The outcome is 1,000 new jobs, but 3,000 jobs were lost over the same three-year period. Furthermore, only 3,640 residences (7.5 percent of Internet subscribers) and 55 businesses have purchased gigabyte connections. This means that 18 new jobs per

[44] "Average and Median Advertised Download Speeds—5a," Organisation for Economic Co-operation and Development, September 2012, http://www.oecd.org/sti/broadband/oecdbroadbandportal.htm.

connection were created, at a cost of $112,000 per job of federal stimulus money. Amazon and Volkswagen have set up operations in the area, but the attraction is not the gigabit network but rather the excellent central-US location with both highway and waterway access.[45]

In addition to federal projects, a number of municipal fiber projects have failed to meet expectations, including ones in Chicago, Seattle, Tacoma, Philadelphia, and Orlando.[46] Investigating the economics of municipal broadband highlights the risks and challenges not just for municipal providers, but also for private providers.

*Economics of a municipal broadband project.* Sometimes a municipality, housing development, or other entity (e.g., homeowner association) decides to build its own broadband network. Below we review the analysis of a municipal FTTH project in Leverett, Massachusetts, written by Yeshiva University law professor Susan Crawford, a leading supporter of municipal broadband, and Robyn Mohr.[47]

That paper defines the cost to deploy FTTH to 630 households as $3.6 million, or $5,714 per household. The city avoids backhaul costs by leveraging MassBroadband 123, a publicly funded fiber network built to connect towns in Massachusetts. Each property in Leverett is assessed an extra property tax increase of $25 per month. This must be paid by every property owner for 20 years regardless of whether he or she subscribes to the service. This equals $300 per year to pay back the principal on the loan, or the equivalent of a 5 percent property tax increase.

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[45] Bronwyn Howell, "Why Is New Zealand Chasing Chattanooga?," *Tech Policy Daily*, April 10, 2011, http://www.techpolicydaily.com/internet/new-zealand-chasing-chattanooga/.
[46] Bret Swanson, "GON, Baby, GON? Or New Life for Muni Broadband?," *Tech Policy Daily*, May 2, 2014, http://www.techpolicydaily.com/communications/gon-baby-gon-new-life-muni-broadband/.
[47] Susan Crawford and Robyn Mohr, "Bringing Municipal High-Speed Internet Access to Leverett, Massachusetts" (Research Publication No. 26, Berkman Center for Internet & Society at Harvard University, December 17, 2013), 62.

One option for paying for broadband service is to charge a flat rate of $61.30 per month (which would include the projected fees for Internet and phone service, taxes, access, operation, and maintenance), a rate that breaks even in seven years, if locked in and if all households pay. In practice, it can be difficult to get all households in a community to subscribe, but the more residents who subscribe, the better.

However, having a set rate for so many years it is not ideal from a consumer perspective. If the past is any indication, prices for substitute technologies will fall. Additionally, the city may want to create tiered rates with varying speeds for residents who are willing to pay more, so the city can recover costs more quickly.

In the Leverett case, the interest fee is assessed only on households that subscribe to the service. That being said, the subscription fee is based on service charges and interest. If many households subscribe, the payoff time is quicker and the total amount paid in interest will be lower. However, if few subscribe, the payoff time is delayed, and the total interest fees grow. It is not uncommon for the number of subscribers to fail to meet projections, meaning the original business case is not realized.

In this example, the Leverett municipality set the price of broadband at $86.30. It should be noted that the fee of $86.30 does not include a TV product, so if subscribers want to watch television (e.g., the Superbowl, the Oscars), they will need to subscribe to satellite television or a pay-per-view service over broadband. Neither does the city's price include premises equipment (smart TV, computer, router, set-top box converter, etc.), some of which needs to be purchased to enable the FTTH network; these are additional costs beyond the subscription fee.

Other factors that have to be included in the analysis of municipal broadband are demographics and the level of economic development. Communities that have anchor businesses

or institutions typically find that corporate broadband users tend to shoulder a larger overhead investment cost, making consumer subscriptions more affordable. In the case of western Massachusetts, not just Leverett, the decline in manufacturing after World War II has left the region economically depressed; the area also struggles to attract investment from other industries. A study by the United States Department of Agriculture explains,

> Areas with low population size, locations that have experienced persistent population loss and an aging population, or places where population is widely dispersed over demanding terrain generally have difficulty attracting broadband service providers. These characteristics can make the fixed cost of providing broadband access too high, or limit potential demand, thus depressing the profitability of providing service. Clusters of lower service exist in sparsely populated areas, such as the Dakotas, eastern Montana, northern Minnesota, and eastern Oregon. Other low-service areas, such as the Missouri-Iowa border and Appalachia, have aging and declining numbers of residents.[48]

It is understandable that city leaders desperate for economic development look at broadband as a panacea or silver bullet. However, broadband alone cannot turn the economy around. Economic development is a complex endeavor.

Leverett has an average household size of 2.41 and an average family size of 2.81.[49] With some 2,000 residents across 23 square miles, it is not densely populated. Every resident could take advantage of satellite broadband, and the study notes that 37 percent of residents do. Presently, Exede Satellite broadband offers 15 GB of data at 12 Mbps download for $80 per month.[50] The town is also served by a fixed-line provider, a DSL solution that provides 6 Mbps and 4G/LTE mobile broadband.

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[48] Peter Stenberg et al., "Broadband Internet's Value for Rural America" (Economic Research Report Number 78, Economic Research Service, United States Department of Agriculture, August 2009), http://www.ers.usda.gov/media/155154/err78_1_.pdf.

[49] "American FactFinder," Search: Leverett, MA, United States Census, accessed March 26, 2014, http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml.

[50] "Broadband Satellite Internet Packages—Check Availability by ZIP Code," Exede, accessed March 27, 2014, http://www.exede.com/internet-packages-pricing/service-availability?zip=01054.

It is unlikely that the town will be able to secure 100 percent subscribership for FTTH, so it should also build a breakeven case for the situation where only families with two to three people subscribe. This would be about 503 households or 79 percent of the total households, still a high rate of subscribership. In that case, the monthly cost increases to $107.87.

For one-person households, a 4G/LTE mobile broadband is frequently sufficient and cost-effective. A single householder will likely already have a mobile connection, and upgrading to mobile broadband is frequently cheaper than buying fixed broadband. AT&T's website notes that for the Leverett zip code, it can offer a smart phone with 10 GB for $115 or 20 GB for $165.[51] The latter is enough capacity to allow a person to consume 100 text emails, 100 websites, 1 hour of high-definition video, 10 digital photos, and 1 hour of video voice over Internet protocol (VoIP) *per day*. The mobile phone can be used as a dongle for the computer if supplemented with mobile Wi-Fi. Because the connection is mobile, it goes where the subscriber goes. Indeed, one-person households make up 30 percent of households in the United States today and are likely a factor in driving the uptake of mobile broadband. The Center for Disease Control notes that almost 40 percent of American households are wireless only, meaning they no longer have landline telephone access.[52]

However, the breakeven point for the FTTH network is somewhere between two and three persons per household, depending on their data needs. Indeed, for an elderly couple that does not use a computer, mobile broadband is the cost-effective solution. For two people, just one a heavy Internet user, mobile broadband may still be cost effective. Only when at least two

[51] "AT&T Mobile Share—Cell Phone, Tablet & Mobile Device Plans from AT&T," AT&T, accessed March 26, 2014, http://www.att.com/att/planner/#fbid=Cnwdb56nmCs.
[52] Stephen Blumberg et al., "Wireless Substitution: State-Level Estimates from the National Health Interview Survey, 2012" (National Health Statistics Reports No. 70, Centers for Disease Control and Prevention, December 18, 2013), http://www.cdc.gov/nchs/data/nhsr/nhsr070.pdf.

people in the household have high data needs does the FTTH business case make sense. However, with three dedicated Internet users, the FTTH case seems to be sound.

Some communities claim that they are not adequately served by existing providers, and argue that developing their own network is a way to make themselves "self-sufficient" for broadband. If the project works, the community will have a viable infrastructure solution. However, such a project requires that city leaders be viable broadband providers, managing the daily operations, enabling upgrades, providing customer service, and so on. As mentioned before, however, municipal broadband projects do not have a high success rate, either financially as investments or by the rate of resident adoption.

Over time, the municipality of Leverett runs the risk of creating a monopoly where no private competitor will dare to enter. The city has also created a path that relies on a technological strategy it will not be able to adjust should conditions change—for example, if the prices of other networks fall or if residents find alternative networks more suitable. Perhaps the worst-case scenario is that if the effort fails (as a number of municipal networks have), the citizens have little ability to recover their money. In these instances, the remaining assets are sold (frequently at fire-sale prices) to private third parties. This underscores a key benefit of private provision of broadband: the company and its shareholders take the risk, not citizens.

Such is the case in Provo, Utah, where Google took over a municipal fiber network for $1, once $39 million had been sunk into the project.[53] The network was financed by a $5.35 monthly fee levied on all the households in the town, whether they subscribed or not. Since Google took over the network, only subscribers pay, but if the project fails financially for Google, Google can sell the network back to Provo for $1.

[53] "Asset Purchase Agreement," Google Fiber Inc. and Provo City Corporation, April 16, 2013, http://www.provo.org/home/showdocument?id=2296.

In any event, the rollout of Google Fiber in Kansas City underscores how Google was shrewd to ensure the conditions to improve its business case, including requiring a minimum number of subscribers before entering, a variety of tax breaks, and a number of other concessions from the city, such as free power, space, conduit use, and permits.[54]

There is no doubt that a private broadband provider would like to operate under the same conditions guaranteed to a municipally owned provider or Google. Private providers would like to be able to charge all households for access to their infrastructure, even those that do not use it, and to offer a compulsory contract with a set rate for 20 years. But such contracts are not possible for most private providers.

Governments can take the risks of investing in broadband, but they can also reconsider the conditions they offer to companies. The current regulatory framework for broadband deployment is not optional. Federal authorities and regulators might consider the following options to incentivize rural broadband development.

1. For mobile broadband, regulators could exchange better coverage for longer spectrum license life. They could offer operators an additional 10 years for their spectrum license if they agree to serve remote areas. Both the operator and the regulator could calculate the net present value of the spectrum versus capital investment (capex) needed for additional investment.
2. For both mobile and fixed broadband, operators could be allowed to amortize capital costs more quickly and increase the percentage of capex that can be written down sooner.

[54] "Google Fiber Project Development Agreement" (Unified Government of Wyandotte County, March 30, 2011), http://rottenpolitics.com/Google_Fiber_Project_Development_Agreement.pdf.

3. Rather than continue the government-mandated universal service program, funding could instead be borne by private providers that take up the costs of rural deployment as part of operating under improved regulatory conditions.
4. Municipalities might also consider a privatization strategy from the beginning, taking up the initial investment, then transitioning to private provision.

*The corporate market for fiber.* While the gigabit business case may be difficult for households, many institutions (hospitals, companies, etc.) contract to build their own fiber networks, given their users and applications. Companies and organizations have more users than a household and more and higher bandwidth requirements. Fiber is frequently part of new high-rise construction, and many institutions, such as hospitals, universities, and financial companies, build bespoke fiber networks. Such build-outs may include a series of products and services on top of the fiber, as well as a variety of contractual obligations, service-level agreements, maintenance requirements, and so on.

Some firms choose a certain broadband provider because they want direct connections to the other firms served by the same provider and its data centers. Their data travel along private networks free of many of the challenges and regulation that plague retail networks. Business-to-business commerce is the single largest activity on the entire Internet, comprising multiple trillions of dollars.[55]

Some companies, especially financial firms where seconds can mean millions of dollars, purchase multiple fiber networks from different providers for redundancy. Needless to say,

[55] Mark Page and Christophe Firth, "Internet Value Chain Economics: Gaining a Deeper Understanding of the Internet Economy" (A.T. Kearney, London, May 2010), https://www.atkearney.com/paper/-/asset_publisher /dVxv4Hz2h8bS/content/internet-value-chain-economics/10192.

companies and institutions pay significantly more than retail consumers. Many firms that specialize in the corporate fiber enjoy freedom from regulations and restrictions that consumer broadband providers must uphold. For example, corporate broadband providers have no net neutrality obligations. They build networks to their clients' specifications, optimizing for some applications and ignoring others.

