Investment in Rural Broadband Technologies[1]

Peter Stenberg
Economic Research Service[2]

Abstract: Rural communities have significantly less access to the Internet through broadband technologies than highly urbanized communities. Policy makers have been trying to address this shortfall through federal, state, local programs. But what is the impact of broadband Internet on rural America? Clearly more activities are shifting to the Internet. Some of these activities have great potential value for the rural economy. Rural economies in the macro sense may benefit from the Internet. The results we obtained from our quasi-experimental design statistical model were consistent with the argument that broadband Internet access has a positive effect on rural communities. Results from the analysis were consistent with the hypothesis that the investment in broadband Internet access leads to a more competitive economy. Further analysis, however, is needed to address the issue of causality much more completely.

As the Internet has matured and become better integrated into the broader economy, more and more applications, products, and services have been developed for the public and private sectors (Leamer and Storper; Greenstein and Prince). On-line activity of all types has increased every year, especially over the last decade, despite the recent slowdown in aggregate retail sales, on-line retail sales continued to increase rapidly. In this economic environment broadband access, or high-speed access, to the Internet has been necessary to fully realize and take advantage of what is available through the Internet.

Broadband Internet service access, however, is not as readily available in rural areas of the country as it is for urban areas nor is access availability uniform across rural areas (Malecki; Oden and Strover; Stenberg; Stenberg and Morehart). Policy makers have been trying to address

[1] Paper to be presented at the 51st ERSA meetings, Barcelona, Spain, August 2011.
[2] The views expressed are those of the author and do not necessarily reflect the views of the Economic Research Service or the U.S. Department of Agriculture

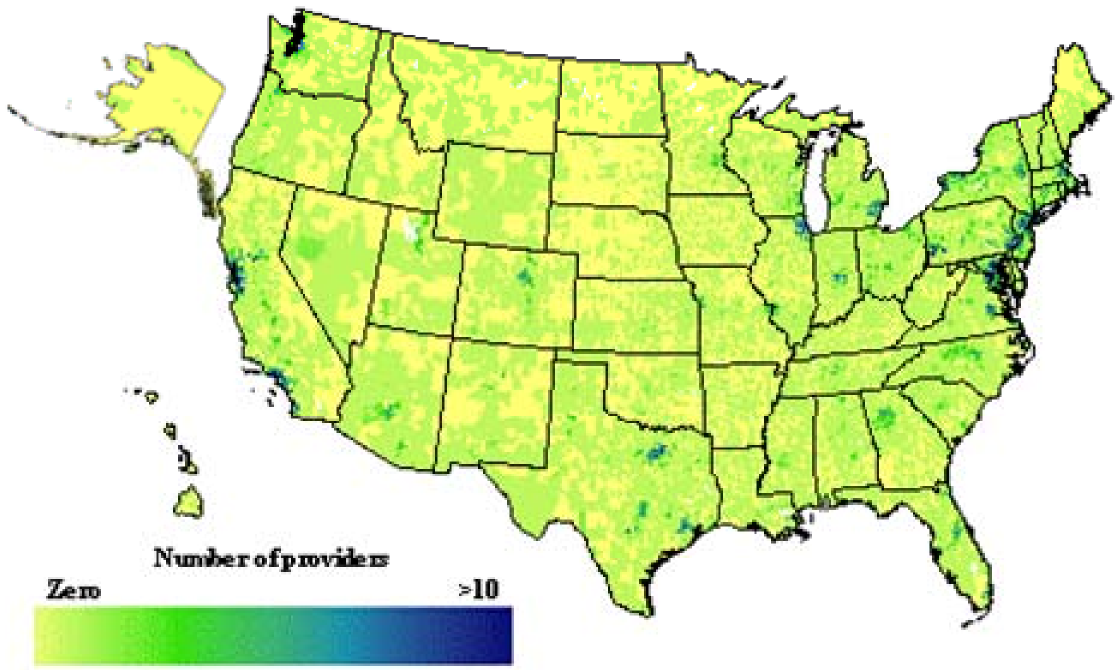
the shortfall in rural broadband access through the Food, Conservation, and Energy Act of 2008 and The Farm Security Act of 2002. In addition the American Recovery and Reinvestment Act of 2009 had a number of provisions providing funds for rural broadband. But what is the regional economic effect resulting from the difference in service access? That is the question that we begin to address here.

