Broadband Technology Adoption in Rural and Urban Households

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Abstract In the United States broadband adoption rates vary across region, urban density, household income, and other socio-economic influences, such that western households are more likely to have broadband Internet than southern households, urban households have greater broadband access than rural households, higher income households more often subscribe to the Internet than poorer households, etc. Diffusion theory helps explain the pattern in household Internet subscriptions. We explore the adoption causality of broadband Internet using descriptive and logistic regression techniques. We find that spatial differences can be explained by differences in household income, educational attainment, and other household characteristics; Internet nonadoption can be the result of both voluntary and involuntary choices. Recent government programs address some of the underlying causes for Internet nonadoption, helping to ameliorate economic disadvantages for some households.

Introduction

The Internet has become widely, though not universally, used by rural residents. Nevertheless rural regions have less access to the Internet through broadband, or high-speed, technologies than richer, more urbanized areas. Not only do rural residents have less broadband Internet availability, but rural residents are also less likely to subscribe even if broadband Internet service were available to them. The rural shortfall in Internet use will have, potentially, fundamental socio-economic consequences for individuals, businesses, governments, and regions. As a consequence federal and state policies have been implemented to increase Internet access across the country including some new programs designed explicitly to increase household Internet participation.

Historically federal and state government Internet programs have mostly leveraged private funds to increase the availability of broadband Internet service. The Rural Utility Service of the U.S. Department of Agriculture (USDA) has been a lead agency for rural Internet policy

[1] 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

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implementation through three on-going programs, the: (1) traditional rural telecommunication infrastructure program requiring all facilities to be broadband capable; (2) farm bill broadband program (authorized by the 5-year farm bills, the Food, Conservation, and Energy Act of 2008 is the latest of these); and (3) Community Connect Broadband Grant Program. The U.S. Department of Commerce-National Telecommunications and Information Administration (NTIA) and U. S. Department of Agriculture-Rural Utility Service (RUS) jointly administered broadband programs resulting from the American Recovery and Reinvestment Act of 2009 that has led to, approximately, a $7 billion investment in broadband infrastructure in the country. Recently the Federal Communications Commission reformed the Universal Service Fund and created the Connect America Fund that provides $300 million in phase I monies for rural broadband system development.

The research presented in this chapter explores the factors that lead to rural resident adoption and use of the Internet. The research addresses the increase experience in rural household Internet subscriptions, socio-economic demographics of Internet subscription, and the rural-urban dichotomy of Internet subscription.

Background

NTIA studies beginning in 1994 have documented the changing user demographics in their national overviews of household computer and Internet use and launched the term Digital Divide into its now familiar place in the telecommunications policy lexicon. The NTIA studies clearly described some of the national demographics of computer, Internet, and later broadband Internet use at different times in the Internet's rapid evolution from the its humble origins in the academic community.

More recent studies describe the current, and more static, situation or examine the adoption of newer, broadband, technologies. Household studies by Choudrie and Dwivedi (2005, 2006); Stanton (2004); Stenberg and Morehart (2008); and the U.S. General Accounting Office (2001) tested socio-economic factors distinguishing adopters and non-adopters of computers and Internet use. Choudrie and Dwivedi (2005) found age, gender, and social grade were important when distinguishing between adopters and non-adopters of the Internet. Their 2006 study found that characteristics such as income and education were important factors. Stanton (2004) tests for a digital divide and found it the widest for computer ownership and the narrowest for Internet connections. Most studies on Internet adoption have focused on the household at the national aggregate level. The early NTIA studies, for example, described differences across many demographic and geographic groupings, not only for households, but also Internet activity in the workplace.

From the beginning, when nearly no household was connected to the Internet from the home, the issue of equal access between rural and urban areas was raised. Rural areas showed distinct paucity vis-à-vis urban areas early on that continues to this day (Parker and Hudson; Oden and Strover).

More recently, however, rural households, when comparing households with similar income and education attainment, were shown to be almost as likely as urban households to use the Internet (Stenberg [2006]). Nevertheless, rural broadband Internet availability, or Internet obtainability through modern high-speed connections, have been less prevalent than in much more densely populated areas of the country. In addition, not all households that can obtain a broadband connection choose to subscribe the Internet. The issue of broadband Internet availability has lessened while the issue of Internet nonadoption (when the Internet is available) has risen to become the crux of today's policy debate on equal access between urban and rural communities (Malecki; Stenberg et al [2009]; Stenberg and Morehart [2012]).

