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The Effect of Per Capita Income on Broadband Access

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Executive Summary

The purpose of this inquiry is to determine the effect of income and ruralness on broadband access. This is relevant because of the economic effects of broadband access, which are not evenly distributed. The primary method of analysis employed was a multivariate regression model incorporating variables measuring broadband access, per-capita income, ruralness, race, and state-level effects. I found that income and ruralness were both significant, and that every $10,000 of per-capita income is associated with a change in broadband access rates of approximately 9%. The results also showed large, significant state-level effects that can be attributed to a combination of state broadband policy, geographical factors, and the combination of internet service providers present in each state.

Introduction

The proliferation of access to broadband internet has led to tremendous improvements in access to information. However, despite the overall increase in wireline broadband availability, the United States has lagged behind other developed countries in terms of broadband adoption. As noted in Table 1, the Broadband Commission for Digital Development's 2015 annual report ranks the United States 23rd overall in terms of fixed broadband subscriptions, with around 30 fixed broadband subscriptions per 100 inhabitants (The Broadband Commission for Digital Development 2015, 86).

Table 1: Fixed Broadband Subscriptions		
Rank	Economy	Fixed Broadband Subscriptions per 100 Capita
1	Monaco	46.8
2	Switzerland	46.0
3	Denmark	41.4
4	Netherlands	41.0
5	Liechtenstein	40.3
6	France	40.2
7	Korea (Rep.)	38.8
8	Norway	38.1
9	United Kingdom	37.4
10	San Marino	37.0
23	United States	30.4

Source: Broadband Commission for Digital Development, p. 86.

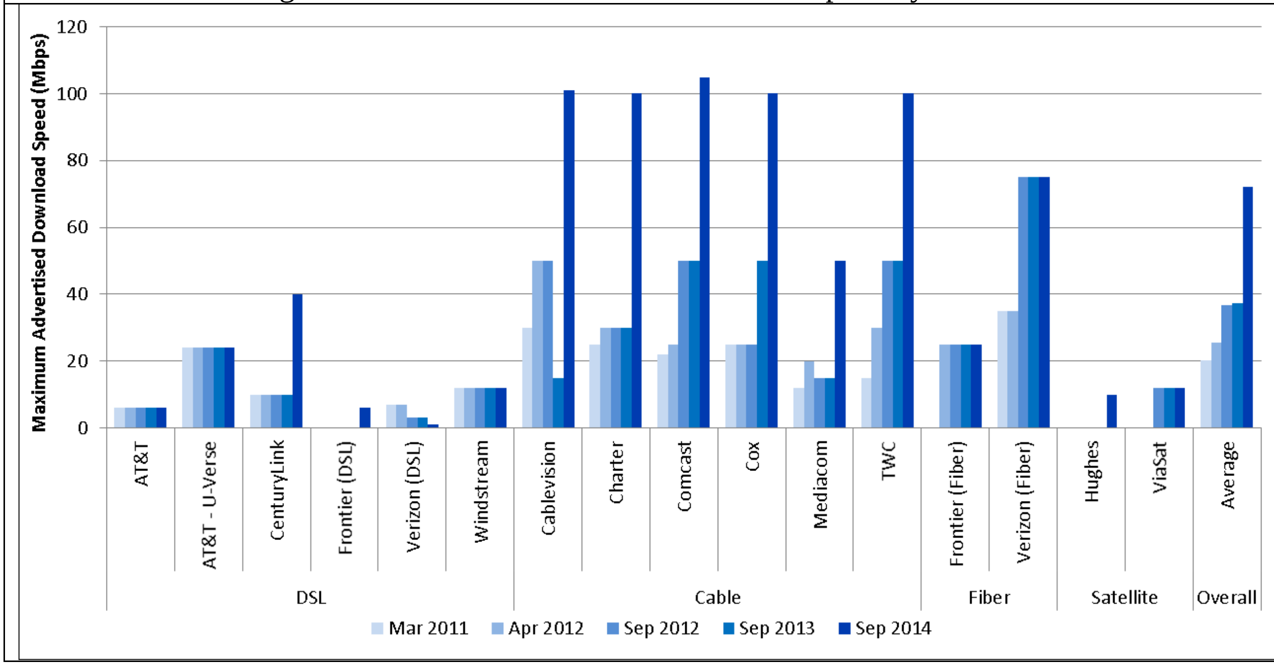
Within the United States, some segments of the population have generally adopted broadband internet service more quickly than others. In particular, studies have suggested the existence of a 'digital divide' in the United States, with wealthier and more urban areas having higher rates of access than areas that are poorer and more rural (Bates, Malakoff, Kand, and Pulidini 2016). The Federal Communications Commission's 2015 Broadband Progress Report changed the standard for fixed broadband service from 4 Megabits per second (Mbps) download to 25 Mbps, as "the speeds required to use high-quality video, data, voice, and other broadband applications all point to a new benchmark," especially for multi-user households (Federal Communications Commission 2015a, 3). As noted in Table 2, using the revised broadband definition, the FCC found that 53% of rural Americans lacked access to broadband in 2013, whereas this figure was only 8% for residents of urban areas.

