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Broadband for Rural America:

Economic Impacts and Economic Opportunities

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Hudson Institute
1015 15th Street, NW
6th Floor
Washington, DC 20005
www.hudson.org

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Hanns Kuttner

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Historically, waves of new technologies have brought Americans higher standards of living. Electrical service and hot and cold running water, for example, were once luxuries; now their absence makes a home substandard. Today, technologies for accessing the Internet are diffusing at an even faster rate than those earlier innovations once did, bringing with them commensurate transformations of Americans' way of life.

Technologies that increase the speed at which data can be transmitted have had powerful effects. Most importantly, they have transformed the Internet from a tool used by a narrow group of academics and technicians into a means of interaction used by a large majority of Americans. Much of this wide reach can be attributed to technologies that have increased the capacity of data to move across the Internet. Twenty years ago, individuals who used the Internet accessed it most commonly through dial-up connections. If most people still had to use dial-up connections, much of what we view as "the Internet revolution" would not have happened. What greater capacity has made possible—a visually richer experience, faster data transfer times—has proven to be an important motivator for Internet use.

However, Americans have not universally benefitted from better Internet access. Geography, especially the divide between rural and urban America, determines how much some Americans can benefit from the Internet. Networks have not been as extensively developed in rural areas as in urban areas. Some people in rural America still have dial-up as their best available, affordable technology, a technology that offers five percent of the capacity for what the FCC has said is the broadband threshold. Others have service that reaches the broadband level, but still does not offer the "lightning-fast" speeds advertised by Internet service providers in urban areas.

Accordingly, our nation faces a "broadband gap," not only with regard to the lack of access in rural areas to service that meets the broadband threshold, but also with regard to the lack of availability of faster service between urban and rural America. This report identifies opportunity costs that arise from this gap. These costs exist today, but the pace at which data transmission capability is growing means that the inequality between the technology being newly deployed and the technology that was deployed a decade or more ago is increasing. Networks that connect research institutions in the United States can move 100,000 times more data per unit of time than the dial-up connections that some Americans still must use. The technology gap is not a fixed deficit that once filled, stays filled. The technology gap will be larger—much larger—in the future, along with the information and technology gap, unless significant action is taken to overcome it.

The problem

The rise of the Internet brought a new dimension to telecommunications. At the time the Internet broke out of the academic and research settings where it was developed, America had a policy model to support universal voice communication, the then-dominant form of telecommunications. This model enabled a country with wide variation in population density that spanned a continent to have universal voice telecommunications. The new capabilities of the Internet challenged that model.

Population density is central to the cost of providing telecommunications services. The fewer customers per square mile, the higher the fixed cost per customer. These costs are for telephone poles, lines, and central office equipment and the labor required to build and install them. The 37 telephone companies which serve half the area of Kansas have only ten percent of the state's telephone customers.[1] The country's commitment to comparable service at comparable prices, embodied in the Communications Act of 1934, as amended, required financial mechanisms to counter the impact of lower density on rural Americans.

At first, consumer access to the Internet could be accommodated through existing equipment and policy because Internet service providers began by offering dial-up service. The same telephone wires that connected users for voice communication also connected them to Internet service providers. The same policies that assured universal availability of voice telecommunications thus had the effect of providing access to this first way for ordinary people and businesses to access the Internet.

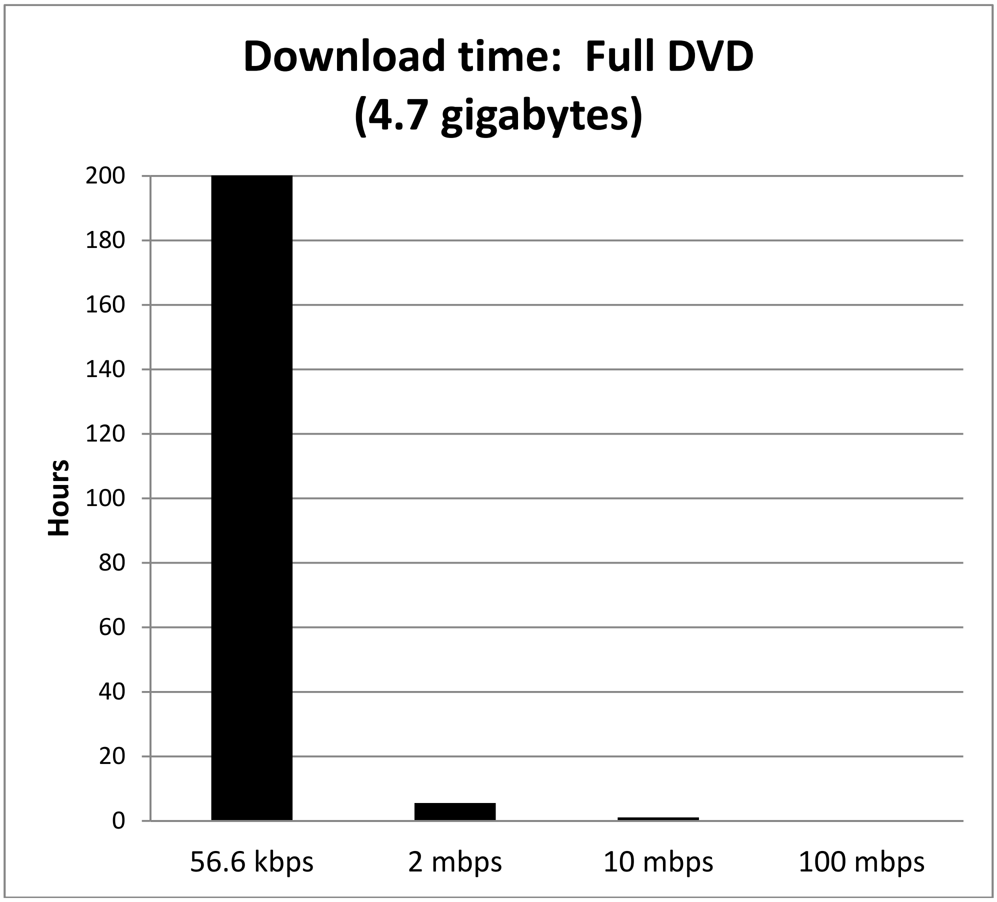
Other technology that provided larger-capacity (often termed "faster") connections to the Internet proliferated. All these technologies fall under the banner of "broadband." Broadband technologies shared one characteristic: they required more telecommunications facilities. The required infrastructure rapidly deployed. This change took place partly within the universal service commitment, as the FCC expanded the universal service commitment to allow support for networks that could deliver both voice and Internet services. This "dual use" decision enabled the capital investment required to bring broadband to some rural areas, but the expanding role of broadband that demands broadband-specific solutions has shown that broadband will not become universal without policies that overcome population scarcity.

