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Wireless Broadband and the Redlining of Rural America

Gregory Rose[1]
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[1] Dr. Gregory Rose is a political economist, econometrician, and game theorist who consults on the economics of telecommunications, broadband deployment, and auction theory for public interest organizations.

Executive Summary

The lack of wired and wireless broadband coverage in much of rural America is a persistent problem that Internet service providers sometimes suggest is caused by actual or proposed federal regulation, such as the Federal Communication Commission's Open Internet policy principles. This study examines eighty counties in twenty-nine states. In each state, it pairs counties with the highest rate of 3G and 4G wireless broadband coverage and counties with the lowest rate of such coverage. The primary finding is that more than 70% of the variation in wireless broadband deployment in those counties is accounted for by five variables unrelated to network neutrality or any other regulation:

- population density;
- median household income;
- number of firms per square mile;
- percentage of population classified as rural by the U.S. Department of Commerce; and
- whether or not 75% of the county's area is within five miles of an interstate highway.

This result suggests that 8-to-10 percent of rural America is likely to be permanently redlined by the incumbent wireless broadband providers because in those areas population density, median household income, and levels of commercial activity are too small to permit efficient aggregation of demand and too much of its geographic area is too remote from primary infrastructure (Internet backbone, interstate highways) to permit cost-effective deployment. This creates conditions under which deployment to such rural areas would depress the rate of return of wireless broadband providers

sufficiently that the stock value of those providers would be punished by financial markets. Thus, at least 8-to-10 percent of rural America is left with no market remedy for being on the wrong side of the digital divide. Only government intervention in the form of direct public investment in deployment of wireless broadband infrastructure and/or subsidized service to these areas will prevent their permanent, market-driven redlining.

The contention by wireless broadband providers that the enforcement and potential expansion of net neutrality regulation restrains investment finds no support in the evidence from rural America. It is not fear of network neutrality rules but rather the fear of punishment by financial markets for deployments that would reduce overall rates of return that explains the redlining of rural America. Following on the recent study by S. Derek Turner, showing that ILEC capital expenditure investment in wireline/fiber broadband increased both absolutely and as a percentage of total revenue after the 2006 AT&T/BellSouth merger (in which the FCC mandated net neutrality conditions for approval of the merger), this paper shows that capital expenditures by the top four wireless broadband providers similarly increased after the AT&T/BellSouth merger and that this increase was characterized by a steady rise in both capital investment and in the rate of change in capital investment. Neither the results of the Turner paper nor those of this study are compatible with the conclusion that network neutrality regulation is likely to constrain investment by wireline/fiber or wireless broadband providers. Wireless broadband providers were willing to make huge investments in deployment, but chose not to deploy in rural areas which threatened to reduce their overall rate of return. Net neutrality is not the culprit in the redlining of rural America; market dynamics are.

The Study and its Methodology

In an earlier study[2] I analyzed the characteristics of 44 unserved or underserved counties in four states, concluding that wireline/fiber broadband providers were systematically redlining 8-to-10 percent of rural America because deploying in those areas would reduce the mean rate of return of publicly-traded wireline/fiber broadband providers which, in turn, leads to punishment by financial markets. This study examines whether the same pattern holds for wireless broadband providers. This has wider implications than the likely persistence of a rural broadband digital divide. The insistence by AT&T[3] and some other broadband providers that FCC net neutrality regulations are likely to delay and deter deployment is belied by a recent analysis of the capital expenditures of these providers,[4] but the suspicion remains that the failure to deploy into much of rural America is related to regulatory disincentives to invest. This study directly addresses this claim and finds that at least 70 percent of the variation in wireless broadband coverage between urban/surburban and rural counties is explained by local variables unrelated to federal regulation.

The central intuitions guiding the regression analysis in this study are several: First, that there is a positive relationship between the percentage of a county covered by wireless broadband deployment and that county's population density, median household income, and the number of business establishments per square mile. Second, that there is

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[2] Gregory Rose, "Serving the Rural Unserved: Time for a Broadband TVA," New America Foundation (forthcoming), 4-11.
[3] Jim Cicconi, "AT&T Statement on FCC Chairman's Brookings Institute Speech," AT&T.com, September 21, 2009 (see at http://www.att.com/gen/public-affairs?pid=14034).
[4] S. Derek Turner, "Finding the Bottom Line: The Truth About Network Neutrality and Investment," Free Press, October 2009.

a negative relation between wireless deployment and the percentage of the county's population classified by the U.S. Department of Commerce as rural.