Table 2: Percentage of Americans Lacking Access to Fixed Broadband at 25/3			
	2014	2013	2012
United States	10%	17%	20%
Rural Areas	39%	53%	55%
Urban Areas	4%	8%	11%
Tribal Lands	41%	63%	68%
U.S. Territories	66%	63%	100%

Source: 2016 FCC Broadband Progress Report, Chairman's Draft, p. 2.

However, the competition among wireline providers using different technologies has also played a role in the growing divergence in broadband access is the difference in average download speed among providers. As seen in Figure 3, average download speeds differ sharply across technological lines. For example, of the six major Digital Subscriber Line (DSL) services, only two have maximum advertised download speeds that meet or exceed the FCC's revised 25 megabit per second (Mbps) standard for broadband. Neither of the major satellite internet providers meet this standard. As such, cable and fiber-optic services have become the dominant providers of broadband (Federal Communications Commission 2015b, 10). Similarly, the FCC has previously noted that fixed wireline broadband consistently outperforms mobile broadband in terms of "speed, latency, price and usage allowances, consistency of service throughout an area, and the potential for congestion" (Federal Communications Commission 2015c, 10).

Figure 3: Maximum Advertised Download Speed by Provider



Source: FCC 2015 Measuring Broadband America Fixed Broadband Report, p. 10.

This analysis has two primary purposes: to determine the effect of income on broadband access, and to determine the extent to which the effect of income is distinct from that of urban-rural discrepancies. This "digital divide" has been observed in rates of broadband access as well as broadband adoption.

Literature Review

It has been clearly established in the literature that broadband access has broader economic impacts. However, the scope and magnitude of these effects are unclear. Additionally, a number of socioeconomic factors have been found to influence broadband adoption, meaning that the economic effects are not evenly distributed. As previously noted, the urban-rural digital divide is one of the best known and most studied examples of this phenomenon.

1. Evaluating the Economic Impacts of Broadband Access

Previous studies suggest that a relationship exists between broadband access and economic growth. Several studies have attempted to quantify the economic impacts of broadband access and determine how the costs and benefits vary. In particular, Bauer et al. (2002) found that potential economic effects of broadband service behave differently, and questioned whether decentralized decision making in the private market could efficiently allocate broadband service (Bauer, Gai, Kim, Muth, and Wildman 2002, 74). They found that some of the benefits from broadband, including more efficient procurement and reduced healthcare costs, behave like private goods, while high-speed access at business or industrial parks have aspects similar to club goods, which only provide benefits if a club is established (Bauer, Gai, Kim, Muth, and Wildman 2002, 74). Club goods are excludable, non-rivalrous goods that are congestible. According to Buchanan, club goods exist in cases where "the optimal sharing group is more than one person […] but smaller than an infinitely large group" (Buchanan 1965, 15). However, Bauer et al. argue that certain services, such as distance learning, may behave more like pure public goods. They claim that the costs and benefits associated with broadband service are can be local, inter-local, or global in scope, and that allocation problems may occur when, for example, costs are local and benefits are mostly global (Bauer, Gai, Kim, Muth, and Wildman 2002, 75).