While measuring the macroeconomic impact of the Internet has been problematic, with the residual often considered to be that contribution, the effect on firms that have invested in information technology has been shown to be great (Bresnahan, et al; Forman; Greenstein). Measuring the regional economic effect from the increasing availability of broadband Internet access across geographical space brings more challenges. First no complete atlas of broadband access availability exists. Second, broadband has not been available for long and the availability of broadband Internet access has rapidly increased across geographical space. Third, drawing out the effect of broadband from all other economic factors that are also taking place is challenging. In this paper we develop a proxy for the likelihood of broadband Internet access. Utilizing the proxy we use a statistical method called quasi-experimental design to explore causal relationships of broadband Internet access while controlling for other possible factors impacting the regional economy.

Rural broadband Internet access

Historical data on broadband availability is severely limited. The only historical national data available comes from the Federal Communications Commission (FCC) Form 477 survey. Form 477 provides data collected from high-speed Internet service providers and indicates whether they have customers in any given zip-code. As can be seen in figures 1 broadband was often unavailable in rural areas in 2000. Broadband, of course, has increasingly become available throughout the country, though its availability has been less in rural areas, especially in more isolated communities (Stenberg and Morehart).

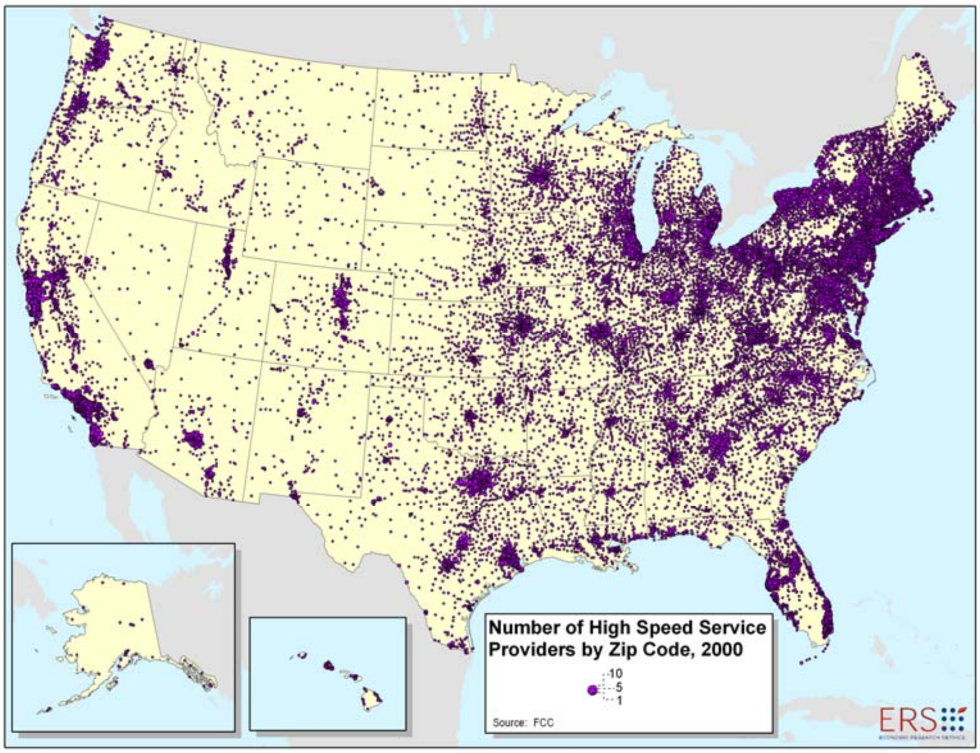
Figure 1: Broadband Internet Availability, December 2000



Source: ERS

From the Form 477 data we developed a density map. This basic broadband data base is composed of zonal building blocks. Essentially these basic building blocks show the likelihood of having broadband available at any zonal point within the lower 48 states at different points of time. Briefly we have done this by using the population centroids of the zip-code areas as the center of the service region (figure 2). The service region is defined as the distance from centroid as measured by the typical limitation of DSL Internet service of 15 thousand feet; due to technical reasons DSL service cannot go beyond a certain distance from its' signals' point of origin without additional equipment along the telephone line. Likelihood is increased the more the number of providers there are within a zip-code. Overlapping provision areas increase the likelihood of service to any location within the overlap.