In contrast to voice telephony, which offers a service with largely the same capability to all subscribers, Internet connection could come at a wide array of capabilities. Beyond dial-up, Digital Subscriber Line (DSL) technology put many of the same copper lines used for voice service to use to provide substantially more capacity to move data. However, the capacity of copper wire is far less than what is available using fiber optic cable.

As more users had capacity beyond dial-up, new, more data-intensive uses began to predominate. Graphics-intensive uses had not been feasible because of the time it would take for the data to download to the user. With more network capacity, they were no longer impracticable. Applications that involved large amounts of data became a focus of innovation. Uses with large data demands, such as the pictures that abound in social media, became part of what the Internet does for the typical user. (Figure 1. Download Times.)

[1] Center for Economic Development and Business Research, *Kansas Rural Local Exchange Carriers: Assessing the Impact of the National Broadband Plan,* Wichita: Wichita State University, 2011.

Figure 1.



Source: Calculations based on calculator at URL: download-time.com

Internet Haves and Have Nots

The rise of uses that move massive amounts of data between users has created a division between "haves," who have higher capacity available to them, and "have nots," for whom only slow service such as dial-up or the more-expensive, less-reliable service provided by satellite are the only Internet access options available. The resulting contrast in what is possible for "haves" compared to "have nots" has many ramifications.

For households, the gap includes both consumer entertainment and personal improvement. While text-based email can be used with the speeds available using dial-up, virtually none of the additional functionality effectively works without broadband. Video streaming, for example, available only with broadband capacity, is a service that allows video communication with friends a continent away, as well as bringing advanced calculus lectures to high school students.

For businesses and institutions, broadband makes possible real-time interaction with customers and suppliers. "E-commerce" is heavily circumscribed in areas without broadband. "E-services," such as education and health care, which come with expectations of using data-intense graphic and video content, cannot be delivered without broadband.

An effort to divide the country into "haves" and "have nots" does not allow for another group: people who "have some," but want more. The Federal Communications Commission (FCC) has defined "basic broadband" as providing at least 4 megabits per second download speed and 1 megabit per second upload speed. As a comparison, Local Area Networks (LANs), operating within businesses and institutions, have speeds of 100 Mbps to 1 gigabit per second. Having more capacity is especially important for business and institutional users whose individual users within the organizations share bandwidth.

The number of Americans who do not have access to broadband

There is no authoritative source of data about which Americans have what level of access to the Internet. Company records cover those who buy service, not those who do not. Government surveys ask people about how they access the Internet, but would be unlikely to find nonusers who would know about a product they do not buy. Thus, numbers about who does not have access at particular speeds get cobbled together as a feasible alternative to direct measurement.

Estimating the number who do not have broadband access requires information on both people and geography. Telecommunications providers know how many customers they have and the data transmission speeds they advertise. Information about people comes from the Census Bureau. The Census Bureau, however, makes information available about the aggregate or average characteristics of households in a locality, not at the individual household level.

The staff of the Federal Communications Commission used these data sources to produce an estimate in 2010 of the size of the population that does not have access to broadband that meets the FCC's National Broadband Availability Target of 4 Mbps download speeds. To do this, they used available data about providers and areas they served. They used statistical relationships observed there to estimate the probability that each geographic area delineated by the Census Bureau had service available that equaled or exceeded the FCC's broadband target. The data was not sufficiently detailed to test whether every household in the Census

Bureau-drawn areas had or did not have service available. Because some, but not all, in a particular area might have service available, the estimate is a lower bound on the number without access to broadband.

The FCC staff estimated that seven million housing units, home to 14 million people, close to 5 percent of the United States population, did not have access to service that met the broadband standard.[2]

More recently, the FCC and the National Telecommunications and Information Administration (NTIA) have collaborated on a National Broadband Map. The National Broadband Map uses more recent data, and more data, than was available to the FCC staff, in part from a network of state-level grantees who collect additional data. Like the earlier FCC estimate, the National Broadband Map must make assumptions about the conditions at the household level based on the finest geographic breakdown available, blocks designated by the United States Census Bureau. The diversity of data sources opens the mapping process to multiple sources of error, and the accuracy of the depictions has been challenged. As with the FCC estimate, it is an estimate of the lower bound of the number of people who cannot access wired or wireless broadband.