Firth and Mellor (2005) propose a framework for evaluating the problems and benefits that result from broadband internet service. They assert that existing studies tend to conflate benefits with applications, attributes, and activities, "creating an impression that it is gross rather than net or marginal outcomes that count" (Firth and Mellor 2005, 225). According to Firth and

Mellor, applications include video on demand, and attributes of service include higher download rates and always-on capability. These attributes and applications enable activities like telecommuting and e-learning. The key question is whether these benefits are outweighed by “negative outcomes such as increased worker isolation and less mentoring (teleworking) financial problems (e-gambling), and displacement of conventional social contacts” (Firth and Mellor 2005, 224)

Howell and Grimes (2010) found that the productivity gains from investment in broadband infrastructure may take a long time to accrue, and that “it is not always apparent when the additional investment [in broadband networks] will stimulate maximum gains” (Howell and Grimes 2010, 128). They suggest caution when evaluating government investment in fiber-optic networks, as most of the applications that benefit from faster broadband service have merely increased “the richness of the graphics employed” (135) while remaining functionally similar to previous services. For example, they assert that “Facebook and Twitter are richer extensions of email, enabling instant written communications between individuals” (135). Howell and Grimes also argue that the long-term effects of expansions in broadband coverage can be difficult to measure, as “the ways in which [information and communications technologies] in general, and broadband networks in particular, contribute to economic performance are many, varied, highly nuanced and many of the factors interact with each other in ways that make it extremely difficult to predict the likely outcome” (142).

Rohman and Bohlin (2013) studied the effect of broadband access and download rate on household income in various OECD and developing countries. Their study found that the economic benefits from broadband are not linear, as is commonly assumed, but are instead stepwise, with the effects resembling “not a continuous S-curve but rather a staircase” (Rohman and Bohlin 2013, 19). This could be the result of particular services requiring increasing amounts of bandwidth to function properly. For instance, low-resolution 360p video streaming requires approximately 635 kbps to view, whereas high-definition 720p requires between 1260 and 1820 kbps (Cisco Systems). Such an effect could be particularly relevant for teleconferencing and e-learning services. Rohman and Bohlin also claim that economic benefits vary regionally, and that the threshold for gaining economic benefits varies regionally (16-17). For example, an increase in broadband speed from 4 to 8 Mbps corresponds to an average income increase of approximately $125 in BRIC countries, but the same increase in OECD countries brings about $1467 (17). Finally, they found that "gaining the same increment of speed levels […] bring a greater benefit in OECD than BRIC economies" (19). The authors attribute this discrepancy to greater productivity increases in OECD countries (18).

2. Factors Influencing High-Speed Broadband Adoption

The existence of a relationship between income and high-speed broadband adoption has been more clearly established in the literature. In particular, Ida and Sakahira (2008) studied the Nippon Telegraph and Telephone (NTT) rollout of Fiber to the Home (FTTH) service and evaluated factors associated with migration to FTTH service. They found that in the Japanese market, higher income individuals are more willing to migrate from Advanced Digital Subscriber Line (ADSL) service to much faster FTTH service, and that "characteristics including income, service usage […], and type of residence significantly influence broadband migration to FTTH" (Ida and Sakahira 2008, 624). Ida and Sakahira (2008) also found evidence suggesting that more "information-poor" users, which were concentrated in particularly isolated rural areas, opted out of FTTH migration at a higher rate (621). These individuals tended to use the internet less frequently, and only for surfing the net rather that for "the remote provisioning of such services as broadcast, health, welfare, education, [and] government" (621).

Similarly, Ida (2009) found that several household variables influenced respondents' willingness to move from ADSL to FTTH service, including income, residence type, and use of broadband for "transmitting moving picture data" (Ida 2009, 230). The study found that increasing income "from the lowest (1) to the highest (6) class" increased subjects' probability of choosing Fiber to the Home by approximately 9% (208). Earlier studies evaluating the effect of price on broadband adoption had similar findings. In particular, Madden and Simpson (1997) found that "demand for telephone network access is own-price inelastic, yet different from zero," and that elasticity varies inversely with income for both the installation and rental price of broadband (Madden and Simpson 1997, 1077).

