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Broadband Internet's Value for Rural America

Peter Stenberg, Mitch Morehart, Stephen Vogel, John Cromartie, Vince Breneman, and Dennis Brown

Abstract

As broadband—or high-speed—Internet use has spread, Internet applications requiring high transmission speeds have become an integral part of the "Information Economy," raising concerns about those who lack broadband access. This report analyzes (1) rural broadband use by consumers, the community-at-large, and businesses; (2) rural broadband availability; and (3) broadband's social and economic effects on rural areas. It also summarizes results from an ERS-sponsored workshop on rural broadband use, and other ERS-commissioned studies. In general, rural communities have less broadband Internet use than metro communities, with differing degrees of broadband availability across rural communities. Rural communities that had greater broadband Internet access had greater economic growth, which conforms to supplemental research on the benefits that rural businesses, consumers, and communities ascribe to broadband Internet use.

Keywords: Internet, broadband, high-speed Internet, rural economies, rural economic growth, digital economy, telemedicine, rural, urban, Census data, June Agricultural Survey, Agricultural Resource Management Survey (ARMS), ERS, USDA

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Contents

Summary

The Internet has become widely, but not universally, available. Two-thirds of U.S. adults had in-home Internet access by 2008. Rural businesses and consumers have become almost as likely as their urban counterparts to use the Internet, though broadband—or high-speed—access is less prevalent in rural areas than in more densely populated areas. The 2008 Farm Act reauthorized USDA's telemedicine, distance learning, and rural broadband access grant and loan programs.

What Is the Issue?

Broadband access is viewed as necessary to fully utilize the Internet's potential. As the Internet economy has matured, more applications now require higher data transmission rates, even in the case of simple shopping websites. In a recessionary economy a number of Internet activities—including job searches and home businesses—may become more critical for households. Whereas an estimated 55 percent of U.S. adults had broadband access at home in 2008, only 41 percent of adults in rural households had broadband access. Evidence suggests that some of this shortfall in broadband use is involuntary, and may be due to the higher cost of broadband provision or lower returns to broadband investment in sparsely populated areas.

What Did the Study Find?

Analysis suggests that rural economies benefit generally from broadband availability. In comparing counties that had broadband access relatively early (by 2000) with similarly situated counties that had little or no broadband access as of 2000, employment growth was higher and nonfarm private earnings greater in counties with a longer history of broadband availability.

By 2007, most households (82 percent) with in-home Internet access had a broadband connection. A marked difference exists, however, between urban and rural broadband use—only 70 percent of rural households with in-home Internet access had a broadband connection in 2007, compared with 84 percent of urban households. The rural-urban difference in in-home broadband adoption among households with similar income levels reflects the more limited availability of broadband in rural settings.

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. Nonetheless, rural areas in some States (such as Nebraska, Kansas, and Vermont) have higher-than-expected broadband service given their population characteristics, suggesting that policy, economic, and social factors can overcome common barriers to broadband expansion.

In general, rural America has shared in the growth of the Internet economy. Online course offerings for students in primary, secondary, post-secondary, and continuing education programs have improved educational opportunities, especially in small, isolated rural areas. And interaction among students, parents, teachers, and school administrators has been enhanced via online forums, which is especially significant given the importance of ongoing parental involvement in children's education.

Telemedicine and telehealth have been hailed as vital to health care provision in rural communities, whether simply improving the perception of locally provided health care quality or expanding the menu of medical services. More accessible health information, products, and services confer real economic benefits on rural communities: reducing transportation time and expenses, treating emergencies more effectively, reducing time missed at work, increasing local lab and pharmacy work, and generating savings for health facilities from outsourcing specialized medical procedures. One study of 24 rural hospitals placed the annual cost of not having telemedicine at $370,000 per hospital.

Most employment growth in the U.S. over the last several decades has been in the service sector, a sector especially conducive for broadband applications. Broadband allows rural areas to compete for low- and high-end service jobs, from call centers to software development, but does not guarantee that rural communities will get them.

Rural businesses have been adopting more e-commerce and Internet practices, improving efficiency and expanding market reach. Some rural retailers use the Internet to satisfy supplier requirements. The farm sector, a pioneer in rural Internet use, is increasingly comprised of farm businesses that purchase inputs and make sales online. Farm household characteristics such as age, education, presence of children, and household income are significant factors in adopting broadband Internet use, whereas distance from urban centers was not a factor. Larger farm businesses are more apt to use broadband in managing their operation; the more multifaceted the farm business, the more the farm used the Internet.

How Was the Study Conducted?

This report summarizes all available nationwide data on broadband use and availability and analyzes the data to isolate interactions between broadband use and economic activities. It also presents results from an ERS-sponsored workshop on rural broadband and ERS-commissioned research studies conducted by others. The aim is to assess the economic impact of not having broadband service on rural communities and their growth, community facilities, access to health care, and well-being, as requested by Congress on December 26, 2007.

We first analyze who uses broadband, what it is used for, and what differences exist between the average urban and rural user to better understand the perceived usefulness of the Internet, especially broadband. We then identify rural areas that have broadband (by ZIP Code), determine when they acquired broadband service, and develop measurements of broadband availability over time. We analyze the effect of broadband Internet access on the rural economy using quasi-experimental design (QED), which allows us to compare two sets of counties alike in most aspects other than broadband availability. The results are interpreted using further analysis of rural businesses and consumers, including farm business logistic regression analysis, rural-farm linkage logistic regression analysis, and workshop research exploring many complex interactions between the Internet and socioeconomic components of the rural community: rural community social interactions; telemedicine; distance education; and rural businesses, including retail, service, and farm.

Introduction

The Internet in its infancy was simply an alternative, and quite straightforward, communication device. Electronic mail was sent from one person to another. Intrinsically the Internet remains a communications device, but as it has grown more universally available, it has become more integrated into the rest of the economy. The simple e-mail system of sending a note has evolved to incorporate blogs, instant messaging (IM), text messaging, Facebook, and Twitter. Business, household, and government activities have moved and are moving onto Internet platforms (Greenstein and Prince, 2006; Leamer and Storper, 2001). Many Internet activities are self-sustaining as personal computers download upgrades and "patches" to their systems and automatic ordering, billing, and payment functions are conducted for households and businesses. The Internet is integral to the development and functioning of the digital or information economy.

Rural communities have not been left out, though from the outset equal access to the Internet has been a contentious issue. The farm sector of the rural economy helped to pioneer rural Internet use (Stenberg and Morehart, 2007), and rural businesses and households have become almost as likely as their urban counterparts to use the Internet (Stenberg and Morehart, 2008). Access to the Internet through broadband (i.e., high-speed) technologies, however, has been less prevalent in rural areas than in much more densely populated areas of the country (see box, "What Is Broadband?"). Broadband Internet access has become the crux of today's policy debate on equal access among urban and rural communities.

Broadband access is viewed as necessary to fully utilize the Internet's potential (Greenstein and Prince, 2006; Parker, 2000). As the Internet economy has matured, more applications now require higher data transmission rates, even in the case of simple shopping websites.

The broad scope of the research presented here complements earlier studies on rural telecommunication policy by Parker and Hudson (1992), Internet access in the Appalachian region by Oden and Strover (2002), and businesses in the digital economy by Malecki (2008).

This report examines (1) what role the Internet plays in the national economy; (2) how much, and for what purposes, consumers use the Internet, especially what differences might exist between broadband and non-broadband Internet use by rural and urban consumers, including such uses as telemedicine, distance learning, and community involvement; (3) what determines whether and how rural businesses use broadband Internet; and (4) how broadband Internet affects the broader rural economy. Specifically, we address a question posed to ERS by Congress on December 26, 2007, concerning broadband's impact on rural communities and their growth, community facilities, access to healthcare, and overall well-being.

While we attempt to measure the observable economic effects of broadband Internet access and use, this study makes no attempt to comprehensively examine all the issues surrounding the growth of the Internet. For one, there are inherent limitations in measuring the economic impact, or value, of a rapidly evolving technology. The telegraph age, for example, ushered in a number of unpredicted developments like the emergence of such companies as Sears Roebuck. This report neither forecasts new developments nor addresses social issues pertaining to Internet uses like privacy, chat rooms, or parental supervision.

What Is Broadband?

The transmission capacity, or bandwidth, of Internet access has been a major impediment limiting the economic returns from online activity. The slower the Internet access speed, the less useful the Internet is. Dial-up, which was the primary access method before broadband access became more widely available, is the slowest way to connect to the Internet. The highest speed by which data can be transferred using dial-up is 56 kilobytes per second (kbps). In rural areas the speed often has been much less, with connection speeds of 14 kbps common. Effectively, this consigns rural dial-up users to using the Internet for text e-mail messages only. Anything requiring large graphics is simply not practical. High-speed Internet access is necessary to make use of much of what is now offered on the Internet.

Broadband is the term used to denote high-speed access to the Internet. Although the term has been used to refer to other services, such as digital television, the matter of most interest to consumers, providers, and policymakers is broadband Internet connectivity (Eisenberg, 2002). With the convergence of video, audio, text, graphics, and other analogous enduring and transient products and services into digital streams that can be transported across the Internet, broadband Internet connections have become a necessity for common Internet usages and applications.

The Federal Communications Commission (FCC), though altering the broadband definition recently, historically defined 200 kilobits per second in one transmission direction as the minimum speed for Internet service to be classified as broadband. Unfortunately, the definition includes a wide array of technologies ranging from the old ISDN and T-1 lines to satellite service. Lumping very slow transmission and sometimes unreliable service in with superfast fiber-optic home service makes economic impact analysis and discussion of broadband Internet service from historical data challenging.

Most broadband Internet access in U.S. households is through DSL or cable modem technologies and is faster than the FCC standard. As of 2007, 55 percent of all households had broadband Internet access: 46 percent of these had DSL, 39 percent had cable modem, and 12 percent had wireless connections (PEW). DSL was the first technology to become widely deployed; cable and, more recently, fiber-optic lines are becoming the technologies of choice.

The Internet Economy

In 1995, there were roughly 16 million Internet users across the globe; by 2008 there were nearly 1.5 billion, about 22 percent of the world's population. Two-thirds of U.S. adults had in-home Internet access by 2008 (PEW). Domain names have grown from 30,000 in 1994 to 168 million in 2008 (Verisign). Hosts, also known as end-user computers, grew from 1,000 in 1984 to 570 million in 2008 (Internet Systems Consortium). The Bureau of Census reports online retail sales went from $31 billion in 2001 to $107 billion in 2007. Also according to U.S. census statistics, online wholesale trade in 2006 was an estimated $613 billion, or approximately 16 percent of sales. Online wholesale trade in farm products was an estimated $5 billion, or 4 percent of all wholesale farm product sales in 2006.

Online economic activities may be grouped into three broad categories: information sharing, purchase channels, and sales channels. Information sharing can range from the trivial to critical life or business issues—from chat rooms to medical or financial storehouses—and is the most common application for businesses and consumers (Hopkins and Morehart, 2001; Stenberg, 1999; Varian, 2003). Even when purchases are not consummated online, purchase decisions are facilitated through price discovery or consumer information gathering. Real estate and automobiles are just two of the markets that have been transformed by price discovery online (Borenstein and Saloner, 2001).

The Internet has led to new sources of supplemental income for some households. Crafts, for example, that used to be pitched only at annual State and county fairs are now marketed year-round to wider audiences, and the Internet has led to the rise of auction sites such as E-Bay where anyone can be a buyer and seller of new and used goods and services.

For businesses, the Internet has reduced geographic isolation, with information from collaborating businesses or customers instantly available. The effective market area for producers has increased, though many businesses have not taken advantage of this potential (Brynjolfsson and Smith, 2000; Malecki and Moriset, 2007).

The increased speed and quantity of information, however, cannot reduce the physical distance that passengers and goods must travel (Malecki and Moriset, 2007). It is not clear whether the number of business trips has lessened due to the Internet (i.e., substituting Internet communication for travel). Anecdotal evidence suggests that as the price of transportation soared in early 2008, businesses cut back on travel (Odlyzko, 2008). Although the moving of farm, agricultural, and other physical goods from point A to point B involves the same distances as always, the Internet has enhanced the ability to track shipments and increased the efficiency of shipping companies.

As the Internet expands the effective market area for businesses, it also increases competition. The financial system is a prime example. Banks were traditionally local in nature. Historically, each farm community had its own bank. The bank held deposits from local residents and, in turn, loaned funds out to local farmers and the business community. This has changed, however, over the last several decades. First, the regulatory limitations on the markets that banks could serve were relaxed or eliminated. With the new regulatory environment and the revolution in telecommunications, the number of locally owned banks has declined (DeYoung and Duffy, 2002; Keeton, 2001).

Depositors have increasingly turned to online banks or investment concerns that offer higher rates of return for their capital (DeYoung and Duffy). This has increased the financial returns of bank depositors, but has reduced the profit that local banks accrued from deposits. Many loan applicants have gone online to find the best rates and terms for home mortgages, home equity, and other loan instruments. This has reduced the cost for the loan applicant, but also eroded the profit from individual loans in the bank's loan portfolio. To address this shortfall, many banks have increased their volume of transactions, often by increasing their effective market area. This may have hastened the consolidation of the financial market over the last 10 years.

E-government is another major development in the digital economy affecting rural America. Four kinds of activities fall within this area: information dissemination, citizen/customer services, government business transactions, and governance (Gallegos, 2002; Lanvin, 2008). Information typically disseminated includes public holidays and events, regulatory actions, issue briefs, public schedules, and school lessons and lunch menus. Twelve percent of all farms and 22 percent of all farms with Internet access, for example, retrieved information from Federal websites, according to analysis of 2007 June Agricultural Survey (JAS) data.

Citizen or customer services include paying taxes and fees, lodging complaints, requesting additional information, scheduling of public facilities, and submitting applications for various programs. Four percent of all farms and 7 percent of all farms with Internet access conducted business with the U.S. Department of Agriculture over the Internet according to analysis of 2007 JAS data.

Government business transaction costs have fallen for governments able to conduct much of their own back-office operations online, including supply purchases, bill payments, travel arrangements, and grant/loan operations with other agencies (Lanvin, 2002; Crescia, 2006). Governance changes are evident in the virtual town hall meetings, online polling, campaigning, and voting that characterized the 2008 election cycle.

Both government and the citizenry have benefited from the development of e-government via decreased costs to deliver or obtain services, increased or enhanced provision of information and services, and improved feedback between the citizenry and government (Lanvin).

Broadband Internet Adoption and Use

Dial-Up Versus Broadband Internet Use

That households and individuals greatly value the Internet, and especially broadband access to the Internet, is readily apparent from the data. Two major data sources directly address individual and household online proclivity and activity: the U.S. Bureau of the Census and PEW (PEW Internet & American Life Project). The Census Bureau has not collected thorough data on online activity since 2003, so we rely on the PEW surveys for our understanding of Internet users (see Appendix B for a description of this and other data used in this report). Aggregate e-retail, peer-to-peer, webpage access counts, and other such information are not used here because such measurements of volume give no information on individual behavior.

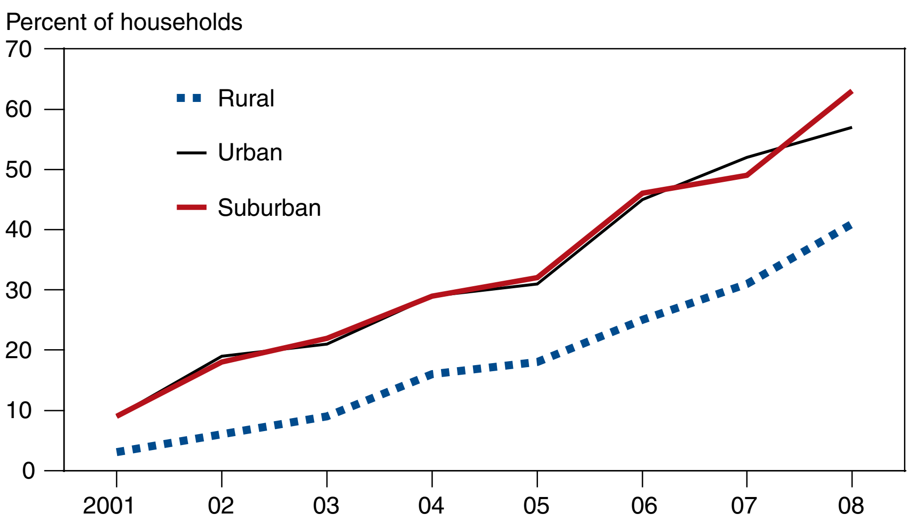
The PEW survey data suggest that rural and urban online behavior is alike if one controls for type of Internet access. In other words, rural and urban users with broadband Internet access have similar online behavior patterns vis-à-vis each other; rural and urban users with dial-up Internet access have similar online behavior patterns as well. Users with broadband Internet access, however, exhibit different online behavior than users with dial-up access.

Among the conclusions drawn from 2008 PEW survey data:

- Three-quarters of all adults used the Internet, with 69 percent having access at home.
- Fifty-five percent of all adults had broadband access at home.
- Only 41 percent of adults in rural households had broadband access at home in 2008.

Broadband access at home has increased dramatically for both urban and rural adults since 2001 (fig. 1).

Figure 1
Trends in home broadband adoption by region



Source: Horrigan, 2008

The number of online activities varies between dial-up users and broadband users, but not between rural and urban broadband users (Horrigan, 2008).[1] Most Internet users go online everyday and most of these send e-mail or get information off the Internet (table 1). Getting information, including visiting State and local government websites, is the most common activity. Many of the activities, such as hobbies and web-surfing, are of a personal nature. Still, 23 percent of adults used the Internet daily to conduct research for their job. Broadband Internet users were more likely than dial-up users to take part in any specific online activity, such as getting news online. The more data intensive the activity, the greater the difference is between dial-up and broadband user participation.

The Internet has reduced the economic involvement of the broker and other business middlemen in the economy. More bank transactions, for example, are taking place through ATMs or online instead of via tellers. According to a PEW survey in 2005, a quarter of all U.S. adults, or 44 percent of all adult Internet users, used the Internet for online banking. On any given day, 14 percent of all U.S. adults perform some online banking activity. Broadband users are especially heavy users of online banking services—over 60 percent of urban and nearly 50 percent of rural broadband users conducted some online banking activity in 2007.

As online data intensiveness increases, broadband access becomes more of a necessity. Nearly all online activities are becoming more sophisticated, using more data intensive processes; e-mail, for example, is becoming more data intensive as people are more inclined to attach photo and video files.

[1]John Horrigan and a number of other researchers whose works are discussed at length in this report presented their research at the Economic Research Service's broadband workshop, September 2008. For a complete listing of participants and papers, see the workshop agenda in appendix F.