Nationwide, the National Broadband Map estimates that 99.7 percent of Americans in urban America live in areas where the maximum download speed available is equal to or greater than 3 Mpbs and the upload speed is equal to or greater than 768 kbps. For rural America, 84.7 percent are estimated to live in areas that meet this standard. Applying these measures to the size of the population produces an estimate that .8 million Americans in areas classified as urban and 9.8 million in areas classified as rural do not have access to service that meets the 3 Mpbs upload/768 kpbs download standard.[3]

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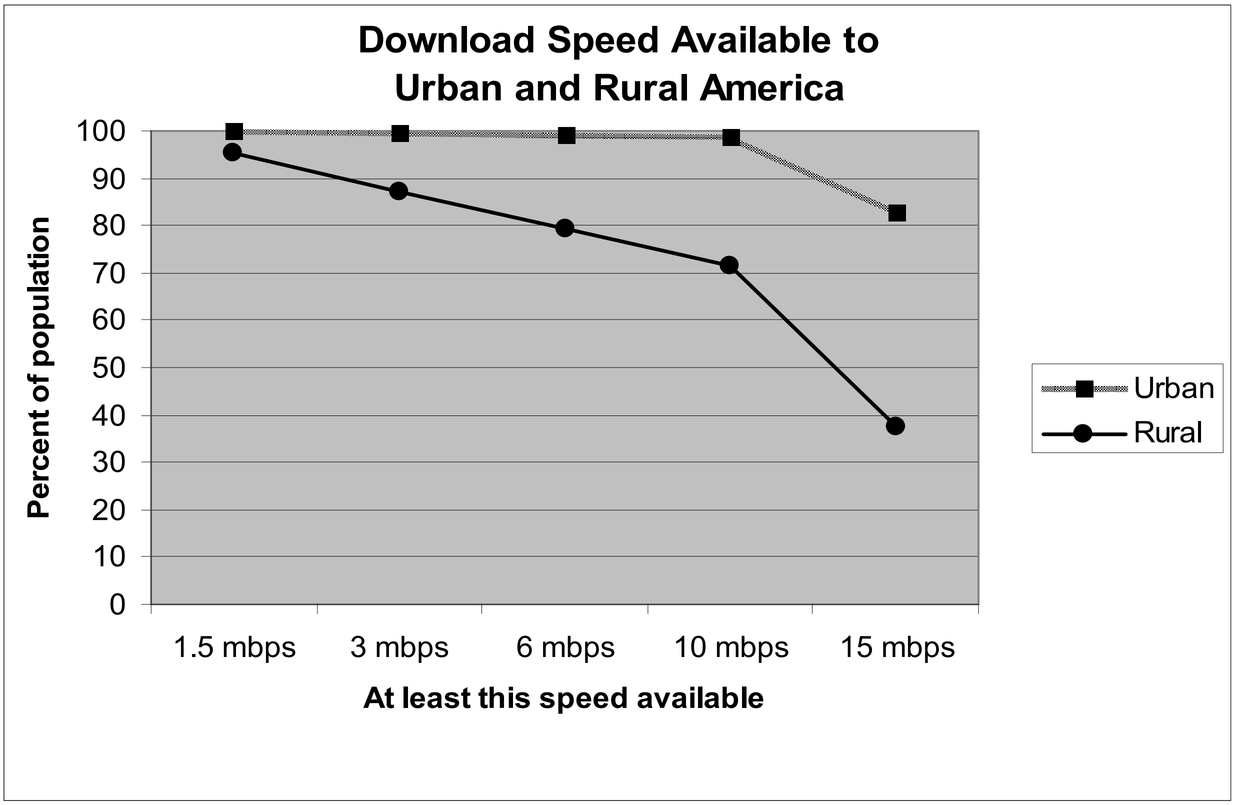
[2] Federal Communicatons Commission, *The Broadband Availability Gap.* Technical Paper no. 1 (Washington, DC: Federal Communications Commission, April 2010).
[3] National Broadband Map, "Broadband Statistics Report. Broadband Availability in Urban v. Rural America," (Washington: National Broadband Map, 2012), broadbandmap.gov/download/Broadband%20Availability%20%in%20Rural%vs%20Urban%20America.pdf.

A baseline scenario

The “haves” obtained broadband access because a telecommunications provider acted on an opportunity to make an investment in a network that would, in turn, offer an adequate return. The single best predictor of “have not” status is population density. Dividing America into urban and rural populations shows stark contrasts in broadband availability.

Figure 2.



Source: National Broadband Map, “Broadband Statistics Report. Broadband Availability in Urban v. Rural America,” Washington: National Broadband Map, 2012, broadbandmap.gov/download/Broadband%20Availability%20%in%20Rural%vs%20Urban%20America.pdf.

The type of economic activity in an area also reflects population density. Table 1 shows employment by sector of the economy across urban areas, higher-density rural areas, and lower-density rural areas. The service sector accounts for the largest share of employment in all areas. Manufacturing is most important in higher-density rural areas, what most people think of as “small-town America.” Not surprisingly, less-dense rural areas lead in the share of the workforce in agriculture. Wholesale and retail trade make up a similar share of the workforce in all three levels of population density.

Table 1. Employment Across Urban and Rural Areas, 2007
(percent of employment)

	Urban	High Density Rural	Low Density Rural
Agriculture, forestry, fishing	1	6	12
Manufacturing	7	13	7
Services	44	34	30
Wholesale and retail trade	14	14	13
Government	13	15	18
Other	21	18	20

Note: In this analysis, 25 persons per square mile measured at the county level is the threshold between high and low density rural counties, and urban is all counties contained in metropolitan areas as classified by Federal Information Processing Standard (FIPS) code for the 2000 census. Does not include self-employment (e.g., farmer, physician in own practice, etc.)