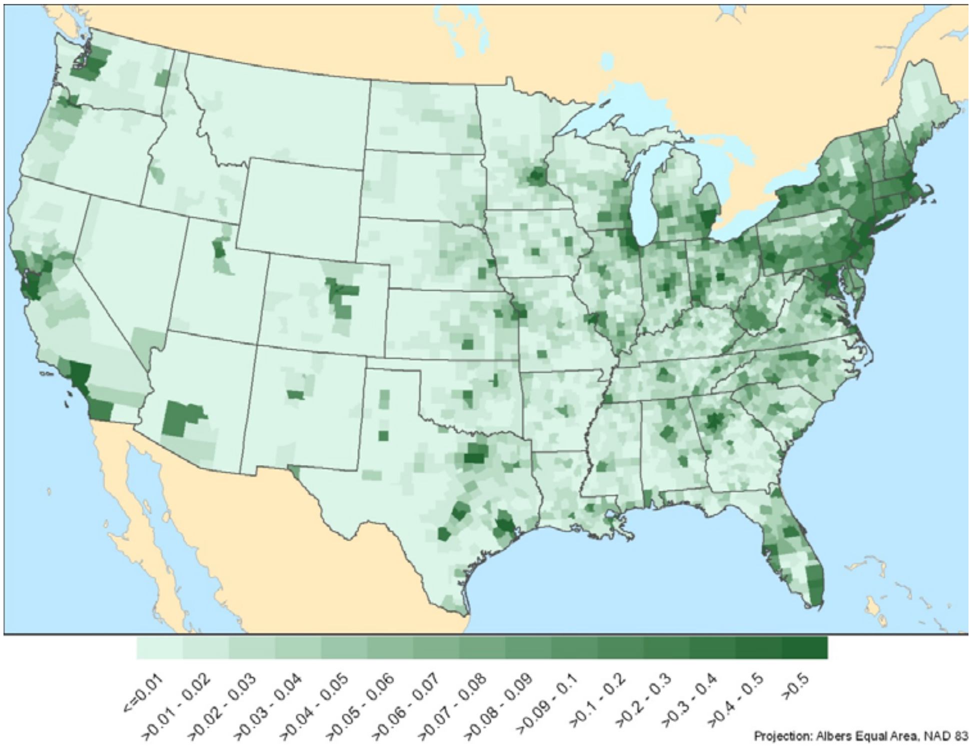
Figure 2: Broadband Internet Availability (centroid representation), December 2000



Our density map was tested against a corresponding June Agricultural Survey data of farm broadband use. The June Agricultural Survey (JAS) data is a geographic-based survey of farms in the lower 48 states. Internet use data has been collected since 1997. The JAS Internet data gives geographic- and time-specific use and non-use of broadband Internet.

Our 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 of the zip-code areas suggesting the population centroid does not match as well the broadband Internet service area. Additional data was used, primarily location of schools 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 area. The resulting broadband density is essentially a likelihood measure -- the probability of broadband Internet access for any given point in geographic space (figure 3).

Figure 2: County Representation of Average Broadband Provision per Square Kilometer, 2000.



Source: ERS

Measuring possible broadband causal relationships in rural economies

The methodological approach that we take is called quasi-experimental design (QED). The approach allows us to separate out the broadband effect from other causal factors in economic growth and is an initial step toward ferreting out the causal relationship. QED is a statistical approach that simulates an ex-post laboratory experiment (Cook and Campbell). Like a laboratory or medical experiment, QED features both a treatment and control group. The treatment group is the group undergoing the "cure," in this case 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, are 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.

QED has been utilized in a large body of regional science research, such as airport impact studies by Farnsworth or Wheat, fiscal policies by Bender and Shwiff, highway infrastructure studies by Blum or Isserman, and military base closures by Isserman and Stenberg. QED, however, has never been used in the study of the regional effect of broadband investment as far as we have been able to ascertain.