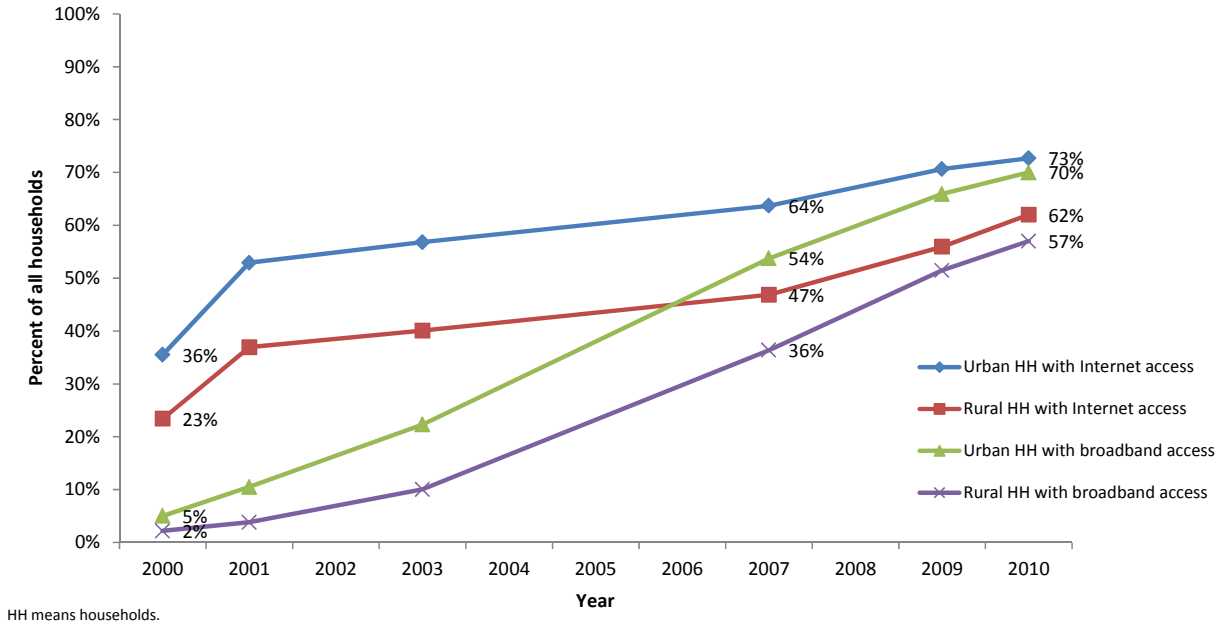
Current Population Survey Data

In the research presented here we use the data from the Bureau of the Census' Current Population Survey (CPS). The CPS is a monthly survey of approximately 50,000 households covering various socio-economic characteristics such as family income, employment status, and age. The data is reported at the state-level and includes type of residential location (i.e. rural, urban, etc.). The computer and Internet data has been collected irregularly over the years as a supplement to one of the monthly surveys. National estimates are based on the statistical analysis of the raw data and a number of weighting protocols. The latest data available, and the data used in the analysis, comes from the October 2010 monthly survey.

Increasing Household Internet Subscriptions

Household Internet subscriptions have increased considerably since 2000 (figure 1). The rate of increase in new subscribers, however, has slowed down considerably since 2001. Many households still don't subscribe, either by choice or situation.

Fig. 1 Internet Access in Households, 2000-2010



HH means households.

During the same period home broadband service subscriptions went from nil to a point where nearly all households that subscribed to the Internet, had it through broadband technologies. Rural-urban spatial differences in overall Internet subscription rates, however, remain with 73 percent of American urban households subscribing to home Internet connections while only 62 percent of rural households do so too.

The technologies for gaining access to the Internet has been changing quite rapidly with a number of alternative broadband technologies becoming available at the same time that dial-up was becoming largely insufficient to all but the most mundane Internet activity. With the increasing sophistication of web-sites and the increasing variety of on-line products and services, accessing the Internet through broadband technologies has largely become viewed as necessary in order to fully utilize what the web has to offer. It has also become the technology of choice for households (where broadband service is available).