Table 1
Online activities, 2008

Activity that has ever been done by a user	All Internet users	Dial-up at home	Broadband at home
		Percent	
Use an online search engine	89	80	94
Check weather reports and forecasts	80	75	84
Get news online	73	61	80
Visit a State or local government website	66	55	72
Look online for information about the 2008 election	55	37	62
Watch a video on a videosharing site like YouTube or GoogleVideo	52	29	60
Look online for information about a job	47	36	50
Send instant messages	40	38	44
Read someone else's blog	33	15	40
Use a social networking site like MySpace, Facebook, or LinkedIn	29	21	33
Make a donation to charity online	20	9	23
Download a podcast	19	8	22
Download or share files using peer-to-peer networks such as BiTorrent or LiveWire	15	15	17
Create or work on your own blog	12	8	15

Source: Pew Internet & American Life Project Survey, April 2008.

Broadband access is not uniform across rural and urban America, nor is the broadband access transmission rate identical across the country. Any shortfall in rural broadband availability is an implicit loss in economic opportunity for businesses, consumers, and governments.

Rural Internet Use

While the surveys conducted by PEW indicate popular online activities among adults, we turn to the Current Population Survey (CPS) to better understand who uses the Internet and where. The most recent CPS data are from a survey administered in October 2007. This large sample survey does not include any questions on what the Internet is used for or where it is accessed outside the home, but it provides a better understanding of who uses the Internet and rural-urban regional differences in household online proclivity.

Table 2 shows the share of households in which at least one person went online—no matter the technology—at home, school, work, or elsewhere in 2007. Over 71 percent of all households included one or more members that went online during the year. The CPS data suggest a variation across the country in the occurrence of going online (table 2). Households in the South were the least likely of the four Census regions to go online (see Appendix A for a description of the regions).

Nonmetro areas, in aggregate, had a lower percentage of individuals going online in 2007. While the variation in overall online use was insignificant between regions outside of the South, the same did not hold for nonmetro areas. Only in the Northeast was there not a significant dropoff in online activity going from metro to nonmetro areas.

Income differences have often been offered as a key explanation for the disparity in Internet use by households (Choudrie and Dwivedi, 2006; Flamm and Chaudhuri, 2007; Stenberg and Morehart, 2006). Lower income households clearly access the Internet less than higher income households (fig. 2). Income, of course, is not the whole story as income is highly correlated with or determined by education, age, and other factors, but household income by itself does raise an intriguing question: to what extent does use of the Internet lead to higher household income, and to what extent does higher household income lead to higher levels of Internet use?

Table 2
Households with at least one person going online at home or elsewhere, 2007

	Metro	Nonmetro	Total
		Percent	
Northeast	71.0	69.5	70.9
Midwest	74.0	65.7**	72.1
South	70.7	58.3**	68.3
West	75.5	68.6**	74.9
Total	72.6	63.3**	71.1

** Metro/nonmetro difference significant at 0.01.

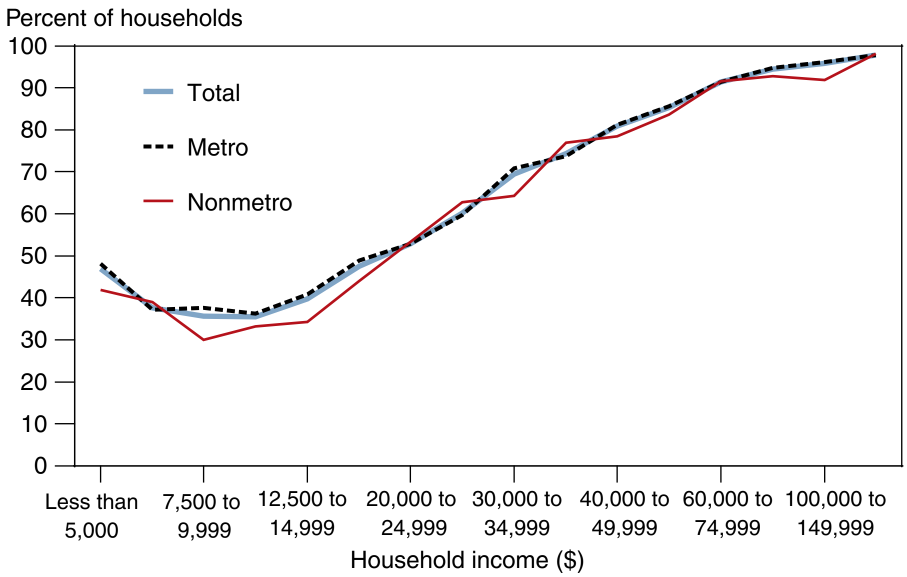
Source: ERS using Bureau of the Census CPS data.

Over 80 percent of households with annual incomes above $40,000 used the Internet during 2007. The rural-urban gap in accessing the Internet—either in-home or elsewhere—is not evident between rural and urban households of the same income (fig. 2).

Sixty-two percent of all U.S. households had in-home Internet access in 2007 (table 3). The West had the highest share of households with in-home access, partially reflecting the more urbanized population distribution there. A significant dropoff in in-home Internet access is apparent between urban and rural households, especially outside the Northeast; fewer than half of rural households in the South had Internet access at home in 2007.

Income is a major factor in whether a household has in-home Internet access (fig. 3). Over 70 percent of all households with incomes above $40,000 had in-home Internet access, and again rural-urban differences are largely nonexistent between households of the same income level. The steeper slope

Figure 2
Households accessing the Internet using any technology anywhere, 2007



Source: ERS using Bureau of the Census CPS data.

Table 3
Households with at least one person going online at home using any technology, 2007

	Metro	Nonmetro	Total
		Percent	
Northeast	64.1	61.0	63.7
Midwest	63.1	53.7**	60.9
South	61.7	46.4**	58.7
West	67.0	56.9**	66.1
Total	**63.7**	**51.9****	**61.8**

** Metro/nonmetro difference significant at 0.01.

Source: ERS using Bureau of the Census CPS data.

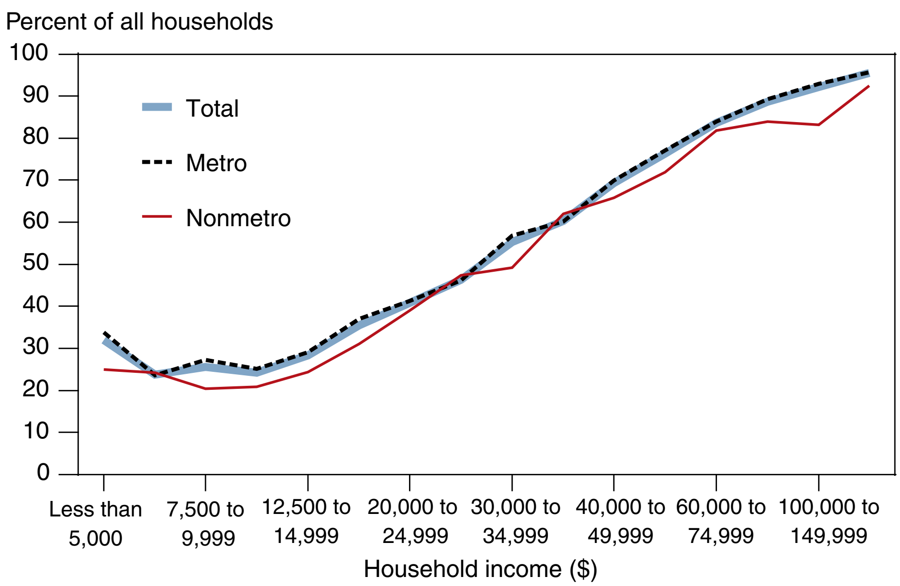
for in-home access rates versus going online anywhere suggests that affordability may be a factor in Internet access at home.

Most households with in-home Internet access have broadband connections (table 4). This rate varies little across regions for urban households. The same cannot be said for rural households. A marked difference in broadband access exists between urban and rural residents, even in the Northeast. Only 70 percent of rural households with in-home Internet access had broadband access in 2007, versus 84 percent of urban households. The data suggest that broadband availability is an issue for rural areas across the country.

The rural-urban dichotomy in broadband access becomes even more apparent when household income is taken into account (fig. 4). Income appears to be a minor factor in opting for broadband over dial-up for an in-house Internet connection. Generally, over 70 percent of Internet users, regardless of income, choose to pay for broadband (fig. 4). Thus, the gap between rural and urban household use of broadband suggests that the availability of broadband services is more of a challenge for rural than urban households (unless there is some systemic difference between rural and urban house-

Figure 3

Home internet access by income, 2007



Source: ERS analysis of Bureau of the Census CPS data.

Table 4

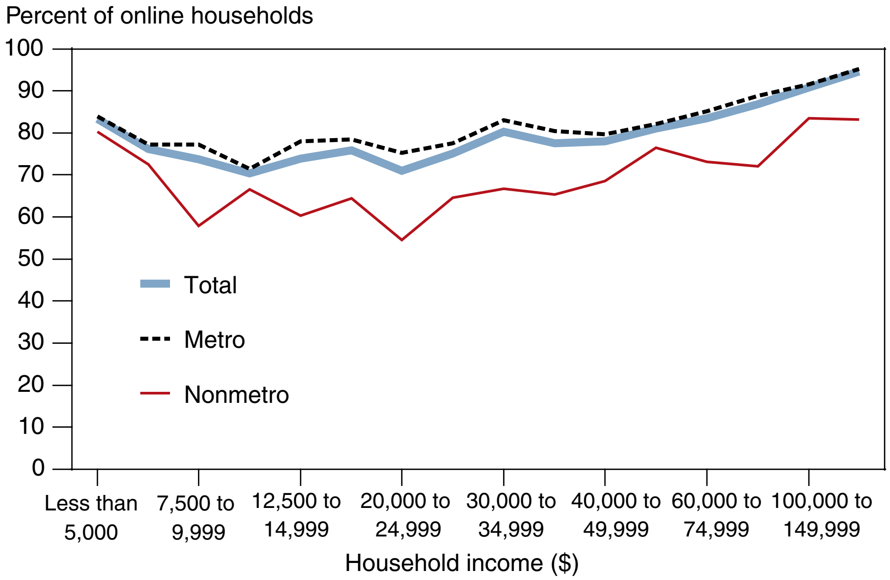
Share of online households with broadband access, 2007

	Metro	Nonmetro	Total
		Percent of online households	
Northeast	87.3	68.8**	85.4
Midwest	82.9	70.6**	80.4
South	83.0	67.3**	80.5
West	85.3	75.2**	84.4
Total	**84.4**	**69.7****	**82.3**

** Metro/nonmetro difference significant at 0.01.

Source: ERS using Bureau of the Census CPS data.

Figure 4
Households with broadband access by income, 2007



Source: ERS analysis of Bureau of the Census CPS data.

holds that otherwise could explain the gap). Systemic household differences, if they exist, would have to explain why rural households are as likely as urban households to use the Internet but do not opt for broadband when they already use the Internet at home.

Further Factors in Rural Broadband Use

The presence of children in the household is a contributing factor in a household's having in-home Internet access (Stenberg and Morehart, 2006; Choudrie and Dwivedi, 2006). One way in which in-home Internet access may improve household well-being is through educational programs. The Internet has increased course offerings for students in primary, secondary, post-secondary, and continuing education programs, especially those attending small, isolated rural primary and secondary schools. The Internet has also improved interaction among students, parents, teachers, and school administrators in primary and secondary education. This is especially significant as studies have shown the importance of parental involvement in their children's education (Moore, 2007; Poley, 2008). As a result, education programs drive household demand for in-home Internet access. Analysis of the CPS data shows households with children have higher rates of in-home Internet access and households with teenage children are the most likely to have it (table 5).

Rural households, however, have uniformly less access to in-home Internet than urban households across all household composition types. Inasmuch as distance education is beneficial to economic well-being, continuation of this rural-urban dichotomy could put rural households at a disadvantage.

Once a household has in-home Internet access, the upgrade to broadband is seemingly not affected by household composition (table 6). The rural-urban gap, however, is more extreme and broadband's role in distance education would seem to put rural households at a further disadvantage.

Table 5

All types of Internet access at home by household composition, 2007

	Metro	Nonmetro	Total
	Percent of households		
Not a parent	65.0	53.4**	63.3
No children under 18 years of age	69.7	59.4**	67.7
Only children less than 6	70.8	55.1**	68.7
At least one child 6-13 and none older than 13	72.8	65.4*	71.7
At least one child older than 13	81.4	76.5**	80.6
Total	**68.5**	**58.1****	**66.8**

** Metro/nonmetro difference significant at 0.01; * difference significant at 0.05.

Source: ERS using Bureau of the Census CPS data.

Table 6

Broadband in homes with Internet access by household composition, 2007

	Metro	Nonmetro	Total
	Percent of online households		
Not a parent	85.7	71.4**	83.9
No children under 18 years of age	82.3	66.9**	79.7
Only children less than 6	90.5	78.4**	89.1
At least one child 6-13 and none older than 13	87.3	71.8**	85.2
At least one child older than 13	85.4	71.8**	83.3
Total	**85.2**	**70.3****	**83.1**

** Metro/nonmetro difference significant at 0.01.

Source: ERS using Bureau of the Census CPS data.

In a recessionary economy a number of Internet activities—including job searches and home businesses—may become more critical for households. The 2007 CPS data give some information on both activities.

Unemployed adults, while less frequent users of the Internet than employed persons, still had high “anywhere” access rates (table 7). People not in the labor force due to retirement or disability had the lowest rate of online activity. Unemployed individuals looking for work were more likely to use the Internet than other people not employed. Rural people in the labor force had a lower access rate than urban people.

The picture changes for home Internet access, where affordability likely becomes an issue for unemployed or disabled/retired persons (table 8). The dropoff in use for these groups holds for both rural and urban residents. These individuals likely go online at such locations as libraries and schools when in-home access becomes unaffordable.

A broadband connection is again the choice for most homes with in-home Internet access across all labor force categories (table 9). Regardless of labor force status, whether the household is in an urban or rural location, if a household has in-home Internet access, the household will most likely have a broadband connection.

Table 7

Online activity using any access technology by labor force status, 2007

	Metro	Nonmetro	Total
	Percent within labor force category		
Employed—At work	83.7	78.6**	82.9
Employed—Absent (on day of survey)	85.9	79.4**	84.8
Unemployed—On layoff	72.8	62.3**	70.6
Unemployed—Looking	77.7	72.8*	76.9
Retired—Not in labor force	52.6	43.7**	50.9
Disabled—Not in labor force	47.1	43.2*	46.1
Total of all adults	**77.2**	**70.6****	**76.1**

** Metro/nonmetro difference significant at 0.01; * difference significant at 0.05.

Source: ERS using Bureau of the Census CPS data.

Table 8

Home Internet access using any technology by labor force status, 2007

	Metro	Nonmetro	Total
	Percent within labor force category		
Employed—At work	74.8	65.0**	73.3
Employed—Absent (on day of survey)	75.0	65.2**	73.5
Unemployed—On layoff	60.3	49.6**	58.1
Unemployed—Looking	63.8	51.4**	62.0
Retired—Not in labor force	48.8	41.3*	47.4
Disabled—Not in labor force	39.6	34.9*	38.4
Total of all adults	**68.5**	**58.1****	**66.9**

** Metro/nonmetro difference significant at 0.01; * difference significant at 0.05.

Source: ERS using Bureau of the Census CPS data.

Table 9

Broadband in homes with Internet access by labor force status, 2007

	Metro	Nonmetro	Total
	Percent within labor force category		
Employed—At work	86.6	72.1**	84.6
Employed—Absent (on day of survey)	87.3	75.5**	85.6
Unemployed—On layoff	75.7	54.2**	72.0
Unemployed—Looking	83.7	72.0**	82.1
Retired—Not in labor force	75.0	59.0**	72.3
Disabled—Not in labor force	75.0	63.2**	72.4
Total of all adults	**85.2**	**70.2****	**83.1**

** Metro/nonmetro difference significant at 0.01.

Source: ERS using Bureau of the Census CPS data.

A small but significant number of households have home businesses covering a wide range of professions such as farmers, doctors, and artisans (table 10). Such households may become more commonplace in the current economic downturn as more households try to compensate for loss of jobs or reduced work hours by starting home businesses. Home businesses are more commonplace in rural areas than urban areas (table 10). In-home Internet access is much more common in households with home businesses (81 percent) than among all households in the aggregate (62 percent). This is true for both urban (83 versus 64 percent) and rural home businesses (70 versus 52 percent).

In summary, a broadband connection is almost the default for a great majority of online households. Analysis of the CPS data suggests that more rural households would have broadband connections if these connections were as readily available as in urban areas, implying lost economic opportunity for some rural households.

The data, however, also suggest that some of the shortfall in rural Internet activity may be due to other factors that precede the decision to get a broadband connection. These factors include the lower average income for rural households, higher average age of the rural population, and lesser educational attainment of rural residents as compared to their urban counterparts.

Table 10
Internet users by home business status, 2007

	Metro	Nonmetro	Total
		Percent	
Households with home businesses	11.7	14.8*	12.2
Home businesses with any kind of home Internet access	83.3	70.1**	80.7
Proportion of home Internet access with broadband	87.6	71.3**	84.6

Note: Difference between metro/nonmetro (*--significant at 0.05, ** -- significant at 0.01).

Source: ERS using Bureau of the Census CPS data.

Geography of Rural Broadband Providers

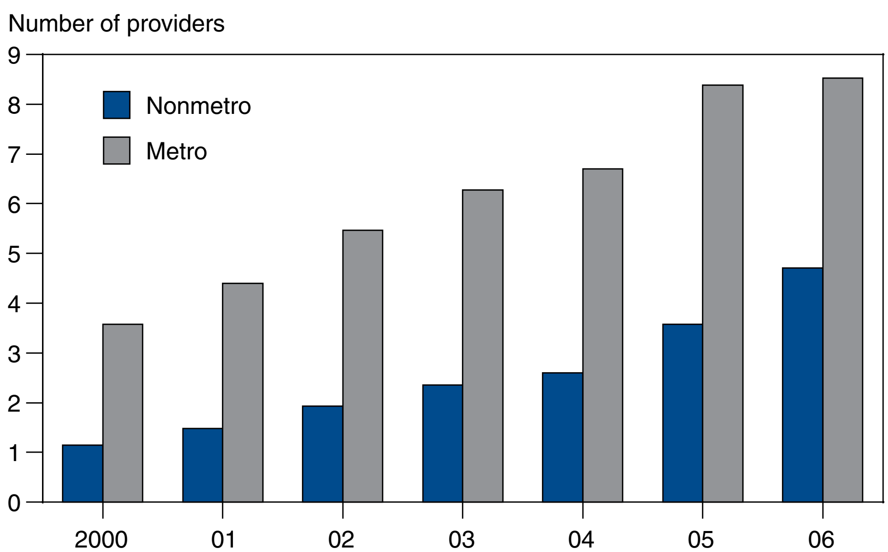
Broadband provision follows a geographical pattern tied to population size and the urban-rural hierarchy. Limited provision is most strongly associated with low population size in a given area, but also exhibits regional patterns that reflect differences in urban concentration and challenges associated with mountainous terrain. The Federal Communications Commission (FCC) data on the number of broadband providers by ZIP Code area (see Appendix B) are the only source of geographically detailed information with national coverage. More robust findings would come from data measuring the actual number of broadband customers and variation in the price of service, rather than just the number of companies providing access. The FCC data, however, serve as the best available proxy of broadband accessibility.