Application of quasi-experimental design

In 2000 broadband was only starting to become widely available and, fortunately, is the first year that we could build a broadband likelihood data base. The data is based on the earliest reliable set of data from the FCC (according to our discussions with the FCC). Our 2000 likelihood data allows some effect resulting from broadband investment to start to appear in rural communities; research such as Greenstein and Prince’s suggest that information technology takes time to be fully utilized after the technology’s introduction.

For QED analysis we use counties as the basic geographic unit; rural economic time series are available primarily at the county level. Rural areas are defined using the Economic Research Service’s rural-urban continuum code. In our analysis the terms rural and nonmetropolitan are used synonymously. The 2002 rural-urban continuum code is used to differentiate rural from urban counties.

Our 2000 broadband likelihood statistics are used to select our treatment counties. The building block data, however, needed to be further refined primarily by reconstituting the data for county-level analysis resulting in measures of means and standard deviations for each of the counties.

The selection of treatment for our broadband analysis is not the traditional yes or no for treatment. Broadband has been widely available, though nowhere near universal across the country. Our cutoff on likelihood measure for treatment is based on inflection points. As the likelihood of broadband availability increases, the number of counties meeting the threshold probability starts to increase exponentially. All metropolitan counties were eliminated from our data base.

We have 228 rural counties in our treatment group. For each of these counties we found a "twin," i.e. a county that most closely resembles the treatment county before its selection. The selection was based on economic structure (farming, manufacturing, retail trade, federal government, state and local government income as a percent of total income), spatial structure (population density, distance from various city sizes, and presence of interstate highway), income (per capita, unearned, and transfer income), and previous growth in population and income for the period 1990-2000. Duplicate counties were not allowed in the control group. Data primarily comes from the Bureau of Economic Analysis' Regional Economic Information System (REIS). The rest originates from the Bureau of the Census and in-house GIS data sets.

The closeness between 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 broadband available 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.

Our post-treatment is the period 2002 through 2006. Year 2006 is the last year data are available. The period provides some time for broadband Internet to start to have an economic effect. Unfortunately for our analysis, the effect may increase over time. The rapid spread of broadband Internet access, however, is a mitigating factor in this potential shortcoming. Due to the rapid spread of broadband Internet access, the initial short period may be the only period where we may be able to detect differences in outcomes resulting from the availability of broadband access. We investigate changes in county employment and income in our QED analysis of the effect of broadband Internet access.

Results from quasi-experimental design analysis

We find that total employment has grown faster in counties that had greater broadband Internet access sooner than other counties (table 1); a number of articles such as Crandall et al seem to 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 with subsequently either reducing actual employment due to the productivity gain or increasing profitability of the firm vis-à-vis other firms in the industry and subsequently increasing employment as market share increases.

At the county-level, however, broadband availability may mean that the county's employers may be more competitive vis-à-vis employers in other counties and as a consequence increasing relative employment growth vis-à-vis other counties. As well as increasing the location's desirability for new employers.

Table 1: Difference in mean employment growth rates

	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**

Source: author

Note: *** significant at 10%, ** significant at 20%, * significant at 30%

Wage and salary jobs as well as number of proprietors grew faster in counties with early broadband Internet access. The farm sector, though, 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. Sub-sectors of the counties' economies (not shown here) generally were not significant, though further analysis is warranted.

Income showed a mixed picture (table 2) though population showed greater growth in treatment counties than control counties. The volatility of farm earnings may have been a factor in this outcome as the QED approach taken here does not take into account the variance in crop and farm structure in treatment and control counties.

Table 2: Difference in mean income and population growth rates

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

Source: author

Note: *** significant at 10%, ** significant at 20%, * significant at 30%

Private earnings are all earnings excluding farm earnings and federal, state and local government earnings. Private earnings were greater for the treatment counties than for the control counties. This is consistent with the hypothesis that broadband Internet access has a positive effect on a rural county's economy.

Robustness

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 socio-economic factors in their selection. Control and treatment county growth rates were more similar in the prior period, 1997-2000 than they were in the subsequent treatment period, 2002-2006. Treatment group selections criteria 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.

Conclusion

There has been a rapid rollout in broadband Internet access but broadband Internet access is not universal across the country. The length of time and quality of access will have some effect on communities. Communities with better access presumably benefit more greatly from the economic benefits the Internet provides.