Source: Special tabulations from Department of Commerce, Bureau of Economic Analysis, Regional Economic Accounts and methodology of the Council of Economic Advisers. In Council of Economic Advisers, "Strengthening the Rural Economy," Washington: 2010, http://www.whitehouse.gov/administration/eop/cea/factsheets-reports/strengthening-the-rural-economy/the-economic-state-of-rural-America

While villages, towns, and small cities in areas outside metropolitan areas have a better chance of being "haves," areas outside population concentrations are likely disproportionately among the "have nots." A baseline scenario for the future of broadband would not expect areas without broadband service getting it. This builds from the assumption that the financial factors that determine where there are enough customers are unlikely to change. Funds provided through the American Recovery and Reinvestment Act of 2009 (ARRA) have provided the capital required to make investments in some areas, and many projects funded by that legislation have not yet been completed. However, once these projects are complete, additional federal dollars are unlikely, especially at the scale provided under the ARRA.

The anticipation of additional users will lead to the investment required to bring broadband service to an area. Population shifts that bring additional households or businesses to a potential service would make those investments more likely. Rural America includes both areas that are gaining and areas that are losing population. Those that are most rural are losing population overall while those that have population centers, albeit not populous enough to qualify as metropolitan areas, have grown. In the decade from 2000 to 2010, in the 433 counties outside metropolitan areas, not adjacent to metropolitan areas, and which had no town or village with more than 2,500, population declined by 1.3 percent. Over the same period, the population in rural counties that contained a city of 20,000 or more grew by 6.9 percent.[4]

Investment in broadband service in an area currently lacking it might also occur if non-Internet users became users. Current use patterns show an age gradient; older people are less likely to use the Internet. The development of uses that are more valued by older people may lead to a shift in

[4] Lorin B. Kusmin, ed., *Rural America at a Glance*, 2011 Edition, Economic Information Bulletin (EIB-85), (Washington: United States Department of Agriculture, 2011).

the assessment of whether it is worthwhile to invest in broadband technologies in some rural areas.

Falling costs are one factor that could lead to additional areas receiving broadband in a baseline scenario. Some of the electronic components used to create higher-speed connections to the Internet are the kinds of equipment that have experienced cost patterns that conform to Moore's Law, with successive generations of technology having greater capacity and lower cost. If these patterns continue, some projects that were not projected to generate an adequate rate of return to justify the investment may become worthwhile in the future. Still, downward trends in electronic components will not influence factors that account for a large majority of costs. Neither the length of fiber optic cable that must be installed to connect two points nor the cost of labor, the largest cost in a typical network expansion project, will be changed by declining electronics costs. As Figure 2 shows, the fact that an area had enough promise to justify the investment in a technology that can produce service that meets the broadband standard does not mean that it will show favorable returns for the investment required to make the additional investments required for higher speeds.

While some who do not have broadband are "can nots," some are "do nots"—households, businesses, and institutions that have broadband service available to them and choose not to subscribe. Surveys of individuals find that a larger share of individuals in rural areas do not use the Internet than in urban areas. The same surveys also show the share of the population that uses the Internet rises with income. Those who live in rural areas on average have lower incomes. When both factors are combined, one sees that at each level of income, similar shares of urban and rural residents report they use the Internet.[5]

Opportunity cost of not having broadband access

Internet access sits at the intersection of a dynamic set of technologies. Many information technologies involve receiving or sending data to distant points. For these technologies, the speed at which data can be sent or received becomes the limiting factor in the usefulness of the technology. The uses to which the Internet was put ten years ago are the not uses that are most important today; the uses that are most important today may not be the most important in ten years. A description of the opportunity cost of not having broadband access must take into account not only the current uses of the Internet, but also the uses it will have in the future.

The cost of not having full access to information and communication technology will grow as the capacity of those technologies grows. The further out we look, the less important current uses are, and the more important become those uses which today are described as possibilities.

The evidence about broadband levels of service first reaching a community shows it brings economic and population growth with it. For example, an analysis of the impact of broadband availability found that counties with broadband availability by 1999 experienced higher

[5] Peter Stenberg and Mitchell Morehart, "Farm Businesses, the Digital Economy, and High-Speed Access to the Internet," *Delhi Business Review* 11, no. 2 (July – December 2010).

employment growth in employment and the number of businesses.[6] In an analysis that looked solely at rural counties, contrasting change in counties with relatively high broadband availability in 2000 and similar counties without, the high broadband counties, over 2002 to 2006, experienced relatively higher growth in total employment, wage and salary jobs and the number of business proprietors.[7]

There are striking differences in the margin along which broadband's effects were measured a decade ago and today. In the study which looked at both urban and rural areas only 60 percent of zip codes had service that met the study's broadband definition at the outset of the study period. Now availability is above 99 percent in urban areas, and the service that counts as "available" is twenty times as fast as that counted as broadband in the analysis that used 1999 as a base year. The broadband availability margin, between areas that have any service meeting the broadband threshold and areas with and without more robust broadband, is at a very different place than it was in the initial analyses of broadband's impact. Today the opportunity cost of not having broadband and not having access to robust broadband is disproportionately borne by those who live in rural America and by the rural economy.

Opportunity costs for households

The most substantial economic opportunity costs for households from the broadband gap are in education and health care. The broadband gap also limits the ability of households (and employers) to take advantage of lower costs of living in rural areas through telecommuting, and prevents their taking part in the growing field of e-services.

