Broadband Deployment and Fiber Expansion Impacts on Home Value and Household Income

Data Science Institute
COLUMBIA UNIVERSITY

Robert (Davis) DeRodes, Zixuan (Armstrong) Li, Yao Li, Bing Xu
Dr. Henning Schulzrinne

Data Science Capstone Project with Dr. Henning Schulzrinne, Computer Science

Investing in America's Rural Broadband and Fiber Future

In 2014, 21% of rural block groups lacked access to broadband with download speeds of at least 10Mbps. In 2015, the FCC announced it would invest $1.98B over the next 10 years to internet service providers to expand broadband to rural areas, while ISP's are investing billions into fiber networks in urban areas. Determining the economic impacts of these broadband improvements in both rural and urban areas is key to understanding it's value as an investment.

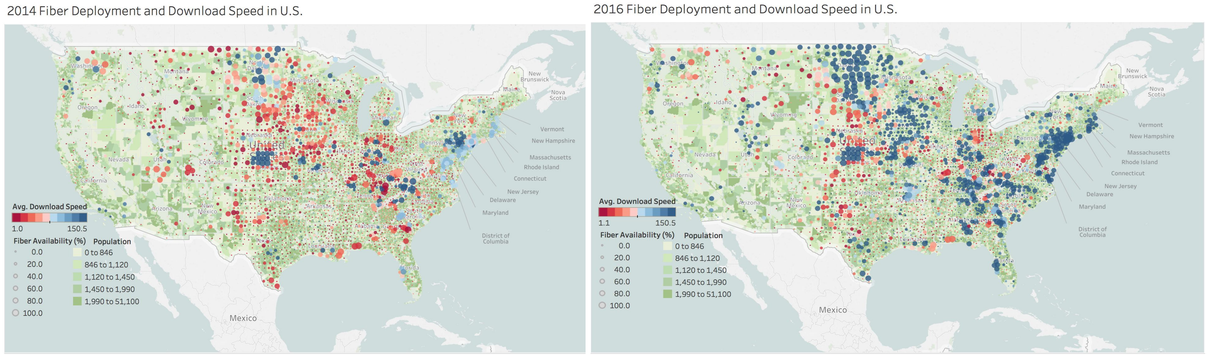

Figure 1. County level fiber deployment rate and broadband speed for 2014 and 2016 over current block group level population density

Data Pipeline and Causal Model

Our data has geographic, demographic, economic, and broadband access information for all block groups in the US. For our data, we developed a causal graph of how the variables theoretically cause each other intuitively. Due to the large amount of possible unobserved confounders, methodologies that control for these will be expected to perform better.

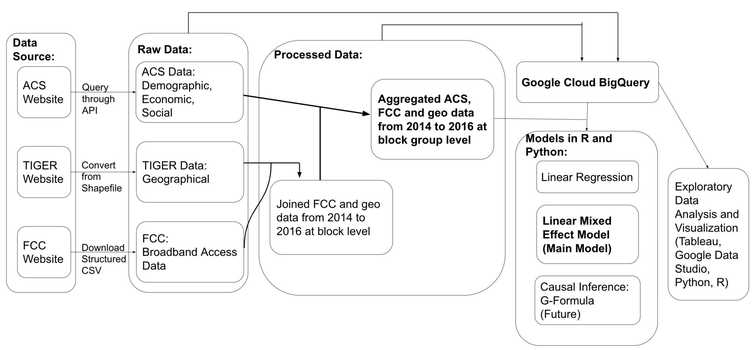

Figure 2. Data ETL, Modeling and Visualization Process

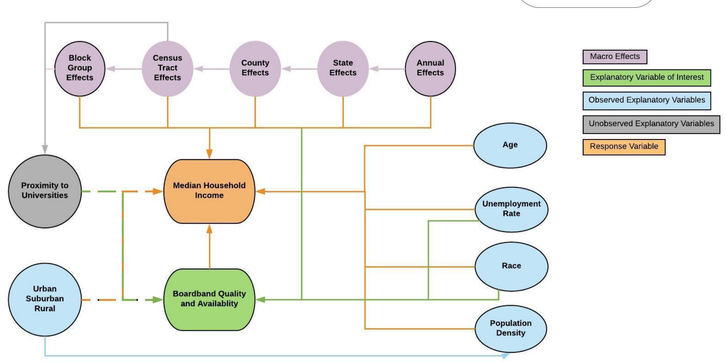

Figure 3. Causal Model

Model Results

In our three models we control for Population Density, Race, Educational Attainment, Proportion of Home Ownership, and Topological Factors. The Fixed Effects model will control for any other time-invariant confounders, while the Mixed Effect model allows for a randomly varying intercept and slope for each observation. All of our models for both broadband in rural areas and fiber in urban areas have positive estimates and almost all the models have significant results (15 out of 16).

Economic Indicator	Model	Percent Increase	p-value
Median Home Value	Linear	3.04%	<.0005
Median Home Value	Fixed Effects	0.30%	0.009
Median Home Value	Mixed Effects	0.11%	<.0005
Median Household Income	Linear	2.53%	<.0005
Median Household Income	Fixed Effects	0.20%	0.187
Median Household Income	Mixed Effects	0.98%	<.0005

Figure 4. Impact of Access to Broadband with at least 10 Mbps Download Speed on Rural Block Groups

Economic Indicator	Model	Percent Increase	p-value
Median Home Value	Linear	17.46%	<.0005
Median Home Value	Fixed Effects	1.30%	<.0005
Median Home Value	Mixed Effects	5.42%	<.0005
Median Household Income	Linear	9.93%	<.0005
Median Household Income	Fixed Effects	0.62%	<.0005
Median Household Income	Mixed Effects	5.89%	<.0005

Figure 5. Impact of Access to Fiber Broadband on Urban Block Groups

Model 1: Linear Regression

$$Y_{bg,t} = x^t_{bg,t}\beta + \epsilon_{bg,t}$$

Model 2: Fixed Effects

$$Y_{bg,t} = (x^t_{bg,t} - \mu^t_{bg})\beta + \epsilon_{bg,t}$$

Model 3: Mixed Effects

$$Y_{bg,t} = x^t_{bg,t}\beta + u^t_{bg,t}\,\gamma_{bg} + \epsilon_{bg,t}$$
$$u^t_{bg,t} \in \mathbb{R}^q$$
$$\gamma_{bg} \sim \mathrm{N}(0, \mathrm{D}),\ \mathrm{D} \in \mathbb{R}^{qxq}$$

Note: bg represents Block Group and t represents Time (2014, 2015, 2016)

Conclusions

We find that there is reasonable evidence that broadband expansion in rural areas and fiber expansion in urban areas have a positive economic impact at the block group level. We also demonstrate how model selection in longitudinal studies can lead to less bias on estimates. The Fixed and Mixed Effects models performed similarly, and generally had much smaller estimates than the biased Linear model.

Acknowledgments

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References

1. **Vamsi Gadiraju, Anthony Panat, Raghav Poddar, Zain Sherri, Sam Kececi, and Henning Schulzrinne. (2018) Who Gets Broadband When? A Panel Data Analysis of Demographic, Economic, and Technological Factors Explaining U.S. Broadband Deployment**
2. **Gabor Molnar, Scott J. Savage, Douglas C. Sicker. (2015) Technological Factors Explaining U.S. Broadband Deployment. Reevaluating the Broadband Bonus: Evidence from Neighborhood Access to Fiber and United States Housing Prices**