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The Economic Benefits of Mobile Broadband

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Abstract

Mobile broadband is becoming increasingly important to national economies and the personal lives of users. However, broadband availability and adoption are not diffusing as quickly in rural areas or among certain minority groups. This article updates the rural and minority digital divide. Empirical estimations of mobile broadband provision and fixed broadband usage in the US show that rural areas have fewer providers and minorities have lower usage rates. The potential for mobile broadband to benefit rural areas through economic development and urban areas through enhancing the digital inclusion of minority communities is also examined.

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1. Introduction

Broadband internet access in general, and mobile broadband in particular, are becoming increasingly important to national economies and the personal lives of users. In the US alone there were about 84.4 million mobile broadband connections at the beginning of 2011, virtually the same as the number of fixed broadband connection (FCC 2011, Table 1). Nevertheless, as with nearly all new technology, broadband availability and adoption are not diffusing as quickly in rural areas or among certain minority groups. This article presents an up to date view of the rural and minority digital divide based on latest statistics, showing that significant divides in both availability and usage persist. The potential for mobile broadband to be an engine of growth for rural economic development is then examined. Mobile broadband also holds significant potential for urban areas as well, given the importance of broadband, particularly mobile broadband, for urban minority communities.

The article proceeds by documenting the gaps in availability and usage between rural and nonrural areas in the next section. Both external evidence and a novel examination of the latest FCC data are presented. The data for the empirical study come from the US Federal Communications Commission's (FCC) census of all broadband providers in the US as of year end 2010. In section 3 the promise for broadband to spur local economic growth is reviewed. Issues regarding broadband and minorities are taken up in section 4. Although minorities generally have as many broadband options as others, given their predominantly urban location, even the latest statistics examined in section 4.1 show that gaps in usage persist and are quite large. The particular promise that mobile broadband may hold for urban minorities regarding social, medical, and economic inclusion is discussed in section 4.2, and section 4.3 points out the relatively greater reliance on mobile forms of broadband by these populations.

Although the digital divide has an international dimension (Eggerton, 2011), the focus here is on the US. Furthermore, rather than focus on any particular public policy toward broadband, the purpose of the article is to set out the facts regarding the state of current broadband deployment and usage and the promise of broadband for rural and urban areas, which should set the backdrop for broadband policy discussion.

2. The State of Broadband Availability and Usage in the US

2.1. Availability

Rural areas in the US generally lag their urban counterparts in broadband availability. For example, one study of broadband deployment in South Carolina using the latest official broadband data from the National Telecommunications and Information Administration (NTIA) found that broadband service is scarcer in the more rural areas of the state (Li *et al*., 2011), and there are far fewer wireline and mobile options in the 10 poorest (rural) counties in South Carolina compared to the 10 with the highest incomes (which are more urbanized). Nationally, the latest FCC Form 477 broadband data, for year-end 2010, shows that while almost everyone in the US has access to broadband in some form,[1] rural residents have fewer providers available for both fixed (Figure 1) and mobile (Figure 2) broadband.[2] The Census tract level figures are population weighted, and so reflect the probabilities of the access options available to an individual in the US.

Figure 3 is a map of the number of mobile broadband providers in the US by Census tract, with hatching to show rural areas.[3] Darker areas on the map have a greater number of mobile providers in the area. The map shows that, in accord with Figure 2, most areas have one to three mobile broadband providers. There are a large number of mobile providers in major metropolitan areas like Chicago and

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[1] Figure 1 uses the National Broadband Plan definition of broadband: at least 3 mbps downstream and 768 kbps upstream. If the traditional FCC definition of 200 kbps transmission at least one way is used, then only an estimated one-tenth of one percent of the population in the US lacks access to a fixed broadband residential provider (author's calculations using the FCC Form 477 (population weighted) tract data).

[2] Data from the Economic Research Service (ERS) of the US Department of Agriculture are used to classify each tract as rural or non-rural. The ERS data categorize tracts based on population density, urbanization, and daily commuting patterns. A tract is considered rural if it has a Census 2000 Rural/Urban Commuting Area code in the range 4-10.