### *Mobile*

*Evolution.* It may be difficult to imagine life without a mobile phone, but the first ones were introduced not so long ago. The first models were developed by Motorola in the 1970s, cost $10,000, and weighed two pounds.[56] The first mobile phones were analog. The introduction of Code Division Multiple Access (CDMA) and Global Systems for Mobile (GSM) marked the shift to digital mobile platforms.

Both the European and American governments aspired for their native technologies to lead the market, but each region took a different approach. The United States left decision-making to the market, while the Europeans coordinated all the players in the European value chain (chip set makers, infrastructure providers, handset makers, mobile operators, etc.) to agree to the same mobile standards. While the US government pursued a technology-neutral strategy, the European government went for GSM, which proved a boon to Ericsson, Nokia, Alcatel, and Siemens. Meanwhile Verizon and Sprint decided on CDMA while AT&T chose GSM (which later proved an advantage for the rollout of the iPhone in 2007). CDMA took off in the United States because the American market itself was (and is) large and lucrative, but it failed to gain global traction. GSM became the global standard.

[56] Tania Teixeira, "Meet Marty Cooper—the Inventor of the Mobile Phone," *BBC News*, April 23, 2010, http://news.bbc.co.uk/2/hi/programmes/click_online/8639590.stm.

Meanwhile, in South Korea, operators chose the CDMA standard, but the government later required them to switch to wide-band CDMA (W-CDMA) and GSM to be part of the world standard.

Only after a nationwide investment in CDMA did American mobile carriers realize that their chosen technology would not be the global leader. Phone manufacturers such as Apple would no longer develop or market cool CDMA phones because they had a global market with GSM. So certain American mobile carriers had to retool with the next-generation standard, and they jumped ahead with 4G/LTE. Not only is 4G/LTE significantly faster than 3G, it provides mutual authentication of users in both licensed and unlicensed spectrum, safety, and enhanced operating features. Given that AT&T already had a GSM network, it had an advantage to make an exclusive launch for the iPhone.

This episode demonstrates the risk of technology-centric policies for mobile and broadband, more generally. Governments realized that a technology-neutral approach bears less risk because it avoids locking players into a standard in a quickly changing market. In a world where mobile is also a part of global goods and services, such decisions also have an impact on trade policy. Indeed, selecting standards can create de facto trade barriers, as the selection of GSM in Europe did for American providers. To be sure, companies compete on standards, and that bears risk. But it is better that the companies take their risks with shareholders' money than taxpayers'.

The marketing and popularization of mobile standards has helped make mobile communications a mainstream phenomenon. Moving consumers over time from 2G to 4G has been helped by a massive marketing and education effort by mobile broadband providers. The United States and Canada contain just 6 percent of the world's population but enjoy 50 percent

of the world's 4G/LTE connections.[57] This puts the region in good stead for the future of wireless innovation.

CTIA–The Wireless Association observes that achievements have been made just in the past five years, including an increase from zero to some 50 million 4G/LTE subscriptions. Smart phone subscriptions have increased from 41 million to more than 150 million. The iPad did not exist in 2009, but 220 million and counting have been sold in the United States since then. Meanwhile the number of apps has increased from 150,000 to 4 million. Mobile penetration increased from the already high 89 percent to 110 percent. This short list of accomplishments does not begin to describe the advances in entirely new industries of m-health, m-education, and m-transportation.[58]

The next wave of mobile innovation is 5G. Although 5G technology is not yet standardized, it should allow more integration between telecommunications and the Internet. Devices will be able to roam seamlessly between networks. Unlike 4G, which is based on a standardized radio technology, 5G emphasizes the development of existing technologies to improve capacity, combined with the evolution of radio technology and a change in system-related design principles.

Innovations can provide wholesale reinvention and reconceptualization of prior technologies. Just as the mobile phone replaced the fixed-lined phone, new standards of mobile technology essentially re-envision the capability of the network.[59]

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[57] "US Represents 50 Percent of World's LTE Connections," CTIA, March 24, 2013, http://www.ctia.org/resource-library/facts-and-infographics/archive/US-LTE-Connections.

[58] Christopher Guttman-McCabe, panelist in "The Right Regulatory Approaches for Successful Spectrum Policy," YouTube video, 1:01:58, posted by the Free State Foundation ("FreeStateFoundation"), April 1, 2013, https://www.youtube.com/watch?v=JVDox3ZORtU.

[59] Kim Stensdal, "Therefore, 5G Is a Totally Different Mobile Network," *Computer World*, May 24, 2013, http://www.computerworld.dk/art/226854/derfor-bliver-5g-et-totalt-anderledes-mobilnetvaerk.

In practice, a 5G network is so advanced that it can optimize unused frequency. Congestion often occurs because so many different devices and applications place extreme demands on the mobile network. However, an intelligent network knows how to optimize bandwidth given such constraints. For example, a text message needs only minimal bandwidth to be delivered, e.g., the 2G standard, so the network can downshift or use a different frequency. But if high-definition video needs to be delivered, the transmission shifts into high gear, such as 4G or 5G. So the limited spectrum is constantly refreshed as tasks are performed.

Some of the American companies working on the next generation of mobile/wireless standards include Qualcomm, Motorola, Microsoft, and Cisco. Mobile technologies that can download an entire movie in a minute are promised with 5G, and 5G networks will be characterized by a higher degree of intelligence and more thoughtful interaction between network devices and services.

Naturally companies researching and developing new technologies expect them to be purchased by broadband providers. Otherwise they would not pursue such research and development. It bears mention that strict rules on net neutrality could threaten the innovation in next-generation wireless networks. Net neutrality is predicated on the notion of a stupid network, a dumb core with smart ends. New wireless networks are characterized by intelligence and decision-making for bandwidth optimization. The notion of a smart network is at odds with the one characterized by net neutrality, where all data are treated the same.

*Economics.* The economics for mobile broadband are highly favorable compared with other networks. Mobile broadband has the advantage of relatively low capital and maintenance requirements, mobility, shared capacity, and usability. Given that most of the world's people

already have a mobile phone, bringing them the Internet via a mobile network is a faster, cheaper, and easier than building wireline connections. Indeed, the growth of fixed broadband in Africa has hardly budged, while mobile broadband has increased 50-fold in the past six years.[60] Of course, mobile broadband requires adequate spectrum, an issue addressed in the following section.

All things being equal, mobile broadband provides the most cost-effective way to produce a megabit of traffic. The inputs to a mobile broadband network are spectrum, infrastructure, terminals, and subscriptions. Under a traditional fixed-line telecom paradigm, these inputs would be offered in a vertically integrated model: that is, users obtain these goods and services from the same provider. Mobile networks, on other hand, are highly diversified, with a number of competing firms at each level and within the value chain itself.

Mobile networks require the allocation of a finite resource: spectrum. A number of firms may compete in an auction for different bands, or the government may award spectrum based on application. A mobile operator will typically contract with an infrastructure provider to build mobile infrastructure, including masts and towers to provide coverage for the given area. Makers of mobile terminals will offer equipment to end users either directly or through a resell agreement with operators. End-user subscriptions can be offered directly to consumers or through a wholesale agreement with mobile network virtual operators (MVNOs). Services can be provided by operators or offered by third parties such as so-called over-the-top (OTT) or pass-through services. This wireless value chain is highly competitive, mature, and efficient.

To recover investment costs, mobile broadband is typically offered on a tiered basis for speed and data. Many plans have limits or caps. In general, most users do not reach their caps, but

[60] "Percentage of Individuals Using the Internet," International Telecommunications Union, 2013, http://www.itu.int/en/ITU-D/Statistics/Documents/statistics/2013/Individuals_Internet_2000-2012.xls.

a small subset of users whose main use is high-bandwidth video (e.g., some gamers) complain of caps. However, mobile broadband can be an effective if not exclusive source of broadband for most of the population. It ensures connectivity for applications such as email, banking, job applications, health information searches, VoIP, and e-commerce at a reasonable price.

Fixed broadband is subject to a variety of ongoing maintenance costs, especially when wires must go directly to a customer's premises. There are maintenance costs for mobile masts, but they are less than those of a fixed-line network. This is why mobile is the more cost-effective way to connect the last mile.

Mobile networks also have the advantage of mobility; the network connection goes where the user goes, unlike a fixed-line connection. Mobile also offers the advantage of shared capacity. When a fixed connection is brought to the home, it cannot be repurposed if the resident leaves. A new resident may move in and chose not to subscribe. The connection goes dormant. With a mobile network, on the other hand, if the subscriber cancels, that capacity can be repurposed for another user.

Perhaps the most compelling reason to enjoy mobile broadband is its usability. Half of all American adults have a smart phone, and 83 percent of people ages 18 to 24 have a smart phone.[61] Many have come to the web first and only with a mobile device; they may have never enjoyed computers, but find tablets and smart phones intuitive and easy to use.

Mobile pricing models are evolving. Some may complain about prices today, but they are falling rapidly. Ten years ago, it took $12,000 and seven weeks to download a movie to a mobile phone. Today not only are handset screens vastly improved, but people routinely stream films to

[61] "Cell Phone and Smartphone Ownership Demographics," Pew Research Internet Project, January 2014, http://www.pewInternet.org/data-trend/mobile/cell-phone-and-smartphone-ownership-demographics/.

their phones at a fraction of the cost and time. One can get 3 GB of data for $60 plus unlimited voice and text in the United States and 120 other countries.[62]

*Spectrum.* To be sure, a limiting factor to realizing the mobile future is the availability of spectrum. The United States has taken advantage of technologies to improve the utilization of spectrum, but relying on efficiency enhancement alone is not enough. The supply of spectrum is fixed, and it needs to be allocated and used more efficiently. Wireless carriers do not even have 16 percent of the airwaves that are best suited to mobile broadband.[63]

The United States faces an exploding demand for mobile data, cellular telephony on licensed spectrum, and a range of devices needing unlicensed spectrum. This situation of squandered spectrum is a great concern to the nation and a threat to future economic growth and global competitiveness. Citing the National Telecommunications and Information Administration's Office of Spectrum Management, the President's Council on Advisors for Science and Technology explains the situation:

> Federal agencies have exclusive use of 18.1% (629 MHz) of the frequencies between 225 and 3700 MHz (traditionally referred to as the "beachfront frequencies"), while non-Federal users have exclusive licenses to 30.4% (1058 MHz). The remaining 51.5% is shared, with Federal use primary and private sector use secondary. Approximately 80% of the shared allocation—or 40% of the total—have a "dominant" Federal use (e.g., radar, aeronautical telemetry) that under the current coordination regime effectively precludes substantial commercial use of those bands. In other words, nearly 60% of the beachfront frequencies are predominantly allocated to Federal uses.[64]

President Obama's actions on this issue including requiring that a combined 500 MHz of federal and nonfederal spectrum be shared or relinquished by 2020. His Wireless Innovation and

[62] "Cell Phone Plans," T-Mobile, accessed March 27, 2014, http://www.t-mobile.com/cell-phone-plans/individual.html.
[63] "Infographic: Growing Demand for Wireless Spectrum," *Mobile Future*, August 28, 2012, http://mobilefuture.org/infographic_growing_demand_for_wireless_spectrum/.
[64] "Realizing the Full Potential of Government-Held Spectrum to Spur Economic Growth" (President's Council of Advisors on Science and Technology, July 2012), 8, http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast_spectrum_report_final_july_20_2012.pdf.