3. The Urban-Rural Digital Divide

As previously mentioned, disparities in income and education are also thought to play a role in the 'digital divide' in internet access between urban and rural areas in the United States, and several studies have attempted to determine the roots of this phenomenon. The discrepancy in internet access rates between urban and rural households was observed as early as 1999, when Sussman (1999) noted that "the infrastructure of information and communication technology has coevolved with industry and transportation as a central property of the metropolis" (Sussman 1999, 35). The inaugural UCLA Internet Report (2000) reported that nearly one third of respondents did not currently have internet access, and only 46 percent had access in their homes (UCLA Center for Communication Policy 2000, 16-17). Rice and Katz (2003) found that Internet and mobile phone usage rates were similar, but there was "considerable divergence in usage patterns and demographic and media influences on those usage patterns" (Rice and Katz

2003, 619). The discrepancies in user patterns observed by Rice and Katz (2003) were associated with income and age, as well as income, work status, and marital status (597).

Mills and Whitacre (2003) found that differences in education and income levels accounted for a substantial portion of the service gap that exists between metropolitan and nonmetropolitan households, with place-based differences accounting for around one third of the gap (Mills and Whitacre 2003, 238-239). Whitacre (2005) found that the overall difference in internet access rates between rural and urban rates of residential internet access was between 8 and 13 percent between 1997 and 2003. Income levels contributed between 20 and 33 percent of the rural-urban divide, while education levels were responsible for between 12 and 22 percent (Whitacre 2005, 92). Whitacre (2005) also found that low-income individuals are particularly unlikely to have access to broadband. They found that households with an average income of less than $20,000 were far less likely to purchase broadband internet service (147) and that a disproportionately high number of households below this income level are located in rural areas. However, Whitacre (2005) does affirm that the 'digital divide' has been confined to broadband access, as rates of dial-up access had converged by 2003 (125-126). Subsequent studies have reached similar conclusions, finding that the probability of broadband adoption increases with income and education in urban and rural settings (Whitacre and Mills 2010, 1899).

Martin and Robinson (2007) analyzed the effect of various social indicators on internet access in the United States and the European Union. Their study found that income is the variable that most directly correlates with barriers to internet use, and that differences in internet use due to gender are less pronounced in the U.S. than in Europe. However, they also found that over time income "is relatively distinctive as a source of *increasing* inequality in the odds of internet use," and that this phenomenon is unique to the United States (Martin and Robinson

2007, 16-17). Martin and Robinson (2007) posit that this could be attributed to a gradual increase in the costs associated with broadband adoption, or to "the delayed diffusion of prerequisite technologies" limiting the adoption of newer technology (17).

Research Design

The purpose of this study is to determine the effect of income on broadband access using county-level data. The model will be constructed using factors known in the literature to be associated with broadband access.

H_1: Per-capita income will exhibit a positive relationship with the percentage of population having access to broadband.

H_2: Ruralness will exhibit a negative relationship with the percentage of population having access to broadband.

1. Data

This project will primarily make use of broadband access data made available by the FCC's 2015 Broadband Progress Report, which measures broadband access for 2013 (Federal Communications 2015a). The data is derived from FCC Form 477, which is reported by each ISP at the census block level. The data was aggregated by the FCC at the county level. As such, the dataset contains 3,141 observations that correspond with each county or county equivalent that has been assigned a Federal Information Processing Standard code by the US government (United States Census Bureau 2010). The dependent variable used in this analysis is the Total Percent of Households with Broadband Access (Total with Access). This variable measures the percentage the households in each county with access to DSL, cable, fiber-optic, or other wireline broadband service at the FCC's revised threshold, which requires 25Mbps download/3Mbps upload. This dataset also contains census-derived information on population density and per-capita income, as well as variables accounting for the percentage of rural and urban households with access to broadband. As noted in Table 4, rural areas generally have much lower rates of broadband access, as well as much lower population density.