Education. While the focus in Internet access has been on elementary and secondary schools, postsecondary opportunities are economically more important as a consequence of the broadband gap. One of the strongest patterns of economic change in the United States has been the rising value of educational credentials. At each incrementally higher level of education, earnings increase. In 2011, the median earnings among those 25 and older who had, at most, completed high school was $28,659; among those had some college, but no degree, $32,036; an associate's degree, $36,853; and among all who had completed a bachelor's degree, $49,648.[8]

Lower levels of formal education among those who live in rural areas help explain lower average incomes for rural residents than for those who live in urban areas. At the high school level, the completion gap has narrowed between those who live in urban and rural areas. However, the college completion gap has grown, from a 9.5 percent gap favoring urban areas in 1990, to a 12.6 percent gap in 1990.[9]

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[6] William Lehr, Carlos Osorio, Sharon E. Gillett, and Marvin Sirbu, "Measuring Broadband's Economic Impact," Paper presented at Research Conference on Communications, Information, and Internet Policy (Arlington, VA, September 2006; revised January 17, 2006).

[7] Peter Stenberg, Mitch Morehart, Stephen Vogel, John Cromartie, Vince Breneman, and Dennis Brown, "Broadband Internet's Value for Rural America," Economic Research Report 78, (Washington: United States Department of Agriculture, 2009).

[8] Census Bureau, "PINC-03. Educational Attainment – People 25 Years Old and Over, by Total Money Earnings in 2011, Work Experience in 2011, Age, Race, Hispanic Origin, and Sex," Webtable, census.gov/hhes/cpstables/032012/perinc/pinc03-000.htm.

[9] Kusmin, *Rural America*.

Broadband creates new opportunities for increasing learning opportunities in rural America. Online education programs create opportunities for people to obtain training and credentials far from the campuses where the training originates. It also creates the opportunity to bring specialized programs to areas where the population density is too low to support a traditional, campus-based program. Online education programs, using rich visual content, are unavailable to people who do not have broadband levels of service.

Health. Health care's share of the economy has grown, doubling since 1970. Residents of rural areas use fewer health-care services than urban areas. Among those under age 65, those in rural areas average about one fewer doctor visit per year. The difference is much larger among the elderly; rural elders averaged 5.5 visits per year while those in urban areas averaged 10.9 visits.[10] As the knowledge that allows diagnosing disease and prescribing effective treatment grows, the health consequences of the service gap will grow.

One opportunity for health-care delivery will come through the proliferation of new monitoring technologies. These technologies will push the monitoring function outside the clinic and into the patient's home. Those at greatest risk of health-status changes will be the earliest focus. For example, a patient discharged home following hospital treatment for congestive heart failure needs close monitoring of vital signs. In-home monitoring systems can provide faster and more consistent reports of data that allow health providers to learn that a patient is decompensating. Earlier awareness that something is wrong increases the potential that an intervention can take place, avoiding a rehospitalization or medical complications.

Those who do not have broadband service will find they cannot use these technologies. (Development of health-related technologies may also convert those who have access to broadband, but do not use it, showing them a compelling reason to become broadband adopters.)

Rural areas have fewer surgeons to do surgeries and fewer specialists to refer patients for imaging services, and it is more difficult for consumers to seek out health-care services at a greater distance. Telemedicine creates new opportunities for rural residents to obtain medical services. The health-care sector is emerging as a heavy user of telecommunications services. Improved imaging techniques result in larger and larger data files. Moving those files between providers requires substantial capacity. The demand from hospitals alone means that any community with a hospital has, or will come to have, a substantial "off ramp" from the broadband superhighway.

Telecommunications may be a limiting factor for the location of health-care services. A place that does not have the telecommunications capacity for efficiently uploading and downloading large imaging files may find providers deciding either not to locate there or to limit the services provided there.

Telecommuting. Employers and government officials have endorsed telecommuting as a win-win. Employers save on occupancy costs, and governments see less use of highways at peak

[10] Sharon L. Larson, Steven R. Machin, Alice Nixon, and Marc Zodel, "Chartbook #13. Health Care in Urban and Rural Areas, Combined Years 1998 – 2000" (Rockville, MD: Agency for Healthcare Research and Quality, 2004).

times. Employees benefit from being able to take advantage of lower housing costs in less-densely populated areas. However, without broadband, an area cannot host telecommuters, costing the “have not” area a household, and leaving telecommuters with a smaller range of feasible housing locations.

E-services. In the future, “e-services” will grow and may come to typify “e-commerce” more than buying goods through websites. These opportunities, or lack thereof, will compose yet another category in the gap between broadband haves and have nots.

Financial services show a relatively advanced example of how a service can be changed by Internet use. Those without broadband surely lose out on convenience. A question that has not yet been addressed is whether consumers who use electronic access to financial services make better use of them than those who do not.

Opportunity costs for businesses and institutions

The opportunity cost to being a broadband “can not” varies by level of analysis. If a technology that increases efficiency does not get used in some areas because the broadband required to support the technology is not available, then there is a loss to the national economy. Applications in the agriculture sector are an example of this. Land is a geographically fixed input. Unlike a manufacturer and a factory, a farmer cannot pick up the land and move it to a place where higher-capacity broadband is available.

The pre-Internet predecessor of "e-commerce," catalog selling, achieved its early success by making available a wider variety of goods than was available locally. Remote sellers today who rely on "e-commerce" may not have available to them the rural households who brought the industry into being.

Some costs are primarily costs to the local economy, but less of a cost to the national economy. A firm doing a site-selection process for a new facility may choose a location with more broadband capacity than another. There may be some efficiency loss to the national economy if the “can not” area offered shorter routes to market, but this efficiency loss is small compared to the loss experienced by the local economy whose broadband “can not” status made it a loser in the site-selection process.

Finally, there are costs to the firms that produce information and communication technology hardware, software, and services. Lack of broadband creates a barrier for their selling their product, one that is no less a barrier than a trade barrier created by a foreign government. As with trade barriers, these lost sales represent an opportunity cost to the American economy. The unserved areas of this country are an “emerging market” that offers yet-untapped potential for information technology.