Infrastructure Initiative described freeing spectrum through incentive auctions (where agencies agree to give up their spectrum in expectation of proceeds from the auction).[65]

A different group, the President's Council on Advisors for Science and Technology, issued a report in 2012 suggesting that relinquishing spectrum was not feasible because of the high cost, lengthy transition time, and disruption to federal agencies' mission. The report suggested that sharing and better management of existing spectrum could ultimately recover 1,000 MHz, twice the amount initially proposed. As a result, Obama issued a follow-up memo to accelerate the sharing of spectrum, expediting commercial access to additional spectrum bands, and eliminating restrictions to commercial carriers' ability to negotiate sharing agreements with agencies.[66]

While sharing has a role in spectrum policy, the United States should certainly not give up the valuable efforts to auction relinquished spectrum for licensed use. Indeed, 84 percent of spectrum in the United Kingdom is traded, and where necessary, the government has seized spectrum from uncooperative government agencies.[67]

A number of economists and engineers have observed the downsides of spectrum sharing. Faulhaber and Farber estimate that sharing can reduce the value of a spectrum by 60 percent.[68] Seth L. Cooper suggests that a sharing requirement made the 700 MHz band D block

[65] "President Obama Details Plan to Win the Future through Expanded Wireless Access," White House, Office of the Press Secretary, February 10, 2011, http://www.whitehouse.gov/the-press-office/2011/02/10/president-obama-details-plan-win-future-through-expanded-wireless-access.
[66] "Presidential Memorandum—Expanding America's Leadership in Wireless Innovation," White House, Office of the Press Secretary, June 14, 2013, http://www.whitehouse.gov/the-press-office/2013/06/14/presidential-memorandum-expanding-americas-leadership-wireless-innovatio.
[67] "Spectrum Management Strategy: Ofcom's Approach to and Priorities for Spectrum Management over the Next Ten Years," Ofcom, October 2, 2013, 3, http://stakeholders.ofcom.org.uk/binaries/consultations/spectrum-management-strategy/summary/spectrum_management_strategy.pdf.
[68] Gerald R. Faulhaber and David J. Farber, "The Open Internet: A Customer-Centric Framework," *International Journal of Communication* 4 (2010): 302–42.

spectrum so unattractive that no commercial actor would take it up.[69] Moreover, in a seminal analysis of spectrum auctions in 25 countries, Thomas W. Hazlett and Roberto E. Munoz conclude that auctions overwhelmingly support consumer welfare, greater than other methods of spectrum allocation, including sharing. They estimate a lost opportunity of $67 billion in consumer welfare over six years for the failure to include an additional 30 MHz in the C block auction in 1996.[70]

Sharing and relinquishing spectrum to market mechanisms are two important paths that the United States needs to pursue. However, other countries, particularly the United Kingdom, New Zealand, and Australia, all with similar legal traditions to the United States, have developed national markets with relinquished spectrum, beginning as early as 1989. The recovered spectrum is auctioned, traded, and leased.

Compared with the United States where some 60 percent of prime spectrum is held by government agencies unavailable to private users, in the United Kingdom, over 75 percent of spectrum is available to all comers. Of this, 46 percent is occupied by private users and 29 percent is shared by private and public users.[71] Public actors occupy just 25 percent. There is no reason the United States cannot and should not develop this toolkit of capabilities.

Federal spectrum holdings in the United States are assigned to a few dozen federal agencies that do not necessarily have the information or incentives to steward their use of the resource. Given the importance of spectrum to the nation's economic health and security, a rational spectrum policy to recover unused and underutilized spectrum is in order. A

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[69] Seth L. Cooper, "Sharing Licensed Spectrum with Government Lessens Prospects for Wireless Broadband," *Free State Foundation* 8, no. 7 (March 4, 2013): 2, http://www.freestatefoundation.org/images/Sharing_Licensed_Spectrum_with_Government_Lessens_Prospects_for_Wireless_Broadband_030413.pdf.
[70] Thomas W. Hazlett and Roberto E. Muñoz, "A Welfare Analysis of Spectrum Allocation Policies," *Rand Journal of Economics* 40, no. 3 (Autumn 2009): 424–54.
[71] "Spectrum Management Strategy."

Consumer Electronics Association study suggests there is a $1 trillion business opportunity in converting some $62 billion worth of spectrum.[72] Mobile telephony is just one of many areas where high-value use can be substituted for low-value use, bringing greater efficiency and economic welfare.

The key theoretical notion underpinning the relinquishing of spectrum is that federal agencies procure other inputs through the market and competitive processes. There is no justification that spectrum, one of the most valuable resources, should not be part of that process. The academic theory formalized by Coase[73] and demonstrated successively with auctions is that those who value spectrum most will pay the most for it and thereby put it to the most productive use. This creates the greatest social benefit.

Federal agencies use the General Services Administration (GSA) to procure their inputs of land and capital. They go to labor markets to hire employees. Thus, agencies already have experience using markets, and this suggests that a GSA-like agency could also manage the allocation of spectrum. As government agencies do in the United Kingdom and Australia, American agencies can pay fees for spectrum, like any other inputs. An additional benefit of this process and the establishment of such an entity would be to create transparency with a centralized database of all spectrum.

Two solutions in the toolkit for getting more spectrum are overlay licenses and the "BRAC the spectrum" approach. An overlay license is a flexible-use license that encourages the new service provider and incumbent to find voluntary settlements to the shared spectrum. The

[72] Coleman Bazelon, "The Need for Additional Spectrum for Wireless Broadband: The Economic Benefits and Costs of Reallocations" (Brattle Group, Washington, DC, October 23, 2009), http://www.itu.int/wsis/stocktaking/docs/activities/1286880939/upload809%5B1%5D.pdf.
[73] R. H. Coase, "The Federal Communications Commission," *Journal of Law and Economics* 2 (October 1959): 1–40.

license is awarded in an auction where the new entrant wins primary rights and the incumbent holds secondary rights and usually has to vacate the band by a certain deadline.[74]

Like all resources, spectrum is scarce, and because it is allocated for free to federal agencies, a shortage has emerged, as is often the case with price controls. Spectrum instead should be priced in the market, which would allocate it to its highest-valued use, increasing the welfare of its users. The drawn-out process of engaging with agency stakeholders is not productive. Phillipa Marks, key architect of the UK and New Zealand policy, has observed that the United States has been too lenient with agencies and "too incremental" in its approach to spectrum.[75] Other countries have used executive power to force government agencies to relinquish their spectrum.

There are times when the president needs to take swift, unimpeded action. The Base Realignment and Closure (BRAC) project facilitated the difficult process of closing bases in phases following the Cold War. The United States needs to take the same approach with spectrum, also known as "BRAC the spectrum." This command-and-control approach has the advantage of removing political pressure and temptation for any political actor to influence the process to relinquish spectrum.[76]

*Implications.* Mobile broadband deserves special attention because it is seen as both a competitor and a complement to fixed broadband. Indeed, many consumers have both fixed and mobile

[74] For further discussion, see Brent Skorup, "Reclaiming Federal Spectrum: Proposals and Recommendations," (Working Paper No. 13-10, Mercatus Center at George Mason University, Arlington, VA, May 2013), http://mercatus.org/sites/default/files/Skorup_FederalSpectrum_v1%5B1%5D.pdf.
[75] Phillipa Marks, "Commercial Demand for Public Sector Spectrum" (presentation, Australian Communications & Media Authority, RadComms Conference, 2011), http://www.youtube.com/watch?v=VfErJk3Qhko.
[76] For a helpful discussion, see Brent Skorup, "Getting Away from Gosplan: A BRAC-like Effort Is Needed to Repurpose Federal Spectrum," *Telecommunications and Technology* 14 (Winter 2013–2014), http://object.cato.org/sites/cato.org/files/serials/files/regulation/2014/1/regulation-v36n4-7.pdf.

broadband subscriptions. However an increasing number of people in developed countries choose to have only mobile broadband subscriptions. This is a particular trend in Japan, a country noted for its FTTH networks, where many youth go mobile-only for broadband.[77] In developed countries with widespread, high-speed 4G/LTE networks, however, an increasing percentage of people, both young and old, find that they can do just about everything they want on the Internet with only a mobile broadband subscription. They may purchase a mobile dongle to plug into a laptop or desktop computer, or they may use a smart phone.

Some maintain that mobile will never be a substitute for fixed broadband because of data caps on subscriptions. However, business models have evolved as significantly as the technologies to deliver video over mobile. It is just a matter of time before the market finds a solution to the issue of data caps.

Given the mobility and flexibility of wireless, it is probably not so surprising that the OECD reports that wireless broadband continues to outpace fixed broadband, which has almost a flat growth compared with the total number of subscriptions. Wireless broadband subscriptions in the 34-country group were up 16.63 percent from a year earlier to a total of 851 million, driven by continuing strong demand for smart phones and tablets.[78] Mobile may make the entire fixed broadband deployment discussion a moot point. Indeed, Sprint Chairman Masayoshi Son calls mobile "the most important infrastructure for the 21st century."[79]

Companies such as Google, Yahoo, and Facebook are remaking themselves as mobile-first. Netflix has an app that makes movies available just for mobile devices and optimized for

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[77] Tony Brown, "Customers Dumping Fibre for 4G in Japan," *Delimiter*, November 21, 2012, http://delimiter.com.au/2012/11/21/customers-dumping-fibre-for-4g-in-japan/.
[78] "Total Fixed and Wireless Broadband Subscriptions by Country—1c."
[79] Charlie Rose, "SoftBank's Masayoshi Son on Persuading Steve Jobs, U.S. Wireless," *Bloomberg Businessweek*, March 13, 2014, http://www.businessweek.com/articles/2014-03-13/softbanks-masayoshi-son-on-persuading-steve-jobs-u-dot-s-dot-wireless.

minimal data consumption. At the Mobile World Congress, Facebook CEO Mark Zuckerberg explained how engineering can make vast improvements in the efficiency and data consumption of Internet applications. There is much to be done on improving the design of Internet applications so they take less bandwidth, meaning that existing infrastructure can accommodate more data. Zuckerberg explained that in 2012, Facebook consumed 14 MB of data per month of a typical subscription; Facebook engineers have improved the platform so that it now takes just 2 MB, and they're on track to bring it down to 1 MB.[80]

Consider that in 2013 a record 25 percent of all of Black Friday purchases were made by mobile devices, up 80 percent from the prior year. Even where fixed broadband is well deployed, many are forgoing fixed connections to make mobile their primary broadband connection. This is happening in the United States and other countries. In Denmark, 7 percent of the population has chosen 3G or 4G mobile broadband as its primary Internet connection, 100,000 more subscribers than FTTH.[81] This is particularly important because in many sectors of the Danish economy, including banking, health, and government, users can only access services digitally. Services are fully functional on mobile devices and at their associated speeds.

***Other Innovations***

*Wi-Fi.* Wi-Fi (wireless fidelity) networks are common in airports, hotels, cafes, hospitals, and commercial buildings, as well as parks, stadiums, and outdoor locations. There are some 198,757 hot spots in America today and counting, more than in any other country in the world.[82] A hot

[80] "Mark Zuckerberg at the Mobile World Congress 2014 (Full Video)," YouTube, 45:39, posted by "isaac nzaramba, " February 24, 2014, https://www.youtube.com/watch?v=VHwkHZpXqWc.
[81] "Broadband Survey 2013."
[82] "JiWire Global Wifi Finder," JiWire, accessed June 19, 2014, http://v4.jiwire.com/search-hotspot-locations.htm. This amount does not include hot spots deployed under programs such as Comcast's neighborhood Wi-Fi.

spot can be as small as a single room with walls that block radio waves or as large as many square miles where multiple access points propagate the network. In order to connect to a Wi-Fi network, a user needs an adapter, which is typically embedded in a computer, smart phone, tablet, or camera. Signals are typically encrypted to ensure privacy and security. Wi-Fi can be a combination of wired and wireless technologies. In general, wires run to a wireless network access point or "hot spot" where an antenna sends out wireless signals.