[3] This map is an update of that in Prieger and Church (2012).

Houston. With some exceptions such as the California Central Valley, rural areas have almost uniformly lower coverage than urban areas. Given that Figure 1 is population weighted and the map is not, the disparity between rural and urban areas is even more visually striking in Figure 2.

Although rural areas lag non-rural areas in the availability of access to broadband, mobile broadband partially fills in geographical gaps in fixed-line broadband coverage in the US. Table 1 presents statistics from the FCC broadband data, showing access to residential fixed and mobile broadband providers. The figures are population weighted, and so reflect the probabilities of the access combinations available to an individual in the US.[4] Of the population underserved by fixed-line high-speed providers (i.e., those without access to any residential offering with advertised service of at least 3 mbps upstream and 768 kbps downstream), 96.8% have access to at least one mobile broadband provider and over a quarter have access to four or more mobile providers. The FCC data include mobile broadband providers offering relatively slow broadband, but the major wireless carriers in the US are deploying 4G technology in their service areas. The data thus indicate that mobile providers can play a significant role in extending broadband service to areas underserved by fixed broadband.

Nonetheless, mobile broadband deployment lags in rural areas, even after controlling for the demographics of local areas. Table 2 presents the results of a Poisson regression on the number of mobile broadband providers in the Census tract, using the 2010 year-end data from the FCC. The regressors include a rural tract indicator, population density, the number of households, median income in the tract, the racial and ethnic composition of the tract, and state-level fixed effects to capture the influence of any regulatory, economic, or social factors related to broadband that are common to the state.[5] Previous waves of these data have been examined by numerous authors (Prieger, 2003; Grubesic and Murray, 2004; Xiao and Orazem, 2005; Flamm, 2005; Prieger and Lee, 2008; Wallsten and Mallahan,

[4] This section relies on and updates the analysis in Prieger and Church (2012).

[5] The tract-level demographic data are from GeoLytics *2010 Estimates*. The rural indicator is from the ERS, as described above.

2010; Prieger and Church, 2012). Unlike some of these investigations, which are interested in testing hypotheses about the causal impacts of various policy variables, the regression performed here is purely for descriptive purposes. These FCC data are censored—provider counts in the range from one to three are grouped—and so the methodology of Prieger and Church (2012) for maximum likelihood estimation for interval censored Poisson regression is employed. The coefficients can be interpreted as usual for a Poisson model; that is, as if they were from a log-linear regression.

The results in the first columns of Table 2, labeled *Poisson Estimation*, show that even after controlling for area income, racial composition, and unobserved state-specific factors, rural areas and areas with lower population density have fewer mobile broadband providers. The coefficient for the rural indicator variable implies that rural areas have approximately 41% fewer providers, other things equal. The coefficient for population density implies an elasticity of the number of mobile broadband providers of about seven—highly elastic. All these estimates are highly statistically significant. In sum, even after controlling for population density and income, rural areas continue to be associated with a lower number of providers.

2.2. Usage

When broadband is not available in rural areas, people cannot use it. The latest broadband report from the NTIA reveals that while the usage gap between rural and urban areas is shrinking, a differential in broadband adoption of over 10 percentage points continues to exist (NTIA, 2011). Lack of broadband availability is a much larger barrier to personal usage in rural areas than urban areas. The NTIA (2011) examined the top reasons for a household not to adopt broadband. Unavailability is the top reason for non-usage for almost one in 10 households in rural locations, whereas it is the top reason only 1% of the time in the rest of America. Even when broadband is available to rural communities, its quality—whether measured by speed or other characteristics like mobility—often lags that found in the nearest urban center.