Urban-Rural Differences in Subscription Rates

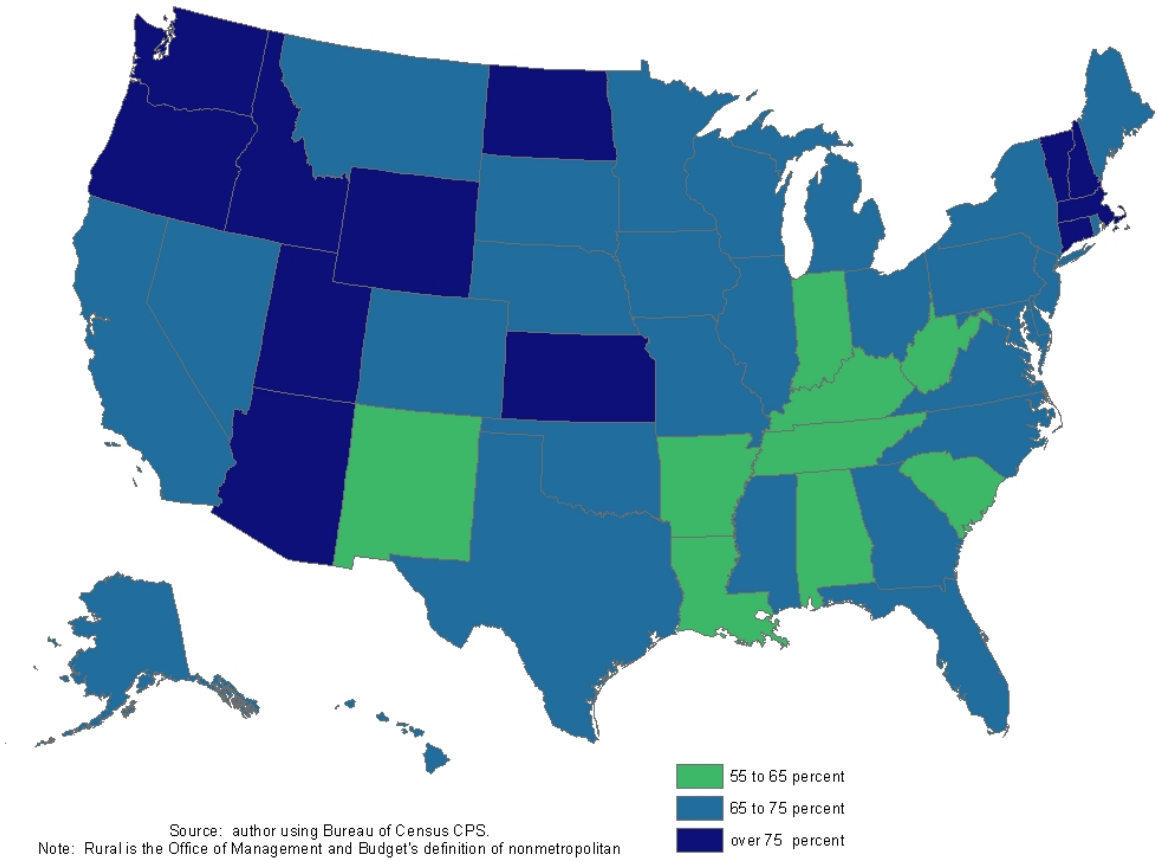
While rural household Internet subscription rates remain low in comparison to urban households, the difference between urban and rural adoption rates is highly variable across the country (figures 2 and 3). The lowest urban rates of Internet subscriptions primarily are in the south. The lowest rural rates also are in the south.

Northeastern and western rural households are, on average, more likely to go on-line than other regional rural households (fig. 3). In a number of states, such as Colorado and New Hampshire, the rural household adoption rate exceeds the national urban rate significantly and substantially. The variability in rural rates of adoption suggests that more than rural isolation is at play when it comes to household subscriptions.

Once a household has purchased Internet access, however, they are most likely to have acquired high-speed access; 96 percent of on-line households in urban areas have broadband, while this penetration rate falls to 92 percent in rural areas (fig.1). This rural-urban difference partially corroborates the argument that broadband service is not as readily available in rural areas as compared to urban areas.