Unlike a mobile or cellular network that uses licensed spectrum, Wi-Fi networks do not license the space they use. That is, Wi-Fi providers need not pay the government for the use of the airspace. Wi-Fi networks also offer innovators a space for experimentation with devices and applications. It also offers the aesthetic value of removing wires and cables from view.

As mentioned before, cable operators envision Wi-Fi as a way to compete with mobile cellular operators. For example, Sprint is competing on the wholesale market by making Wi-Fi hot spots available to cable operators.[83] Wi-Fi is an important broadband innovation that is increasingly becoming a national network strategy.

*Satellite.* Satellite broadband for consumers is an outgrowth of satellite communications for government and corporations. While many consumers have been less than satisfied with satellite broadband in the past, the technology has improved, and people can purchase commercial-grade satellite technology at a competitive price. Satellite broadband is available to 99 percent of Americans. This is important technology for remote areas, particularly sparsely populated mountainous areas.

[83] Tammy Parker, "Sprint MVNO Scratch Wireless Crafting Wi-Fi-Centric Service for Cable Operators," *FierceWirelessTech*, April 20, 2014, http://www.fiercewireless.com/tech/story/sprint-mvno-scratch-wireless-crafting-wi-fi-centric-service-cable-operators/2014-04-20.

Satellite Internet works in the following way: The satellite provider has a network operations center (NOC) connected to the larger Internet via a fiber network. The NOC transmits the requested data via a dish to a geostationary satellite 22,300 miles above the equator. This location allows the satellite to move in lockstep with the Earth's rotation. The satellite then transmits the data to the subscriber, who has a small home satellite and router. The user can both upload and download data from the home location.[84]

Satellite broadband packages of 5–15 Mbps download start at $40 per month. The commercial grade of 16/4 Mbps is faster than the speeds in most countries, and at $70 per month today may be preferable to a FTTH outlay that could take many years to break even. There is a fee for equipment (e.g., $10 per month), or the equipment can be bought outright.

Satellite broadband is not appropriate for heavy downloaders and online gamers, but some video games work adequately.[85] However, satellite broadband is more than adequate for web browsing and email. It can also enable video conference and video streaming, with 15 hours for a standard plan and some 23 hours for an upgraded plan. For many providers, usage during the hours of midnight to 5 a.m. does not count toward the monthly cap.

*Other innovations.* The broadband marketplace will continue to benefit with improvements in backhaul, video compression, content delivery, multicasting, and other innovations. These innovations allow more data to be delivered over existing networks more efficiently. Backhaul can also be used more efficiently, with two different network facilities using the same backhaul.

[84] "How Does Satellite Internet Work?," Ground Control, 2014, http://www.groundcontrol.com/How_Does_Satellite_Internet_Work.htm.
[85] "What Games Work and What Games Don't Work on Exede Internet?," *Exede*, accessed March 27, 2014, http://help.exede.net/articles/General/Exede-Games.

Providing caches of content in content delivery networks around the world is one solution that already speeds up Internet traffic for more than one-third of the world's content.[86] Netflix has even built its own content delivery network. Another possibility is to take advantage of high-efficiency video coding[87] to compress data so that more can be delivered across less bandwidth. Such technologies typically halve the amount of bandwidth needed to deliver data every five years.

Yet another possibility is to deliver OTT video via multicasting, the technology that delivers cable programming on managed network facilities today. This could allow Netflix to be delivered to a theoretically infinite number of people with minimal bandwidth. Scientists in Belgium have created a solution that turns a unicast stream into a multicast stream, and creates a solution in which OTT providers such as Netflix can cooperate with IPTV providers to use bandwidth more efficiently.[88]

A smart vision of the future embraces a variety of network solutions and innovations. There is no one network that can do it all. In general, consumers don't know or care whether they are on DOCSIS, LTE, Wi-Fi, DSL, VPN, or FTTH. What they want is a fast and secure connection that is seamless from home to car to office.

The broadband future demands not one, but many technologies. Each network technology has advantages and disadvantages, and no one network is either "neutral" or "future-proof." It all depends on the economics, geo-demographics, and needs of users. This equation is shifting all the time.

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[86] "Cisco Visual Networking Index."
[87] "Finding the Key to High Efficiency Video Coding," *Digital Video Broadcasting Scene* 36 (December 2010), http://www.dvb.org/resources/public/scene/DVB-SCENE36.pdf.
[88] Niels Bouten et al., "An Autonomic Delivery Framework for HAS in Multicast-Enabled Multimedia Access Networks" (IBBT, 2012), http://www.danms.org/prev_danms_/danms12/images/presentations/Bouten.pdf.

It is important to bear these facts in mind, as many will urge that the government should get involved in fiber deployment, especially when consumers are not doing enough on their own to demand the technology. But there is no reason to get bogged down in thinking that without FTTH the future is being held back. An ideal future is one where a variety of robust broadband technologies compete.

**Investment**

Such innovation in broadband networks would not be possible without significant private investment. The United States is a global leader in investment in broadband networks. This is evident in its pure amount of investment, as well as the per capita investment rate. Furthermore, a high investment across a range of technologies has been sustained over a long period of time.

We reviewed the data from Infonetics on private capital expenditure on communications equipment for all operators globally.[89] The measure encompasses expenditures on broadband aggregation equipment, wireless infrastructure, routers, switches, fiber equipment, VoIP infrastructure, video infrastructure, time division multiplexing voice equipment, customer premises equipment, and other categories of capital investment (capex). Labor cost is not included in this measure, but also represents a significant outlay for broadband deployment.

While broadband investment can be cyclical, with periods of higher or lower spending, the United States has been a pacesetter, investing some $1.2 trillion since 1996[90] to build and upgrade wired and wireless networks, lay thousands of miles of fiber-optic cable (more than the whole EU

[89] "Telecommunications Market Research: Telecom Market Analysis," Infonetics Research, 2013.
[90] "America's Internet Leadership," National Cable and Telecommunications Association, accessed January 21, 2014, http://www.ncta.com/positions/americas-Internet-leadership.

combined),[91] erect cell towers, and increase capacity to meet consumer demands. Average annual investment is some $60 billion per year, and the 2013 tally was close to $75 billion.

US investment has continued even through the financial crisis that started in 2008. The US contribution has remained steady at roughly a quarter of the world's total, even though the total pie of infrastructure investment has increased from $130 billion in 2003 to some $330 billion in 2013.

The story is different for the EU. A decade ago, the EU accounted for roughly one-third of the world's communications capex. That number today has plummeted to less than one-fifth, mainly because the EU has not kept pace with the United States, Canada, and Japan, and largely because of onerous utility-style regulation.

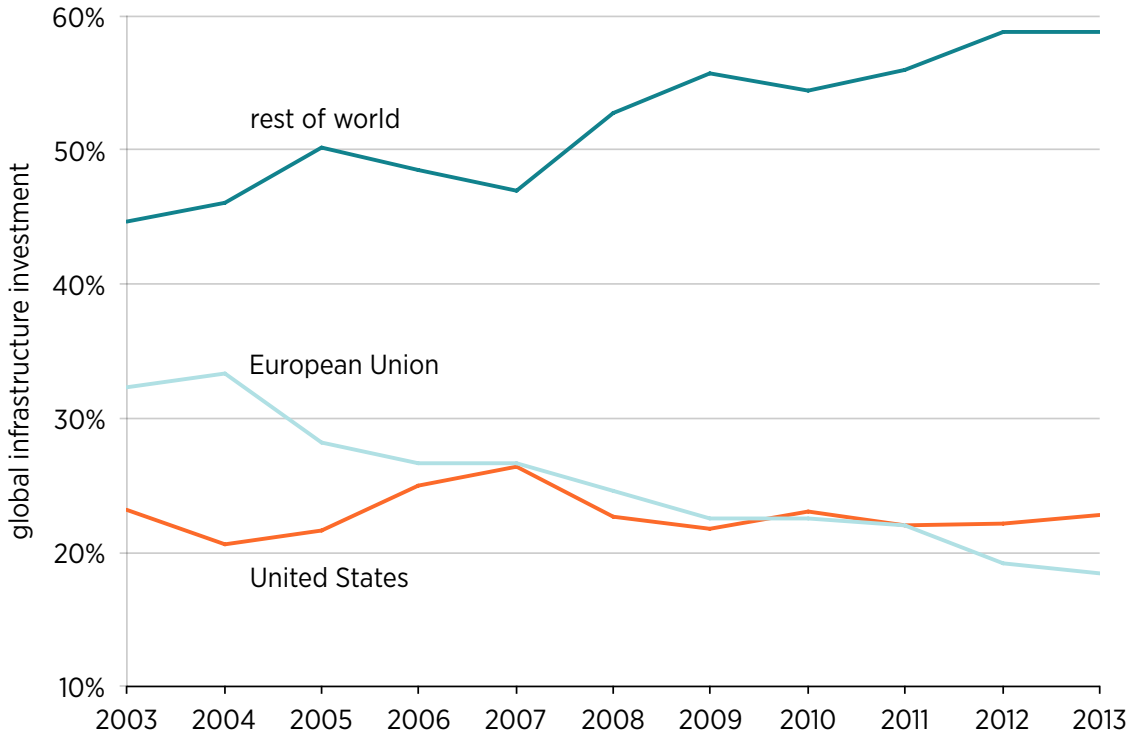
It is also helpful to compare broadband investment on a per capita basis. Americans, who comprise just 4 percent of the world's population, enjoy nearly one-fourth of the world's broadband infrastructure investment, both fixed and wireless. For the past 10 years, the average is 23 percent. Bank of America Merrill Lynch estimates the proportion of investment in wireless networks at $34 billion in the United States in 2013, representing approximately 24 percent of the world's wireless capital investment.[92]

Table 3 illustrates broadband investment for a number of countries around the world. Comparing the United States and the EU shows a growing gap in per capita spending on infrastructure. Providers in the United States invest at twice the rate of EU operators. It is also interesting that the EU and South Korea have the same average per capita investment rate. This demonstrates the advantage of bringing broadband over a highly populated area. China, for all its

[91] "CRU Monitor: Optical Fibre and Fibre Optic Cable," CRU International Ltd., September 2012, http://www.cru group.com.
[92] "US Invests More in Networks Than Any Other Nation," CTIA, March 13, 2014, http://www.ctia.org/resource -library/facts-and-infographics/archive/us-investment-networks.

economic growth, is underinvested in networks compared with the world average. Japan has the highest per capita rate, but this is facilitated by a number of generous government policies. Infonetics suggests that Japan's investment boom has peaked. Canada is similar to the United States in having a competitive broadband marketplace and being highly capitalized.

**Figure 3. Percentage of Global Infrastructure Investment**




Source: Infonetics Research, "Service Provider Capex, Opex, Revenue, and Subscribers," Quarterly Worldwide and Regional Database, 3rd ed., October 30, 2013.