Communication is a complementary technology to information technology. Some applications derive their value from being able to exchange large quantities of data. The growing use of these applications reflects the declining cost of manipulating data. It is not the case that the data manipulation could not have been done before, but it is the declining cost of doing so that has fueled adoption of information technology. The cost per calculation has fallen by a factor of 1,000 over the past quarter-century.[11] The collapse of calculation cost has made possible the growth of data models and tools such as those used by retailers to continually analyze purchases in real time to make decisions about what to order and at what price to sell. However, these technologies assume that the data required can rapidly move back and forth between store and warehouse, warehouse and supplier.

Sectors with opportunity costs include agriculture, manufacturing, and retail. While service sectors, particularly health care, already demonstrate opportunity costs, the greater economic opportunities are foregone in the manufacturing and retail sectors from lack of the telecommunications capacity that information technologies require. The potential created by the decline in the cost of computing is immense. More is yet to come, and thinking about the impact of broadband capability must keep in mind potential, but not yet actual, applications.

Agriculture

Agriculture is the key sector that creates economic costs to the national economy from lack of broadband capacity. The broadband "can not" phenomenon is most common in places where agricultural uses of land predominate and population density is lowest. Those who live in town have a shot at broadband by being close to an existing central office and meeting the technical criteria to have access to DSL service that relies on the existing copper wire telephone network. Those who live further out cannot get broadband without substantially more capital investment.

As Table 1 shows, as population density falls, the relative importance of agriculture grows. This pattern supports seeing an overlap between information and communications technology in agriculture and the problem of broadband "have nots."

Agriculture is where the economy of the broadband "can not" areas has the greatest impact on the rest of the economy. Increased agricultural productivity has increased the American standard of living by decreasing the share of family budgets required for food.

Agriculture has also been a rising source of exports, reflecting the global competitiveness of the American agriculture sector. A more productive agricultural sector means more exports and a more favorable balance of payments position (which in recent years has meant a smaller trade deficit).

The agriculture sector has already shown a keen interest in adopting communications technology. Broadband service has eliminated the distance between producers and commodity markets, allowing producers to obtain real-time reports of prices in option markets and act to hedge against losses. Websites make it possible to learn about livestock for sale, reducing the cost of searching for breeding stock. Machinery producers have made features available that allow real-time sharing of information about machinery performance from the field. A call to the dealership does not start with "I've got a problem here," but rather the dealership staff saying, "I

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[11] Erik Brynjolfsson and Andrew McAfee, *Race Against the Machine: How the Digital Revolution is Accelerating Innovation, Driving Productivity, and Irreversibly Transforming Employment* (Lexington, MA: Digital Frontier Press, 2011).

see one of the grain heads on your combine isn't working." Irrigation equipment can be monitored remotely, and when it stops or needs attention, a text message or email can be generated, eliminating the need for regular on-site inspections.[12]

While these uses show a pattern of robust adoption of telecommunications-dependent technology, much more awaits. A group of agriculture and information scientists at the University of Illinois recently concluded, "Information technology … could have at least as big an impact on agriculture in the next half century as mechanization had in the previous century."[13]

What lies ahead is the transition to agriculture that operates as a cyber-physical system, that is, a system that achieves higher levels of output with fewer inputs by combining vast quantities of information to identify the optimal use of the land and inputs including seed, equipment, water, and fertilizer. The capacity to move large amounts of data rapidly will be a limiting factor to the development of this system.

This cyber-physical system will operate through multiple channels. One is development of improved inputs, particularly seeds. Another is mechanization. A third channel is sensing and monitoring systems. These channels will come together in decision-making processes that enable making better decisions at the plant and animal level. Plant and animal-specific information will allow higher levels of productivity than current systems that rely on generalizations about what is optimal for specific species or areas of land.

Productivity gains through mechanization began with engine power replacing animal power for moving implements across fields. Then new types of equipment that combined functions (thus the term "combine") appeared that reduced the number of times equipment must pass over a field.

Most recently, electronic controls have replaced mechanical controls. The combination of electronic controls and positioning systems has produced "precision agriculture." Supplementing data available from satellites with signals from wireless communications systems has pushed the level of control from meters to centimeters.

When combined with the capacity of broadband, the machine that began as a tractor is evolving into "a mobile geospatial data-collection platform with the capacity to receive, use, sense, store, and transmit data as an integral part of its ... performance."[14]

Advances in sensors are increasing the range of data that can be collected. Information about the extent of insect or plant pathogen can be gathered by automatic sensing devices that transmit data to central data bases.

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[12] Rachel Brown, *Smart Agriculture and the Role of Broadband*, (Arlington, VA: Foundation for Rural Service, 2012).
[13] K. C. Ting, Tarek Abdelgaher, Andrew Alleyne, and Luis Rodriguez, "Information Technology and Agriculture. Global Challenges and Opportunities," *The Bridge* 41, no. 3 (Fall 2011): 6 – 13.
[14] John F. Reid, "The Impact of Mechanization on Agriculture," *The Bridge* 41, no. 3 (Fall 2011): 14 – 21.

While many of the features of precision agriculture draw on row crops, other types of agriculture, particularly livestock and poultry, will also be influenced by the availability of sensors and monitoring systems that track processes at the animal level.

Bringing all this data together will require additional telecommunications capacity. Because it will surpass the ability of any one person to process, the data will require algorithms that turn all the pieces of information into actionable decisions.

Information and communications technology will lead to a future in which every agricultural decision is backed by more information. Further, the number of decisions made will be far greater, heading to the plant- and animal-specific level, as the cost of making such fine-grained decisions falls due to improved information and communications technology.