Lagging rural subscription rates are not merely due to differences in income or other demographics. The latest FCC broadband subscription data allow an examination of the digital divide in fixed broadband usage between rural and urban areas. An ordered logit regression of the December 2010 subscription rate categories for residential fixed broadband is in Table 2. The FCC reports residential broadband subscription at the Census tract level in six categories: no subscription, a subscription rate between zero and 20%, a rate between 20% and 40%, a rate between 40% and 60%, a rate between 60% and 80%, and a rate greater than 80%. In the first estimations, broadband is defined to be 200 kbps in at least one direction. The results using the same regressors as for the Poisson regression are in the columns labeled *Ordered Logit Estimation 1* in Table 2. The estimated odds ratios[6] are all significant, and show that subscription lags in rural areas and is higher in more densely populated areas, even after controlling for income, race, and ethnicity. The odds ratios for the rural indicator, 0.693, implies that the odds of having a subscription rate higher than 40% (for example) in a rural area are only 69.3% as large as the odds in a nonrural area.[7] Similarly, the odds ratio of 1.115 for log income implies that the income elasticity of the odds of having a subscription rate higher than 40% (for example) is 0.0115 (and significant).

In the next set of columns in Table 2 (labeled *Ordered Logit Estimation 2*), the ordered logit estimation on the subscription rate is repeated with the addition of an indicator variable for having more than three fixed broadband providers in the tract. This variable serves as a rough proxy for both price competition and a more attractive set of service offerings. The odds ratio on the provider indicator is significant and greater than one, as expected. More importantly for present purposes, it does not significantly change the estimates of the rural or population density odds ratios. Thus even

[6] Group the categories into higher and lower sets. The odds ratio for a regressor *x* shows the impact (in multiplicative terms) of a one unit increase in *x* on the odds of being in the higher set of categories instead of the lower set. In an ordered logit regression, the odds ratio is the same regardless of where the dividing line between the sets is.

[7] Similarly, the odds of having a subscription rate higher than 20% in a rural tract area is only 69% of the same odds in a nonrural tract, and so on.

after controlling for income and (in an admittedly rough way) the price and the variety of broadband options, there is still significant evidence of a rural digital divide in broadband adoption. *Ordered Logit Estimation 3* in the final columns of Table 2 shows that even when a stricter definition of of broadband is used (at least 768 kbps downstream and greater than 200 kbps upstream, the NTIA BTOP definition) for the subscription rates, the results are very similar.

Thus, both external sources and the estimations performed here show that there are large gaps in broadband adoption in rural areas. While it would be interesting to perform similar estimations on mobile broadband subscription rates, the FCC does not make available such information at the tract level.

3. Broadband as an Engine of Rural Economic Development

A rapidly growing literature suggests there are many potential and demonstrated ways in which broadband deployment benefits economic development. The research to date includes case studies, qualitative analyses, and systematic empirical work. This section reviews a sampling of what we now know about the linkages between broadband and economic development. Given that wide availability of high-speed mobile broadband in the US is just beginning, the review of the literature begins with a general discussion of the economic benefits from any form of broadband. Next, what studies have uncovered regarding the specific contribution that broadband makes to rural economies is discussed. The section concludes with lessons concerning mobile broadband in particular and its potential as an engine of rural development.

3.1. The Impact of Broadband on the Economy

Over the past decade, enough experience with widespread adoption of broadband has been gained to begin to allow systematic empirical exploration of the linkages between broadband and economic development. Given the nascence of the mobile broadband era, the review of the literature begins with a general discussion of the economic benefits from any form of broadband, mobile or fixed.

Mobile broadband, as with fixed broadband, has tremendous potential to transform economic activity because it is a *general purpose technology* (GPT). Bresnahan and Trajtenberg (1995) characterize a GPT by its pervasiveness, potential for technical improvements, and potential to increase the productivity of R&D in downstream sectors. A GPT like broadband thus spreads throughout all aspects of the economy and creates productivity gains in many industries. In the case of Internet and broadband GPT, the technology directly raises productivity in ICT-intensive industries (Varian *et al*., 2002). The beneficial effects of improved productivity and lower costs in industries that are heavy users of ICT ripple outward to other sectors of the economy that use these firms' outputs as inputs. Prieger and Heil (2010a,b) review the mechanisms by which the diffusion of ICT leads to general microeconomic and macroeconomic growth. Below, some of the specific personal economic benefits of broadband for local areas are also discussed, including making telemedicine possible and enhancing distance-learning opportunities. There are many more potential benefits of broadband for rural areas than have ever been quantified, such as expanding the access of rural businesses to supplier networks and increasing the attractiveness of rural tourism, just to mention two.