These intuitions seem plausible: the higher the population density, the greater the number of prospective subscribers; the higher the median household income, the greater the likely takeup rate for 3G/4G services *and* the greater the average revenue per user (ARPU); the larger the number of firms per square miles in a county, the larger the number of potential business customers for more lucrative business wireless broadband plans; and the more rural a county is, the lower the population density, median household income, and number of firms per square mile is likely to be. To these fairly commonsense suppositions, I added the hypothesis that proximity to an interstate highway increases the percentage of a county, whether urban or rural, which will be included in wireless deployment. This hypothesis arises from the fact that wireless broadband companies have targeted the long-distance trucking industry for major marketing campaigns and that population (as well as other business travelers) tends to aggregate around the interstate highway system.

The underlying data set consists of eighty counties in twenty-nine states.[5] These eighty counties are paired in each state based on the highest (90 percent or more) and lowest (90 percent or more) levels of 3G and 4G wireless broadband coverage (in square biles) offered by Verizon, AT&T, T-Mobile, and Sprint 3G and 4G wireless broadband.[6] The following data were collected from the U.S. Census Bureau for each county: population density per square mile, median household income, and the number of firms per square mile.[7] The percent of each county's population classified by the U.S. Department of Commerce as rural was obtained from the Economic Development Intelligence System, U.S. Department of Commerce, as of August, 2009. Finally, the percentage of each county's area within five miles of an interstate highway was calculated from the 2010 *Rand McNally Road Atlas*, and each county coded

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[5] The counties and states included in the dataset are Inyo, Mono, Trinity, San Francisco, Los Angeles,and Sacramento counties, CA; Mohave, Coconino, Maricopa, and Pima counties, AZ; Lincoln, Nye, Clark, and Carson City counties, NV; Millard and Salt Lake, counties UT; ,Jefferson and King counties, WA, Gilliam, Malheur, Multnomah, and Washington counties, OR; Brewster, Terrell, Menard, Harris, Travis, and Dallas counties, TX; Latimer and Oklahoma counties, OK; Marion, Meigs, Shelby and Davidson counties, TN; Mingo, Logan, Marshall, and Ohio counties, WV; Wayne and Philadelphia counties, PA; Warren, Hamilton, New York, and Queens counties, NY; Caledonia, Rutland, Chittenden, and Washington counties, VT; Aroostook and Kennebec counties, ME, Clinch and Fulton counties, GA; Washington and East Baton Rouge counties, LA; Otero and Bernalillo counties, NM; Los Animas and Jefferson counties, CO; Lincoln and Laramie counties, WY; Corson and Hughes counties, SD; Divide and Burleigh counties, ND; Cook and Hennepin counties, MN; Iron and Wayne counties, MI; Lewis and Jefferson counties, KY;Walker and Montgomery counties, AL; Monroe and Hillsborough counties, FL; Franklin and Suffolk counties, MA; Coos and Hillsborough counties, NH; and Sioux and Lancaster counties, NB.

[6] The coverage area in each county was mapped to the zip code level from maps publicly provided by Verizon see (http://www.verizonwireless.com/b2c/CoverageLocatorController), AT&T (see http://www.wireless.att.com/coverageviewer/#?type=voice), T-Mobile (see http://coverage.t-mobile.com/idealer.aspx), and Sprint-Nextel (see http://coverage.sprint.com/IMPACT.jsp?).

[7] U.S. Census Bureau, State and County QuickFacts, at http://quickfacts.census.gov/qfd/states/.

dichotomously 1, if more than 75% of the county was within five miles of an interstate highway, and 0 if not.

The following regression equation was evaluated:[8]

$$\ln PCTCOV = \beta_0 + \beta_1 \ln POPDEN + \beta_2 \ln MEDINC + \beta_3 \ln \text{FIRMS} + \beta_4 \ln PCTRURAL + \beta_5 INTERSTATE + e, \quad (1)$$

where ln*PCTCOV* is the natural logarithm of the percentage of a county's population within 3G or 4G broadband coverage by at least three of the four largest wireless broadband providers, ln*POPDEN* is the natural logarithm of the population density of a county in people per square mile, ln*MEDINC* is the natural logarithm of the median household income of a county, ln*FIRMS* is the natural logarithm of the number of firms per square mile in a county, ln*PCTRURAL* is the natural logarithm of the percentage of a county classified as rural, *INTERSTATE* is a dummy variable coded 1 if 75% of the area of a county is located within five miles of an interstate highway and 0 if not, and *e* is the disturbance factor. When these variables were regressed on ln*PCTCOV*, the following results were obtained:

Table 1. OLS Regression Results

Variable	Estimate	Std. Err.	Tstat	P-value
Intercept	-28.1068	7.1361	-3.9387	0.0002
ln*POPDEN*	0.78620	0.3000	2.6208	0.0106
ln*MEDINC*	2.3149	0.6401	3.6164	0.0005
ln*FIRMS*	0.5932	0.2982	1.9895	0.0503
ln*PCTRURAL*	-0.1670	0.0907	-1.8419	0.0694
INTERSTATE	1.8062	0.3645	4.9547	<0.0001

The overall model was tested by F-statistic (29.1146) and found significant at $p < .0001$. The coefficient of determination, R^2, of the model was 0.7059.

[8] The technique used was Ordinary Least Squares (OLS) regression.

We can see that population density was a significant determinant of the percentage of county population covered by 3G or 4G wireless broadband at $p = 0.0106$, while median household income was significant at $p = 0.0005$. Both firms per square mile and percentage of county population classified as rural were significant at $p < 0.1000$. Whether 75% of a county's area was within five miles of an interstate highway was significant at $p < 0.0001$. ln*POPDEN, lnMEDINC*, ln*FIRMS*, and *INTERSTATE* are positively-signed, indicating that the higher the value of these variables, the higher the percentage of a county's population covered by 3G or 4G wireless broadband. ln*PCTRURAL* is negatively-signed, indicating that the higher the value of this variable (i.e., the more rural), the lower the percentage of a county's population is covered by 3G or 4G wireless broadband.

Implications of the Study Results

These results closely parallel those of the earlier study and they do not augur well for the future of wireless broadband coverage across rural America.[9] Briefly put, the higher a county's population density, the higher a county's median household income, the larger the number of firms per square mile in a county, the smaller the percentage of a county's population classified as rural, and the more likely 75 percent of a county's area was within five miles of an interstate highway, the greater the probability that 90 percent of the county would be covered by 3G or 4G wireless broadband service. Conversely,

[9] Note that these results compare favorably with the probit regression modeling of U.S. broadband deployment undertaken the GAO in 2006: Government Accounting Office, "Telecommunications: Broadband Deployment Is Extensive throughout the United States, but It Is Difficult to Assess the Extent of Deployment Gaps in Rural Areas," GAO-06-426, May 5, 2006 {hereafter, GAO Study].

the lower a county's population density, the lower a county's median household income, the smaller the number of firms per square mile in a county, the larger the percentage of a county's population classified as rural, and the more likely 75 percent of a county's area was not within five miles of an interstate highway, the lower the probability that 90 percent of the county would be covered by 3G or 4G wireless broadband service.

Even cursory examination of the characteristics of counties in which 90 percent or more of county area is covered by wireless broadband, compared to those of counties in which 90 percent or more of the county area remains uncovered, reveals stark disparities. The mean population density in covered counties is 2,995.6; in uncovered counties it is 25.7. The mean median household income in covered counties is $51,702; in uncovered counties it is $39,327. The mean number of firms per square mile in covered counties is 503.2; in uncovered counties it is 2.3. The mean percentage of population classified as rural in covered counties is 12.4 percent; in uncovered counties it is 71.7 percent. When tested by chi-square, the differences between the means of these characteristics of uncovered counties and the national means are significant at $p < 0.001$. In similar testing of the difference means of these characteristics of covered counties and the means the results were not statistically significant. This strongly suggests that a core 8-to-10 percent of rural America is condemned forever – absent government intervention – to exclusion from wireless broadband access.

Relative Rate of Return is the Driving Factor in Rural Deployment

Certainly the cost of deployment in some rural areas contributes to the disinclination of providers to deploy in those regions. However, in most cases the

estimated cost of deployment to a rural area is statistically indistinguishable from that of deployment into suburban sprawl.[10] While the costs of deployment associated with geographic area and terrain in most rural areas to not appear to differ significantly from those associated with suburban areas, the difference in cost *per subscriber* between many rural areas and most urban and suburban regions is significant. This has implications for the rate of return a provider can reasonably expect from rural areas.