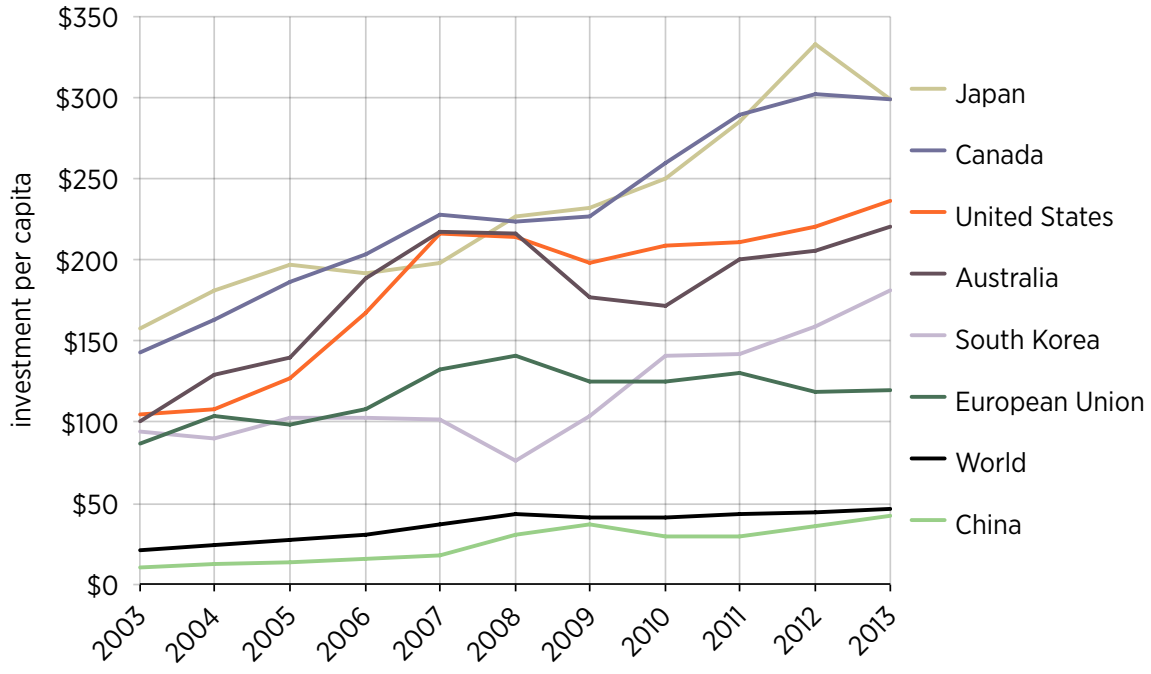
Note: Country capex totals were collected by summing the investment of each country's Internet service providers. These were then divided by global infrastructure investment.

**Table 3. Infrastructure Investment per Capita**

| | United States | European Union | China | Japan | South Korea | Canada | World |
|---|---|---|---|---|---|---|---|
| 2003 | $104.62 | $86.25 | $10.01 | $157.24 | $93.71 | $142.90 | $20.79 |
| 2004 | $107.58 | $103.35 | $12.53 | $181.10 | $89.74 | $162.99 | $23.92 |
| 2005 | $126.94 | $98.41 | $12.93 | $197.32 | $102.23 | $186.57 | $26.72 |
| 2006 | $167.62 | $107.63 | $15.16 | $191.82 | $102.17 | $202.91 | $30.65 |
| 2007 | $216.46 | $131.87 | $17.58 | $198.47 | $101.05 | $228.05 | $37.24 |
| 2008 | $214.38 | $140.65 | $30.43 | $226.73 | $76.10 | $223.90 | $42.79 |
| 2009 | $198.38 | $125.01 | $36.93 | $232.00 | $103.45 | $226.66 | $41.21 |
| 2010 | $208.98 | $125.14 | $29.16 | $249.52 | $140.70 | $260.05 | $40.83 |
| 2011 | $210.82 | $130.06 | $29.44 | $285.30 | $141.68 | $288.76 | $43.07 |
| 2012 | $220.42 | $118.49 | $35.32 | $333.10 | $158.58 | $301.72 | $44.64 |
| 2013 | $236.08 | $119.41 | $42.29 | $299.09 | $181.56 | $299.16 | $46.29 |
| Average | $182.93 | $116.93 | $24.71 | $231.97 | $117.36 | $229.42 | $36.20 |

Source: Infonetics Research, US Census Bureau, and European Commission.

**Figure 4. Infrastructure Investment Per Capita**




Source: Infonetics Research, US Census Bureau, and European Commission.

Note: Country capex totals were collected by summing the investment of each country's ISPs. Each country's total was divided by its population in that given year to obtain infrastructure investment per capita. Infonetics provided exchange rates for each year, which were used to convert numbers to US dollars.

**Competition**

The elementary idea of a perfectly competitive market is one with many buyers, many sellers, perfect information, a homogeneous good, no taxation, and no barriers to entry. These conditions exist almost nowhere in the world in any industry. The textbook examples of perfect competition typically involve two or more farmers selling the same crop, but as soon as new crops and new farming methods are introduced, the competitive dynamics change.

Broadband is different from traditional farming. Broadband is a highly sophisticated service requiring many inputs and technology. It needs substantial economies of scale to achieve efficiency.

Indeed, contracts for wireless are hardly uniform, because the subscriber has a choice of networks, speeds, services, handsets, and so on. Rather than static competition with many sellers and a homogeneous good, today's competition in broadband is marked by dynamism: high innovation, high investment, and different technologies. In addition, broadband markets are characterized by network efforts and multi-sidedness. Thus, broadband becomes a platform for a variety of actors.

On account of the high fixed costs and entrance barriers, traditional telecommunications was run as a government monopoly. It was not always practical to have multiple firms set up their own telephone poles and wires, so the right to deploy is typically offered to one entity in exchange for certain covenants to serve a defined area or population and specific rates. The advent of new information technologies and other innovations have allowed broadband networks to develop differently than traditional telecommunications.

With different technologies a broadband market can have just two private players—for example, a cable and a DSL provider—and still be competitive. Cable companies and DSL

providers continue to upgrade their networks with fiber while employing different technologies to deliver broadband, such as DOCSIS and VDSL.

Competition can be examined in the broadband market by looking at technology development in standards, infrastructure facilities, services, devices, operating systems, and platforms. It is not the level or number of players that drives technology in broadband, but the technology development.

Competition can also be observed through the development in fixed and wireless services from over-the-top providers, called that because the services are provided over the top of the network. Though mobile operators provide their customers with a package of voice, data, and SMS, consumers increasingly use their data subscriptions to access competing communication services such as Skype, GTalk, Viber, Rebtel, WhatsApp, KakaoTalk, Line, and so on.

At $385 billion and $188 billion, respectively, both Google and Facebook have larger market caps than any broadband provider in America, not to mention larger user bases. Facebook is the new Tier 1 provider with a wireless platform offering voice, text, and data services accessed by 1.3 billion users.[93] It recently acquired the world's leading OTT provider of messaging with 450 million users, WhatsApp, for $19 billion.[94] While telco, cable, and cellular providers face significant regulation, Google, Facebook and other OTT providers are essentially unregulated in their provision of communication and information services.

Nineteen billion dollars is a staggering sum, but four times this amount is lost by the telecom industry worldwide every year as users switch to OTT services, estimates Informa.[95]

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[93] "Company Info," Facebook, December 2013, http://newsroom.fb.com/company-info/.
[94] "Facebook to Acquire WhatsApp," *Facebook Newsroom*, February 19, 2014, http://newsroom.fb.com/news/2014/02/facebook-to-acquire-whatsapp/.
[95] Mike Hibberd, "OTT App Use Undermining SMS Revenue," *Telecoms*, November 13, 2013, http://www.telecoms.com/197721/ott-app-use-undermining-sms-revenue/.

This substitution effect is a classic example of the innovator's dilemma and demonstrates that as a wireless provider grows bigger, so do the incentives for an upstart innovator to disrupt its revenues.[96] This dynamism can also be observed in the market for long-distance calling, one-third of which is now conducted by Skype. In the long-distance calling market, OTT VoIP operators cost traditional providers some $100 million per day ($36.5 billion per year), up from $41 million per day in 2012, about 4 percent of mobile industry revenues according to Informa.[97] Dynamic competition is a potent force and a more appropriate form of discipline than regulation. On account of OTT services, the average revenue per user for the global mobile cellular industry has fallen by nearly 40 percent in the past decade.[98]

Just as in voice and SMS services, there is heavy OTT competition in the market for video entertainment platforms. Netflix, just one of a number of OTT video providers, has more subscribers than any cable company in the world: 50 million globally and more than 36 million in the United States.[99] Another upstart is Roku, a standalone set-top box that brings hundreds of channels to an Internet device via broadband. There are a number of other providers with different business models, including YouTube, Hulu, Amazon, and Vimeo. With such a robust, indeed disruptive, market for broadband, it is curious that a government should want to legislate broadband and the video market rather than allow the consumer-driven interplay with providers to continue to evolve.

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[96] Clayton Christensen, *The Innovator's Dilemma: The Revolutionary Book That Will Change the Way You Do Business* (New York: Harper Business, 2011).
[97] Hibberd, "OTT App Use Undermining SMS Revenue."
[98] "Global Wireless Matrix 2013 Q4," Bank of America Merrill Lynch, 2014, http://corp.bankofamerica.com /business/ci/global-research.
[99] Reed Hastings and David Wells (CEO and CFO, respectively, Netflix) to shareholders, July 21, 2014, http://files .shareholder.com/downloads/NFLX/2273280957x0x769748/9b21df7f-743c-4f0f-94da-9f13e384a3d2/July2014 EarningsLetter_7.21.14_final.pdf.

Consider that the EU has a 2020 Digital Agenda and a broadband goal that 100 percent of Europeans should have a connection of 30 Mbps or higher by 2020. Aside from the coercive aspects of this rule (there may be people who never want an Internet connection regardless of how fast or cheap), how can EU leaders predict what kind of broadband connections will be needed in 2020? How can EU leaders know what innovations will come in the future? A video compression breakthrough could make 1 Mbps adequate to deliver 1 GB of data, but under the government rule, companies would have to fulfill the goal even if it is no longer needed.

To be sure, dynamic competition and disruptive innovation don't fit into a tidy box. New competitors are not under traditional obligations such as interconnection requirements, data portability, licensing, and so on. In an era marked by rapid change, it is easier to flog the captured telecom industry, but regulators should have the courage to allow the industry to evolve and retire regulations when they are obsolete.

***Is There a Cable-Telco Duopoly?***

In her book *Captive Audience: The Telecom Industry and Monopoly Power in the New Gilded Age*, Susan Crawford asserts that there is a cable-telco duopoly for broadband and that four firms—AT&T, Verizon, Comcast, and Time Warner—control America's broadband market, charge unfair prices, and leave their networks to languish.[100] As our paper shows, there is no truth to the claim that American broadband providers do not invest in networks. On the contrary, they are leaders in broadband investment. As for broadband prices, they scale with consumption, and American unit costs for broadband are lower than those of most countries in the world. Crawford's sweeping assertions fail to account for important differences, such as network type,

[100] Susan Crawford, *Captive Audience: The Telecom Industry and Monopoly Power in the New Gilded Age* (New Haven, CT: Yale University Press, 2013).

speed, taxation, subsidies, media license fees, homeowner fees for broadband, and so on. It is interesting to note that many of the countries that Crawford praises (Sweden, South Korea, Japan, etc.) have fewer broadband providers, each with higher market shares than those in the United States. Furthermore, Sweden has lower overall coverage for next-generation broadband access and lower coverage in rural areas.

We reject Crawford's assertion that there is a cable-telco duopoly. In fact, the FCC reports more than 1,700 providers of broadband in the country.[101] There are hundreds of cable and telecom providers that account for 70 percent of the broadband connections in US households.[102] But competition should not be measured just in the number of firms; it should be measured by the variety of networks and the level of technology. As this paper has shown, the United States has a more evenly distributed subscribership in broadband across technologies (DSL, cable, mobile, FTTH) than the EU, the geographic region with which it should be compared, as well as a higher percentage of next-generation access availability.