The economic literature on technology and economic growth characterizes the linkages between broadband and productivity according to whether the technology's benefits for the firm are directly related to the firm's decisions of which inputs and production processes to use. In this view, the direct impact of an ICT such as broadband follows from a firm's decision to adopt the technology to lower its production costs and to enhance the productivity of its labor by providing its workers with better "tools." In addition, broadband's role as a GPT leads to indirect productivity enhancements for firms, through what Mayo and Wallsten (2011) term *growth externalities*. Mayo and Wallsten (2011) posit two ways in which broadband can lead to growth externalities. Both are framed in the context of the endogenous growth model that has dominated the academic field of macroeconomic growth for more than two decades.[8] First, as broadband technology improves and its diffusion increases, society's stock of "knowledge" (here used as a catchall term for the disembodied product of research and development technology, i.e., information that increases the production possibilities of firms apart from any physical inputs used) increases, which in itself raises each firm's productivity "from the outside." Thus, a firm becomes more productive when general knowledge increases apart from any decision of its own to adopt a particular technology. An example of this mechanism is how a firm designing new products can take advantage of the diffusion of broadband in society. Such a firm can design certain aspects of products and software assuming that consumers will have broadband connections to update firmware, register products, or download additional functionality. A second way broadband leads to growth externalities is that it lowers transaction costs for firms to acquire and use knowledge. Rather than being part of the knowledge itself, as in the first mechanism, under this view broadband is valuable as a facilitator of knowledge acquisition and deployment. For example, in a broadband world, knowledge useful to a particular industry can be disseminated quickly to interested parties, and broadband can aid the acquisition of new products and services complementary to the new knowledge.

What might the overall impact on the US economy be from broadband? Estimates vary according to how widely one defines "broadband" and the statistical methodology used, but the impacts appear to be large. Greenstein and McDevitt (2009) tackle the task of finding broadband's net contribution to US GDP. Using the same methodology as for official calculation of the national income and product accounts, they conclude that the direct, net impact of broadband's deployment was approximately $8.3 to $10.6 billion of new GDP in 2006. They also find an additional $4.8-6.7 billion in new consumer surplus created by broadband (net of what would have accrued with dial-up service), which does not show up in GDP.

[8] See pp. 178-179 in Mayo and Wallsten (2011) for the mathematical models of endogenous growth underlying the following discussion.

Greenstein and McDevitt's figures are notably smaller than most other estimates of broadband's impact on the US economy, for at least two reasons. They focus only on direct benefits of broadband and carefully net out the benefits from the replaced technology, dial-up Internet access. Most other studies, often not published in peer reviewed journals, come to estimates of broadband benefits that are higher by an order of magnitude (e.g, Crandall and Jackson,2003; Entner, 2008; Deighton and Quelch, 2009).[9] Before continuing on to results from other individual studies, it should be noted that while a growing body of research finds a positive association between broadband availability and economic growth, pinning down the exact magnitude of the causal relationships is difficult. The task is conceptually difficult, because while broadband may promote development, economic growth stimulates further deployment and usage of broadband in turn. Thus, real-world data differ markedly from data generated from a controlled experiment, and disentangling the simultaneous causality in the former is hard. Further difficulty stems from the lack of sufficiently granular data on broadband deployment and usage over periods long enough to enable such studies. With improved data being released by the FCC and the National Broadband Map, this may change in coming years. Looking back, however, Holt and Jamison (2009) conclude their review of the empirical literature with the caution that although broadband's positive economic impact in the US appears to be clear, the impact cannot be analyzed with precision. In an even more recent review, Mayo and Wallsten (2011) characterize the theoretical and empirical research addressing how broadband enhances economic performance as "nascent and as yet emerging" (p.175). In part, this is because the impact of broadband changes rapidly over time as technologies, industries, and business' adaptation to ICT evolve. Whatever the exact question should be and its precise answer, the scope of the importance of broadband to the modern economy is clearly large.