Gary Kim identifies this as a factor determining deployment: Even where deployment costs can be overcome, there may be an insufficient number of potential subscribers and their income may be low enough that an acceptable rate of return can be guaranteed only with substantial subsidies:

> People often assume that customer demand is unmet because service providers don't want to provide service. Nothing could be further from the truth. Most small, rural communications providers, some of which are cooperatives, suffer from a lack of customers. Of the 1,000 or so small, independent telcos or cooperatives in the United States, half to 70 percent (or more, in some cases) of total revenue comes from other telecom companies in the form of "access charges" (allowing customers to receive long distance calls) or from support mechanisms such as the Universal Service Fund.
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> That means half to 70 percent of revenues do not come directly from customers, in part because there are so few customers, and in part because those customers do not pay anything like a rate that would provide an actual financial return on providing service. Put another way, the most-important revenue sources are other telecom providers and taxpayer subsidies provided precisely because, in the absence of those subsidies, wired network service simply is not feasible.[11]

The GAO study also makes this point somewhat more obliquely:

> The Universal Service Fund (USF) has programs to support improved telecommunications services. The high-cost program of the USF provides eligible local telephone companies with funds to serve customers in remote or rural areas

[10] This matter would be easily resolved if the FCC were to require providers to publicly report deployment costs by zip code.
[11] Gary Kim, "Broadband Stimulus: Who is 'Unserved,' and Why?" (available at http://ipcarrier.blogspot.com/2009/03/broadband-stimulus-who-is-unserved-and.html).

> where the cost of providing service is higher than the cost of service in more urbanized areas. The high-cost funds are distributed to providers according to formulas based on several factors, such as the cost of providing service, with funds distributed to small rural incumbent local exchange carriers (ILEC) and larger ILECs serving rural areas based on different formulas. Competitive local exchange carriers can also qualify to receive high-cost funds. While high-cost funds are not specifically targeted to support the deployment of broadband infrastructure, these funds do support telecommunications infrastructure that is also used to provide broadband services. We were told by some stakeholders in certain states that high-cost support has been very important for the upgrade of telecommunications networks and the provision of broadband services. In particular, some stakeholders in Alaska, Ohio, and North Dakota told us that high-cost support has been critical to small telephone companies' ability to upgrade networks and provide broadband services. Additionally, the e-rate program of the USF has provided billions of dollars in support of Internet connectivity for schools and libraries. Another USF program, the Rural Health Care Program, provides assistance for rural health facilities' telecommunications services.[12]

However, neither Kim nor the GAO identify the problem with sufficient precision. Publicly-traded firms are all dependent on private capitalization and are, therfore, extremely sensitive to variation in stock price and evaluation of their firms by traders. In rural areas the indirect effects of low population density and low median household income are likely to be particularly felt after deployment: aggregation of demand becomes a vexing problem. The rate of return on investment in a minimum of 8%-to-10 percent of rural areas in the U.S. and abroad is limited by constraints on the number of available subscribers and their relatively low income levels, even where deployment costs have been substantially assumed by government. These factors affect both the profit margin (profit as a percentage of sales revenue) and the rate of return on invested capital (profit as a percentage of the capital invested in production) of private providers. Reduction of a firm's profit margin or ROI results in adverse evaluation of a firm's stock by traders and analysts, usually followed by downward adjustment of stock price.

[12] GAO Study, 23-24.

Providers are certainly aware of this market dynamic and one Verizon regional executive, who asked for anonymity as a condition of answering questions for this study, makes this amply clear:

> We know better than to propose deployment in areas which promise only marginal rates of return on investment. There isn't much that gets the attention of the head office faster than suboptimal performance reducing the company's rate of profit. And proposing deploying to an area which guarantees suboptimal performance – too few customers who can afford our rates – will get you shot down. "We've got to listen to the market," is something you always hear from the head office when they turn down deployment proposals. That means that a lot of rural areas get redlined, but not for any reasons of discrimination. It's because the guys at the top are scared of how lower rates of return will affect stock price.

Indeed, senior executives with the vast majority of their total compensation tied to the firm's relative stock price are acutely sensitive to the relative rates of return on new capital investment. For example, Verizon's CEO, Ivan Seidenberg, receives 100 percent of his performance-based equity compensation in Performance Stock Units (PSUs) that pay out based on a formula tied to Verizon's rate of total shareholder return (TSR) relative to an industry peer index. Other senior executives at Verizon receive 60 percent of their performance-contingent equity compensation in PSUs, based on relative TSR, while the other 40 percent is paid in Restricted Stock Units (RSUs) that directly track Verizon's share price.

The profit rates of all incumbent wireless broadband providers are relatively low and it is plausible that any significant diminution of the profit rate would have immediate adverse impact on stock performance. However, this has dire implications for rural broadband. It implies that, even if the government fully subsidizes the costs of deployment, there will be areas – perhaps including as much as 8-10% of rural population – to which publicly-traded private providers, even the major incumbents, will in principle

not provide broadband service because they offer too little return. Interestingly, this almost exactly parallels the historical experience of both rural telephony and rural electrification.