Table 4: Percent of Americans With Broadband Access and Population Density			
	Urban Areas	Rural Areas	Total
Percent With Broadband Access (Percentage)	91%	47%	83%
Population Density (Population/Land Area)	2,402.0	17.9	90.9

Source: FCC 2015 Broadband Progress Report

The FCC data were merged by FIPS code with county-level data obtained from the USDA's Atlas of Rural and Small Town America, a 2014 publication that contains county-level economic, demographic, and occupational data. Notably, this dataset contains several variables that the literature establishes as being correlated with broadband access. These include the USDA's 2013 Rural-Urban Continuum Code, a nine-point scale that "distinguishes metropolitan counties by the population size of their metro area, and nonmetropolitan counties by degree of urbanization and adjacency to a metro area" (United States Department of Agriculture Economic Research Service 2016). As noted in Table 5, this scale contains six rural and three urban classifications, based on total population, urban population, and proximity to metropolitan areas. Thus, it takes into account another aspect of the cost of broadband deployment: the "long haul" fiber-optic connection between metropolitan and rural areas that is required to provide internet access (Columbia Telecommunications Corporation, as qtd in National Association of Telecommunications Officers and Advisors, 9). This dataset also provides demographic indicators taken from the American Community Survey and United States Census that are based on race, ethnicity, income, unemployment rates, migration rates, poverty, education and age.

Table 5: USDA Rural-Urban Continuum Code	
Code	Description
Metro Counties	
1	Counties in metro areas of 1 million population or more
2	Counties in metro areas of 250,000 to 1 million population
3	Counties in metro areas of fewer than 250,000 population
Nonmetro Counties	
4	Urban population of 20,000 or more, adjacent to a metro area
5	Urban population of 20,000 or more, not adjacent to a metro area
6	Urban population of 2,500 to 19,999, adjacent to a metro area
7	Urban population of 2,500 to 19,999, not adjacent to a metro area
8	Completely rural or less than 2,500 urban population, adjacent to a metro area
9	Completely rural or less than 2,500 urban population, not adjacent to a metro area

Source: USDA ERS Rural-Urban Continuum Codes

2. Methods

The primary method of analysis is a multivariate regression model with state-level dummy variables to account for unobserved state-level factors. As previously noted, the dependent variable is the Percentage with Broadband Access. The model includes eight control variables, along with fifty dummy variables corresponding to each state. The primary explanatory variable is per capita income. Other independent variables were also included in the model. The USDA's Rural-Urban Continuum Population Density were included to account for the rural-urban digital divide and control for the cost-effectiveness of deploying broadband infrastructure, which varies by population density and proximity to metropolitan areas. Also included are variables that account for race, low education, and age.

Table 6: Variables, Measurements, and Expected Relationships		
Variable	Measurement	Expected Relationship
Per Capita Income	United States Dollars ($10,000 scale)	Positive
Rural-Urban Continuum	1-9 Categorical	Negative
Low Education (no HS grad)	Percent without HS Diploma	Negative
African-American Non-Hispanic	Percent African-American	Negative
Native American Non-Hispanic	Percent Native American	Negative
Population Density (1000 PPSM)	1000 People per Square Mile	Positive
Net Migration Rate	Net Migration (pct. 2010-‘14)	--
Employment Change	Pct. Change 2013-‘14	--

As previously noted, studies have found that low income individuals are less likely to have access to broadband. Similarly, households with African-American heads of household are less likely to have home internet access (Mills and Whitacre 2003). Percent Native American is included to account for the low rates of broadband access on tribal lands, where the FCC has reported 63 percent of residents lack access to broadband (Federal Communications Commission 2015a). Less educated heads of household may not perceive the benefits of broadband access, making them less likely to purchase broadband internet service (Whitacre 2005). Population density directly affects the cost-effectiveness of deploying broadband infrastructure, but increases in cost effectiveness have been shown to decline in dense metropolitan areas due to increasing costs of underground fiber deployment (Columbia Telecommunications Corporation 2014, 11). Change in unemployment rate and migration rate are included to account for the effects of economic shocks, as in-migration has been shown to decrease in response to economic shocks (Monras 2015, 2).