[9] See also the four other non-peer reviewed studies cited in Table 1 of Rohman and Bohlin (2012), claiming to find broadband investment multipliers of 1.45 to 3.6.

3.2. Broadband and Economic Development

This section discusses evidence from three major studies that empirically analyze the link between broadband deployment or usage and economic growth in the US and abroad. The growing literature indicates that the potential for broadband to stimulate economic development is real, although perhaps hard to quantify.

In the US, several studies have shown that output and employment are correlated with the deployment of broadband infrastructure. In one of the first, Crandall *et al*. (2007) examine private employment growth in the 48 contiguous states during 2003-2005, and find that it is positively associated with broadband penetration (measured as broadband subscriber lines per capita in a state). Their regression methodology does not control for the simultaneity of broadband penetration and economic growth, or for other potentially contaminating effects of unobserved factors within a state. Nonetheless, the study documents that the association between broadband and employment growth persists after controlling for related factors such as the wage level, unionization rates, education of the work force, and the tax climate.[10] The particular methodology of Crandall *et al*. does not allow the authors to claim that they have precisely identified the causal role of broadband in stimulating growth. Furthermore, Mayo and Wallsten (2011) show that Crandall *et al.*'s results may be particular to the relatively short period they study. However, other studies have found a more robust set of results with econometric methods that allow researchers greater claim to having uncovered causal relationships between broadband and economic development. We review a few of these studies in the rest of this section.

Gillett *et al*. (2006) perform one of the first careful econometric studies on broadband availability and local economic development in the US using sub-state geographic data. The authors state that "[t]he results support the view that broadband access does enhance economic growth and

[10] Crandall *et al*. (2007) also find that the correlation between broadband penetration and state GDP is positive, although the result lacks statistical significance.

performance, and that the assumed economic impacts of broadband are real and measurable" (p. 3). The study classified each ZIP code area in the nation based on its broadband availability in 1999, using the FCC Form 477 data on broadband providers, and then followed the growth in employment and other economic indicators over time. The statistical methodology included matching ZIP code areas with broadband to those without to create "treatment" and "control" groups, regression analysis, and other econometric techniques designed to distinguish causality from mere correlation.

The major findings are that broadband added 1.0-1.4% to the growth rate of local employment and 0.5-1.2% to the growth rate of the number of business establishments over the years 1998-2002. Housing rents, as a proxy for property values, were more than 6% higher in 2000 in areas where broadband was available by 1999. Broadband availability also appeared to add 0.3-0.6% to the share of businesses in sectors that are intensive users of ICT. As has generally proved to be the case with such studies, Gillett *et al.* did not find a statistically significant impact of broadband on wages. The authors conclude that "broadband is clearly related to economic well-being and is thus a critical component of our national communications infrastructure" (p. 3).

In another nationwide study, Kolko (2010) finds that broadband expansion is correlated with economic growth over the period 1999-2006. This relationship, naturally enough, is strongest in industries that rely heavily on ICT: information; professional, scientific, and technical services; management; and administrative services. The design of the study benefits from looking at outcomes at the subcounty (ZIP code) level and from taking seriously the question of reverse causality. Regarding the latter, the author finds that broadband providers do not merely target areas where they expect higher economic growth, because later employment growth does not predict earlier broadband growth. In another attempt to move from correlation to causality, Kolko (2010) estimates an instrumental variables regression that explicitly accounts for the potential simultaneity of broadband and employment growth.[11] The results, while apparently sensitive to the exact specification of the statistical model, strengthen the claim that the association between broadband and employment growth is at least partly causal.