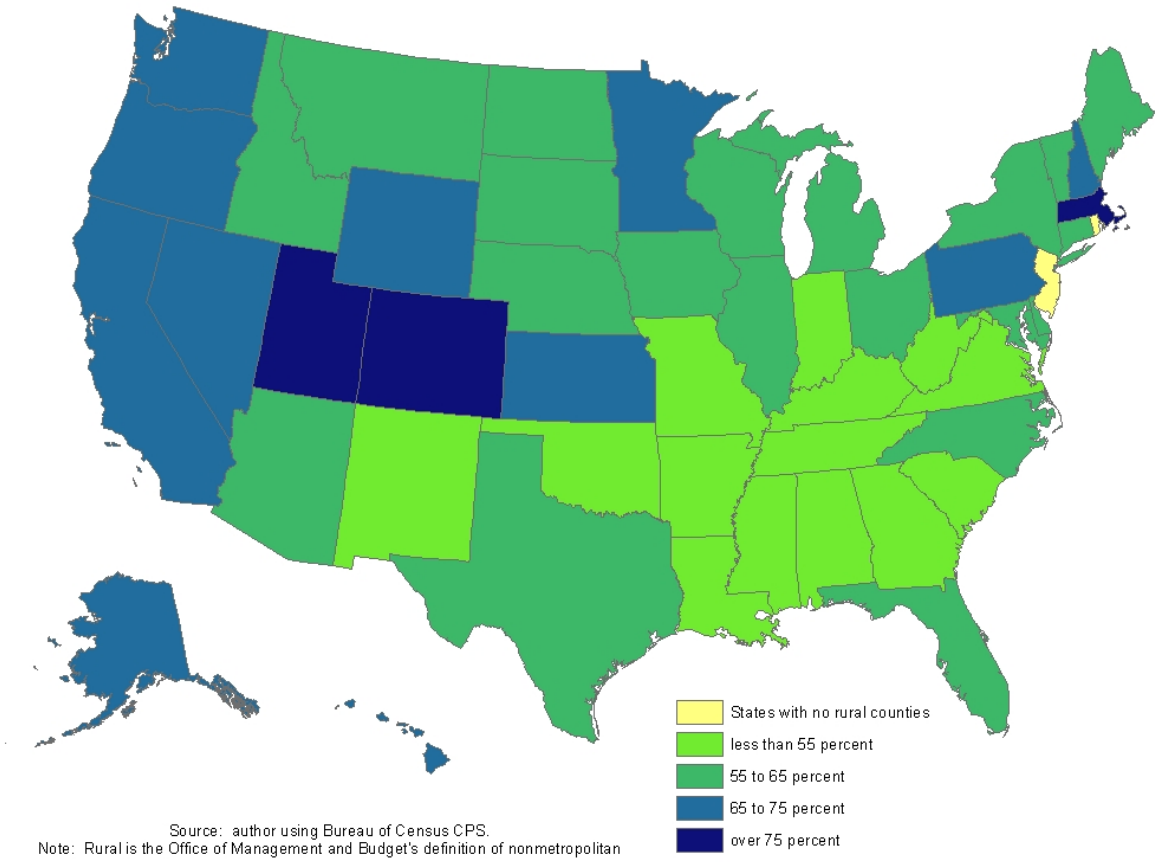
While rural northeastern and western rural households generally have higher broadband subscription rates than other parts of the country, they remain with lower rates than their regional urban counterparts. Rural broadband access has, across the country overall, also been of a lower quality than in urban areas with rural households relying more often on satellite and wireless connections instead of cable or fiber technologies than households in urban areas. Rural households also use DSL, a generally slower and, arguably, less reliable technology, more often than urban households.

Figure 2: Urban Households with Broadband Internet subscriptions, 2010



Source: author using Bureau of Census CPS.
Note: Rural is the Office of Management and Budget's definition of nonmetropolitan

Figure 3: Rural Households with Broadband Internet subscriptions, 2010



Source: author using Bureau of Census CPS.
Note: Rural is the Office of Management and Budget's definition of nonmetropolitan

Rural broadband subscriptions have become more ubiquitous, but many challenges remain for rural service providers. Rural areas by their very nature of low population do not have the economies-to-scale urban areas have. Costs, therefore, are higher for each potential customer of the rural service provider. If the provider can pass on the additional costs this would make broadband Internet access less affordable for businesses and consumers. Given the relative lack of competition faced by rural service providers, they may have the ability to pass on the costs. If costs can't be passed on to customers, rural service providers have less incentive to provide the service. In addition, mountainous terrain and harsh weather present additional challenges. Reliable measures of actual costs faced by rural businesses and consumers are not well known and are the subject of new surveys by a number of researchers.