Metro ZIP Code areas average 88 square miles apiece and include just over 16,700 people on average.[2] Nonmetro ZIP Code areas are generally much larger (131 square miles) with far fewer people (3,000) on average. Such population diversity drives geographic variation in the cost of broadband provision. While U.S. metro areas averaged close to nine providers per ZIP Code area in 2006, nonmetro ZIP Code areas averaged half that number (fig. 5).

Despite significant expansion, the metro-nonmetro gap in number of broadband providers remains and has even widened by some measures since 2000, when broadband provision was much more limited in scope. It is not surprising that, as broadband access has expanded to encompass a large majority of Americans, the remaining areas of limited coverage increasingly reflect the higher costs associated with providing service to smaller populations.

[2]Metro and nonmetro categories used here are based on the ERS Rural-Urban Commuting Areas and are defined using criteria similar to OMB's county-based metro and nonmetro areas. Nonmetro ZIP Code areas are defined as those outside urban centers of 50,000 or more and their surrounding commuting zones

Figure 5
Average number of broadband providers per ZIP Code by metro versus nonmetro area, 2000-2006



Source: USDA, Economic Research Service, using data from the FCC.

The Economics of Broadband Delivery

The main economic principles underlying the diffusion and adoption of communication services across rural-urban space are twofold: companies invest where they earn the highest returns and households adopt if they can afford these services and either need or desire them (Davies, 1979; Rogers, 1995). The adoption and use of communication and information services, therefore, are not uniform across the country or among income groups.

Here we are interested in differences between rural and urban areas or, in Federal policy terminology, between high-cost and low-cost areas. Residents in rural areas have always faced higher costs for telecommunication services than those in urban areas and, at least for the foreseeable future, will continue to do so. Economies of scale for the current technology set are at the core of why they face higher costs (Stenberg, 2004).

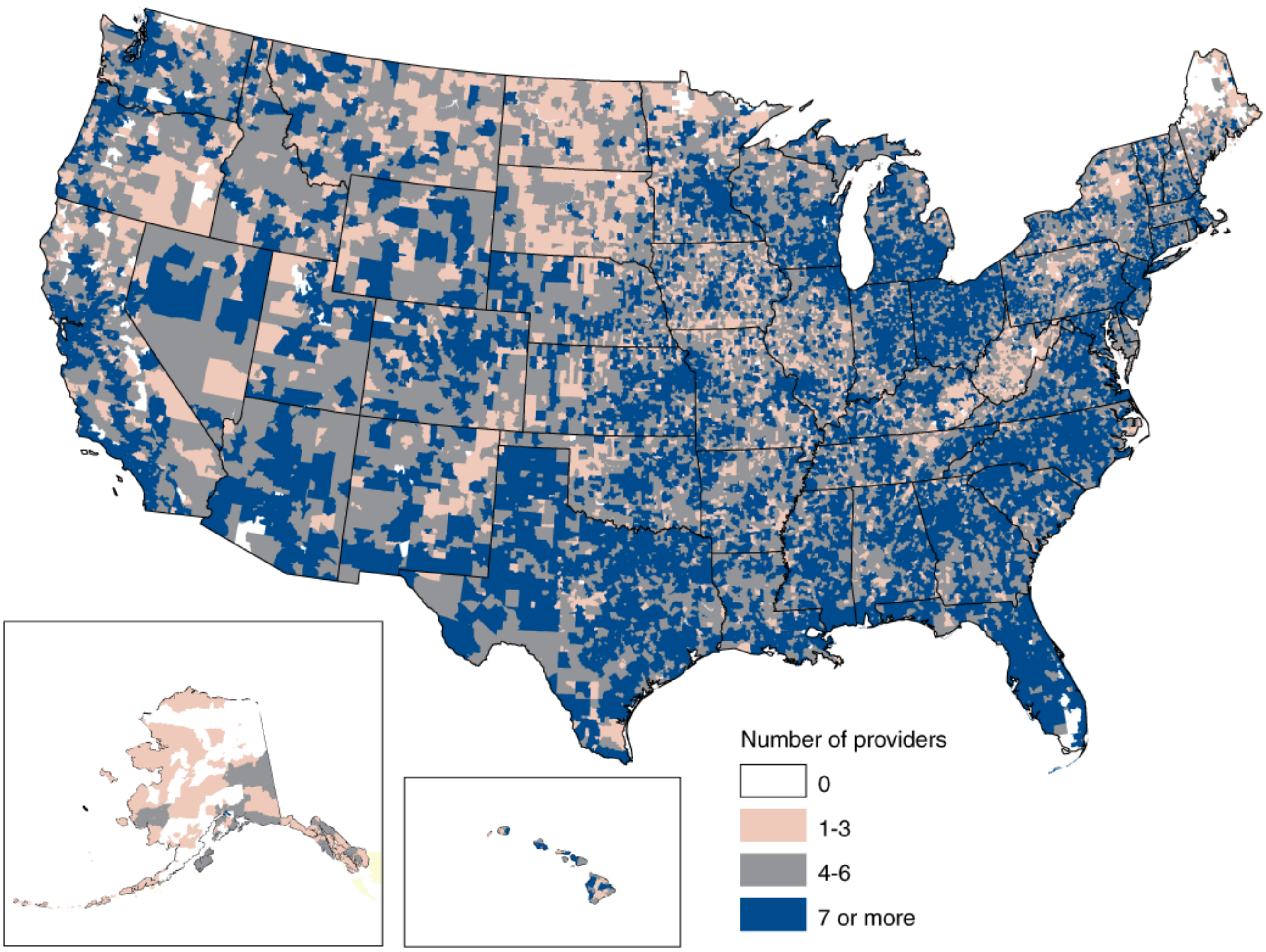
Rural areas are characterized by low population density. With fewer people in any geographic space, the per capita costs of providing telecommunication services rise. Fewer customers share in the cost of the central office switches, loop maintenance, and other common components of the local telecommunication system.

Rural areas also have few large businesses or government operations. In the United States, private business and government use of telecommunication services has indirectly subsidized household use. In practice, this has meant that urban telecommunications service providers often charge higher rates to their business customers and lower rates to household customers than they would in a perfectly competitive market for telecommunication services (Egan, 1996). Rural telecommunications companies often do not have this luxury.

Rural telecommunications service providers must spend more per customer for maintenance and repair crews than urban providers. Rural maintenance and repair crews, especially those providing services in very remote regions, cover a larger territory than urban crews, resulting in more overtime, more travel expenditures, and all the other resultant expenditures that crews face when they are not near their home base (National Telephone Cooperative Association, 2000). Rural providers also need more resources per customer than urban telecommunications service providers, including duplicate facilities and backup equipment, to ensure network reliability (Egan, 1996).

Clusters of lower service provision in 2006 highlight clearly discernable regional patterns (fig. 6). The northern Great Plains, eastern Oregon, and northeastern New Mexico are sparsely populated. The Missouri-Iowa border area has experienced persistent population loss and an aging population. An extensive area of low service is evident in West Virginia and eastern Kentucky, but extends from Tennessee through upstate New York. This mountainous terrain, divided by innumerable ridges and narrow valleys, impedes broadband service provision to its widely dispersed, rural and small-town population. Though topography creates similar challenges in the West, people living there tend to concentrate more in towns and small cities, making broadband service less expensive to provide to each household.

Figure 6
Number of broadband providers, 2006

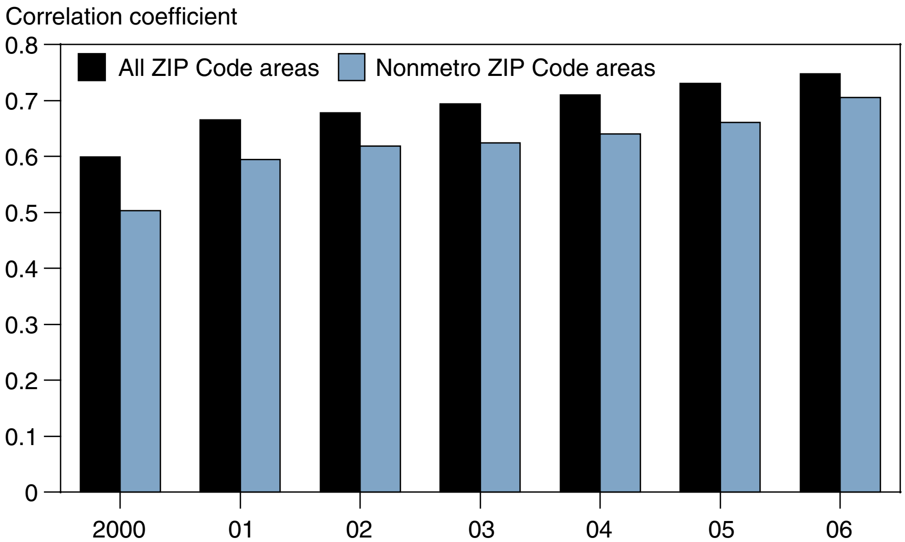


Source: USDA, Economic Research Service, using data from the FCC.

Access to services of any kind—hospitals, grocery stores, public transportation, Internet—is strongly related to overall population size, the degree to which population is concentrated in urban centers, and the population of neighboring areas. In the case of broadband service, as measured by the FCC data, population size is the predominant explanatory feature. For all ZIP Code areas nationally, the very strong (0.6, or 60 percent) correlation between population size and service provision in 2000 increased to 0.75 by 2006 (fig. 7). Thus, low-service areas that remain, though far fewer, are more likely to be in sparsely settled territory throughout nonmetro America.

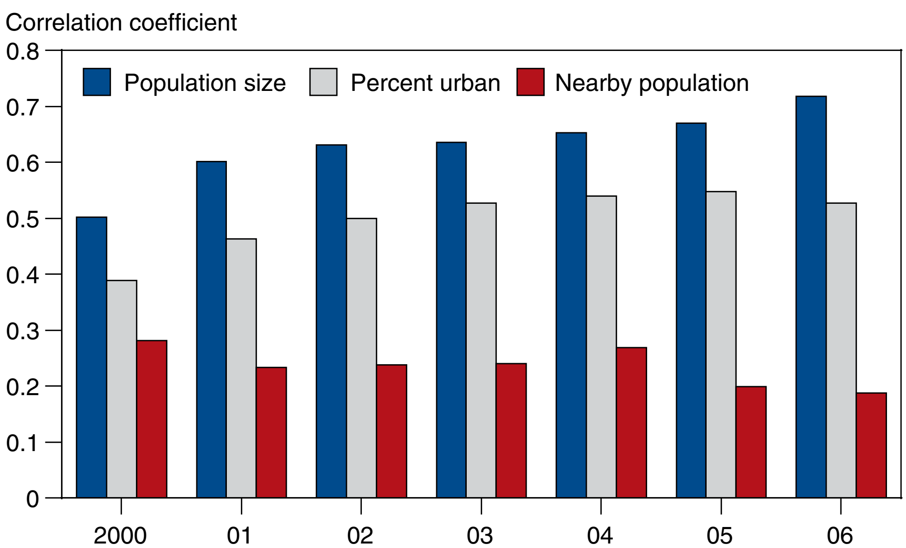
Within nonmetro areas, population size is the strongest predictor of where broadband access is likely to be available. Other dimensions of nonmetro population distribution, however, strongly correlate as well, especially the degree of population concentration as measured by percent urban (fig. 8). Correlation between broadband provision and the relative size of neighboring ZIP Code areas weakened from 2000 to 2006, as broadband provision increased.

Figure 7
Strength of relationship between number of broadband providers and population size, 2000-2006



Source: USDA, Economic Research Service, using data from the FCC.

Figure 8
Strength of relationship between number of broadband providers in nonmetro ZIP Code areas and three population measures, 2000-2006



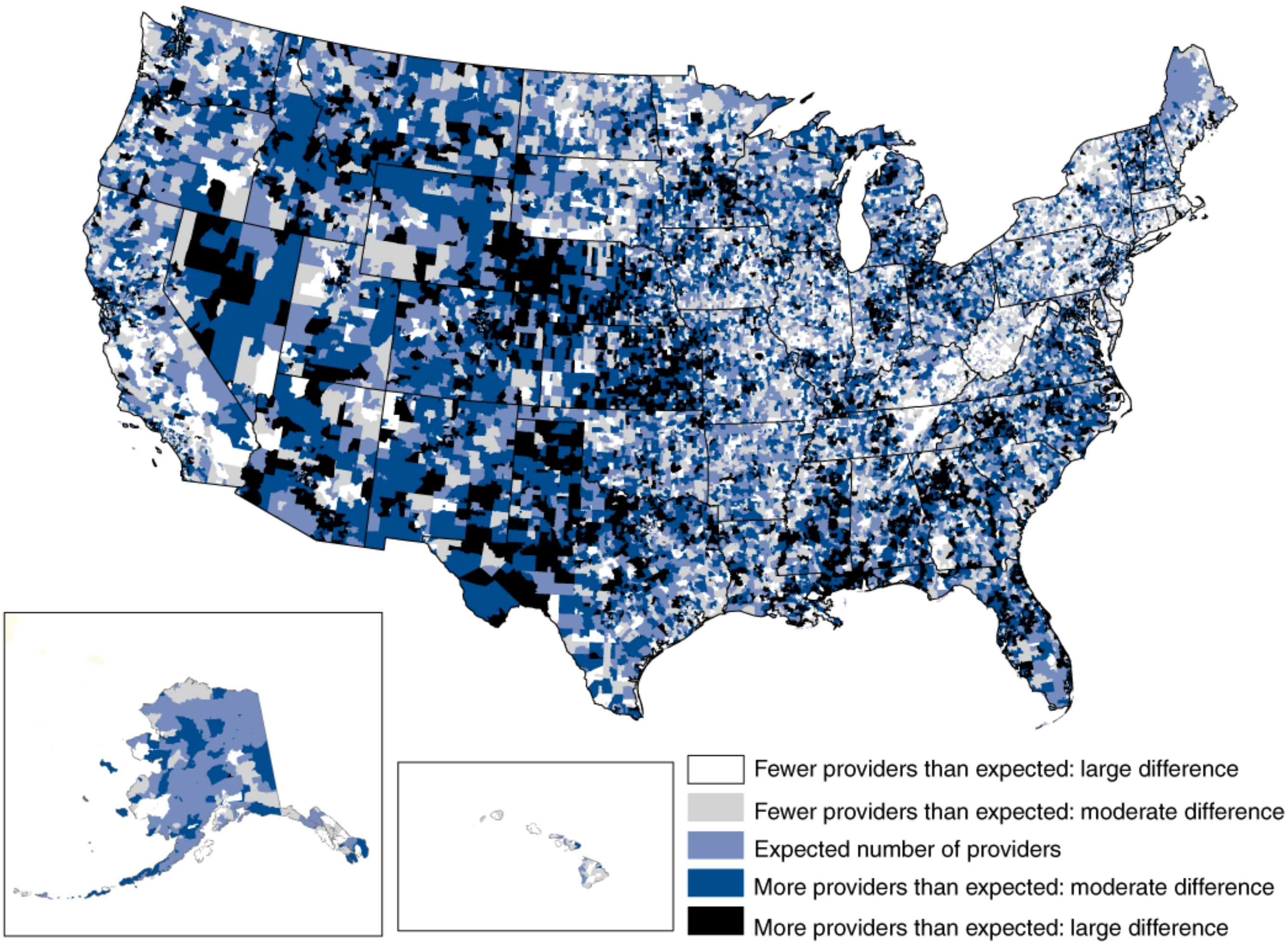
Source: USDA, Economic Research Service, using data from the FCC.

Results of a regression analysis conform to expectations regarding the geography of broadband provision driven by relative costs per capita (for a description of the ordinary least squares model, see Appendix C). In combination, the three population-based measures explained 63 percent of variation in broadband availability. Population size contributed the largest effect, but percent urban and size of nearby populations also were significantly related to broadband provision in 2006.

Additional insights may be gained by examining where the number of broadband providers is higher or lower than expected, once these very strong and universal population effects are taken into account. This is accomplished by mapping the residuals from our regression model for 2006 (see Appendix C for an explanation of the model and the variables used). Residuals are measured for each ZIP Code area as the difference between the actual number of providers in that area and the number of providers predicted by the model, based on the area's population size, urban concentration, and proximity to nearby population centers. In the West, higher-than-expected service occurs in the most sparsely populated sections (fig. 9). In Nebraska and Kansas, including the more densely settled eastern parts, broadband provision is higher than expected, compared with most neighboring States. Vermont similarly stands out among New England States.

Figure 9

Difference between the actual number of providers and the expected number based on population, 2006



Note: The map shows residual regression values. The highest and lowest categories are greater than one standard deviation above and below the mean residual value of zero. Areas of moderate difference fall between one-quarter and one standard deviation above and below the mean. Areas with the expected number of providers are within one-quarter standard deviation above or below the mean.

Source: USDA, Economic Research Service, using data from the FCC.

In Appalachia, broadband service provision is consistently lower than expected. The Ozarks in northeastern Arkansas show values similar to Appalachia, pointing to the role of topography in influencing broadband provision in the eastern half of the United States.

Higher-than-expected service in Vermont, however, suggests that economic and social factors may influence the level of broadband service in nonmetro ZIP Code areas. Higher levels of income and education may increase demand for broadband. Vermont's economy depends more heavily on tourism and recreation, and its population has high levels of college and technical training, especially in engineering, finance, and health. Both these features help explain differences in service levels compared with more southern Appalachian areas.

The geography of broadband service provision in 2006—in particular, the contrast between higher- and lower-than-expected service areas—suggests several factors contributing to service gaps beyond basic population barriers. First, the variation in broadband coverage is less pronounced in the West, especially in the Intermountain West, compared with the Midwest and Appalachia. This may be due to a more concentrated population pattern (though this analysis accounts for some of this effect by including percent urban); a recreation-based economy, attracting tourists who increasingly demand broadband availability; or a rapidly growing population made up of younger, more educated individuals, including tech-savvy entrepreneurs whose businesses depend on being connected to urban-based clients.

Second, Appalachia's prominence as an underserved area suggests that topography significantly increases the cost of providing broadband service in this region. Education levels are below the national average, but no more than in many Coastal Plain States areas that are better served. The higher dependence on mining and other resource-based industries may play a role, but lower levels of broadband service exist even in areas of Appalachia where retirement and tourism have become important. And if a higher dependence on mining lowers Internet demand, the same is not true for agriculture. When population is taken into account, places with higher employment in agriculture exhibit higher levels of broadband support.

Finally, higher-than-expected service in States such as Nebraska, Kansas, and Vermont indicate that State-level policies and programs may be behind the widespread availability of broadband. Here, we face limitations of data that simply show the number of providers in a ZIP Code area and may not always reflect differences in costs or level of service. Still, conditions at the State level seemingly can transcend economic and social differences that tend to handicap some rural areas.