As previously noted, I merged the two datasets by FIPS code, and dropped the state- and national- level observations to ensure a consistent unit of analysis. I inverted the included variable that measured the percent of households without broadband access to create the dependent variable for this analysis and re-specified the primary explanatory variable to $10,000 increments. Similarly, I rescaled the control variable for population density to increments of 1,000 people per square mile. I also generated a set of state-level dummy variables to account for unobserved state-level factors that could influence results. I then performed a linear regression using the previously mentioned variables. I used robust standard errors (clustered by state) to address issues related to evidence of heteroscedasticity discovered when performing post-regression diagnostics.

Results

As seen in table 7, the data indicated that rates of broadband access were substantially higher in urban areas than in rural areas. The mean of urban households with broadband access was 69.7% (SD=40.9%), compared with 37.5% (SD=31.6%) for rural households. Overall, around forty-nine percent of households had access to broadband internet service (M = 49.1%, SD=36.6). The overall distribution was approximately symmetrical (SK=-.139), but the rural distribution was slightly positively skewed (SK=-.305). The distribution for urban households, however, was more strongly left-skewed (SK=-.901).

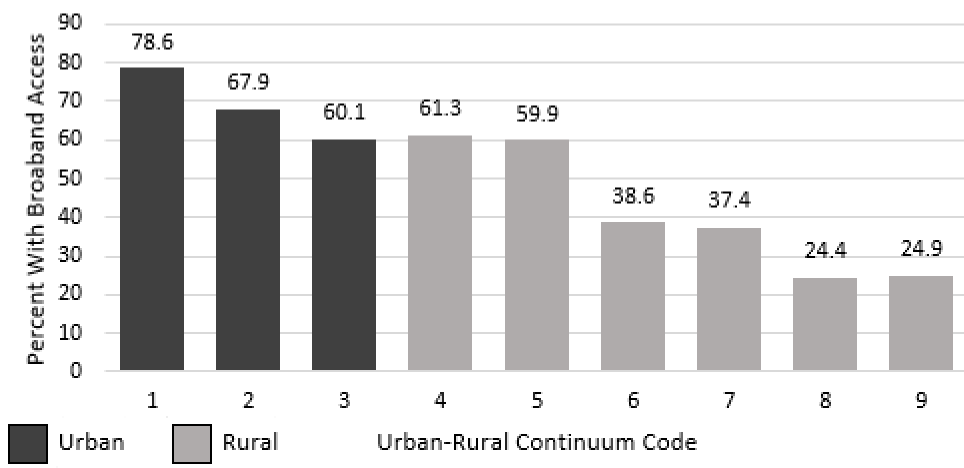
Table 7: Percent of Households with Broadband Access

Category	Mean	Standard Deviation	Skewness
Urban	.697	.409	-.901
Rural	.375	.316	.305
Total	.491	.366	-.139

However, using the USDA's Urban-Rural Continuum provides a more nuanced view of the urban-rural digital divide. As shown in figure 8, there is a clear trend of mean broadband access decreasing as mean ruralness increases, with the most urban areas having, on average, the highest average rates of access and the most rural areas having the lowest. However, a noticeable plateau exists between continuum codes 3 and 5 that crosses the urban-rural boundary.