In the EU, more than 70 percent of all broadband subscriptions are DSL. Looking more closely at the OECD figures of broadband facilities, only Belgium and the Netherlands have a better deployment of cable and DSL facilities than the United States. The Information Technology & Innovation Foundation (ITIF) prepared an index of competition based on the most recent OECD figures (for 2008 and 2009) and places the United States at number three in the world for intermodal competition, the competition between broadband networks.[103]

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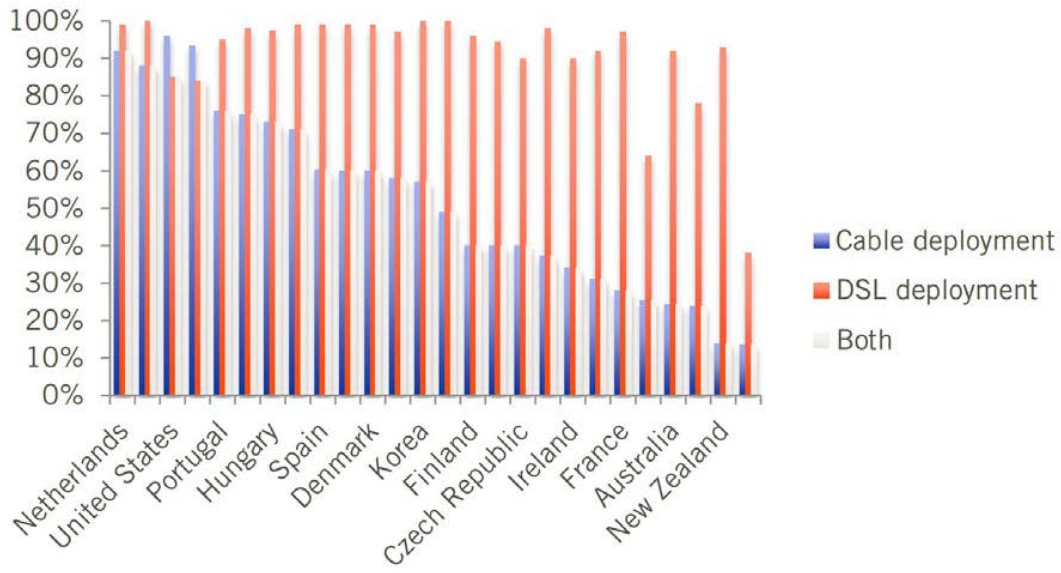
[101] Ajit Pai (FCC commissioner), "The IP Transition: Great Expectations or Bleak House?" (remarks before the Internet Innovation Alliance, Washington, DC, July 24, 2014), http://www.fcc.gov/document/commissioner-pai-remarks-internet-innovation-alliance.

[102] Leightman Research Group, "2.6 Million Added Broadband from Top Cable and Telephone Companies in 2013," Press Release, March 17, 2014, http://www.leichtmanresearch.com/press/031714release.html.

[103] Richard Bennett, Luke Stewart, and Robert Atkinson, "The Whole Picture: Where America's Broadband Networks Really Stand," Information Technology & Innovation Foundation, February 2013, http://www2.itif.org/2013-whole-picture-america-broadband-networks.pdf.

The OECD does not have the data to complete the analysis for the impact of FTTH and 4G/LTE. However, data from EU's Digital Scoreboard and the National Broadband Map show that the deployment of next-generation mobile and fiber is significantly higher in the United States. Thus, it can be deduced that the United States would still perform well in the ITIF's ranking if these metrics were added. The percentage of broadband market share of 4G/LTE and FTTH continue to increase in the United States versus DSL and cable. The American market is getting more, not less, diverse in broadband networks.

**Figure 5. Intermodal Broadband Deployment by Nation**

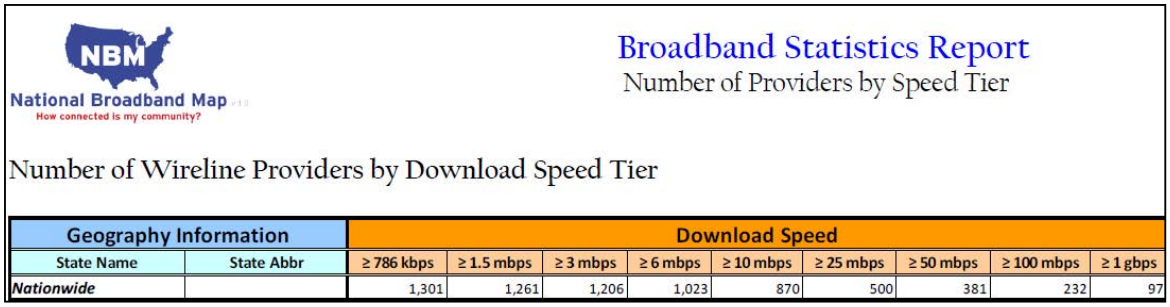



Source: Richard Bennett, Luke Stewart, and Robert Atkinson, "The Whole Picture: Where America's Broadband Networks Really Stand," Information Technology & Innovation Foundation, February 2013, http://www2.itif.org /2013-whole-picture-america-broadband-networks.pdf.

A duopoly is defined as two firms in a market. Within any state of the United States, there are dozens of wired broadband providers. The National Broadband Map lists the total for the country, noting several thousand providers in all. Some 99 percent of Americans can access

wireless broadband speeds of 16 Mbps download, four times the minimum defined by the FCC and higher than most of the world's broadband connections. Thereafter, 88 percent of Americans have at least two providers for fixed broadband; more than half of all Americans have three or more providers. As for wireless broadband, over 90 percent of Americans have at least three providers.[104]

**Figure 6. Number of Wireline Providers by Download Speed Tier**




| Geography Information | | Download Speed | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| State Name | State Abbr | ≥ 786 kbps | ≥ 1.5 mbps | ≥ 3 mbps | ≥ 6 mbps | ≥ 10 mbps | ≥ 25 mbps | ≥ 50 mbps | ≥ 100 mbps | ≥ 1 gbps |
| *Nationwide* | | 1,301 | 1,261 | 1,206 | 1,023 | 870 | 500 | 381 | 232 | 97 |

Source: "Analyze-Summarize-Nationwide," National Broadband Map (National Telecommunications & Information Administration), June 30, 2013, http://www.broadbandmap.gov/summarize/nationwide.

As such, the United States should not aspire to have many providers simply for the numbers' sake. This paper shows that competition in the broadband industry comes from the level of technology, not the number of providers. The United States has enjoyed high innovation, investment, and competition in broadband precisely because firms have been able to consolidate and manage scale. This paper has also described how broadband firms innovate and diversify their technologies.

[104] "Analyze-Summarize-Nationwide," National Broadband Map (National Telecommunications & Information Administration), June 30, 2013, http://www.broadbandmap.gov/summarize/nationwide.

If the EU provides any evidence, it is that static competition created through managed access (regulated reselling and unbundling) not only does not increase investment or innovation, but does not support overall next-generation broadband coverage.

Those concerned about market power and concentration should look at the markets for mobile operating systems (two players), search engines (one dominant player), and social networking (one dominant player) rather than at fixed or wireless networks.

A more effective example of duopoly is the market for search engines. Google accounts for two-thirds of all searches in the United States. Microsoft and Yahoo (which both run Microsoft search engine technology) account for 28.7 percent of all searches. Together these firms account for 96.2 percent of all searches in the United States.

**Table 4. US Search Engine Rankings**

| comScore Explicit Core Search Share Report*<br>February 2014 vs. January 2014<br>Total U.S. – Home & Work Locations<br>Source: comScore qSearch | | | |
|---|---|---|---|
| **Core Search Entity** | **Explicit Core Search Share (%)** | | |
| | **Jan-14** | **Feb-14** | **Point Change** |
| *Total Explicit Core Search* | *100.0%* | *100.0%* | *N/A* |
| Google Sites | 67.6% | 67.5% | -0.1 |
| Microsoft Sites | 18.3% | 18.4% | 0.1 |
| Yahoo Sites | 10.4% | 10.3% | -0.1 |
| Ask Network | 2.4% | 2.4% | 0.0 |
| AOL, Inc. | 1.3% | 1.3% | 0.0 |

Source: "US Search Engine Rankings," comScore, March 18, 2014, http://www.comscore.com /Insights/Press_Releases/2014/3/comScore_Releases_February_2014_U.S._Search_Engine _Rankings.

Google takes the lion's share of search advertising revenue and much online revenue in general. Google accounts for more than 40 percent of the revenue of online advertising, though Facebook is gaining, currently at 8.2 percent.[105] But market power and concentration are not problematic in themselves, only in their abuse. Indeed, these companies are innovative even though they have high market concentration. The same is true for broadband provision.

Crawford declares that broadband is too important to be left to the market and calls for a nationalization of the nation's networks to roll out FTTH. The same statement can be turned around to say that the sheer needs of information and decision-making are so vast and the nature of the technology so rapidly changing that broadband cannot be left to the government. As we outline in this paper, rather than the government deciding the broadband future, America is better served by a multitude of competing broadband providers in a market-led, technology-neutral framework.

**Digital Economy**

The large size of the American market allows the United States a number of advantages, including economies of scale for operators when making investments, not to mention the advantages of having a federal democracy with a common language and currency. The large American market is lucrative for the larger value chain of products and services to be delivered by broadband. It also has implications for network and device innovation, fostering a rich ecosystem for various actors and platforms to engage.

[105] "Mobile Growth Pushes Facebook to Become No. 2 US Digital Ad Seller," eMarketer, December 19, 2013, http://www.emarketer.com/Article/Mobile-Growth-Pushes-Facebook-Become-No-2-US-Digital-Ad-Seller/1010469.

At times it is important for the federal government to assert national authority over the states. The 1993 Omnibus Budget Reconciliation Act,[106] in addition to introducing the legislation that allowed competitive bidding for spectrum, reinforced the role of the federal government to ensure a national telecommunications market. Mobile operators were able to take advantage of one set of systems and processes to serve the entire country, rather than having to roll out state by state. Had the states taken the lead, there likely would have been 50 different, potentially conflicting, sets of regulatory obligations. The United States would probably be in the situation the EU is in today, with a fragmented market, lack of scale, and no major Internet companies. The EU—with 28 nations, 17 languages, and 11 currencies—is hardly a single market physically, let alone digitally.

It is not an accident that European entrepreneurs come to the United States to tap America's innovation community and de facto single market (also leveraging the English-speaking part of Canada). It takes the same input to launch a start-up for a market with 316 million inhabitants as it does for 1, 5, or 50 million. With network effects, it is easier to add a country once a market is established in the United States, rather than the other way around. These network effects also apply to telecommunications, where providers want to supply the same economies of scale and innovations to as many customers as possible.

***Measures of the Digital Economy***

Broadband alone is not an adequate measure of the digital economy. The relationship between broadband and a range of economic inputs (market size and scope, digital skills, regulatory framework, etc.) determines the digital economy. A number of economists have attempted to

[106] "Omnibus Budget Reconciliation Act of 1993, Title VI," US Government Printing Office, accessed June 12, 2014, http://www.gpo.gov/fdsys/pkg/BILLS-103hr2264enr/pdf/BILLS-103hr2264enr.pdf.

model this, but it is difficult to explain, if not predict, how a country can maximize its economic growth with the single input of broadband. Essentially, each country has a complex interplay of factors that drive its economic outcomes. For that reason, policymakers should be wary of investing in broadband as a way to increase economic growth. Such propositions are generally built on political, not economic, reasoning.

There are some challenges to measuring the impact of broadband on the Internet economy. For one, broadband-enabled services and efficiencies have long been internalized in many traditional companies. One consulting firm estimates that three-quarters of the Internet's value is captured by established firms.[107]

Another challenge is to differentiate information communication technology (ICT) companies from "Internet" companies, and the line is increasingly blurred. Traditionally, an ICT company was one primarily engaged in computer hardware or software, for example, IBM, HP, Intel, or Oracle. An Internet company, on the other hand, was one conceived on the Internet and conducting its primary business there: for example, Google and Facebook. Microsoft and Apple are both ICT and Internet companies. They sell hardware and software and have both digital and brick-and-mortar stores.

Additionally, many Internet services, such as search engines and social networks, are difficult to value empirically. In practice, Google and Facebook are evaluated by their advertising revenues. However, users may value them even more.

Another important measure of America's broadband health can be seen in the number of leading Internet companies that come from the United States. Mary Meeker's annual report on Internet trends offers insight year over year that points to US leadership in Internet companies.

[107] Pélissié du Rausas et al., "Internet Matters."