Broadband's Effect on the Rural Economy

Measuring the rural economic effects resulting from investment in broadband is challenging. Separating out the broadband effect from other causal factors in economic growth is difficult, especially given that broadband has not been available for long and its use has grown rapidly. The methodological approach that we take is called quasi-experimental design, and what is undertaken here may be considered an initial step toward ferreting out a causal relationship.

Quasi-experimental design (QED) is a statistical approach that simulates an ex-post laboratory experiment (Cook and Campbell, 1979). Like a laboratory or medical experiment, QED features both a treatment and control group. The treatment group is the group undergoing the "cure," which in this case includes areas with some minimum level of broadband availability.

The control group, or the untreated group, serves as the counterfactual to the treatment group. In theory, the counterfactual is what would have happened to the treatment group if they had not undergone the "cure." The control group provides the baseline forecast. Divergence in the post-treatment period is attributed to the effect resulting from the treatment.

Selection of control and treatment in QED (unlike a true laboratory experiment) is not perfectly random, hence the term "quasi." Treatment groups are self-selected. Control groups are selected based on their characteristic similarity with the initial, or pre-treatment, characteristics of the treatment group.

QED has been utilized in a large body of regional science research. It has been used in airport impact studies such as Farnsworth (1972) and Wheat (1970), fiscal policies such as Bender and Shwiff (1982), highway infrastructure studies such as Blum (1982) and Isserman (1987), and military base closure research such as Isserman and Stenberg (1994).

We use the year 2000 broadband density surface developed from the FCC broadband access data (see appendix C, specifically the section on enhancing the FCC data). In 2000, broadband was only starting to become widely available and it is the first year a broadband likelihood database could be constructed. Broadband access is based on the earliest reliable set of data from the FCC (according to our discussions with the FCC). Our 2000 likelihood data allow some effect resulting from broadband investment to start to appear in rural communities. Information technology takes time to be fully utilized after the technology's introduction (Greenstein, 2000; Bresnahan et al., 1999; Greenstein and Prince, 2006).

We selected 228 rural counties for our treatment group that had relatively high broadband availability in 2000. For each of these counties, we found a rural "twin," a county that most closely resembles the treatment county (outside of broadband availability) based on economic structure (farming, manufacturing, retail trade, Federal Government, and State/local government income as a percent of total income); spatial structure (population density, distance from various city sizes, and presence of interstate highway); and income (per capita, unearned, and transfer income) in 2000; as well as the growth in population and income from 1990 to 2000. Duplicate counties were not allowed in the control group (see appendix E for further discussion of the methodology used).

Our post-treatment period is 2002 through 2006. Year 2006 is the last year for which broadband data are available, and the 5-year period provides time for an economic effect from broadband service to manifest itself. Due to the rapid spread of broadband Internet access, the initial short period may be the only period when we are able to detect differences in economic outcomes resulting from the availability of broadband access.

We investigate changes in county employment and income in our QED analysis, and find that total employment grew faster in counties that had greater broadband Internet access sooner than in similarly situated rural counties without broadband access (table 11). Previous studies (Crandall et al., 2007) suggest that employment is not expected to be greatly influenced by broadband access. Simply put, the issue becomes whether the use of broadband Internet in business increases productivity, which subsequently either reduces actual employment (due to the productivity gain) or increases employment (as market share increases). At the county level, however, broadband availability may mean that the county's employers are more competitive with employers in other counties. This would attract both new jobs and potentially new employers.

Wage and salary jobs, as well as number of proprietors, grew faster in counties with early broadband Internet access. The farm sector seems largely to have been unaffected by broadband Internet access. The farm sector, however, seems more likely to embed broadband Internet access into productivity as its basic inputs are more fixed than other sectors of the economy. Subsectors of the counties' economies (not shown here), like wholesale trade, generally showed no significant effect from broadband access, though further analysis is warranted. The difference in nonfarm jobs starts to disappear as other counties get increased broadband access.

Income showed a mixed picture (table 12), though population showed greater growth in treatment counties than control counties. The normal year-to-year volatility of farm earnings due to weather and other causal factors not accounted for in the QED approach taken here may have been a factor in this outcome. Nonfarm earnings showed greater growth corresponding to

Table 11

Difference in employment growth rates between early broadband and control counties

	2002	2003	2004	2005	2006
Total number of jobs	0.003	0.0079*	0.0104*	0.0114*	0.0113
Total number of proprietors	-0.0068	0.0072*	0.0199*	0.0280*	0.0363*
Farm proprietors	-0.0001	0.0001	0.0009	0.00197	0.0058
Nonfarm proprietors	-0.0075	0.0048	0.0152*	0.0195*	0.0224*
Wage and salary jobs	0.0062*	0.0092*	0.0088*	0.0075*	0.0053*
Farm jobs	-0.0052	-0.0028	-0.004	-0.0050	-0.0010
Nonfarm jobs	0.00343	0.0076*	0.0096	0.0101	0.0087

Note: * significant at 10%.

Source: ERS using selected data from Bureau of the Census and Bureau of Economic Analysis data.

Table 12

Difference in income and population growth rates between early broadband and control counties

	2002	2003	2004	2005	2006
Population (number of persons)	0.0041*	0.0063*	0.0065*	0.0076*	0.0093*
Personal income	0.0141*	0.0064	0.0028	0.0037	-0.0012
Per capita personal income (dollars)	0.0100*	-0.0002	-0.0047	-0.0049	-0.012
Private earnings	0.0163*	0.0234*	0.0274*	0.0206*	0.0192
Farm earnings	0.7545	0.0568	0.2863	0.4327	0.5483
Nonfarm earnings	0.0114*	0.0114	0.0126	0.0068	0.0009

Note: * significant at 10%.

Source: ERS using selected data from Bureau of the Census and Bureau of Economic Analysis data.

broadband availability. The difference between control and treatment counties lessens over time as other counties get better broadband access.

Private earnings—all earnings, excluding farm earnings and Federal, State and local government earnings—were greater for the treatment counties than for the control counties. The results we obtained are consistent with the argument that broadband Internet access has a positive effect on rural communities.

Our analysis supports the hypothesis that investment in broadband Internet access leads to a more competitive economy. Further analysis, however, is needed to address the issue of causality more completely. Why and how broadband may lead to the results of the QED analysis was the subject of other ERS research at the ERS Broadband Workshop. It is the subject of the rest of the report.

Rural Communities and Broadband Internet Use

Broadband Internet availability has direct implications for the well-being of communities. Limited or nonexistent broadband restricts Internet use in rural communities and subsequently the benefits derived from its use. Research suggests that broadband use fosters community involvement, enhances the provision of services such as health and education, and expands household income prospects through such activities as telework.

Community Interactions and the Internet

In the Internet's infancy some researchers warned that its use would weaken community ties, splinter common interests, and erode levels of voluntary or community participation, according to Stern et al. (2008). Local communities would be destroyed as people went online and found their own virtual communities of shared interest.

Sociological research over the past decade, however, has found this concern largely unjustified. In fact, Internet use has been shown to bolster community vitality through civic engagement and community participation (Stern and Dillman, 2006; Stern et al., 2008; Wellman et al., 1996). The concern has now evolved into fear that those with antiquated or no connections to the Internet are systematically being left out of community activities (Stern et al., 2008).

By use of a logistic regression model, Stern et al. showed that the use of the Internet is associated with higher degrees of community participation across a variety of groups and organizations. People use the Internet to receive information via e-mail from organizations or to search out information groups. Using broadband technologies corresponds positively with higher levels of passive and active community participation. Stern et al. concluded that the **quality** of Internet access is also important to a community's sociological well-being, regardless of factors such as income, age, education, and race.

Stern and others' data suggest that rural communities that rely most on volunteerism to function might be at a disadvantage as a consequence of either a lack of Internet access or an unwillingness to adopt broadband technologies. Furthermore, the lack of broadband service may in itself discourage the development of proficiencies in using the Internet. In other words, sluggish dial-up service may preclude individuals from growing efficient in daily Internet use, and thereby attenuate their contribution to their local communities.

Broadband Internet services, however, offer more definitive, or at least economically measurable, benefits to rural communities. These benefits covered during the 2008 ERS broadband workshop span medical, educational, and job services. One particular benefit is telemedicine.

Telemedicine and Telehealth

Rural communities have long faced challenges in getting adequate local health care. Telemedicine and telehealth have been hailed as vital to health care provision in rural communities, whether simply improving the perception of locally provided health care quality or expanding the menu of medical services (Goetz and Debertin, 1996). More accessible health information, products, and services confer real economic benefits on rural communities and their residents: reducing transportation time and expenses, treating emergencies more effectively, reducing time missed at work, increasing local lab and pharmacy work, and providing savings to health facilities from outsourcing specialized medical procedures (Capalbo and Heggem, 1999; Whitacre, 2008).

These benefits have been recognized by Federal policy. The USDA administers a number of programs aimed at improving in-clinic medical technology and broadband Internet access to fully utilize medical technologies in rural clinics. The 2008 Farm Act (the Food, Conservation, and Energy Act of 2008) expands these programs.

Telemedicine studies have primarily been case studies on how hospitals have adapted to telemedicine or cost-benefit studies for hospitals adapting particular telemedicine applications. Whitacre (2008) examined the economic benefits from a community perspective. Rural hospital services affect a community directly in the health of its citizenry and financially since rural hospitals in the States studied are most often partially funded by local sales taxes. As a consequence, understanding the full economic potential of telemedicine is important in understanding the economic benefit of such programs for rural communities.

Whitacre visited hospitals in 24 rural communities across Arkansas, Kansas, Oklahoma, and Texas. Four telemedicine benefits were catalogued: (1) hospital savings resulting from outsourcing specific procedures, (2) transportation savings accruing to patients, (3) income savings resulting from reduction in missed work, and (4) increases in local lab and pharmacy work.

Whitacre found wide variation in the way rural hospitals use teleradiology, teleoncology, and telepsychiatry, the specific telemedicine services analyzed in the study. The biggest benefit noted by hospital staff was in improved turnaround for patients. Cost savings for the hospital were typically not great, though annual cost savings varied significantly. Transportation savings to patients also varied considerably. The estimated transportation cost savings for patients not having to go to a more distant hospital after the initial visit was estimated to range from $2,000 to $110,000 per year per hospital across the 24 hospitals.

Estimated savings to patients who would have missed additional work time had they gone beyond their local hospital ranged from $3,000 to $70,000 for the 24 rural hospitals. Additional pharmacy and lab work that was gained by rural hospitals or their local affiliates was estimated to range from $31,000 to $1.5 million per annum. The cost of not having telemedicine thus was estimated to average $370,000 per annum for the 24 rural hospitals. Communities with larger hospitals (2,000 or more patient encounters per month) would be forgoing over $500,000 per year if telemedicine were not offered.

Distance Education

Education has long been shown to contribute positively to individuals' economic well-being as well as to national economic growth (through labor productivity gains). Education, also a major factor in the well-being of rural America, has been undergoing a transformation because of broadband Internet, with promising economic consequences. The institutional changes taking place between students, parents, faculty, and education administrators are already evident.

School-to-school distance education systems have opened to other provider groups that reach beyond schools or learning centers (Poley, 2008). Learners include students in K-12 and higher education as well as new immigrants, continuing education students, and individuals taking courses for personal development. Providers of distance education include universities, community colleges, private companies, communities, professional organizations, primary and secondary schools, and individuals.

Learners "attend" anytime during the 24-hour day, at work sites, learning centers, and in the home (Poley). Elementary school learners can visit educational sites that were introduced in the classroom, complete research projects (often with the assistance of parents), and check up on assignments while home sick. Their parents also can interact with teachers more freely. Secondary school students can enroll in online Advance Placement courses and other college-prep and college-level courses.

Distance education for post-secondary institutions also saves resources—for schools by reducing overhead and for rural households by reducing travel costs. It enables motivated learners to complete a course of study that might otherwise be incompatible with their work schedules and parental responsibilities (Poley). The promise for rural residents is increased access to educational resources, at lower costs than without distance learning.

The Service Sector in the Internet Economy

Most employment growth in the United States over the last several decades has been in the service sector, a sector especially conducive for broadband applications. Analysis of Bureau of Economic Analysis data shows services making up 50 percent of real private gross domestic product (GDP), 60 percent of personal consumption expenditures, 16 percent of private investment, and 25 percent of total trade in 2007.

As the sector has grown, information technology has increased the sector's productivity and globalized its marketplace. Information technology and the service sector are primary drivers of economic growth (Mann, 2008). As the global economy has grown, so have markets for information technology and services that process or trade through the Internet (Mann, 2006). Information technologies have allowed services to be fragmented between nontraded and tradable segments, such as back-office operations of financial firms, airline reservation offices, and software development for private business.

During the ERS-sponsored workshop on rural broadband in 2008, Mann identified four overarching effects of the Internet on the service sector:

- Greater international division of labor in services or standardization of services,
- Greater supply of intermediate services or fragmentation of services,
- Greater demand for intermediate services or fragmenting of services, and
- Globalization of both the supply and demand for services.

This has led to increasing private service sector exports and imports (table 13), with the United States exporting more services than it imports.

Not all service sector trade is uniformly distributed. Mann (2008) concluded that the trade in services has harmed low-wage service work like call centers and may continue to do so. Codification of work processes, such as in the software industry, also puts some high-wage work at risk of going overseas. Broadband allows rural areas to compete for low- and high-end service jobs, such as software development, but does not guarantee that rural communities will get them.

Telework

Telework is one part of the service sector that could be greatly enhanced by broadband Internet. Might rural communities benefit? Do rural communities have people that would be interested in and able to work online? Are there firms that would be interested in rural sourcing rather than global sourcing some of their services? Morris and Goodridge (2008) addressed this during the ERS workshop. They surveyed businesses across the country and found that approximately 12 percent were engaged in global offshoring of some service support activity, mostly (52 percent) to India.

The major advantages with offshoring cited by businesses were reducing costs, freeing up management time, and offering “24/7” customer access. Disadvantages were increased incidences of customer dissatisfaction and morale problems among domestic employees. The businesses indicated that

Table 13
Trade in private services, 1997-2006

	Exports			Imports		
	1997	2002	2006	1997	2002	2006
Private services ($ million)	83,929	122,207	187,771	43,154	72,604	116,524
	Percent of private services					
Education services	10	10	8	3	4	4
Financial services	15	18	23	14	13	12
Insurance services	3	4	5	14	30	29
Telecommunications	5	3	3	19	6	4

Source: Mann, 2008.

57 percent of customers were dissatisfied with outsourced services and only 15 percent were satisfied. Around three-fourths of these businesses would be interested in bringing back some of the jobs if rural employees could be recruited. The most common reasons cited for bringing back service jobs were increased customer satisfaction (63 percent), favorable government tax incentives (53 percent), and ease of identifying skilled labor in rural America (51 percent).

Morris and Goodridge conducted three surveys in 2006 and 2007, with one drawing on individuals across the entire country. Of rural residents, 37 percent were very interested in working from home to earn additional income, 39 percent were moderately or somewhat interested, and 21 percent were not interested. Homemakers were least likely to be interested in working at home (40 percent), though 30 percent would be interested in working anywhere from 11 to 20 hours a week at home.

Fifty percent of retirees, however, were interested in returning to the workforce, citing flexible schedule, supplemental income, social interaction, and intellectual stimulation as inducements. Fifty-four percent of retirees nationwide stated that they had broadband Internet access; the rate for rural retirees is uncertain, but is likely much lower given our analysis of Current Population Survey data. The relative lack of broadband access in rural communities may inhibit rural telework opportunities for retirees and others.

Broadband Availability Leads to Use

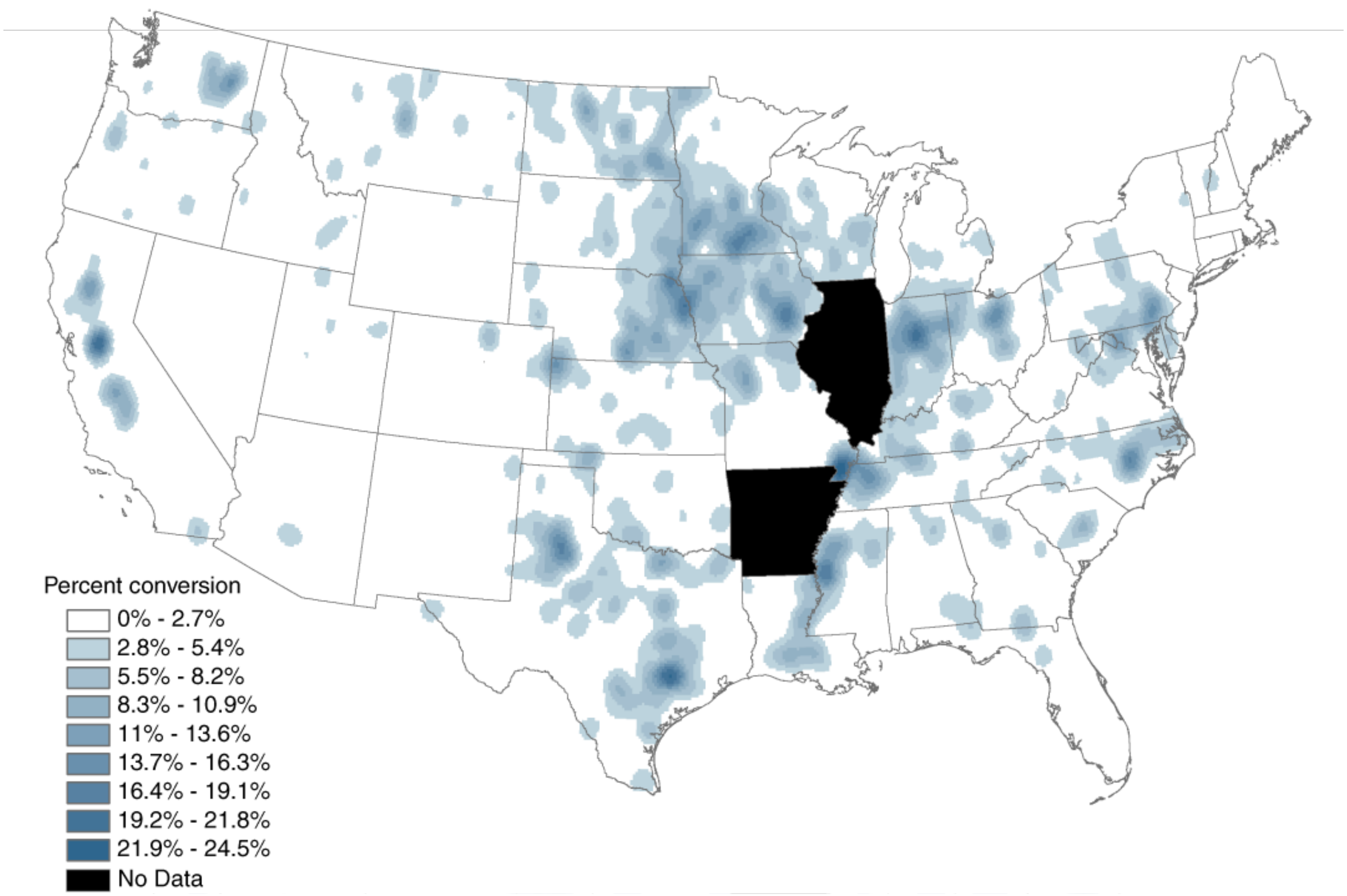
Several questions arise regarding policy intervention in broadband markets. Is there pent-up demand for broadband in areas that are unserved or underserved? Does greater availability beget correspondingly greater use of broadband Internet? When terrestrial broadband (DSL or cable) first becomes available, pent-up demand would be evident if conversion rates to broadband access are higher than in communities that have had terrestrial broadband for some time or are served only by satellite broadband. If the adoption rate is not higher, then broadband may be oversupplied or satellite is sufficient. A higher adoption rate would be another indicator that households do indeed value the Internet and broadband's advantages over the dial-up alternative.