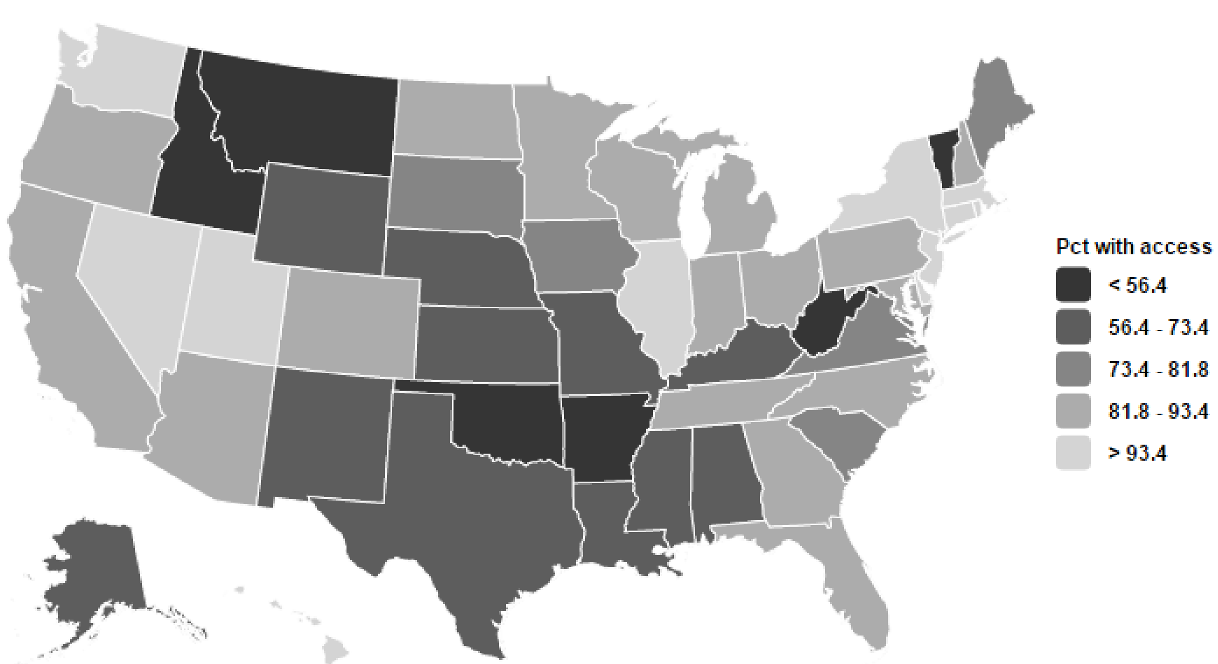
As noted in table 4, the counties within this range are either metropolitan counties with a population of less than 250,000 or are non-metro counties with urban populations exceeding 20,000. Similar plateaus exist within the rural category, with households in counties containing urban populations between 2,500 and 19,999 having mean broadband access rates of around 40 percent regardless of adjacency to metropolitan areas. Likewise, households in counties with 2500 or fewer urban residents had similar rates of broadband availability irrespective of proximity to metropolitan areas.

Fig. 8: Broadband Access by Rural-Urban Continuum



As shown in fig. 9, broadband access exhibited a great amount of variation by state, ranging from 99% in Connecticut and Rhode Island to 20% in Vermont and 13% in Montana. Many of the state-level dummy variables included in the model were highly significant, indicating the presence of otherwise unobserved state-level factors. In particular, the coefficients for Connecticut (Coef. = .1378, P = .000), Vermont (Coef. = -.3889, P = .000), and Oklahoma (Coef. = -.3389, P = .000) are both highly significant and have large coefficients. However, these effects are not uniform in direction, and not all are statistically significant. The observed state-level disparities may be explained by a host of factors that include differences in state-level broadband regulation, geographical effects, or differences in the mix of broadband providers present within each state. This is line with previous studies that have suggested that competition among broadband providers, and especially competition between owners of infrastructure, can significantly increase broadband penetration (Hoffler 2007, 411). However, high costs of entry mean that such competition does not necessarily exist in all markets. Furthermore, some states, like Massachusetts, have created policies that foster municipal broadband while twenty-two others have enacted policies that limit or outright prohibit community broadband services (Baller 2014).

Fig. 9: Broadband Access by State



After re-specification using robust standard errors clustered by state, the model's overall R-squared indicated that the model accounted for approximately 53 percent of the variation in the distribution ($R^2 = .533$). As indicated in Table 10, several variables included in the model were statistically significant at the 95% level. The regression constant was also significant at the

95% level. The primary explanatory variable, Per Capita Income, had a positive coefficient (Coef. = . 0936, P = .002), meaning that on average each $10,000 increase in per capita income corresponded to a 9.36 percent increase in the rate of broadband access. Rural-Urban had a relatively large negative coefficient (Coef. = -.0472, P = 0.00), with each level of increasing ruralness corresponding to a 4.7% decrease in broadband access. Percent Native American was significant as well (Coef. = -.0026, P = .007), although percent African-American was not (P = .347). This could indicate that the previously identified digital divide between African-Americans and the general population may be closing. As expected, population density was significant, though only at the 90% level. An increase of 1000 people per square mile was associated with a 3.96% increase in broadband access (Coef. = .03966, P = 0.042). Somewhat surprisingly, Net Migration Rate was also significant at the 90% level, with a small positive coefficient (Coef. = .0087, P = .018). This could be due to individuals moving to areas with better economic prospects, and therefore better rates of broadband access. Conversely, this result is also consistent with previous studies that have found "mild support for broadband access impacting net migration in urban areas," and is therefore potential evidence of endogeneity within the model (Mahasuweerchai, Whitacre, and Schideler 2010, 5). Percent Employment Change, the other variable included to account for economic shocks, was not significant (Coef. = .0023, P = .395).