For the 2014 report ranked by annual revenue, the United States has 13 of the top 20 Internet companies; China, 4; Japan, 2; South Korea, 1. The EU has zero.[108] US companies comprise 90 percent of the market value and 80 percent of the revenue for these 20 firms.

This does not take into account all the small and medium-sized companies that would have never existed without broadband, not to mention Microsoft, a major company which is not included on Meeker's list.

The following section provides a brief overview of some of the leading studies of the Internet economy in an attempt to evaluate the role of broadband. Some studies from the OECD are reviewed, along with reports from the Boston Consulting Group and the United States International Trade Commission.

*Boston Consulting Group.* In 2012, the Boston Consulting Group produced a report titled "The Internet Economy and the G-20" in which it estimated that 4.7–5.4 percent of America's gross domestic product (GDP) is related to the Internet.[109] This quotient is based on over 15 statistical databases of national and industrial income. Given that America's GDP was estimated to be $17.1 trillion in December 2013,[110] the Internet economy should be just under $1 trillion, using this report's methodology.

This study also showed that Americans' perceived value of the Internet ranged between $1,456 and $3,506 per year, which is an estimate of what they would be willing to pay for the

[108] Mary Meeker, "2014 Internet Trends," Kleiner Perkins Caufield Byers, May 28, 2014, slide 138, http://www.kpcb.com/internet-trends.
[109] David Dean et al., "The Connected World: The Internet Economy in the G-20; The $4.2 Trillion Growth Opportunity," (BCG Report, Boston Consulting Group, March 19, 2012), 49, https://www.bcgperspectives.com/Images/The_Internet_Economy_G-20_tcm80-100409.pdf.
[110] "BEA National Economic Accounts—Current Dollar and Real GDP," Bureau of Economic Analysis, December 23, 2013, http://www.bea.gov/national/index.htm.

Internet if they did not have a broadband subscription.[111] Indeed, most consumers pay significantly less than this for broadband, so this measure shows that consumers get more value than what they pay.

*OECD.* A study on the "Broadband Bonus" by Shane Greenstein and Ryan McDevitt, published by the OECD in 2012, measured the consumer surplus of broadband in 30 OECD countries. It estimates the percentage of GDP per capita that is a "broadband bonus" or consumer surplus. In 2010, 0.28 percent of GDP per capita, or $135.40, was the average excess benefit for each American. This percentage gradually increased from 2006 to 2010. The study suggests that this trend will continue as Internet traffic in the United States increases.[112]

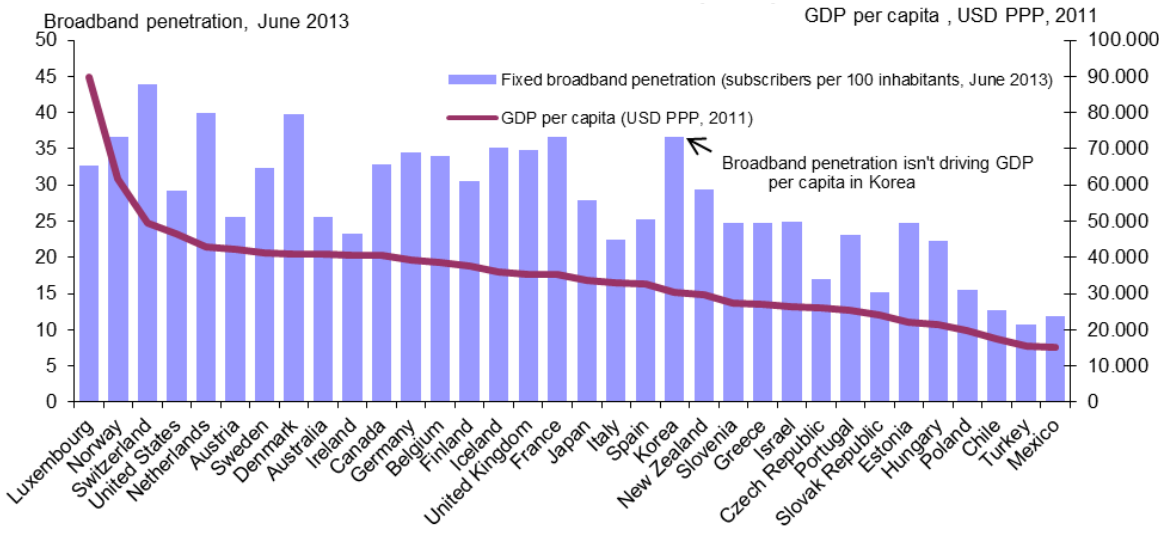
On its Broadband Portal, the OECD includes a table on broadband penetration in 2013 and GDP per capita in 2011. It notes only a mild correlation between the two. If the notion is that broadband penetration is driving GDP, then countries with higher broadband penetration should have higher GDP, a correlation value of close to 1. Instead, there are many contradictions, chiefly South Korea, where broadband penetration wildly exceeds GDP. The correlation value is only 0.30. Two of the world's richest countries per capita, Luxembourg and Norway, have the highest correlation values, 0.89 and 0.61, respectively. In these countries, it may be the case that existing wealth was used to build broadband networks, not the other way around.

Such comparisons are important when policy discussions about broadband grow heated. There is a frequent refrain impugning the United States because it does not have the highest speeds. However, if speeds were all that mattered, then the Internet should be dominated by

[111] Dean et al., "Internet Economy in the G-20," 13.
[112] Shane Greenstein and Ryan McDevitt, "Measuring the Broadband Bonus in Thirty OECD Countries," *OECD Digital Economy Papers* 197 (April 19, 2012): 19.

South Korea, Japan, and Hong Kong, the countries Akamai reports as having the highest speeds.[113] Why didn't Google, Facebook, and Amazon come from these countries? Alternatively, why hasn't the world taken up the Asian version of these platforms?

**Figure 7. Broadband Penetration and GDP Per Capita**




Source: "Broadband penetration and GDP—1k," Organisation for Economic Co-operation and Development, June 2013, http://www.oecd.org/sti/broadband/oecdbroadbandportal.htm.

To be sure, the country with the fastest broadband speeds has bragging rights. A broadband target of 100 Mbps or greater is politically expedient, but not necessarily meaningful. It is not the speed that matters; it is how the country puts broadband to use, regardless of the speed.

In South Korea the primary uses of broadband are entertainment (primarily video games) for consumers and video conferencing for businesses. The problem with these two applications is that they drive little revenue versus the traffic they consume on the web. Much real-time

[113] "The State of the Internet, 3rd Quarter, 2013 Report," *Akamai* 6, no. 3 (2013), http://www.akamai.com/dl/akamai/akamai-soti-q313.pdf?WT.mc_id=soti_Q313.

entertainment is piracy, and the money in games is largely in the hardware; less than 5 percent of players pay for games. Video conferencing was thought to be a great revenue opportunity, but it is another bandwidth-intensive service that can largely be enabled for free by OTT providers. So these two endeavors do not generate the significant cash flow, let alone employment.

Broadband has enabled some industrial productivity and supports a marginal "Gangnam Style" entertainment economy in South Korea. It is estimated that the performer Psy made about $1 million from his famous song, including the almost 2 billion YouTube views, the iTunes sales, and so on.[114] Few performers will achieve that level of success. But this is not a replicable business model, let alone a business case for broadband.

Furthermore, the South Korean broadband project has not yielded the jobs that were expected. Broadband has enabled entertainment but not jobs. A report by the Korea Information Society Development Institute bemoans the situation of "jobless growth."[115] The government is also concerned about Internet addiction, which afflicts some 10 percent of the country's children between ages 10 and 19, who essentially function only for online gaming but not in other areas of society.

What people should care about is how broadband makes an economy and its workforce more productive. The United States, even without having the fastest broadband speeds, has been able to create global Internet companies, transform its workforce, and create a growing stream of digital products and services. This has a lot to do with everyday Americans having broadband access and using it to produce and consume a range of goods and services. The trade association

[114] Betsy Isaacson, "'Gangnam Style' Makes Estimated $870,000 from YouTube Alone (CORRECTED)," *Huffington Post*, January 23, 2013, http://www.huffingtonpost.com/2013/01/23/gangnam-style-youtube_n_2533620.html.

[115] Ju Jaeuk and Jung Hyun-Joon, "A Study on the Impact of New ICT Service and Technology on Employment," *Research Report* 12, no. 11 (n.d.): 1–76.

for America's wireline providers, US Telecom, estimates that about 11 million full-time jobs, representing 9 percent of America's workforce, are directly enabled by broadband ICT companies.[116] Forrester Research predicts that 43 percent of the US workforce will be telecommuting by 2016, allowing for more time with family and less on the way to work.[117]

Moreover, America's broadband networks are built mostly by private investment, so taxpayers are not on the hook. That could be called broadband bang for the buck.

US broadband speeds have been increasingly consistently since 2009, according to Akamai, a leading source of Internet speed data, and the April 2014 Akamai State of the Internet report shows that peak average speeds in the United States are up 25 percent over the previous year. If US states were ranked as countries in the Akamai report, nine states would rank equally among the 15 fastest regions in the world, with Washington, DC, third in the world, Massachusetts fourth, and Virginia fifth. Indeed, 36 states plus Washington, DC, recorded peak speeds of 30 Mbps or faster, according to Akamai.[118]

*United States International Trade Commission (USITC).* In some respects, it might be easier to get an idea of the economic impact of broadband by looking at digital exports. If the distribution and consumption of American digital goods and services abroad can be isolated, that can at least give some indication of the relative quality and impact of America's broadband networks.

In July 2013, the USITC reported for the first time on digital trade (it was primarily interested in trade of physical goods and services heretofore). The report, "Digital Trade in the

[116] Patrick Brogan, "Broadband and ICT Ecosystem Directly Supports Nearly 11 Million High-Paying U.S. Jobs" (Research Brief, USTelecom, Washington, DC, February 28, 2012), http://www.ustelecom.org/sites/default/files/documents/022812_Employment-Research-Brief-final.pdf.
[117] Ted Schadler, "US Telecommuting Forecast, 2009 to 2016" (Digital Home Report, Forrester Research Inc., McLean, VA, March 11, 2009), http://www.forrester.com/US+Telecommuting+Forecast+2009+To+2016/fulltext/-/E-RES46635?isTurnHighlighting=false&highlightTerm=US%20telecommuting&al=0.
[118] "The State of the Internet, 3rd Quarter, 2013 Report."

U.S. and Global Economies, Part 1,"[119] estimates the digital export sector to be $356.1 billion in 2011, up from $282.1 in 2007, making it America's third-largest category of exports after industrial supplies and capital goods.[120] It is interesting that this sector of the economy has grown by 26 percent during a period when the overall economy has been in recession.

Internet exports are digitally enabled goods and services shipped from the United States. By definition they are neither commodities, such as corn or wheat, nor manufactured goods, such as automobiles or pharmaceuticals, but are rather digital products and services, such as search engine technology, cloud computing, and online video services.

The USITC asserts, "Digital trade has been made possible by the widespread availability of broadband."[121] Companies have built their enterprises on this infrastructure, and consumers use it to access the digital goods and services of these firms. The USITC report explains:

> Digital trade is expanding as a result of the increasing number of Internet-connected devices and the near-ubiquity of the Internet. In addition to broadband access becoming widespread and a surge in the number of Internet-connected mobile phones, the number and variety of other Internet-connected devices is also increasing. One survey during the fourth quarter of 2012 found that U.S. homes had 425 million devices connected to the Internet via broadband, led by desktop and laptop computers, smartphones, tablets, gaming consoles, high-definition TVs and streaming-media TV set-top boxes such as digital video recording devices and DVD players.[122]

The USITC calls particular attention to the role of mobile in driving the Internet export economy, from consumers both in the United States and abroad. It notes,

> Wireless broadband has enabled digital trade to expand into all aspects of modern life. U.S. consumers are increasingly obtaining wireless broadband Internet access via mobile devices. Broad-based usage of mobile telephones to access the Internet started, more or less, with the introduction of Apple's iPhone in 2007. Over the next 2–5 years, the introduction of competing smartphone brands and the relentless development of

[119] "Digital Trade in the U.S. and Global Economies," 4–1.
[120] "U.S. International Trade in Goods and Services," US Census Bureau, US Bureau of Economic Analysis, June 4, 2013, http://www.census.gov/foreign-trade/Press-Release/2012pr/final_revisions/final.pdf.
[121] "Digital Trade in the U.S. and Global Economies," 1–9.
[122] Ibid., 1–13.