Broadband Adoption on the Farm

The paucity of national geographically specific data presents a challenge in trying to analyze whether availability leads to broadband adoption. Data from USDA's June Agricultural Surveys provide a unique opportunity to examine geographically specific rural changes in Internet access methods (see Appendix B for a discussion of the June Agricultural Surveys). Figure 10 shows the conversion to broadband Internet access by farms across the

Figure 10

Conversion to broadband use among U.S. farms, 2005-07



Source: ERS, using June Agricultural Survey data from USDA's National Agricultural Statistics Service.

country between 2005 and 2007. Unfortunately, a change in area identifiers did not allow us to match data for Illinois and Arkansas; hence, these States are omitted from the map and our analysis. By conversion we mean farms that did not already have broadband Internet access converted to broadband Internet access; farms may or may not have had dial-up Internet access.

The data presented in figure 10 show sharp differences in conversion rates across the country. When cross-referenced with the FCC broadband availability data (as estimated for likelihood for specific farm locations in December 2004 and December 2006, see Appendix C), our analysis of farm use of broadband supports the hypothesis that people embrace terrestrial broadband when given the option. Roughly 24 percent of all farms using the Internet in 2005 already had broadband Internet access of some type, and so could not convert. Conversions were nearly nonexistent in areas where broadband was available mostly via satellite.

Farms were unlikely to make the direct jump from no Internet use to broadband Internet access; farms that already had dial-up Internet access were more likely to acquire broadband Internet access. DSL service was the most common broadband Internet access option among farms, whereas cable and fiber optics have shown the largest gains in highly urbanized areas over the last few years. The preponderance of DSL service for farms indicates both the rural location of most farms and Internet users finding satellite a less desirable option.

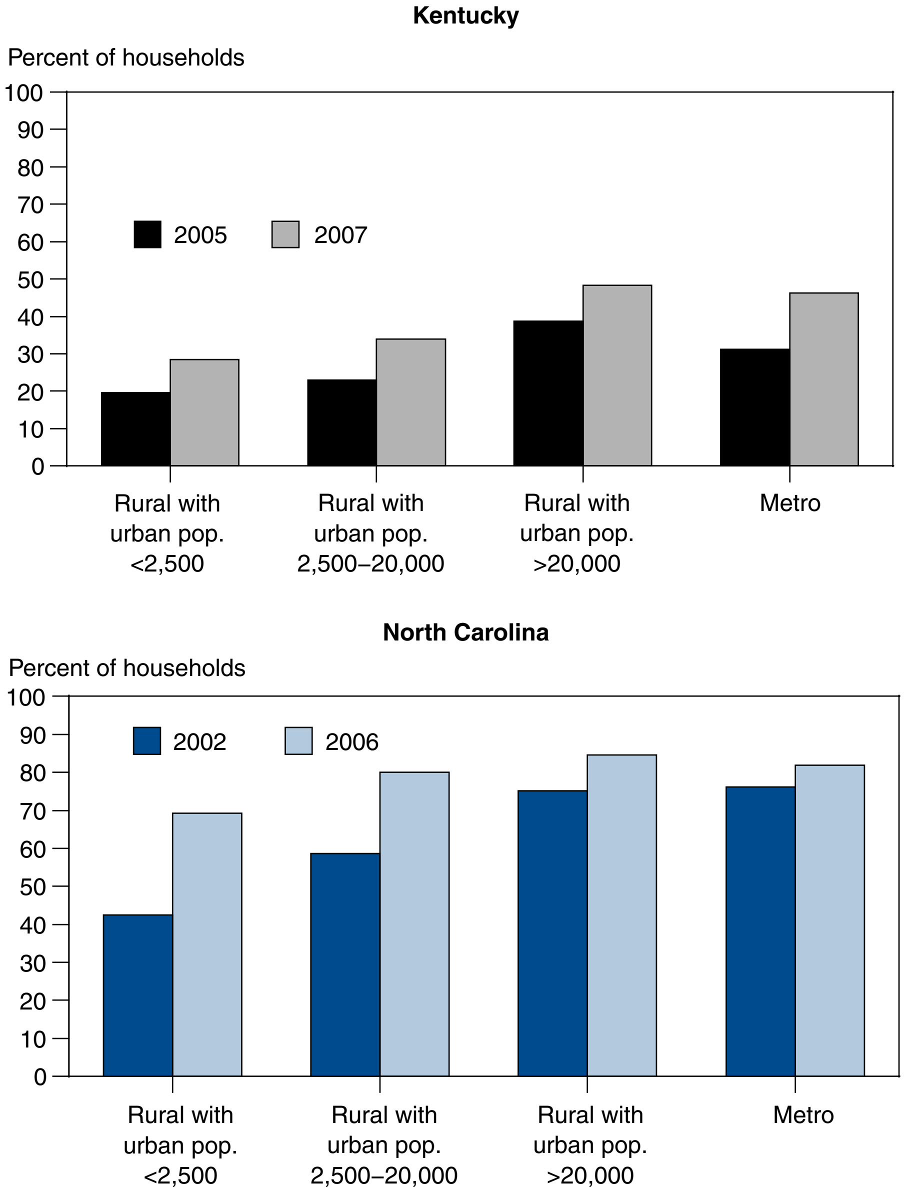
Rural Broadband Availability and Adoption

Some States collect data on broadband availability, enabling a more refined analysis of broadband deployment and adoption. Renkow (2008) examined broadband availability and adoption in two such States—Kentucky and North Carolina. Kentucky had both broadband availability and adoption data. North Carolina had broadband adoption data only. Broadband availability and adoption increased substantially during the last several years, with the largest proportional gains occurring in counties that had been the least well-served at the beginning of the period, typically rural counties. North Carolina had higher rates of adoption by all households than Kentucky (fig. 11).

Renkow found that population density was more important than income in driving broadband deployment. The relative insensitivity of local income to patterns of broadband deployment may indicate that broadband providers perceive demand as being highly income inelastic. If so, cost of physical infrastructure would be the primary consideration in extending capacity into unserved or underserved areas.

The growth of broadband availability even in the most sparsely populated counties, however, is striking. More than three-quarters of households in all but 8 of Kentucky's 120 counties had broadband available to them by 2007. Seven of these eight counties were the least densely populated counties in the State. Interestingly, county adjacency to major urban areas was not related to broadband provision, as within-region clustering seems common. In addition, Renkow found evidence to suggest that the broadband loan program administered by USDA's Rural Development Utilities Programs stimulated broadband deployment in rural areas.

Figure 11
Residential broadband adoption in Kentucky and North Carolina



Source: Renkow, 2008.

Broadband Internet Use and Rural Businesses

One of the salient features of the Internet is its capacity to provide information quickly and cheaply compared to other dissemination methods (Henderson et al., 2000). Wider and more convenient access may reduce the costs of communicating, transacting, and sourcing information. With improved information and knowledge, individuals' perception of products and services provided would be more accurate, thereby improving the adoption of worthwhile technologies and discarding those that have little value (Hooker et al., 2001; Just and Just, 2001). As a result, Internet use may lead to greater efficiency in the agricultural and other rural business sectors (Borenstein and Saloner, 2001; Gloy and Akridge, 2000; Greenstein and Prince, 2006).

Crandall (2008) pointed out during the ERS workshop that the effect of information and communications technology (ICT) on productivity growth is clear. Overall U.S. labor productivity growth from 1995 to 2000 was 2.5 percent per year, with an estimated 30 percent of it ascribed to ICT-producing and 56 percent due to ICT-consuming sectors of the economy (Fuss and Waverman, 2005). Measuring broadband Internet's contribution to this, however, is challenging due to data limitations and the problems of separating out overlapping causal effects (Crandall). As a consequence, empirical studies directly linking broadband to regional productivity growth are largely nonexistent.

Crandall and some of his colleagues, however, studied the effect of broadband on output and job growth. In their attempt to establish a relationship between State gross domestic product (GDP) or job growth and broadband deployment, they conducted a cross-section regression analysis on variables capturing local economic characteristics (unionization, business tax, education, wage rates), quality-of-life characteristics (climate, mean temperature), and broadband lines per capita. They found that total nonfarm employment growth was significantly related to broadband lines per capita. The results for GDP were not statistically significant. The strongest effects of broadband Internet on employment growth were in finance and insurance, real estate, and education services. The results largely supported an earlier study by Gillett et al. (2006).

Rural Businesses and Broadband

Pociask (2005) found evidence that rural small businesses did not use broadband as much as their urban counterparts. He attributed the lower usage to fewer employees, on average, in rural businesses and higher prices for rural broadband service. Socioeconomic characteristics—such as rural-urban differences in age, education, and affluence—may also play a role (Pociask, 2005; Stenberg, 2000). But what does this gap in broadband adoption mean for rural businesses?

Lamie et al. (2008) in their ERS workshop paper examined rural small business adoption of e-commerce practices. The rural businesses in their study were primarily manufacturing and retailing firms that fell into one of a number of e-commerce classifications: traditional local businesses that increased their market ranges and sales through e-commerce, virtual businesses (all marketing and sales conducted through e-commerce), businesses that used e-commerce primarily to reduce marketing inputs and costs, and businesses that used e-commerce primarily for business-to-business (B2B) or business-to-consumer (B2C) transactions.

Most businesses in their study used e-commerce because it provided an opportunity for increased profits and enhanced sustainability. E-commerce may benefit a firm in product development, inventory management, manufacturing, marketing and sales, and customer service. The 28 rural businesses in the case study had varied experiences in the application of e-commerce. Most felt that e-commerce activities benefited their operations. Economic returns from their e-commerce activities were enhanced if the business served a niche market, took advantage of public and private IT service providers in the maintenance of their e-commerce operation, and integrated e-commerce into multiple aspects of the business operation.

Rural Retailers and Broadband

Retailers are a particularly important type of rural business. They are present in nearly every community, are often major local employers, and often serve as a social hub. In their workshop presentation, Stoel and Ernst (2008) examined the attitudes and beliefs of rural retail business owners (specifically apparel, hardware, and grocery) that may act as impediments to accepting the Internet in their businesses. Included were owners' attitudes toward use of the Internet in their business, the perceived ease of use, and the Internet's usefulness in operational efficiency, strategic positioning, and other applications.

In their survey of 181 retail business owners, Stoel and Ernst found that retail store owners that used the Internet were less enamored of the Internet than nonusers, perhaps due to a fuller realization of some of its shortcomings or to a begrudging compliance with suppliers' demand that they use it. Broadband Internet access, however, did appear to facilitate using the Internet for operational effectiveness and business strategic positioning. Rural broadband users seemed to capitalize on the Internet's capacity to increase operational effectiveness and exploit market niches. Broadband users perceive the Internet to be easier to use than non-broadband users (which may say something about slow-speed toleration in business Internet operations).

Ernst and Stoel (2008), in a more thorough survey of rural grocers, found that these retailers felt that they had to be more price competitive because consumers received more information and explored more options via the Internet. As a result, businesses were expanding their markets and commercial business was moving faster. Rural grocers did not believe that e-commerce reduced their profits or threatened their existence. Rather, customers were more familiar with their business because of the Internet.

Farm Businesses and Broadband

Agriculture is another rural business sector that benefits from the Internet. For farm operators with Internet access in 2000, 98 percent used it to gather information. Price tracking (82 percent) was the next most common application (Hopkins and Morehart, 2001).

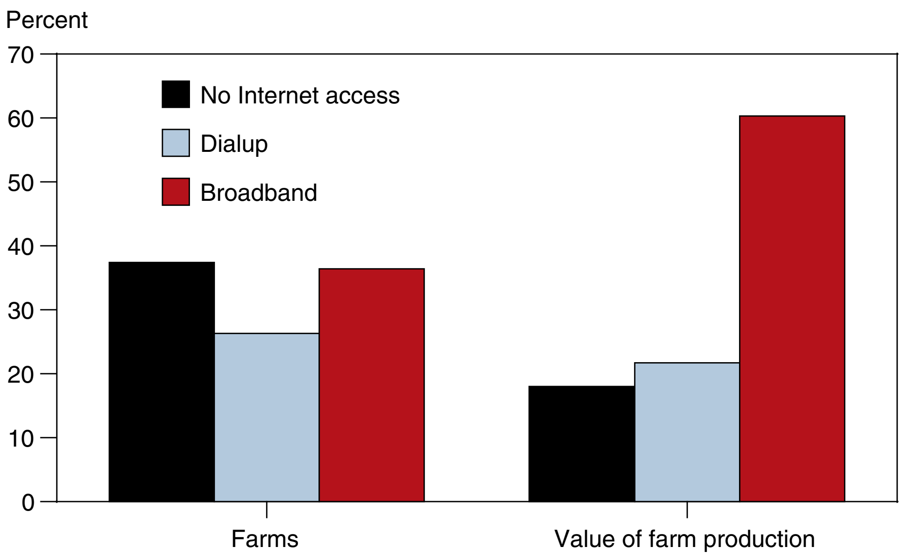
With growth in e-commerce, horticulture and other specialty farm products are increasingly sold direct to households. E-commerce has increased efficiencies in existing relationships along the food marketing chain, reduced the cost of expanding market area, and brought about new services such as supermarket home delivery and direct-to-consumer sales (Kinsey and Buhr, 2003).

Not all types of agricultural production lend themselves readily toward direct sales from producer to consumer. Still, the wholesale and retail food industry has enhanced its productivity with Internet adoption (Akridge, 2003; Beurskens, 2003; Henderson et al., 2000; Stricker et al., 2003; Zilberman et al., 2002).

Respondents to the 2007 Agricultural Resources Management Survey (ARMS) were asked if they had Internet access and if it was “high-speed.” A majority of farms (63 percent) reported using the Internet in their farm business (fig. 12). Among those using the Internet, the predominant access method was broadband and this group of users accounted for over 60 percent of U.S. farm production. This is consistent with other estimates of farm broadband use. USDA’s National Agricultural Statistics Service (NASS) reported that, for the first time in 2007, the majority of farm Internet users were connecting with broadband Internet technologies (USDA/NASS, 2007).

Prior research has identified several demographic and socioeconomic attributes that have consistently distinguished those who use the Internet from those who do not (Forman, 2005; Stenberg, 2006; Stenberg and Morehart, 2007). These include income, education, age, and number of children. In our analysis of the determinants of broadband Internet use among farm households, we include household income, education level attained by the farm operator, age of the farm operator, off-farm work by spouse, presence of school-age children, number of hired farmworkers, rural-urban farm location, county net migration, and number of local broadband providers.

Figure 12
Distribution of farms and value of farm production by Internet use, 2007



Source: ERS analysis of 2007 ARMS (USDA, NASS and ERS).

Income has consistently been cited as a primary factor determining Internet use (Stenberg, 2006). The greater the income level, the more likely that work is highly skilled. In addition, the more highly skilled the work, the more likely that computer technologies and the Internet are part of the work environment. As household income increases, regardless of location, the likelihood of Internet use increases (Stenberg, 2000).

Educational attainment has long been recognized as a determinant in income level (Becker, 1964). The prevalence of the Internet and computer technologies in educational institutions provides additional exposure and experience as years of formal education increase. Consequently, the greater an individual's education, the greater the likelihood of Internet use at home or in the workplace (Stenberg, 2006).

Many (Oden and Strover, 2002; Grant and Meadows, 2002; Stenberg and Morehart, 2007) have cited age as a factor in determining the likelihood of Internet use. The literature suggests that older individuals are reticent about adopting the Internet, while the young readily adopt. The average age of farm operators claiming no Internet use in 2007 was 62, compared with 54 for those who accessed the Internet using broadband (table 14).

Only about a third of spouses on farms with no Internet use reported working off-farm, compared to more than 50 percent on farms that used the Internet. On the one hand, off-farm employment may provide more income and exposure to Internet technologies, instigating home or farm adoption. On the other hand, a spouse who works off the farm may indicate financial stress and lesser wherewithal to invest in farm-specific Internet use. Households with school-age children are expected to have a higher awareness of the Internet and more demand for bandwidth-intensive applications (Grant and Meadows, 2002). In keeping with this, the percentage of farms with school-age children was nearly two times higher in 2007 when Internet use was reported than when it was not (table 14).

We hypothesize that the greater the size and complexity of the farm business, as evidenced by the number of hired farmworkers, the more likely the farm is using broadband to access the Internet. Farms with broadband Internet access had twice the number of farmworkers, on average, as farms with no Internet access. Broadband use is also expected to be higher in ZIP Code areas with more providers, as competition for customers likely lowers the price differential between broadband and dial-up. The mean number of providers, however, showed little variation across Internet use categories (table 14) reflecting the predominantly rural location of farm operations.