While broadband has increasingly become available in rural and poor areas, the issue has increasingly become a quality issue. In terms of broadband Internet service, quality means the reliability and speed of data transmission. The general rule, as the FCC and others have noted, and as would be expected from market analysis (for broadband service): the lower the population density, the poorer the community, and the higher the cost of service delivery cost

(due to mountains and other challenges), the less quality of service available. All of the characteristics of population density, relative wealth, and physical topographic challenges commonly hold, but with some notable exceptions, for rural areas.

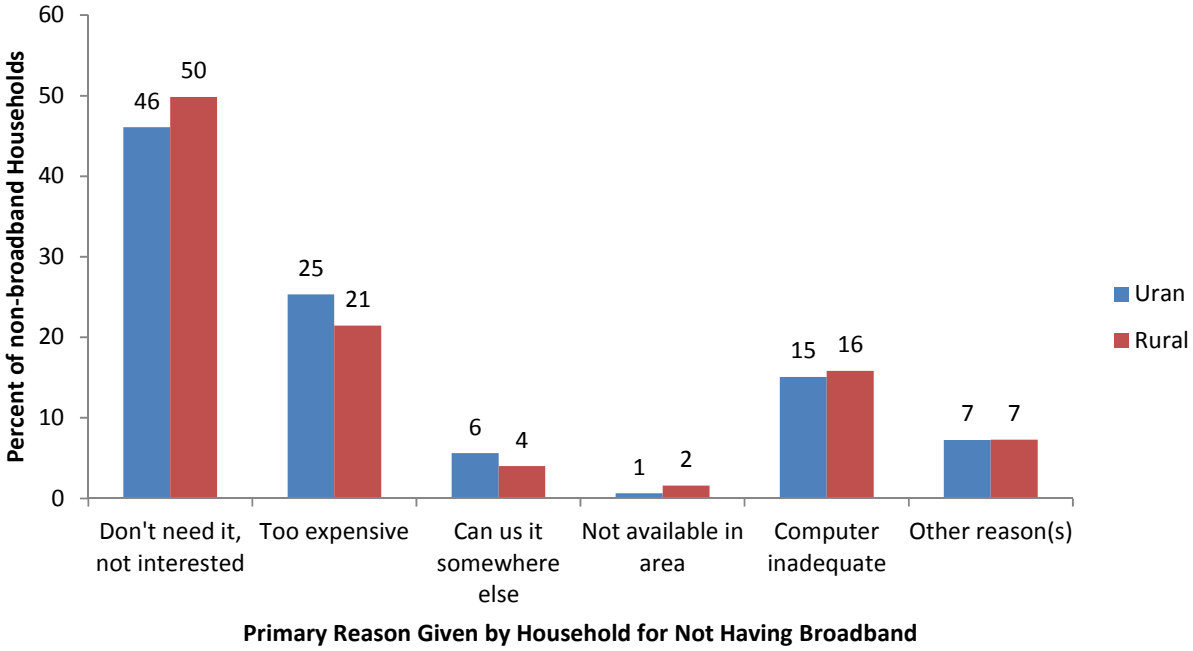
Table 1: Technology used by households getting on the Internet, 2009			
	Metropolitan	Nonmetropolitan	Total
A regular dial-up telephone	6.1	11.9	6.9
DSL,cable modem,fiber optics,satellite, wireless (such as Wi-Fi),mobile phone or PDA,	93.3	87.7	92.5
Something else	0.6	0.5	0.6
Total	100.0	100.0	100.0

As has been shown in the National Broadband Map (NTIA) Native American reservations, rural poverty counties, and other counties stand out with their lower levels of service. The more densely populated areas, such as the megapolis stretching from Washington, DC to Boston, have the highest percent of fast (4 Mbps) broadband service for households while the low population areas, such as the Dakotas, have the lowest percent. Some of the wilderness areas, such as central Maine and parts of the Rockies, also show the expected low percent.