Conclusion

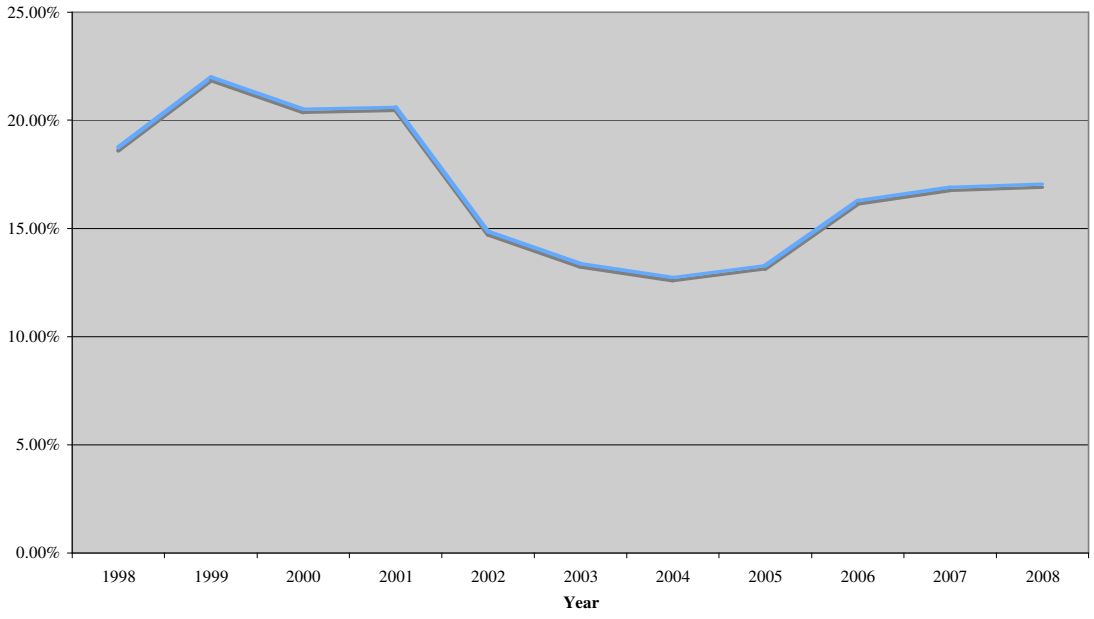
The suggestion that the reluctance of wireline/fiber incumbents to deploy in rural America is a result of network neutrality regulations has been devastatingly refuted by S. Derek Turner,[13] whose study published last year by Free Press shows that the capital expenditures of these incumbents increased both absolutely and as a percentage of revenue after the FCC required AT&T to operate a neutral network as a condition of acquiring BellSouth. Turner's study shows that the notion that enforcement of the FCC's Open Internet principles was a factor in the redlining of rural America by wireline/fiber incumbents has no empirical basis.

A similar conclusion can be put drawn regarding incumbent wireless broadband providers. Table 2 provides a graphical representation of the capital expenditures of the top four incumbent wireless broadband providers – Verizon, AT&T, Sprint, and T-Mobile – from 1998 through 2008:

As with the wireline/fiber incumbents, wireless incumbents' capital expenditures declined in the recessionary fluctuation occasioned by the 9/11 attacks, but were increasing with rapidity in 2004 and 2005. This continued after the FCC adopted its open Internet principles in 2005; after the AT&T merger with BellSouth with its net neutrality

[13] Turner, *op. cit.*

Table 2.
Mean Capex of Top Four Wireless Broadband Providers As a Percentage of Mean Revenue



conditions in 2006; and after the FCC in 2007 adopted 700 MHz auction rules that attached the open Internet principles and explicit *Carterfone* "open access" conditions to the nationwide license for 22 MHz of former TV band spectrum later acquired by Verizon Wireless for $4.65 billion. What is striking here is that not only did the first derivative (the rate of change) of the curve increase in value for the period 2006-2008 in comparison to 1998-2006, but so also did the second derivative (the rate of change in the rate of change) of the curve. This is hard evidence that net neutrality regulation had nothing to do with the decision of wireless incumbents to redline rural America. Wireless broadband providers were willing to make huge investments in deployment, overall, but chose not to deploy in rural areas which threatened to reduce their overall rate of return.