Maximum-likelihood methods were used to estimate a multinomial logit model that estimates the relationship between farm household socioeconomic characteristics and the type of Internet connection used. For the most part, coefficient signs and variable significance are consistent with expectations (table 15). The model fit—as indicated by the McFadden r-squared value of 0.089—is somewhat poor, even for a cross-sectional analysis. The coefficients represent the log-odds of a farm household using dial-up or broadband Internet access, relative to the base class (no Internet use by the farm). That is, what is the chance that, instead of not using the Internet at home, the household has an in-home dial-up or broadband Internet connection? These

Table 14
Weighted means and (standard errors) for selected variables, 2007

Variable	Name	Internet use: No Internet	Internet use: Dial-up	Internet use: Broadband	All family farms 1997
Continuous variables:					
Operator age	OP_AGE	61.90	55.15	53.85	57.20
		(0.45)	(0.34)	(0.38)	(0.20)
No. broadband providers	NOPROVIDERS06	6.80	6.71	6.83	6.79
		(0.09)	(0.09)	(0.09)	(0.05)
Household income	TOTHHI	61,614	77,831	121,141	87,523
		(3,912.25)	(2,396.71)	(5,286.60)	(2,548.60)
No. farmworkers	NOWORKERS	0.42	0.63	0.98	0.68
		(0.04)	(0.03)	(0.03)	(0.01)
Dummy variables:					
Population change	MIGCLS	0.58	0.60	0.56	0.58
		(0.01)	(0.01)	(0.01)	(0.01)
Children	CHILD	0.24	0.40	0.42	0.35
		(0.01)	(0.02)	(0.02)	(0.01)
Spouse working off-farm	SPOFF	0.34	0.52	0.51	0.45
		(0.01)	(0.02)	(0.02)	(0.01)
College education	COLLEGE	0.12	0.22	0.36	0.23
		(0.01)	(0.01)	(0.02)	(0.01)
Urban	RURAL	0.21	0.21	0.25	0.22
		(0.01)	(0.01)	(0.02)	(0.01)
Not urban or rural		0.61	0.64	0.60	0.61
		(0.01)	(0.01)	(0.02)	(0.01)
Rural		0.18	0.14	0.15	0.17
		(0.01)	(0.01)	(0.01)	(0.01)

Source: ERS using FCC and 2007 ARMS (USDA, NASS and ERS).

are not the odds of using dial-up or broadband, only the odds relative to not being connected to the Internet at all. The sign of the coefficient gives the direction of the relationship: increase or decrease in probability due to the predictor. For example, as the age of the farm operator increases, the probability of having dial-up or broadband Internet access relative to no Internet access declines, as indicated by the negative and significant coefficients. (More discussion on the underlying methodology of this analysis is presented in Appendix D.)

Other significant model results include:

- Larger farm businesses, as indicated by more hired workers, have a higher probability of broadband Internet access.
- Farm households with income above $50,000 have a higher probability of broadband Internet access.
- The relative probability of broadband Internet use does not increase as the number of providers in an area increases.

Table 15
Multinomial logistic regression results

Variable	Dial-up	Broadband	Dial-up	Broadband	Dial-up	Broadband
	Estimate	*Estimate*	*Std.Err*	*Std.Err*	*T value*	*T value*
(Intercept)	-0.77	-0.57	0.07	0.09	-11.26**	-6.27**
OP_AGE	-50.75	-65.10	9.08	10.49	-5.59**	-6.21**
$(OP\_AGE)^2$	-27.76	-32.38	6.75	6.99	-4.13**	-4.64**
NOWORKERS	0.08	0.15	0.03	0.03	3.32**	5.18**
TOTHHI above 50k	0.27	0.44	0.07	0.06	4.01**	8.03**
NOPROVIDERS06	-11.45	-12.88	5.69	6.52	-2.01*	-1.97*
$(NOPROVIDERS06)^2$	-12.22	-5.32	4.98	6.69	-2.45**	-0.08
MIGCLS	0.11	-0.02	0.09	0.08	1.20	-0.26
CHILD	0.17	0.29	0.09	0.12	2.10*	2.52*
SPOFF	0.29	0.12	0.10	0.12	2.93**	1.03
COLLEGE	0.70	1.34	0.11	0.11	5.89**	11.96**
Not urban or rural	-0.24	-0.38	0.12	0.10	-1.96*	-3.60**
Rural	-0.09	0.10	0.06	0.06	-1.39	1.61

LR = 380954.54; AIC = 3905755.62; McFadden R^2 = 0.089; McFadden Adj R^2 = 0.089.
Note: ** - significant at 0.01, *- significant at 0.05. Equations simultaneously estimated.
Source: ERS using FCC and 2007 ARMS (USDA, NASS and ERS).

- Having school-age children in the household is associated with higher probability of broadband Internet use.
- Operators with at least a college degree are more likely to use broadband.
- Farms located in mixed urban/rural areas are less likely to use broadband than those in urban areas.

The model's results suggest that household characteristics such as age, education, presence of children, and household income are significant factors in adopting broadband Internet use. Farm business complexity, as measured by the number of farmworkers, was also related to the use of the Internet and broadband Internet access. Distance from urban centers was not a factor in Internet use. Our proxy for county economic well-being—population migration—was not significant and may be indicative of cross currents that are present; counties under economic distress may invest in broadband to help mitigate the distress, or may not have the economic wherewithal for broadband investment.

The relationship between Internet/broadband use and farm location is less clear. Farms in mixed urban-rural areas were less likely to use dial-up or broadband Internet. This may be a result of cost or availability of service. More isolated farms, as measured by the rurality of the county, had mixed, though not significant, results. These results warrant further analysis.

Farm-Rural Linkages in the Internet Economy

The Internet may change the economic relationship between farms and their local economies. Using data drawn from the 2004 ARMS, we investigate how Internet use affects the geography of farm input purchases.

Conceptually, farmers may choose to (1) purchase inputs in the nearest local town, (2) bypass the nearest local town but purchase inputs within the market reach of the nearest farm service center, or (3) bypass the farm service center altogether. Purchasing patterns are examined for three broad categories of resource inputs: farm inputs (feed, seed, and fertilizer), farm machinery and equipment, and farm credit. Comparing input purchases in each of these three mutually exclusive categories allows us to observe the changing nature of farm/local area interrelationships and the use of the Internet. We present results using logistic regression from one of these models in table 16.

Our results suggest that the market reach of the nearest town may no longer define what the farm operator perceives as local. Making farm purchases over the Internet is the strongest factor increasing the likelihood of the operator bypassing the nearest town and even the more distant farm service center (table 16).

As farm operators increase their participation in e-commerce, their relationships with local suppliers are likely to weaken. Farm operators may increasingly opt for distant suppliers to secure lower prices or better access to niche inputs. Suppliers with an established Internet presence, including local ones, would appear better positioned to retain customers within the local economy.

Table 16

Logistic regression results[1]

Choice variable: Bypass the nearest town?	Type of purchase		
	Farm inputs	Farm equipment	Farm credit
		Odds ratios	
Farm level variables:			
Log (gross farm sales)	1.1258***	1.1223***	1.1938***
Operator's years experience	1.0063	1.0192***	.9964
Years of education	1.0710**	1.0675*	1.0244
Internet farm purchase	2.0649***	2.0148***	1.5553*
County-level variables:			
No. of farm inputs merchants	.9360***		
No. of farm equipment dealers		.9303**	
Remote county	.7456*	.7417*	1.0081
Log (highway miles)	1.3623***	1.0956	1.2733**
Log (population density)	1.1720**	1.1713*	1.0674
Log (per capita income)	1.2686	1.0424	1.4158
		Model statistics	
No. of observations	2,793	2,793	2,793
Log pseudolikelihood	-1,861.19	-1,620.98	-1,817.38
Wald 2	44.33	41.48	45.88
Prob > 2	0.0000	0.0000	0.0000
Pseudo R2	.0386	.0388	.0343

[1] *Odds ratio*$_i$ = exp ($\hat{\beta}_i$). Significance level of the coefficient estimates ($\hat{\beta}_i$):* p<.1; ** p<.05; *** p<.01.
Source: ERS analysis of 2004 ARMS data (USDA's NASS and ERS) and other data.

Conclusion

The Internet, and more specifically broadband Internet, has become an integral part of the broader economy. Since the digital or information economy incorporates computer processes, telephony, information storage and use, hardware, and software, however, it is challenging to separate out the Internet's contribution to economic growth and well-being. In fact, the Internet's economic contribution has more than occasionally been estimated using the residual in economic growth not otherwise explained.

Rural communities are invested in the digital economy, though equal access across the rural-urban landscape is questionable. Rural and farm households are almost as likely as urban households to use the Internet, but are less likely to use broadband. Rural businesses are less likely than urban businesses to use the Internet. Broadband access is less prevalent in rural areas than in more densely populated areas, and analysis of CPS data suggests that lower broadband use in rural areas may be involuntary.

Broadband provision follows a geographical pattern strongly tied to population size and the urban-rural hierarchy. Lack of broadband is most strongly associated with low population size in the area. Low broadband provision also exhibits very strong regional patterns that reflect differences in urban concentration and topography.

Broadband users use the Internet more intensively than dial-up users and now outnumber dial-up users. The high adoption rate of broadband technologies by urban Internet users indicates that people value what the Internet has to offer. Rural Internet users have less in-home broadband access, and this is likely due to its higher cost and limited availability in rural settings. Government policies to encourage deployment of broadband services in rural areas have increased availability and in some cases encouraged competitive pricing. Unfortunately, there are little national data that link Internet access choice with the cost of service. As a result, it is difficult to distinguish between financial and other motives when examining broadband adoption. Nonetheless, by using the Internet more intensively, on more activities, using newer (and presumably better) technologies, and bringing the Internet into their homes, schools, and workplaces, society has clearly indicated that it values Internet access.

More activities are shifting to the Internet. Some of these activities have great potential value for the rural economy. Education programs and offerings—primary, secondary, higher education, and continuing education—have become richer on the Internet. Telework is becoming a more practical option for workers and businesses. Some medical services may lend themselves readily to the Internet environment, with potential cost savings for rural residents and medical clinics that offer in-situ services not otherwise readily available in rural settings. Rural businesses are adopting more e-commerce and Internet practices, enhancing economic vitality and expanding market reach. Individuals are using the Internet to get involved with their communities.

Analysis of farm businesses indicates that household characteristics such as age, education, presence of children, and household income are significant factors in adopting broadband Internet use. Distance from urban centers was not a factor in Internet access. Larger farm businesses are more apt to use broadband in managing their operation; the more multifaceted the farm business, the more the farm uses the Internet.

Analysis suggests that rural economies benefit generally from broadband Internet availability. In comparing counties that had broadband access relatively early (by 2000) with similarly situated counties that had little or no broadband access as of 2000, employment growth was higher and nonfarm private earnings greater in counties with a longer history of broadband availability.

Government policies that encourage deployment of broadband services have broadened their availability in rural America. The 2008 Farm Act (Food, Conservation, and Energy Act of 2008) reauthorized USDA's telemedicine, distance learning, and rural broadband access grant and loan programs. The American Recovery and Reinvestment Act of 2009 provided $2.5 billion to USDA for loans and grants to increase broadband provision in rural areas. As much as these funds address the needs of unserved and underserved communities, rural broadband availability will increase.

More research is needed in many areas to better understand broadband and rural economies. Better information on broadband availability, use, cost, and technical characteristics is needed to gain a better understanding of broadband Internet's potential effect on rural economies. Broadband availability data are only now being collected below the ZIP Code area; the more geographically granular the data the better our understanding will become on unserved and underserved areas. Price data are largely unavailable, hindering economic analysis of supply and demand of the regional broadband market.

Detailed broadband Internet use data also have not been collected since 2003. Our understanding of broadband users' online behavior is limited. For example, we know certain Internet-based education activities are taking place, but the extent to which Internet practices are taking place in rural education systems (in either the school or at home) is still unclear.

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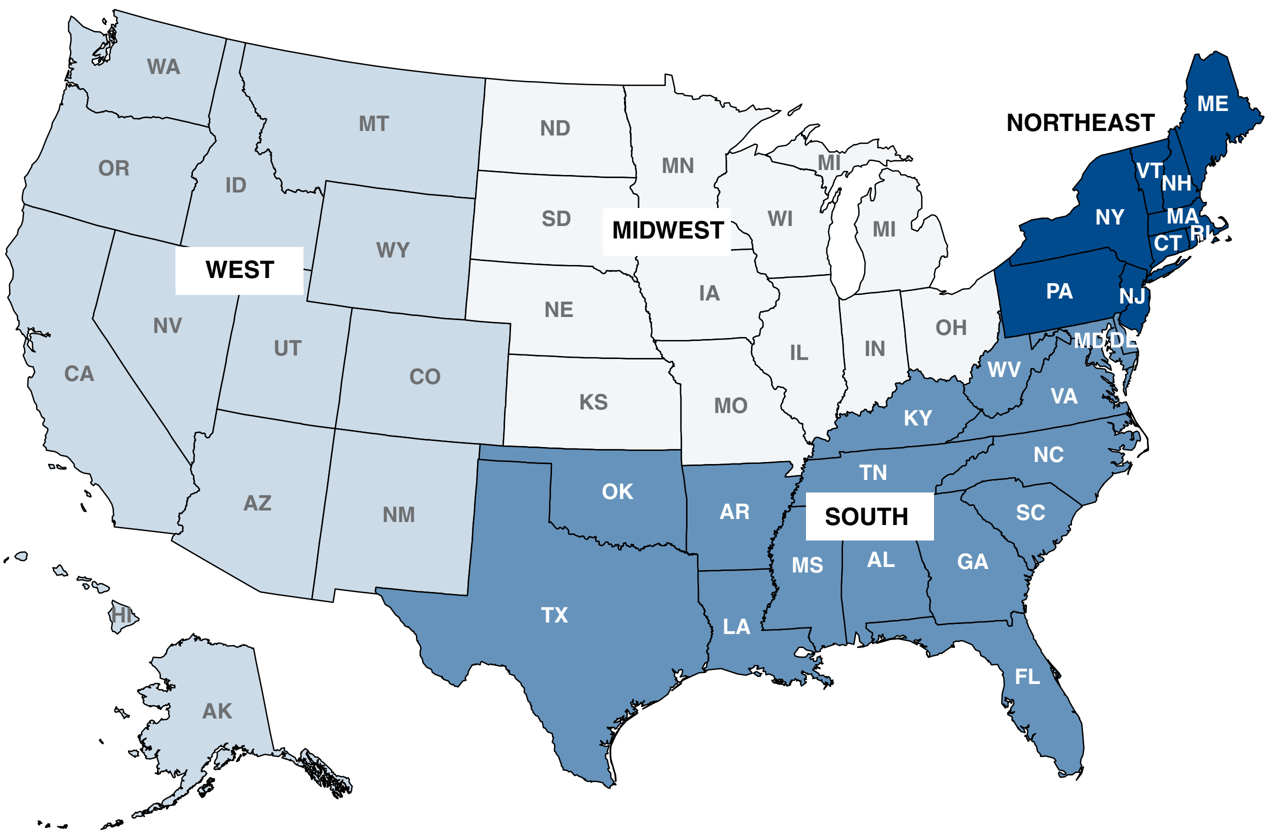
Appendix A: Bureau of the Census Regions

Figure A-1

Bureau of the Census Regions



Appendix B: Data Used in the Study

Agricultural Resources Management Survey

Most of the farm-level data used in the analysis are from the 2007 Agricultural Resources Management Survey (ARMS), conducted annually by USDA's Economic Research Service and National Agricultural Statistics Service. The survey collects information needed to measure the financial condition (farm income, expenses, assets, and debts) and operating characteristics of farm businesses, the cost of producing agricultural commodities, and the well-being of farm operator households. The target population of the survey is operators of farm businesses representing agricultural production in the 48 contiguous States. A farm is defined as an establishment that sold or normally would have sold at least $1,000 of agricultural products during the year. Farms can be organized as proprietorships, partnerships, family corporations, nonfamily corporations, or cooperatives. Data are collected from one operator per farm, the senior farm operator. A senior farm operator is the operator who makes most of the day-to-day management decisions. For this study, operator households organized as nonfamily corporations or cooperatives and farms run by hired managers are excluded.

June Agricultural Survey Data

The June Agricultural Survey is conducted by USDA's National Agricultural Statistics Service every year to provide estimates of farm numbers and land in farms, crop acres planted, grains and oilseeds in storage, livestock inventories, and land values. In 1997, 1999, 2001, 2003, 2005, and 2007, the surveys included questions about Internet access. In 2005 and 2007, the questions addressed broadband Internet access. The 2007 computer usage estimates are based on responses from over 31,400 agricultural operations and represent all sizes and types of farms.

Federal Communications Commission Form-477 Data

The Federal Communications Commission collects data from Internet service providers twice annually: in June and December. The data have been collected since December 1999 through what is called the FCC Form-477. The data collected include number of lines, various company characteristics, and most importantly where broadband is currently provided. Initially, very small providers were not required to file the form, but eventually all providers were required to return the form to the FCC every 6 months. On the form, a company specifies each ZIP Code in which it has customers. Recently, the FCC has started to collect more detailed information on type of broadband service and location of broadband service provision.

PEW Surveys

PEW data are collected by Princeton Survey Research Associates. Sample sizes for each survey are around 2,500, with total sampling error of +/-2 percent and sampling error of +/-3 percent for Internet users. Data were collected from various surveys and reports available from PEW Internet & American Life Project's website (http://www.pewinternet.org/index.asp). Urban, as defined by the U.S. Census Bureau, includes any population concentration of 2,500 or more people.

Current Population Survey

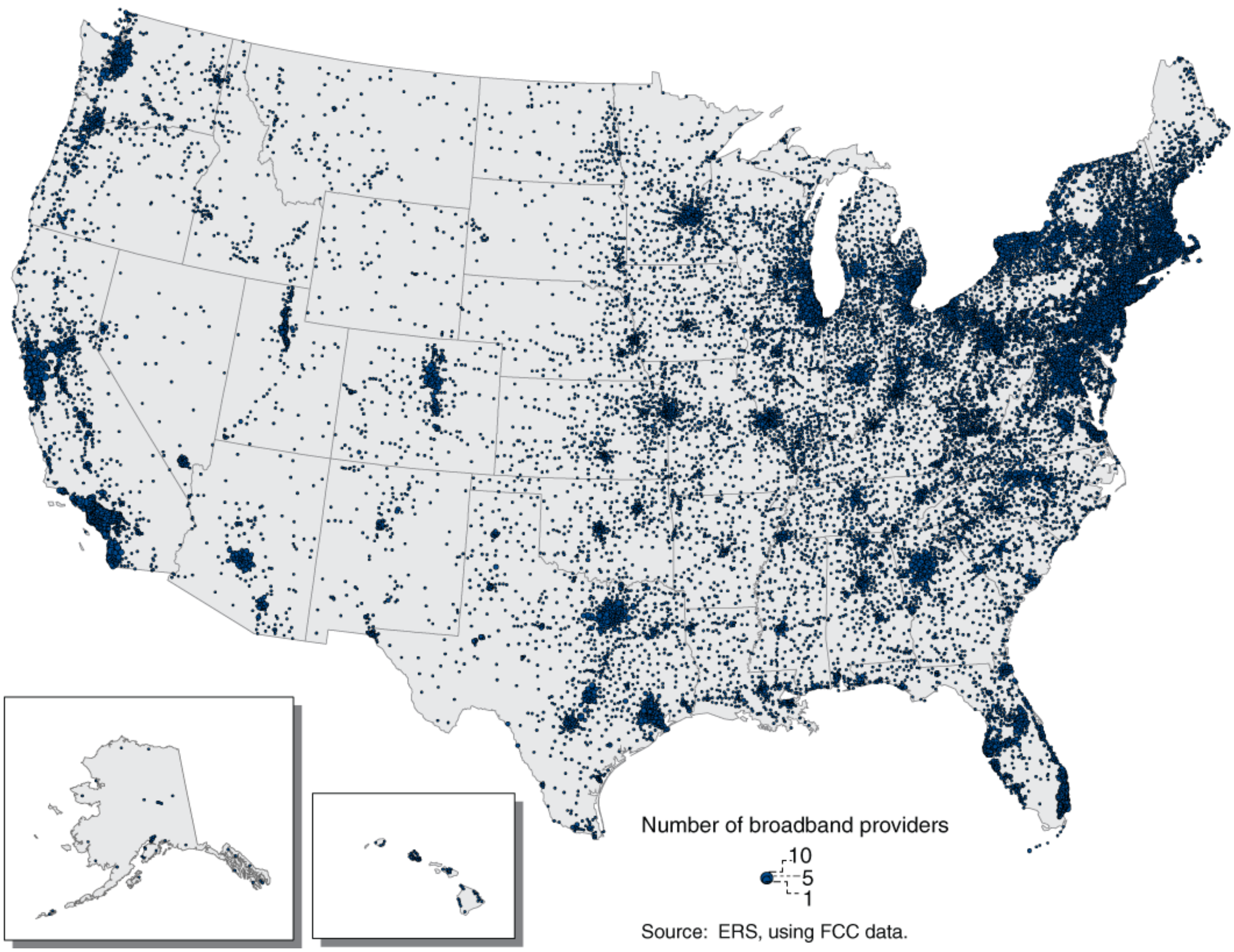
The U.S. Census Bureau conducts monthly Current Population Surveys. The surveys constitute 57,000 households containing 134,000 persons. On an irregular basis, the Bureau's monthly survey includes questions on Internet and related technologies. These special surveys provide broad-based and statistically reliable information on the ways that information technologies, in general, and broadband more specifically are transforming the way we live, work, and learn. As of this writing, the last survey on information technology took place in October 2007, but only asked four Internet-related questions, whereas an October 2003 survey asked detailed questions on what, where, and how the Internet was used. Estimation conducted in this report had a sampling error no greater than +/-2 percent. Urban, as defined by the U.S. Census Bureau, includes any population concentration of 2,500 or more people.