Self-reported Reasons for Non-subscriptions by the Household

While most Internet policy discussion has focused on service availability, not having a home Internet subscription, however, is sometimes by choice whether it be voluntary, in a sense, such as they just don't want it or involuntary, in a sense, such as can't afford it(fig. 4). It has been many years since the start of the Internet age and with it the large geographic footprint that Internet services now have. As a consequence not having it is largely by choice. The largest pluralities of those who do not have home Internet subscriptions are those who do not want it. Rural residents, however, are slightly more likely to cite the availability, or more precisely the lack of available Internet service, in the area as a reason for not having it in the home.

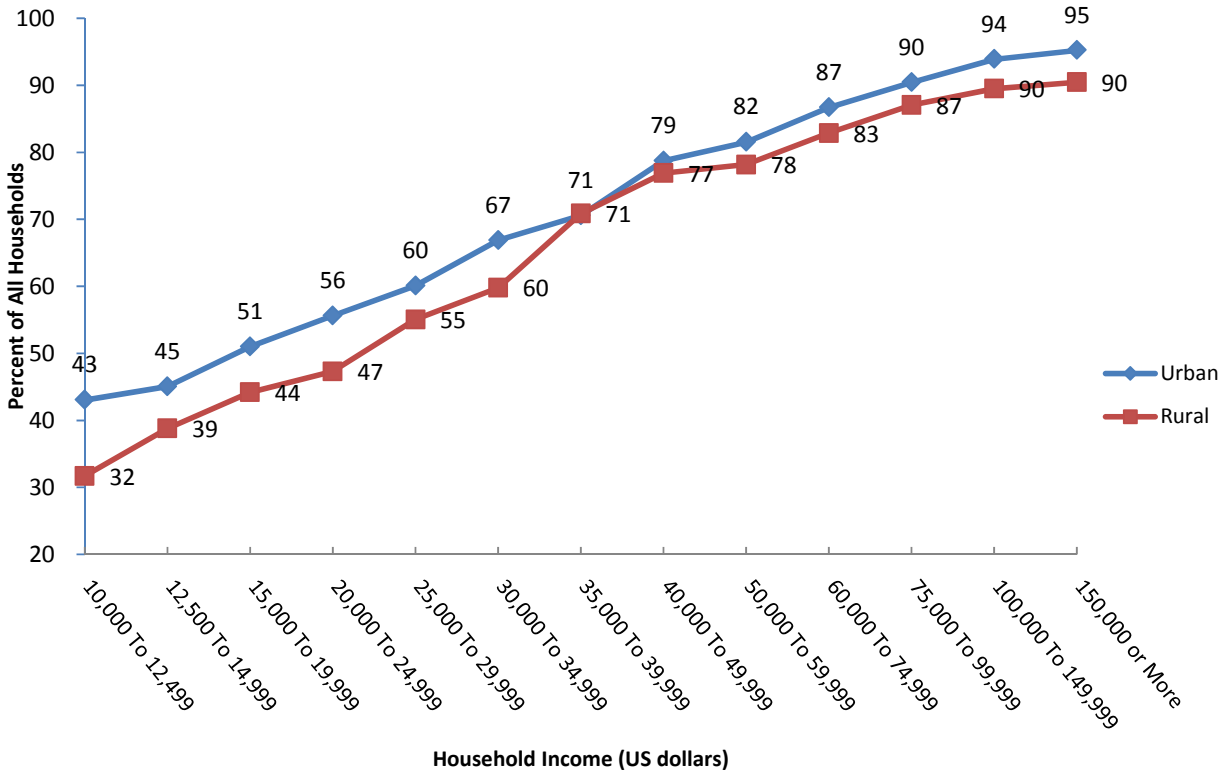
Fig. 4 Most Important Reason Households Gave for Not Having Internet Service, 2010