Some of the particular findings of Kolko (2010) include that broadband is associated with population and employment growth. Compared to areas that had no broadband providers, areas with one to three providers had 6.4% higher employment growth and 2.4% more population growth. Although the figures cited indicate that employment grew more than population, the research uncovered no significant effect of broadband on the employment rate. The author suggests that may be because people follow the jobs—not a bad outcome in itself for areas seeking to grow.

There are also several explorations of the linkage between broadband penetration and economic growth at the national level using international data. The research in recent years comes to a consensus that a 10 percentage point increase in broadband's household penetration boosts a country's GDP in the range of 0.1 percent to 1.4 percent.

In a typical cross-country study, LECG (2009) adopts a macroeconomic growth model to look at the experience of 15 developed Western countries over the period 1980-2007. The report finds that the countries with high levels of general ICT diffusion enjoyed significant productivity gains from broadband. In particular, in such countries an increase of 10 percentage points in broadband penetration increases productivity by about 1.3%.[12] Countries that have low general ICT diffusion see no productivity increase from broadband. The report suggests that the countries without broad ICT diffusion—mostly the

[11] As Kolko (2010) explains: "The instrumental variable strategy identifies a factor – in this case, slope of terrain – that affects broadband expansion without independently affecting employment growth, holding other factors constant. The relationship between employment growth and the variation in broadband expansion that is predicted by slope identifies the causal portion of the effect of broadband on growth, at least for the areas in which slope is a good predictor of broadband expansion." Instrumental variables estimation is a standard tool of econometrics and has been applied fruitfully in many economic inquiries. Van Gaasbeck (2008) also employed the technique of instrumental variables to conclude that broadband usage leads to employment growth in her study of California counties.

[12] The report estimates several specifications of the model, including versions designed to minimize bias caused by unobserved, country-specific factors and the simultaneity of broadband and general economic expansion.

southern European countries in the study's sample—may have high costs of adopting new technology or barriers to "re-skilling" their workforce to take advantage of ICT to improve labor productivity. These factors are less likely to be an issue in the US, even in rural areas, although ensuring that labor is properly trained to use modern ICT should be a goal in any country. We discuss broadband's potential to encourage human capital formation through distance learning in a subsequent section.

Other international studies use broader samples of countries, but come to similar conclusions. Qiang and Rossotto (2009) use a macroeconomic growth modeling framework similar to that of LECG (2009), but look at a large panel of 120 countries for the period 1980-2006. They find that broadband penetration—measured by broadband subscribers per 100 people—has a statistically significant association with the growth rate of real GDP in a country. The "broadband dividend" for a high-income country of an extra 10 percentage points of broadband penetration during the period is an extra 1.2 percentage points of per capita GDP growth. The magnitude is about the same (but less statistically precise) for low-income countries. Although their study did not fully control for the simultaneous causality between broadband usage and economic growth and omitted factors potentially causing both, other studies that do employ these controls come to similar results. In one, Czernich *et al.* (2011) estimate a sophisticated econometric model in the spirit of Qiang and Rossotto (2009), using data for 25 OECD (developed) countries during 1996–2007. The authors conclude that a 10 percentage point increase in broadband penetration raised annual per capita growth by 0.9–1.5 percentage points, in accord with the earlier study, although the methodology was quite different.

Studies linking development to mobile broadband are still few in number, and are often consulting reports with a "back of the envelope" flavor rather than carefully documented, academically rigorous econometric studies. A recent report by Deloitte (2011) gives a sense of the magnitudes involved. The estimated $25-53 billion investment in 4G mobile wireless technology in the US is projected, using standard GDP multipliers for the industry, to create $73-151 billion in GDP growth and between 371,000 and 771,000 new jobs.