Supply-chain innovations

The availability of more information will support advances in supply-chain management. These improvements will both improve efficiency and increase the safety of the food supply.

Emerging concepts in food safety require the ability to monitor the food supply from "farm to fork." Monitoring capacity will increase through greater use of tags and readers. As their price declines, sensed information will become ubiquitous. When combined with broadband-level communications capability, it will be possible to locate any item in time and space.[15]

Current knowledge about where things are will improve supply chains by facilitating "just-in-time"-type improvements. This will reduce waste. Knowledge about the past, about where things have been and when they were there, will support traceability, increasing the ability to follow pathogens that enter the food supply back to the source.

Locavore/direct-to-consumer sales

While the larger trend in agriculture has been greater production efficiency through economies of scale, it is not the only trend. Communications technologies have lowered the cost of matching producers and suppliers. The result has been innovation in supply chains. Websites and email have made it easier for chefs looking for local sources of ingredients to establish and manage relationships with producers.

Sales of locally-produced products are not the only way lower matching costs create new ways to bring together buyers and sellers. The Internet allows producers of specialty products to set up shop via a website. Search engines and advertising tied to search terms allow producers to come to the attention of potential purchasers at a far lower cost than that required for selling via catalogs or mailings to lists.

Specialty production does not have the economies of scale that most agriculture hopes to achieve. Nonetheless, it is a form of agriculture that departs from the long-term trend of using

[15] Ting et al., "Information Technology and Agriculture."

less labor per unit of production. Greater demand for labor means more people living in rural settings.

Manufacturing and sales

The economic impact of telecommunications on manufacturing and the selling of goods includes both its impact on economy-wide totals and the location where activities take place.

A distinction can be made between large, multi-location firms and those with one location. For large firms, broadband capability makes a difference for where they carry out business. Broadband availability figures in location decisions. For some kinds of businesses, lack of adequate capacity means a particular location is not feasible. However, the firm will locate that facility somewhere. The economic impact of that decision is significant for the place where the facility does or does not get located; its impact at the national level is the relative efficiency of the location without sufficient broadband. If the two locations are equally efficient along other domains, such as distance to major customers, then there is no efficiency loss. If the location with inadequate broadband is less efficient, then there is a loss to the national economy.

A large, national firm has options available that are not open to smaller firms. It may have a national contract with a broadband provider. The provider may agree to arrange for service wherever the firm decides to set up operations. The broadband provider may build the equivalent of a private expressway, providing higher-capacity Internet access for that firm's plant or facility without providing any additional access for consumers, businesses, or institutions in the community.

For smaller firms and firms that have only one location, lack of broadband can create difficult decisions. Lack of broadband access can create pressure to move or close, especially if information and communication technologies create efficiencies that firms operating elsewhere can use.

Over the long run, broadband availability will feed back into businesses and institutions through the pace of information technology adoption. As promising new information technologies reach the market, they will confer advantages on firms that adopt them. Lack of broadband will lead to cases of of firms that want to adopt particular information technologies, but cannot, because they lack the broadband capacity to move data fast enough.

Much of the analysis of broadband impacts on the manufacturing and sales sectors of the economy is speculative. Data collection on broadband accessibility has focused on households, not business or institution location. While manufacturing employment accounts for a larger share of employment in more densely populated rural areas than in either urban or less densely populated rural areas, there is no national survey that samples businesses and asks about their broadband access.

Microenterprise/start ups

The Internet has lowered the bar to starting a business to sell goods or services. Thanks to search engines, anyone with a product to sell and a website to promote it has access to the national market. Physical proximity is not important when selling via the Web. Broadband access is. Those who do not have broadband access will find it more difficult to start a Web-based business.

The rural economic development effort within the US Department of Agriculture has promoted e-commerce as an approach to being an entrepreneur who works in rural areas. The Southern Regional Development Center's e-commerce Extension Initiative has developed tools for those who want to open an "e-presence" to sell goods and services.[16] The unique products of artisans, craftspersons, and specialty food producers who are in rural America without broadband or robust broadband are more likely to be missing from the national market.

Service sector

The service sector's share of the economy has grown in both urban and rural areas. Lack of broadband can be an obstacle to service sector development. Wages are lower in rural areas, reflecting in part a lower cost of living in rural areas. Rural areas provide the most effective domestic competition for some work that could be done either in the United States, or outside the United States and imported.

Rural America is proving to be a "middle shore" for information technology work. While more costly than offshoring IT work to Russia or India, rural IT firms are building their own value proposition. They present themselves as providers of computer coding services whose convenience, cultural familiarity with the United States, and lower need for oversight make them a better value proposition for some kinds of work.[17]

Onshore Outsourcing is an example of the kind of firm that is creating a new niche. Based in Macon, Missouri, a town of 5,400 residents in the rural, northeast quadrant of the state, it offers software development services to large firms. Without broadband, it would not be able to test the operation of programs on clients' systems.

This firm recruits workers who have aptitude for computer programming, but no training in the specific applications the company develops, and puts them through a "bootcamp" for software development. The company taps workers who have the ability to produce the computer code that companies in urban areas want, but do not yet have the skill to do so. It makes the implicit assumption that the workers it trains want to stay in Macon, justifying a training investment that will be recovered over a lengthy period of employment.

Companies like Onshore Outsourcing make a pitch to US companies to use them rather than outsource IT development to India or Russia. Broadband makes it feasible for companies to

[16] The SRDC's e-Commerce tutorials are available from the URL srdc.msstate.edu/ecommerce/tutorials.
[17] Mary J. Lacity, Joseph W. Rottman, and Shaji Khan, "Field of Dreams: Building IT Capabilities in Rural America," *Strategic Outsourcing: An International Journal*, 3, no. 3 (2010): 161 – 91.

consider outsourcing to India or Russia in the first place. Ironically, broadband connections make Bangalore and Moscow closer to the IT departments of companies in urban America than are places in rural America that do not have as capacious broadband connections.