> high-speed network infrastructure by telecommunications companies have made the mobile phone access to the Internet increasingly ubiquitous.[123]

Companies' growth on the Internet has been facilitated by extensive broadband networks that support a large consumer market with broadband access and a growing penetration of Internet-connected devices. The global nature of broadband networks has allowed American firms to export their digital goods and services to other countries.

America's digital economy is by no means limited by the borders of the United States. Particular leverage comes from neighboring Canada, with whom the United States has the world's largest trading relationship. The proximity of these countries gives Internet companies a boost for an even larger de facto English-speaking digital single market. Indeed, Facebook reports that although the United States and Canada account for only 17 percent of monthly active users, they comprised 40 percent of revenue in 2013.[124]Over the past decade, digital exports have grown to become an ever more important part of the American economy.

**Policy Measures**

Following is a review of suggested policy measures to ensure continued investment, innovation, and competition in the broadband market.

***Technology Neutrality (No Subsidies)***

This paper has demonstrated that each broadband technology has different advantages for cost, usability, throughput, and so on. A smarter strategy is to support an environment where different

[123] Ibid., 1–12, E-8, E-9.
[124] "Facebook—Quarterly Report," Facebook, November 1, 2013, http://investor.fb.com/secfiling.cfm?filingID=1326801-13-31&CIK=1326801.

broadband technologies compete, and consumers choose the technology (or combination thereof) that suits their needs.

Some supporters of FTTH demand that their technology be subsidized, but this distorts the marketplace, and as we have shown, subsidies for FTTH are not necessarily effective in increasing adoption. A better approach is technology neutrality, to not favor any one broadband technology above another and not give any subsidies for broadband deployment.

Given the cash flow of the broadband industry, Americans' voracious appetite for the Internet, and the fact that existing broadband technology enables all current applications, there is little justification for subsidies. Broadband deployment should stand on its own with private providers bearing the risks and the market driving the business models. Should FTTH not be desired by consumers, so be it. If the government subsidizes broadband, taxpayers are compelled to pay whether they like it or not. With private provision, people can choose whether to participate.

Where appropriate, content and application providers may also participate in supporting the cost of broadband; for example, health care providers may purchase wireless subscriptions for their users to stimulate uptake of health monitoring technologies.[125] Although not the topic of this paper, there are a variety of ways for content and application providers to help lower subscription costs, such as zero rating, sponsored data, and so on. These models are used in many countries to lessen the digital divide.[126]

While the notion of technology neutrality can be debated within the context of the philosophy of science, for this context of broadband policy, the idea is that regulation should

[125] Daniel Lyons, "Innovations in Mobile Broadband Pricing" (working paper, Social Science Research Network, March 31, 2014), http://papers.ssrn.com/abstract=2418563.
[126] Roslyn Layton, "Net Neutrality and Its Impact to Telecom Business Models and Broadband Investment" (Working Paper, Aalborg University Center for Communication, Media and Information Studies, 2014).

neither require nor assume a particular technology. By extension, the rules should neither favor nor discriminate against a particular technology.

When a government enters a market with subsidies, it creates advantages for some and disadvantages for others, making a level playing field impossible. Another unintended consequence of subsidies is that they create perverse incentives for firms to serve the government, not their customers. If the government gives subsidies, firms will rent-seek, or lobby, for special rewards.

Sometimes a strange argument is made that the government should invest in broadband to create "competition." Essentially, when the government enters the broadband market, it creates a monopoly. No private provider can compete against the government. The government is not a neutral provider, and governments have many advantages over companies. The government does not pay taxes. It does not have shareholders. It can demand payment by force. If the government gets involved in the broadband market, private firms typically exit.

***Consolidation***

Consolidation is a widely discussed topic in business and strategy literature, but it has certain nuances and implications for the broadband industry. Just to review, the arguments for consolidation, or why one company would buy another, include gaining market share, deploying better business models across a larger customer base, accessing new technologies, getting better terms for financing, identifying assets belonging to a target company, and winning a better bargaining position with suppliers and clients.

Key benefits of consolidation are lowering overhead costs and making operations more efficient. For example, a single financial department can serve two companies.

When applied to network industries such as telecommunication, consolidation can have some important benefits, including reduced operating expenditures on network operators, reduced capital expenditure with fewer sites (or the removal of redundant sites), reduced marketing costs (fewer brands to market), and better utilization of spectrum and infrastructure investment. In mature economies, sales and marketing costs can consume up to 25 percent of an operator's revenue, so reducing this line item through a consolidation is an attractive proposition. In the context of broadband networks, consolidations and joint ventures allow savings on operating and capital expenditure.

***Removing Barriers at the Local Level***

Major barriers to deploying mobile infrastructure exist at the local level. A single mobile mast can cost as much as $100,000 and take 12–18 months to deploy.[127] This is a problem in the United States and throughout the world. Municipalities often hinder the deployment of infrastructure by charging exorbitant rents, making unnecessary delays, requiring unreasonable conditions and fees, and opposing masts and towers for a variety of reasons (environmental, historical, aesthetic, etc.), some legitimate, some arbitrary.

Owing to the nature of mobile networks that require thousands of masts and towers to be deployed near one another, a particular site for a mast may be needed in order for the network to work as a whole. In such situations, a public or private landowner has a monopoly of sorts on the site in question and can extract an unusually high fee, sometimes four times the market rate.[128] If policymakers want to ensure mobile infrastructure deployment in rural areas, it may be in the

[127] "How Mobile Operators Can Reduce Cost for Mobile Masts and Improve Mast Regulation," Strand Consult Publications, 2012, http://www.strandreports.com/sw4546.asp.
[128] "How Mobile Operators Can Reduce Cost."

public interest to remove barriers, especially on public land. The FCC has begun a process to accelerate mobile infrastructure deployment and to investigate barriers.[129]

***Focus on Internet Adoption***

A key mistake of government policy in broadband is to focus on supply, not demand. Indeed, it is the services and applications on the Internet that people desire, not the networks themselves. This paper has explained the difference in broadband deployment ("supply") and adoption ("demand").

The ITU reports that 81 percent of America's population uses the Internet, but Pew Research Center's study on Internet and American Life reports that 86 percent of all adults go online, and 95 percent of teens.[130] The elderly are a different story. Those who did not grow up with the Internet and never used it for their job may find little reason to start. However, the elderly can benefit greatly from the Internet—whether to check health information, connect with friends and family, or engage in hobbies good for aging brains such as bridge or learning a language—but they often need help getting online.

Those who don't use the Internet cite the lack of usability and relevance as the reasons for their infrequent use, not cost.

Increased broadband deployment does not solve the problem of adoption. It doesn't matter if FTTH is brought to every last corner of the United States. If a person never used a computer before and doesn't know how, no network connection, however fast or fancy, will get

[129] "FCC Proposes to Remove Barriers to Wireless Infrastructure," Federal Communications Commission, September 26, 2013, http://www.fcc.gov/document/fcc-proposes-remove-barriers-wireless-infrastructure.
[130] Mary Madden et al., "Teens and Technology 2013—Main Findings," Pew Research Center, March 13, 2013, http://www.pewinternet.org/2013/03/13/main-findings-5/.

him to start.[131] This notion is underscored by Everett Rogers, synonymous with the Diffusion of Innovation theory, who explained that adoption of technology is a social, not economic, process. Rogers's model has been applied to numerous innovations and is especially popular to explain the growth in mobile devices.[132]

Rogers defined diffusion as a process in which innovation is shared via communication channels over time among the members of a social system. Peers are especially important in getting people to adopt technology.

Rogers emphasizes that in any society, a small percentage of the population, "laggards," might never adopt a technology. Based on Rogers's model, it may not be worthwhile to increase Internet adoption by this group because there are diminishing social returns. Forcing a person to adopt the Internet may be coercive. It does raise an important question, however, about whether providers should maintain both old and new technologies when a small set of users refuse to evolve.

In any event, the United States is well equipped in its supply of broadband networks. If there is any focus, it should be on increasing digital skills. The Chairman of the OECD Committee on Digital Economy Policy Jørgen Abild Andersen observes, "A well-functioning infrastructure with broadband access for all is not worth anything if citizens and businesses are not able to use this access because 'e- Skills' are missing."[133]

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[131] Kathryn Zickuhr and Aaron Smith, "Home Broadband 2013," Pew Research Center, August 26, 2013, http://www.pewinternet.org/2013/08/26/home-broadband-2013/.
[132] Everett Rogers, *Diffusion of Innovations*, 5th ed. (New York, Free Press, 2013).
[133] Jørgen Abild Andersen, "OECD Framework for Internet Policy Making," email exchange with authors, January 27, 2014.

**Conclusion**

The amount of Internet traffic that the United States consumes increases significantly every year, and it is on track to surpass South Korea as the nation that consumes the most data per capita. This suggests that either America has an overcapacity of networks, or it is implementing upgrades and innovations just in time. The latter scenario may be more efficient from an economic perspective. It is not socially desirable to overbuild network capacity if it is not yet needed.

America's broadband market is characterized by a high level of innovation in networks, services, and technologies. Network innovations continue to improve the capacity and throughput of broadband networks. Americans avail themselves of a variety of network solutions, including DSL, cable, FTTH, mobile, Wi-Fi, and satellite, to meet their preferences.

Technology development is what drives competition in the broadband market, not the number of providers. Networks have undergone an evolutionary shift where the services they provide need not have any relationship to the underlying network. The outcome is that communication increasingly takes place on unregulated third-party platforms on top of networks, not within the networks themselves. This suggests that America's Communications Act, structured with titles covering common carriage, radio, and cable, is obsolete for today's increasingly all Internet protocol (IP) world.

America's private broadband providers invest more per capita than all but two nations in the world. Americans, who are but 4 percent of the world's population, enjoy nearly a quarter of the world's broadband investment. There is no evidence that America's broadband networks are languishing.

The fact that America is a de facto single market with a common language and currency is an important reason America has scale in the global digital economy. The wide availability of broadband networks and high adoption of broadband have allowed the United States to develop its digital economy, already some 5 percent of GDP and growing. Digital goods and services are the third-largest category of exports. Thirteen of the world's top 20 Internet companies are American and they drove over $366 billion in revenue in 2013, about one-third of Internet-enabled GDP. Thus, we conclude the following:

1. It is impossible to support the claim that America's broadband networks are falling behind. America could not build the world's largest digital economy on a foundation of failing broadband networks.
2. Alternatively, if it is the case that America's broadband networks are substandard, it doesn't matter anyway. The United States, with a high portion of its economic activity related to broadband, its number and size of broadband-related companies, and its high rate of broadband-enabled employment (about 11 million jobs or 9 percent of full-time employees), still leads in the global digital economy.[134]
3. Modern economic growth is a combination of many factors, with broadband being just one input. There is no solid evidence that higher broadband speeds deliver greater GDP. It is therefore not justified to build new networks just to obtain higher speeds. Existing networks satisfy the needs of current applications.
4. At 81 percent (if not 86 percent), America has a high rate of broadband adoption. If there is a role for the government to play in broadband, it should be to support the education of people who lack digital skills rather than to deploy broadband networks.

[134] Brogan, "Broadband and ICT Ecosystem Directly Supports Nearly 11 Million High-Paying U.S. Jobs."