Appendix C: Using the FCC Data

Broadband Availability Over Time

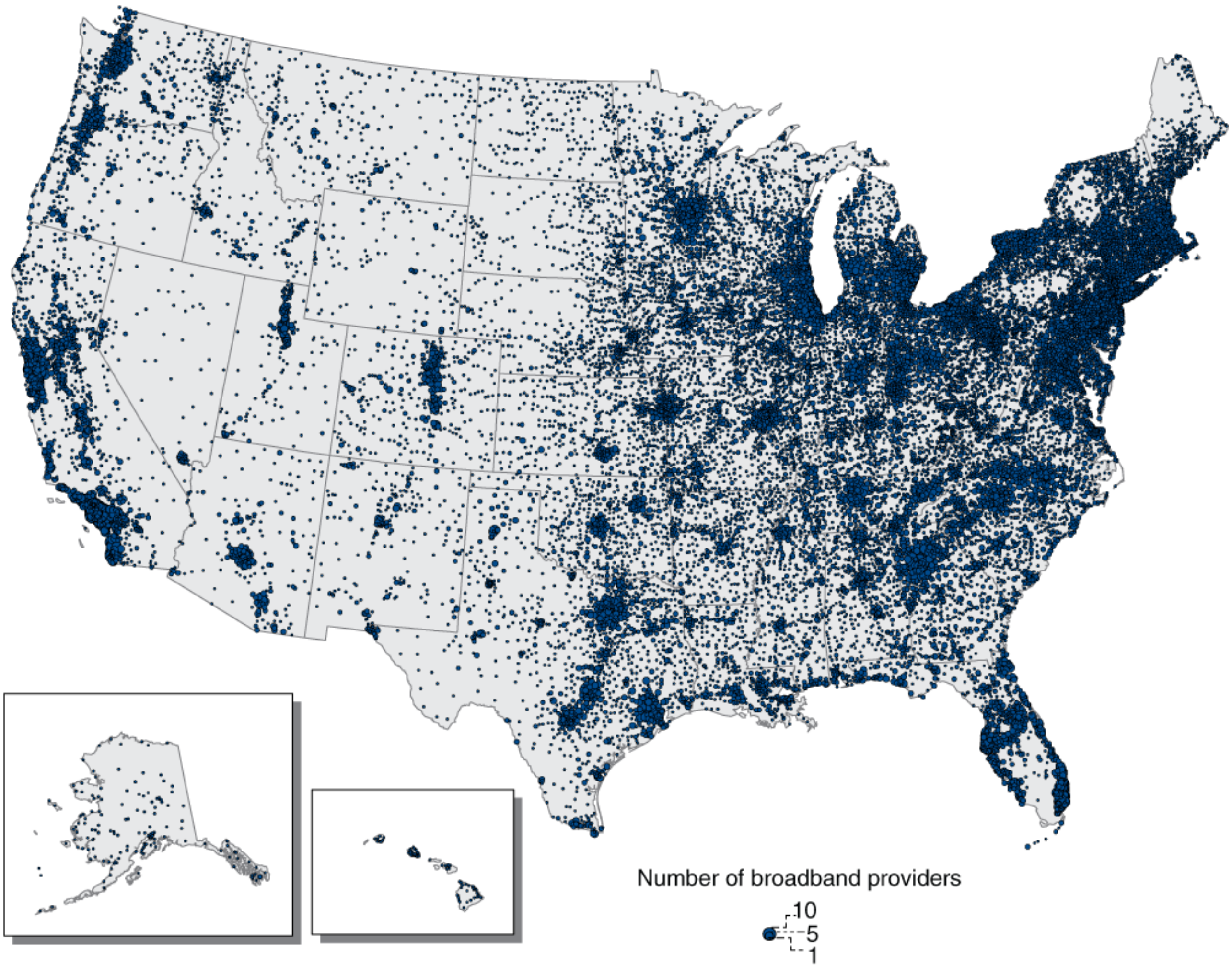
The growth in broadband availability has been rapid. This can be seen in the following maps (fig. C-1 - C-4) developed from the FCC data that show broadband availability from December 2000 through December 2006. Each dot in the maps represents a ZIP Code area that has at least one provider. The dots are located at the population center for their corresponding ZIP Codes. Dots are used to represent broadband availability as rural broadband service most commonly radiates out from towns into the surrounding countryside. These maps give a contrasting view of broadband availability from the isopleth map (fig. 6, p. 16) shown in the main body of this report. Some persistent wilderness areas and the development of broadband service along arterial roadways become apparent in the dot maps over time (from 2000 to 2006).

Figure C-1
Number of high-speed service providers by ZIP Code, 2000



Source: ERS, using FCC data.

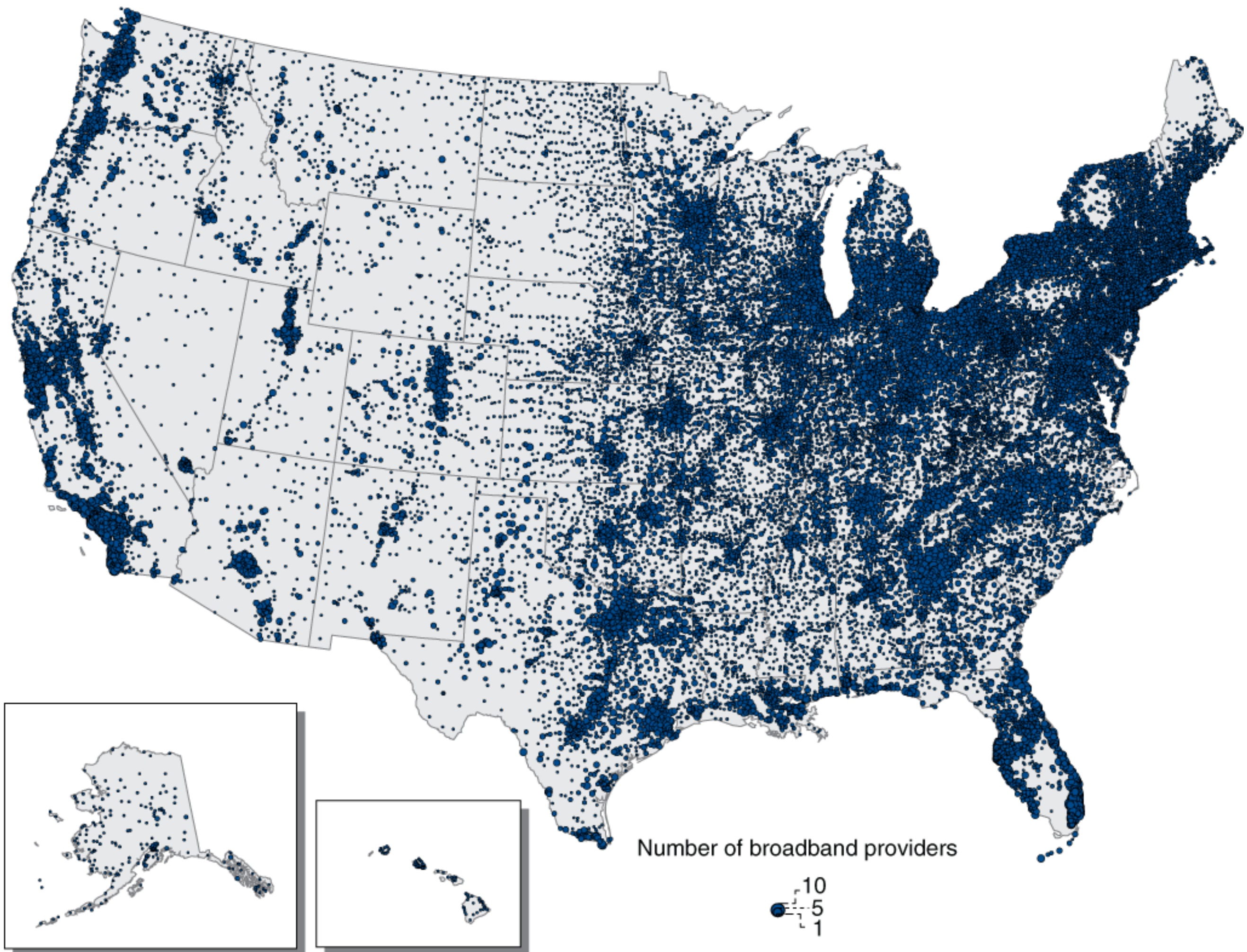
Figure C-2
Number of high-speed service providers by ZIP Code, 2002



Source: ERS, using FCC data.

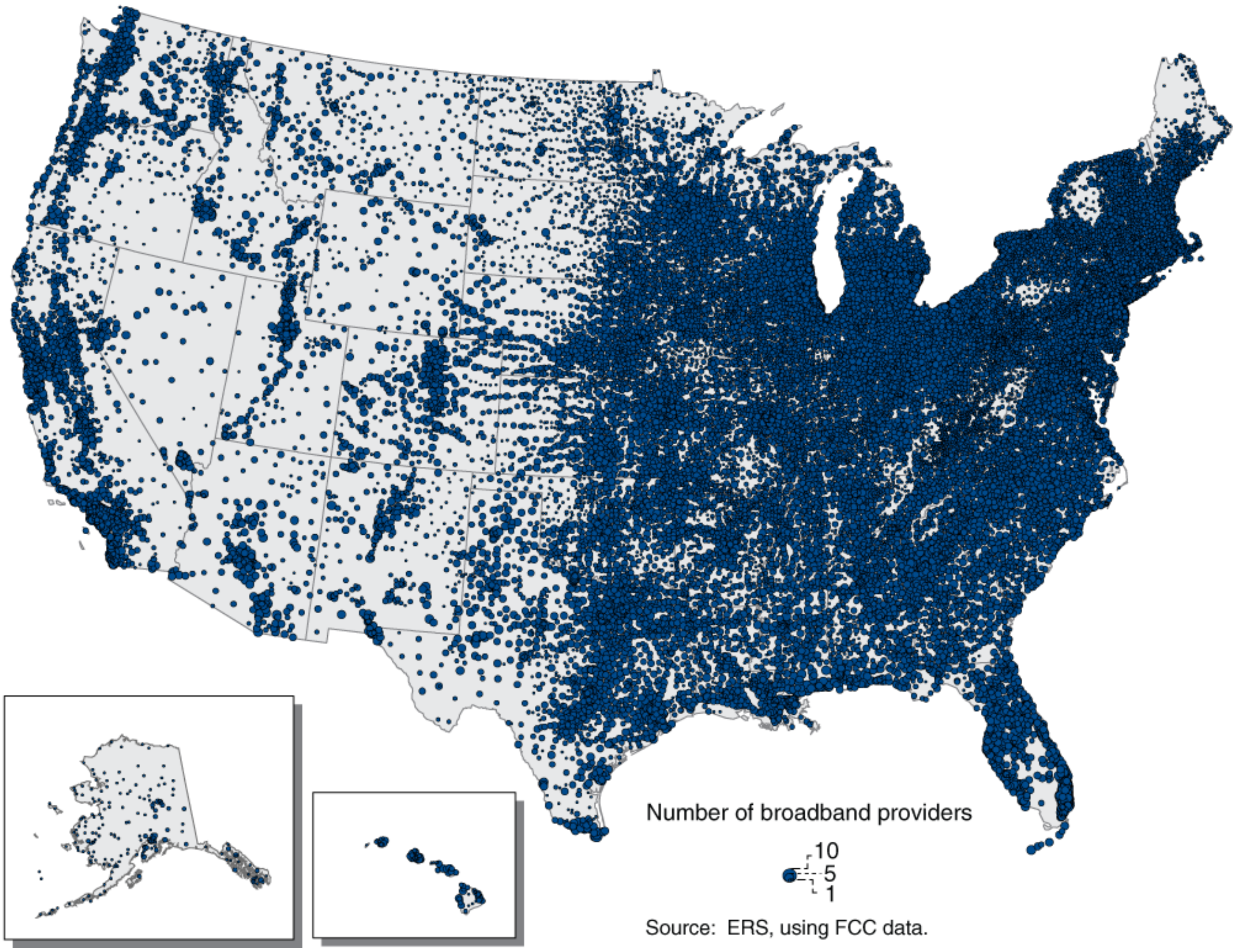
Figure C-3

Number of high-speed service providers by ZIP Code, 2004



Source: ERS, using FCC data.

Figure C-4
Number of high-speed service providers by ZIP Code, 2006



Source: ERS, using FCC data.

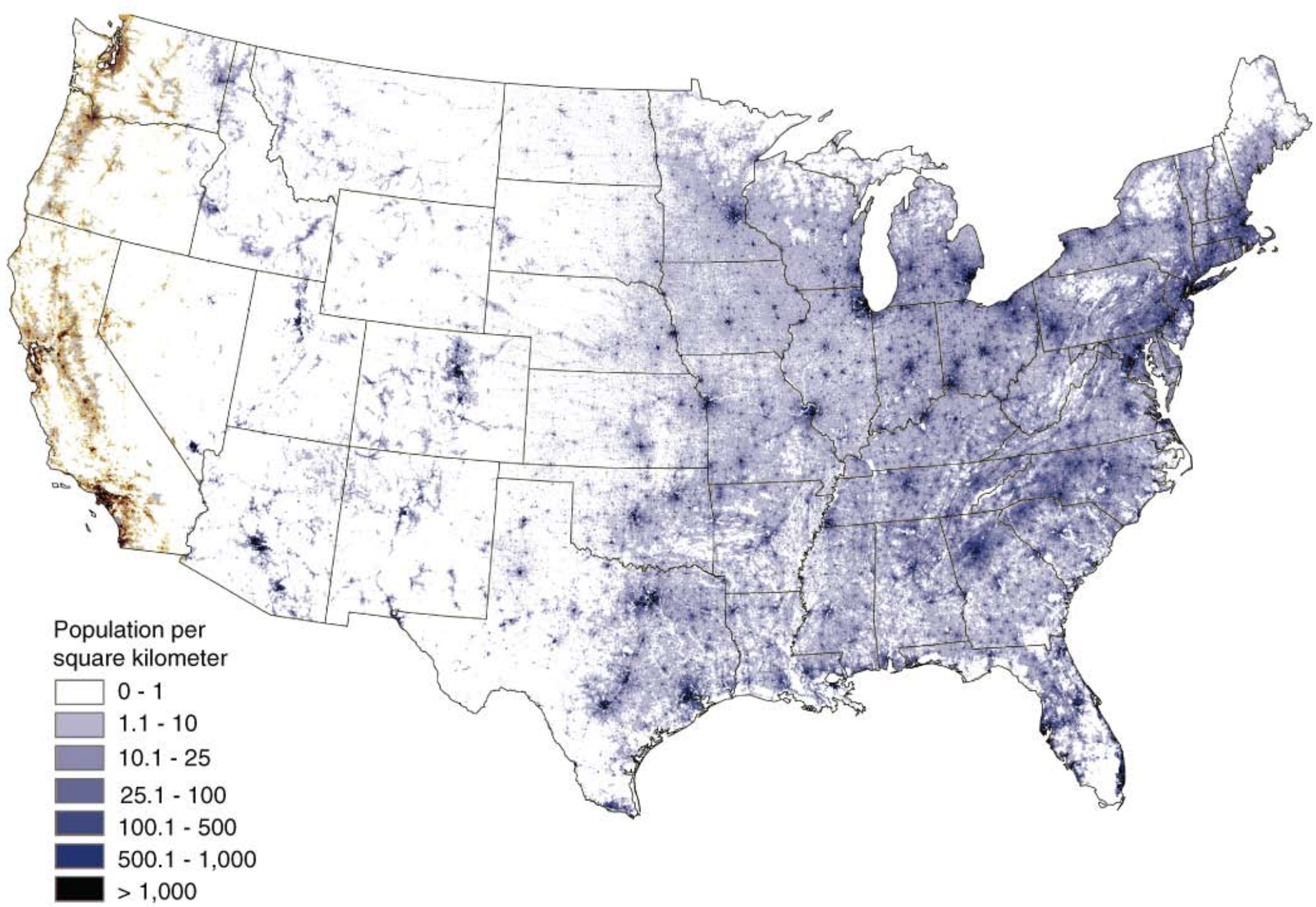
Broadband deployment has generally followed population density. This can be seen from the population density map (fig. C-5).

Enhancing the FCC Data

Population and adjoining area affect broadband availability. These facts underlie our enhancement of the FCC broadband availability data. From the FCC data we developed broadband availability density maps that constitute our most basic measure for a number of our research applications. This basic broadband database is composed of equally sized 2-km sub-ZIP Code zonal building blocks. The databases are further refined and adapted to each line of research in our broader rural broadband Internet study.

Essentially, these 2-km grid cells show the likelihood of having broadband available at any location within the lower 48 States at different points of time. To generate these broadband probability surfaces, we first locate the number of providers at the population centroid of the ZIP Code, where providers are most likely to maximize potential customers. Next, we pass a kernel density function over the provider locations using an 8-km search radius.

Figure C-5
Population density across the United States, 2000



Source: ERS using Bureau of the Census, Census of the Population, 2000.