Revealed Factors in Household Internet Subscriptions

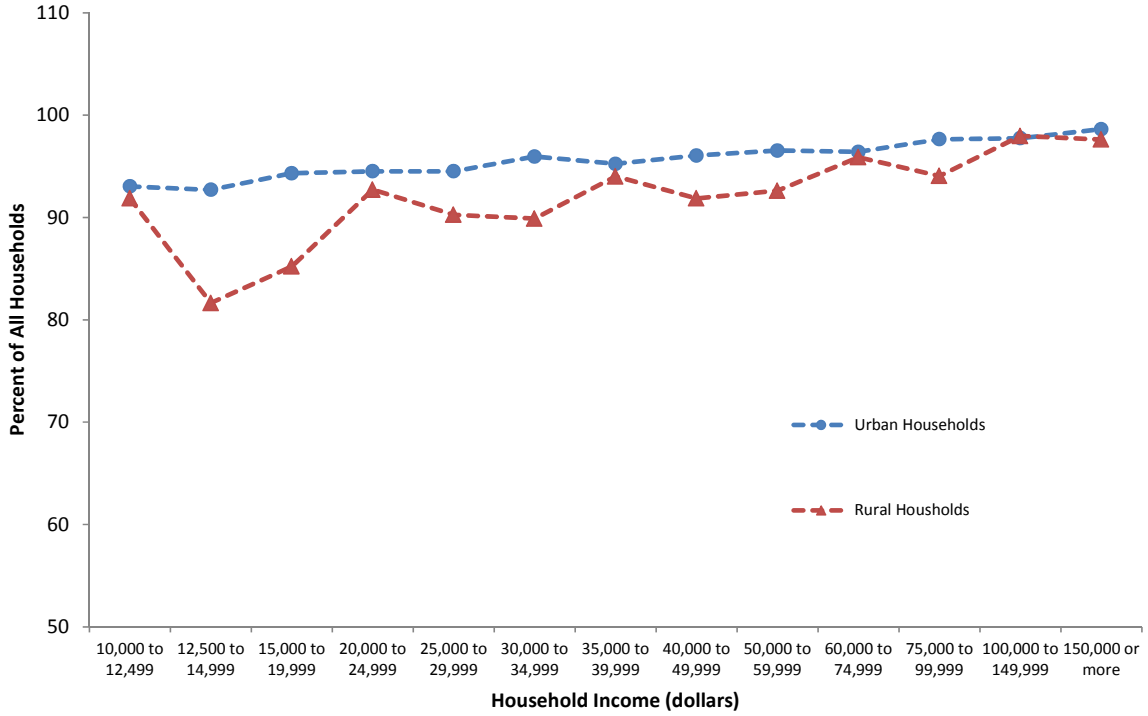
Service cost still remains a major reason cited by rural residents for not having Internet access although the decrease in the cost of broadband technologies over the last decade has had a significant impact on increasing Internet use. Federal Internet programs also have increased Internet use. Nevertheless, as can be seen in fig. 5, household income plays a significant role in household Internet subscriptions. Rural household Internet access, at any given income level, generally falls below the correspondent urban household Internet access rate, this is one indication that broadband service has not been as readily available in rural areas as in urban areas.

Fig. 5 Rural and Urban households with Internet Subscritptions using any technology, by income, 2010



As stated already, once a household is purchasing Internet services they are most likely to have broadband (fig. 6). The gap between rural and urban households, however, remains remarkably flat, outside some data sampling noise and the off-campus college student effect at the lowest income level, when controlling for income. The result indicates that expense is not much of a factor after controlling for income irrespective of the rurality of the household, the gap between urban and rural households would mostly, but not entirely, be a consequence of service availability. Some of the aggregate differences in adoption rate between rural and urban households would likely be as a consequence of the lower incomes found in rural households' vis-à-vis urban.

Fig. 6 Broadband as a share of household Internet subscriptions by income, 2010



Exploring Causality through Multinomial Logistic Regression Analysis

What determines broadband adoption by households? We hypothesize that income, family type (married or not), age, rural-urban place of residence, and some other factors are determinants in broadband Internet use as some of them have already shown their influence in computer use as well as the early Internet use. Our null hypothesis is that Internet use is a random event with no determinants. As is often the case when the dependent variable is categorical, we employ the logit model to examine factors that influence Internet adoption. The logistic specification is well suited to this type of application and has been used in similar studies. See for example Gloy and Akridge.

A multinomial logistic regression is employed for the 2-market situation of Internet subscription and broadband Internet subscription. This allows further understanding of the latent demand for broadband after a household subscribes to an Internet service.