Separating out the effect that broadband Internet access has, however, is challenging. Notably, broadband Internet access data leaves much to be desired for research analysis purposes. We have made great strides in the measurement of broadband Internet access given the paucity of geographic broadband Internet access data by creating broadband Internet access surface maps, developing location specific probabilities, and adapting these to the needs of specific modeling techniques.

Broadband Internet access is not the only economic factor contributing to economic growth. QED methodology, however, is a major step in sorting out the crosscurrents effecting economies and developing a better understanding of how broadband Internet access effects rural areas.

The results we obtained are consistent with the argument that broadband Internet access has a positive effect on rural communities. Results from our analysis were consistent with the hypothesis that the investment in broadband Internet access leads to a more competitive economy. Further analysis, however, is needed to address the issue of causality much more completely.

References

Bender, Bruce and Steven Shwiff (1982). "The Appropriation of Rents by Boomtown Governments," *Economic Inquiry*, vol.20, pp.84-103.

Blum, U. (1982). "Effects of Transportation Investments on Regional Growth: A Theoretical and Empirical Investigation," *Papers of the Regional Science Association*, vol. 49, pp.169-84.

Bresnahan, Timothy F., Erik Brynjolfsson, and Lorin M. Hitt (1999). *Information Technology, Workplace Organization, and the Demand for Skilled Labor: Firm-Level Evidence*, National Bureau of Economic Research, NBER Working Paper Series, Working Paper 7136.

Cook, Thomas D. and Donald T. Campbell (1979). *Quasi-Experimentation: Design and Analysis Issues for Field Settings*, Chicago: Rand McNally College Publications.

Crandall, Robert, William Lehr, and Robert Litan (2007). "The Effects of Broadband Deployment on Output and Employment: A Cross-sectional Analysis of U.S. Data," *Issues in Economic Policy*, The Brookings Institution, No. 6, July.

Farnsworth, Don (1972). *The Ohio County Airport Study 1964-1972*, Ohio Department of Commerce, Division of Aviation, Columbus, Ohio.

Forman, Chris (2005). "The Corporate Digital Divide: Determinants of Internet Adoption," *Management Science*, 51:4, pp.641-654.

Greenstein, Shane, and Jeff Prince (2006). *The Diffusion of the Internet and the Geography of the Digital Divide in the United States*, National Bureau of Economic Research, NBER Working Paper Series, Working Paper 123182.

Greenstein, Shane, *Building and Delivering the Virtual World: Commercializing Services for Internet Access*, National Bureau of Economic Research, Working Paper 7690, May 2000.

Isserman, Andrew M., and Peter L. Stenberg (1994). *The Recovery of Rural Economies from Military Base Closures: Control Group Analysis of Two Decades of Experience*, Research Paper 9408, Regional Research Institute, West Virginia University.

Isserman, Andrew M. (1987). *Highways and Rural Economic Development: Results from Quasi-Experimental Approaches*, Research Paper 8907, Regional Research Institute, West Virginia University.

Leamer, Edward E., and Michael Storper, *The Economic Geography of the Internet Age*, National Bureau of Economic Research, Working Paper 8450, August 2001.

Malecki, Edward J. (2002). ‘The Economic Geographic of the Internet’s Infrastructure,” *Economic Geography*, 78(4), pp.399-424.

Oden, Michael, and Sharon Strover (2002). *Links to the Future: The Role of Information and Telecommunications Technology in Appalachian Economic Development*, Appalachian Regional Commission, Washington, DC.

Stenberg, Peter L., and Mitchell Morehart (2007). "The Internet in U.S. Farm and Rural Businesses", in Irene Johansson (Eds.), *Entrepreneurship and Development-Local Processes and Global Patterns,* University West, Sweden.

Stenberg, Peter L. (2006). "Investment and Household Adoption of Communication and Information Services Across the United States" in *The Emerging Digital Economy: Entrepreneurship, Clusters and Policy*, Johansson, Borge, Charlie Karlsson, and Roger Stough (Eds.), Springer, Berlin, Heidelberg, New York, pp. 263-76.

Wheat, Leonard (1970). *The Effect of Airline Service on Manufacturing Growth in Cities Below 40,000 Population*, U.S. Department of Commerce, Economic Development Administration, Washington, DC.