The resulting surface provides estimates of provider access with the highest likelihood at the population centroid of ZIP Codes and decreasing probability toward the edge of the search radius. This search radius is larger than the typical limitation of DSL Internet service of 15,000 feet (4.5 km); due to technical reasons, DSL service cannot go beyond a certain distance from its signal's point of origin without additional equipment along the telephone line. The 8-km search radius helps to balance our assumption that all providers within a ZIP Code are centrally within the ZIP Code. Likelihood of service increases with more providers within a ZIP Code. Overlapping provision areas increase the likelihood of service to any location within the overlap, so high provision in adjoining zonal areas further increases the likelihood of broadband availability.

Our density map was tested against June Agricultural Survey data of farm broadband use. The June Agricultural Survey (JAS) data are a geographic-based survey of farms in the lower 48 States. Internet use data have been collected since 1997. The JAS Internet data give geographic- and time-specific use and non-use of broadband Internet. (See Appendix B for further discussion of the JAS data.)

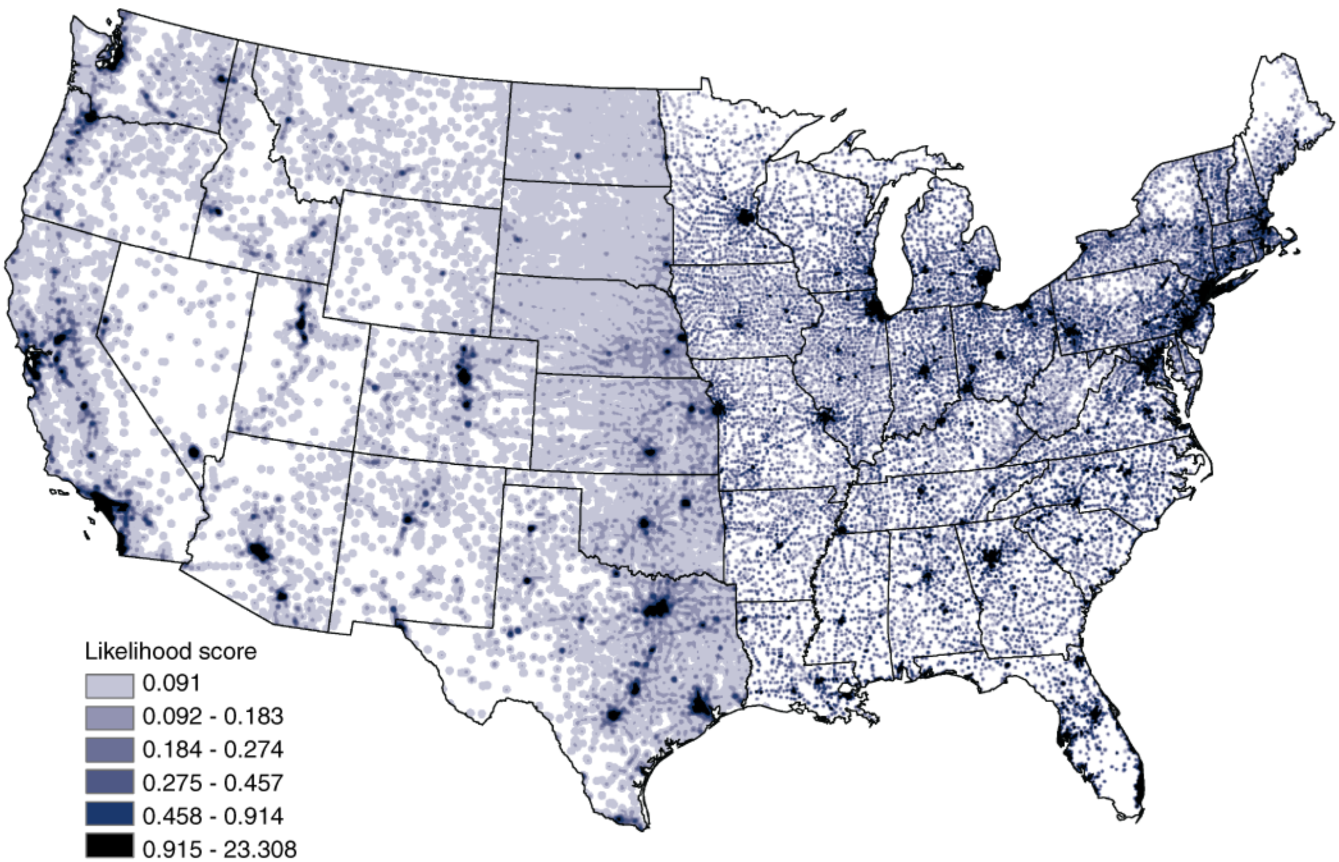
The density map matched very well with the JAS data in all areas except what is essentially the Great Plains region. The challenge here is the large geographic size of some ZIP Code areas, suggesting that the population centroid indicates less well the broadband Internet service area. The location of schools is used to further define the likelihood of broadband Internet service in an area; schools are useful because of their widespread use of broadband Internet. With the additional data, the surface map was adjusted to include additional provision areas. The resulting broadband density is essentially a likelihood measure—the probability of broadband Internet access for any given point in geographic space. Likelihood of broadband Internet access is centered in urban areas and radiates out from these urban centers (fig. C-6). The FCC data and the various selected indices that we developed here, one of which is shown in figure C-7, form the basis for much of the analysis in this report.

Our data were left as geo-specific or reconstituted into either county or ZIP Code areas for our analysis. Reconstitution into ZIP Code or county-level estimates required using population weighting of the provider likelihood estimate. A county aggregation of the data can be seen in figure C-7.

Estimation of Expected Number of Broadband Providers Using Population Measurements

To estimate the expected number of broadband providers, we began with the FCC's measure of the number of providers in a ZIP Code area in an unmodified form. To avoid disclosure of information on individual companies, areas that recorded 1-3 providers were combined into one category and assigned a value of 2. We used a population-based regression analysis to measure the relationship between the number of broadband providers and three components of U.S. population distribution: the overall population in the ZIP Code area in 2005, the percent of the ZIP Code's population living in urban areas as defined by the U.S. Census Bureau in 2000 (the most recent data on urban-

Figure C-6
Broadband availability based on 2005 FCC ZIP reporting and distance to schools in the West



Note: White areas would be expected not to have broadband Internet access. The darker the area, the more likely the area will have broadband.
Source: ERS using Bureau of the Census, Census of the Population, 2000.

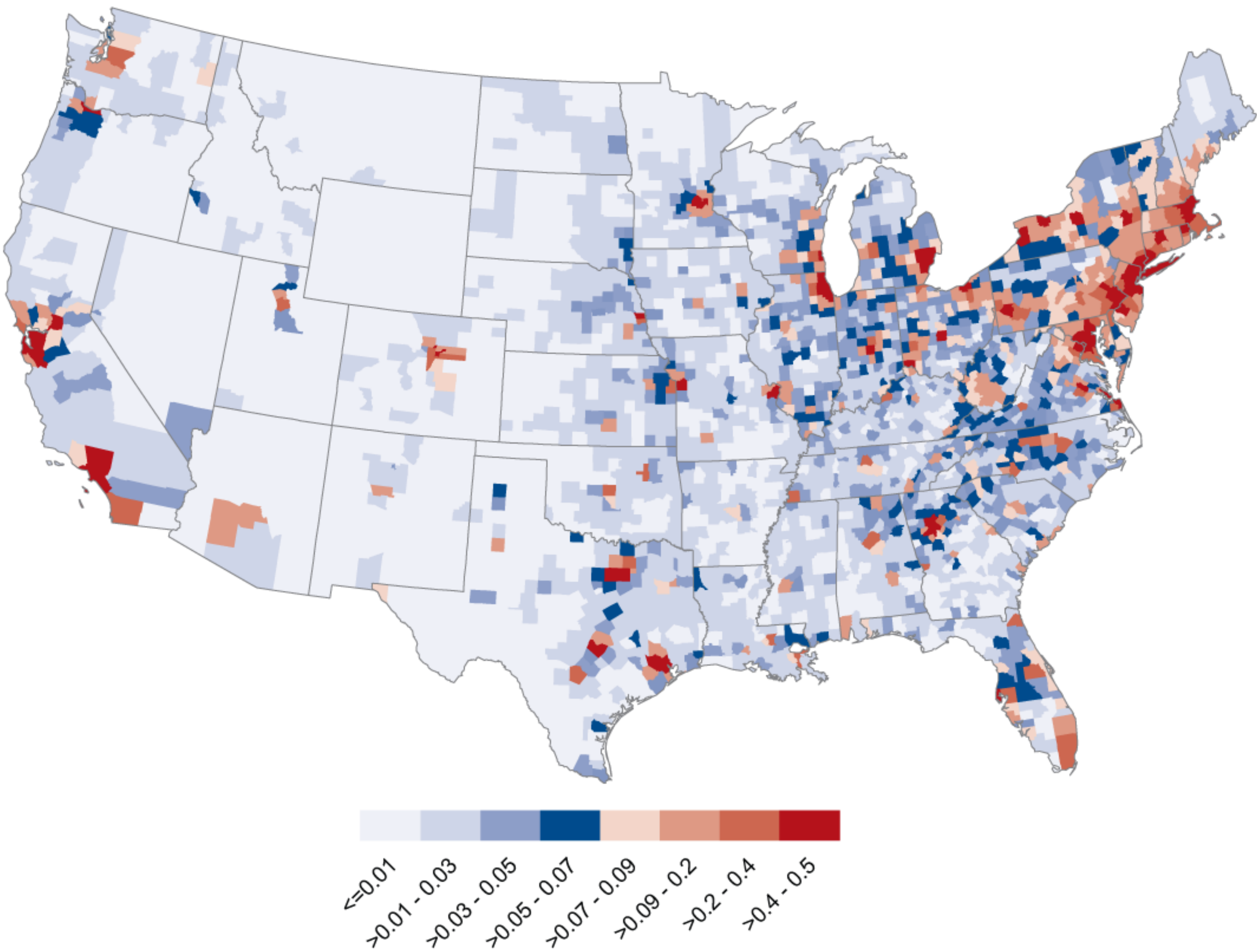
rural population), and a measure of the ZIP Code's accessibility to nearby populations.

ZIP Code area accessibility is used to distinguish areas that might be similarly sized but are differently positioned relative to large population centers. All things being equal, a nonmetro ZIP Code area adjacent to a metro area will likely have more providers than a more isolated area. To calculate accessibility for each ZIP Code area *a*, we identified all other ZIP Code areas within 200 miles, divided the population of each of these areas by the distance (squared) to area *a*, and summed the results. Values range from 0.0002 in Prudhoe Bay, Alaska to 150 million in Los Angeles (table C-1).

The independent variables were logged for the regression analysis to meet the assumption of linearity with the dependent variable. Parameter estimates represent the change in the number of broadband providers that occurs with a 1-percent increase in the independent variable. For example, a 1-percent increase in population size will increase the number of providers by 1.07. The standardized parameter estimates indicate the relative strength of the influence of each independent variable. Population size has twice the effect

Figure C-7

County representation of average broadband provision per square kilometer, 2000



Source: ERS using Bureau of the Census, Census of the Population, 2000.

Table C1

Descriptive statistics and linear regression results measuring the effect of population size, percent urban, and population accessibility on number of broadband providers, 2006

	Mean	Standard deviation	Minimum	Maximum	Parameter estimate	Standardized estimate
Dependent variable: Number of broadband providers, 2006	6.59	3.58	0	21	n/a	n/a
Independent variables: Population size, 2005	9,922	13,878	0	114,726	1.08	0.55
Percent urban, 2000	39.93	43.90	0	100	2.54	0.22
Population accessibility, 2005	20,944.09	1,045,331.36	0	150,709,763	0.21	0.13

Note: Descriptive statistics for the independent variables are shown for unlogged values; logged values were used in the regression analysis. All parameter estimates are significant at the .01 level. The proportion of variation in broadband provision explained by the regression (adjusted R-square) equals .63.

Source: USDA, Economic Research Service, using data from the FCC and U.S. Census Bureau.

on number of broadband providers compared with percent urban, which in turn has a stronger effect than accessibility.

Parameter estimates may be used to calculate the expected number of broadband providers in a ZIP Code area. Residuals from the regression show the difference between the actual and expected number of providers (fig. 9, p. 18). For example, Grafton, West Virginia's ZIP Code area had 10,316 people, was 59 percent urban, and had an accessibility measure of 385. Taking the natural logs of these values (4, 0.2, and 2.6, respectively), multiplying them by their parameter estimates, and summing the results show a predicted value for Grafton of 5.4 providers. The number of broadband providers in this ZIP Code area, as reported by the FCC in 2006, was 2, so the model indicates that Grafton has roughly 3 fewer providers than predicted.

Appendix D—Modeling Broadband Use on the Farm

Discrete choice models are interpreted in terms of an underlying behavioral model, the so-called random utility maximization (RUM) model. The decisionmaker chooses the alternative with the highest utility. Let x_{ij} be an attribute vector of alternatives j that individual i faces; let b be the impacts of the changes of the attributes; let e_{ij} be a random component. The random utility function of alternative j for individual i can then be written as $U_{ij} = b'x_{ij} + e_{ij}$. Suppose that alternative j is chosen and that alternative k is not chosen. Individual i will choose j to maximize the random utility function, if and only if $U_{ij} > U_{ik}$ for any $k \neq i$. Since e_{ij} is a random component of the individual utility function, the probability that individual i actually chooses alternative j is written as $P\ (U_{ij} > U_{ik})$ for any $k \neq i$. The true utilities of the alternatives are considered random variables, so the probability that the alternative is chosen is defined as the probability that it has the greatest utility among the available alternatives.

Using the conceptual framework put forth by Flamm and Chaudhuri (2007), we assume that the underlying utility of Internet use is related to economic and demographic attributes (Flamm and Chaudhuri, 2007). The purchase-decision outcome (j) consists of one of three choices: no purchase, dial-up, or broadband. The x_{ij} are represented by the explanatory variables described in the farm businesses and broadband section. Under certain restrictive assumptions, the probability that individual i chooses alternative j can be expressed as $P_{ij} = P(U_{ij} > U_{ik}) = \exp(b'x_{ij}) / \sum_{k=1}^{K} \exp(b'x_{ik})$.

The model that results under certain distribution assumptions about e is usually called the conditional logit model. Apart from the assumptions underlying the RUM model, the conditional logit model implies that "the choice probabilities have the property which is called independence of irrelevant alternatives" (McFadden, 1974). This means that the ratio of the probabilities of choosing two alternatives is independent of the characteristics of all other choice possibilities. The conditional logit model is sometimes called the multinomial logit model. Following Greene (1993) and Maddala (1983), this latter term is reserved for models where the probabilities of the individual making a certain choice are functions of the characteristics of the individual, while the term conditional logit model is used when the choice probabilities are functions of characteristics of the choice alternatives. The way the problems are set up is different in these two models. The likelihood functions, however, will be the same.

Appendix E—Quasi-Experimental Design

Quasi-experimental design (QED) is a statistical approach that simulates an ex-post laboratory experiment featuring both a treatment and control group. Selection of control and treatment in QED, unlike a true laboratory experiment, is not perfectly random, hence the term "quasi." Treatment groups are self-selected. Control groups are selected based on their characteristic similarity with the initial, or pre-treatment, characteristics of the treatment groups. The QED approach taken here follows those of Isserman and Rephan (1995). SAS and other software were used in the analysis. A couple of the SAS routines used here were initially developed by Isserman.

The closeness between counties that is used to select the control counties is derived using a discrete measure called Mahalanobis distance. Mahalanobis distance measures the similarity between the treatment county and each county that could potentially be part of a control group. The measure is derived from the differences between the treatment county's and another county's characteristics' measures. The Mahalanobis distance is

$$MAHAL_{bj}=(X_b-X_j)^T\,\Sigma^{-1}(X_b-X_j),$$

where b is the treatment county, j is the potential control group county, X is the vector of variables that measure a county's characteristics, and Σ is the variance-covariance matrix of the variables calculated over all possible control counties. There are a number of ways to compare treatment versus control groups in QED. In the application here, there is one control county for each treatment county. No control county is allowed to appear more than once in the control group. The pairwise counties are the basic unit of analysis. The difference in growth is computed for each pair. The mean and standard deviations of these differences are computed, as are t-statistics between the treatment and control groups.

Robustness checks were made by analyzing prior-period growth rates. A tautology did not exist between the selection of control counties and their post-economic growth measures as the selection of control counties employs a large array of spatial and socioeconomic factors. Control and treatment county growth rates were more similar in the prior period, 1997-2000, than in the treatment period, 2002-2006. Selection criteria for treatment groups were relaxed and strengthened (i.e., cutoff points in broadband likelihood were increased and decreased). No appreciable change in outcomes was found as a result of these changes; the model was not sensitive to minor changes in treatment group inclusiveness.

More analysis on the robustness, however, needs to be completed to further substantiate the results and address more completely the issue of causality. Treatment group selection and control group characteristic variables will be further varied to test sensitivity in selection process.

Appendix F: Economic Research Service Broadband Workshop, September 29-30, 2008

Broadband in the Rural Economy

Keynote: Rural Digital Economy
Edward Malecki, The Ohio State University

Internet and Rural Business Activity

Broadband Deployment and Economic Development in Kentucky and North Carolina
Mitch Renkow, North Carolina State University

Rural Broadband Internet Use and Rural Economy
Peter Stenberg, Economic Research Service, RRED

Comparing Rural Retailer Internet Users and Non-Users: Access Speed, Demographics, Attitudes and Beliefs.
Leslie Stoel and Stan Ernst, Ohio State University

Rural Grocers and Technology Adoption: Attitude Matters. Size Matters More.
Stan Ernst and Leslie Stoel, The Ohio State University

Food and Nonfarm Rural Business

Internet Marketing of Nursery and Greenhouse Products
Enefiok Ekanem and Fisseha Tegegne, Tennessee State University

Positive Examples and Lessons Learned from Rural Small Business Adoption of E Commerce Strategies
David Lamie, David Barkley, Clemson University, and Deborah Markley, University of Missouri

IT and E-Commerce Companies
John Leatherman, Kansas State University, and Hanas Cader, South Carolina State University

Farm and Rural Households

Farm Businesses and Broadband Internet Use
Mitchell Morehart and Peter Stenberg, Economic Research Service

Farming and the Internet: Reasons for Nonuse
Brian Briggeman and Brian Whitacre, Oklahoma State University

What Skills Are at the End of Broadband Cables in Rural America? Do They Match Up with Firms Wishing to Engage Rural Sourcing?
Doug Morris and Lyndon Goodridge, University of New Hampshire

Digital Economy

IT in the Global Economy
Catherine Mann, Peterson Institute for International Economics and Brandeis University

Effects of Broadband Deployment on Output and Employment
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Home Broadband Adoption in the United States: Patterns, Barriers, and Consequences
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Community Internet Use

The Role of the Internet in Rural Community Participation—Examples from Recent Survey Data
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Rural Distance Education
Janet Poley, University of Nebraska-Lincoln and President of the American Distance Education Consortium

Economic Impact of Rural Telemedicine
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