Health services

The urban-rural gap in health service use, along with the increasing role of information and communication technology in health care, make health care a leading opportunity for broadband-enabled change that will both increase the standard of living in rural America and expand the market for medical products and services produced largely in urban America.

Telemedicine describes medical services in which patient and provider are in different locations, with radiology and consultative services being two key examples. With radiology, an image is acquired where the patient is and forwarded electronically to a radiologist who is in a different location. With consultative services, interactive television allows a physician to be in one location and the patient in another.

An effort to quantify the economic effects of telemedicine looked at four economic effects: savings to a hospital from not having to have a specialist physician, regardless of the current need for the physician's services; savings to patients from travel avoided; savings to patients from less missed work; and dollars captured in local communities as individuals remained in the community for an episode of care.

In a study of telemedicine in Oklahoma, the largest local economic effects were the value of other services that were obtained locally when telemedicine allowed a patient to be served locally rather than be sent to another town. For radiology, telemedicine allowed patients to avoid trips of 30 to 54 miles. For psychiatry consultations, the alternative was a 60-mile trip in one community and 116 miles in another. For some individuals, avoiding a trip for an imaging study was a matter of convenience; for others, it meant they could be treated in the local hospital rather than transferred to a hospital with a radiologist present on staff.[18]

Not all hospitals in Oklahoma have broadband capacity to support telemedicine. Of 44 hospitals that responded to a survey, 13 reported Internet speeds that fell below the 4 Mpbs threshold in the FCC definition for the lower bound of broadband service.[19]

Telemedicine allows small hospitals to provide services that they would otherwise be too small to provide. The longstanding growth trend in health-care costs, increasing faster than the economy overall, means that rural hospitals that do not expand their offerings via telehealth will have two results. First, the cost of travel will deter some patients from seeking out specialized services, increasing the service use gap between those who live in urban and rural areas. Second, a growing share of health-care use in rural communities will involve local residents traveling to the distant provider to receive care.

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[18] Brian Whitacre, Pamela S. Hartman, Sarah Boggs, and Val Schott, "Evaluating the Economic Impact of Telemedicine in a Rural Community," AGEC-1007 (Stillwater, Oklahoma State University, 2010).

[19] Oklahoma State University Center for Rural Health, "Electronic Health Record Survey of Oklahoma's Rural Hospitals," n.d.

The explosive growth of capability, both in medical technology and telecommunications, will open more and more possibilities for rural hospitals. The advent of sophisticated decision-support systems will increase the range of health-care services that can be delivered locally, but supported remotely. Even remote surgery will become possible, carried out by da Vinci robot system devices that are controlled by surgeons who may be hundreds of miles away.

In addition to lost opportunities, lack of sufficient broadband may soon create real problems for existing hospitals. The minimum standard for electronic information flow in the health-care system is increasing. The expectation that the records for a patient transferred from one hospital to another arrive in electronic format and that they arrive before the transferred patient, avoiding duplication of tests, threatens the viability of hospitals in areas that do not have sufficient broadband service.

Conclusion

Over the past fifteen years, the Internet revolution has transformed American life, providing a hitherto unimaginable degree of rapid access to an array of goods, services, and information. The Internet revolution has broadened what telecommunications makes possible and has increasingly become an essential part of most Americans' lives. The Internet has transformed commerce, brought new education opportunities, enhanced financial services, facilitated medical treatments across great distances, and even offered a strengthened sense of community. Those who do not have access to the capability of broadband are effectively not able to participate in something that accounts for a growing share of the American standard of living.

The experience of larger and larger amounts of data moving at faster and faster speeds, however, has been achieved to a higher degree in urban America than outside it. There is a very real danger of a growing technology gap between rural and urban America. This gap, if not addressed, will have growing consequences for the American economy, both urban and rural.

The national economy will lose out on opportunities for processes that occur in rural America to become more efficient. Agricultural productivity has been an important contributor to overall growth in economic productivity. Telecommunications capabilities will be a limiting factor to the diffusion of productivity-enhancing agricultural technology. Rural America is the first step on American soil for some manufacturing and service-sector production that returns to America. Where this return cannot be supported because of inadequate broadband, America loses.

Both rural and urban America stand to gain from greater broadband penetration in rural America. More broadband use increases the size of the Internet market for producers and increases the competition for goods and services for consumers.

In short, rural America stands at a precipice. A growing technology gap looms.

Without broader access to broadband capacity, rural America will lack one of the necessary tools to contain, if not narrow, the gap. Such a gap will mean a loss of opportunities for those who live where technology is used less and a loss of economic potential for those who make the products and services that would close the gap. Because communication technology continues to advance, the gap can only grow unless investment continues in the places where the capabilities are furthest behind.

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About the Author:

Hanns Kuttner is a Visiting Fellow at Hudson, working on the Institute's Future of Innovation Initiative and other economic projects. His career spans the policy and research world. During the presidency of George H.W. Bush, he was part of the White House domestic policy staff with responsibility for health and social service programs. Most recently, he was a research associate at the University of Michigan's Economic Research Initiative on the Uninsured. He has also worked for the federal agency which runs the Medicare and Medicaid programs and advised the state of Illinois on restructuring its human service programs.

Kuttner has an A.B. from Princeton University. His graduate training was at the University of Chicago, where he received an M.A. degree from the Irving B. Harris Graduate School of Public Policy Studies.

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