Table 10: Linear Regression Output

VARIABLES	(1) Percent with Broadband Access
Per Capita Income ($10,000)	0.0936***
	(0.0284)
Rural-Urban Continuum Code	-0.0472***
	(0.00409)
Pct. Low Education (No HS Diploma)	0.000180
	(0.00190)
Pct. African-American	0.000748
	(0.000788)
Net Migration Rate	0.00870**
	(0.00355)
Pct. Employment Change	-0.00231
	(0.00269)
Population Density (1,000 PPSM)	0.0397**
	(0.0190)
Pct. Native American	-0.00256***
	(0.000915)
Constant	0.573***
	(0.105)
Observations	3,141
R-squared	0.533

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Based on the data, we may reject the null hypothesis that the percentage of households with access to broadband is not correlated with per capita income, as well as the null hypothesis that there is no relationship between broadband access and ruralness. However, other variables did not exhibit their hypothesized relationships. The most notable of these is Low Education (Coef. = .0001802, P = .925), which was not statistically significant and had a very low coefficient.

Conclusions

The literature suggests that several socio-economic indicators correlate with broadband adoption, and the purpose of this study is to determine whether income correlates with access. To determine whether this was the case, I fit a model using multivariate regression. This analysis provides evidence that the relationship between broadband access and income is small, but significant. The results also reaffirm the continued existence of a large rural-urban discrepancy in terms of broadband access, which was expected. The effect of income can be observed beyond the urban-rural digital divide, even if no significant effect was observed for particularly low-education populations. That said, some variables did not exhibit the expected relationship. For example, there was no significant effect for low education and for African-American populations, indicating that that those populations may have converged with the general population in terms of broadband access, controlling for other factors. It is also possible that the effects of these variables is captured by per capita income. However, Native American populations were highly correlated with lower rates of broadband access. Other results were unexpected because of their significance. The most notable of these was the relationship between broadband access and net migration rates.

These results have potential policy implications, especially for states interested in improving their rates of broadband access. As previously noted, the results indicated the presence of significant state-level effects, both positive and negative. States with unusually low rates of access could re-evaluate current policies to determine whether they are responsible for inhibiting broadband expansion. On the other hand, some states have already enacted policies aimed at improving broadband access. Several have introduced subsidies to promote broadband expansion in rural areas. In particular, Massachusetts has created a public-private partnership to administer a state-owned middle mile network whose purpose is to facilitate access in the rural Western part of that state, and Kentucky has begun the implementation process for a similar network (Coleman 2015). However, understanding factors associated with broadband access could also allow policymakers to target their efforts toward particular underserved populations. For example, more could be done to assist populations with lower than average rates of access, especially Native Americans living in rural areas on tribal lands. Approximately 85% of this population is without broadband access (Federal Communications Commission 2015a).

Additional analysis is needed to determine the underlying causes of the state-level effects. As previously noted, they could be attributed to differences in state-level utility regulation or differences between the mix of broadband providers present in each state. Subsequent research could potentially identify whether specific providers are associated with lower rates of broadband access, or if the variation is due to the presence or absence of carriers that make use of particular broadband technologies. Finally, the relationship between broadband access and net migration rates could be more fully explored.

Limitations

Given the evidence in the literature supporting the impact of broadband access on economic growth, concerns related to endogeneity remain. As previously noted, the relationship between broadband access and net migration rate also raises some concerns about potential endogeneity. The model also exhibited evidence of unexplained non-linear effects that were revealed by the Ramsey RESET Test. Additionally, performing a similar analysis at the household level rather than the county level may yield more useful results.

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