It should be noted that estimates of goodness-of-fit are given in model estimations here. R-squared estimates are traditionally given for logistic regressions, but they are not the same as in noncategorical dependent variable regression models, such as in OLS. A number of different

methods have been used to proxy the R-square of noncategorical regression models. Nevertheless R-squared estimates used in logistic regressions are highly controversial, with no broad acceptance of any one estimation methodology over another, and, as many statisticians argue, may be misleading and should only very carefully be used to compare models.
The model was fitted with the independent variables:

- Income
- Education
- Number in family
- Rural of urban location

Results of Multinomial Logistic Regression Model

The model fit well though the pseudo r-squares were low as is common with multinomial logistic regressions (table 2). All of the independent variables were significant and with the expected sign. Like the literature on Internet adoption, the greater the educational attainment, the more likely the household would purchase an Internet connection. Furthermore, the model shows that once a household has an Internet connection the more likely they will purchase broadband Internet access. The results provide some evidence that households do want faster Internet connections.

Table 2: Multinomial logistic regression of broadband adoption

	Model Fitting Criteria	Likelihood Ratio Tests		
	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	3.470E7			
Final	2.316E7	1.153E7	8	.000

Pseudo R-Square

Cox and Snell	.046
Nagelkerke	.080
McFadden	.055

Parameter Estimates

			Std. Error	Wald	df	Sig.	Exp(B)	95% Confidence Interval for Exp(B)	
								Lower Bound	Upper Bound
Internet, no broadband	Intercept	-1.088	.002	403795.709	1	.000			
	No. In HH	-.055	.000	44634.322	1	.000	.947	.946	.947
	Education	.007	.000	83744.633	1	.000	1.007	1.007	1.007
	HH income	.087	.000	866044.232	1	.000	1.091	1.091	1.091
	Urban	-.248	.001	71423.743	1	.000	.780	.779	.782
	.	.	.	.					
Broadband	Intercept	.196	.001	30902.894	1	.000			
	No. In HH	.021	.000	16345.191	1	.000	1.021	1.021	1.022
	Education	.005	.000	108426.474	1	.000	1.005	1.005	1.005
	HH income	.179	.000	8639467.497	1	.000	1.196	1.196	1.197
	Urban	.401	.001	385518.618	1	.000	1.494	1.492	1.495

Note: The reference category is no Internet

The more people in the household, the more likely the household would purchase broadband Internet access. The larger households, of course, are more likely to have school-age children. School-age children, with their exposure to the Internet in their schools as well as their increasing need to get on-line for school assignments and instruction, have become major demand drivers for in-home Internet subscriptions. Even when school-age children are not present, the greater number of people in the household will mean a greater likelihood of that one of the household members need or want an Internet connection for work or other purposes. The negative sign (for Internet, but no broadband) for the number of people in the household is also a sign of the importance of broadband Internet when a family has children.

The model also shows that the greater the income the more likely a broadband subscription will be obtained by both rural and urban households. While prices may be perceived cheap with many able to purchase broadband service for less than 50 U.S. dollars a month, purchasing the personal computer, software, and other equipment can still be prohibitive for households of lesser means.

Rural household are less likely than urban to have adopted broadband Internet, some of this is a result of the lower income and educational attainment of rural vis-à-vis urban households. The negative sign for urban location in "Internet, no broadband" is another sign of the greater broadband availability in urban areas than in rural areas.

Conclusion

More activities are shifting to the Internet with some of these activities having great potential value for the rural economy. Rural communities have recognized this by investing resources into the emergent digital economy. Equivalent Internet access across the rural-urban landscape, however, remains questionable. Rural households still are less likely to have broadband Internet available to them than their urban peers, but nearly all rural households that have the Internet, like their urban brethren, use broadband technologies from the home.

As a consequence, availability of broadband Internet service is no longer the primary reason for not having home Internet subscriptions, as it is now has come to pass that a much larger share of households without the Internet choose not to subscribe rather than can't subscribe. Much of the rural-urban household variance in broadband adoption rates can be explained by the divergence in household characteristics. Rural households tend to have less income and lower educational attainment, on average, than urban households. Broadband availability though greatly increased, however, remains a significant negative factor for rural residents in being able to purchase the services.

The rural underperformance in Internet use will have fundamental socio-economic consequences for individuals, businesses, governments, and regions. As a consequence federal and state policies continue to address broadband availability, but some new programs diverge

from the original Internet infrastructure model and are designed explicitly to increase household Internet participation. More research is needed to better understand the dynamics of household choice with respect to broadband Internet services to better illuminate the policy discussion and program development.

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