3.3. Broadband and Rural Development

Dickes *et al.* (2010) notes that there is now a body of "substantial research" on the economic and social benefits that rural areas can enjoy from access to broadband service. Of course, the general economic benefits discussed above also apply to rural areas, such as cost savings and improved efficiency for business. Today, e-commerce virtually requires broadband. While the advantages for companies of adopting e-commerce have been well studied (Prieger and Heil, 2010b, 2012), the benefits need not accrue only to firms in urban areas. Barkley *et al*. (2007) performed a series of over two dozen qualitative case studies on rural businesses that adopted e-commerce. While the authors note that their findings are not necessarily statistically representative of all rural businesses, e-business was successfully adopted by most of the firms in the studies. In fact, one of the potential dangers Barkley *et al*. note for small firms moving into the world of e-commerce is lack of preparation for the rapid sales growth that can occur. Uses of e-commerce included developing new products, lowering marketing costs, increasing sales and reaching new markets, and improving the efficiency of managing inventory and distributing products and services. While many of these functions can be accomplished with both wired and wireless broadband networks, some tasks such as updating inventory and delivery records at the point of delivery are uniquely suited to mobile broadband.

A few examples of benefits of broadband that are of particular interest for rural communities are increased community involvement, greater opportunities for income expansion through telework, and increased human capital through distance learning and telemedicine (Stenberg *et al.*, 2009). The Internet can foster community interaction by lowering the effective cost of civic engagement and community participation. It is much easier for a rural resident to inform himself about local land-use planning issues, for example, by accessing information online than it would be to go to a municipal records center in town. In this example, downloading all of the necessary documents and maps with anything slower than a broadband Internet connection would be painfully slow. Stenberg *et al*. (2009) cite several empirical sociological studies that find the Internet use bolsters civic engagement. Importantly, some of the research indicates that the quality of the Internet experience—using broadband technology, for example—is important for a community's participation by residents and its general civic health. While the mechanism of causality may not be clear, the data show that using broadband is positively correlated with higher levels of community involvement (Stern e*t al*., forthcoming). One avenue by which improved ICT leads to greater civic engagement is ICT's contribution to social capital. That is, as Stern and Adams (2010) claim, better communication technologies "lead to increased contacts and the broadening of one's social network as well as [to] a new avenue to find information about participating at the local level" (p. 1390). The authors suggest that such social capital formation is most important in rural communities, where residents must rely more on local relationships with others to achieve personal and community goals.

Stenberg *et al.* (2009) discuss the survey work of Morris and Goodridge (2008) to draw together three related facts indicating that broadband may have an interesting role to play in rural telework. First, as is well known, many US businesses engage in global outsourcing for service support. Second, despite the cost advantages to businesses of outsourcing, 57% of customers in one survey were dissatisfied with services outsourced to foreign countries. Third, almost two-fifths of rural residents are interested in working from home and would be open to telework opportunities. The percentage was even higher for retirees, many of whom have decades of experience as knowledgeable and responsible employees. Stenberg *et al*. bring these facts into conjunction with the finding that about three-fourths of outsourcing businesses are interested in bringing some outsourced positions back to the US if rural employees could fill the roles. For many such positions to work out, however, quality broadband connections would presumably be a necessity.

Telemedicine is an application that is often mentioned as a beneficial service enabled by broadband in rural areas. While the appeal of telemedicine is clear—it gives rural communities access to some of the same health care infrastructure that urban areas enjoy, albeit "virtually"—its benefits are hard to quantify broadly. In one of the few empirical studies on the potential economic benefits of telemedicine, Whitacre *et al*. (2009) found that five rural communities in Oklahoma that participated in telemedicine saved a total of $3.5M in healthcare cost for teleradiology and telepsychiatry alone. The authors note that the economic benefits of telemedicine in rural areas can include "transportation savings and improved productivity for residents, increased lab and pharmacy work performed locally, and potential cost savings to the hospital from outsourcing telemedicine procedures" (p.194). Note further that to the extent that rural wages in the healthcare sector are lower than their urban counterparts, any medical service like lab work that e-medicine allows to be performed in rural areas instead of in urban areas produces an economic savings for society.

Some studies on specific aspects of telemedicine show its great promise. Seto (2008) conducted a comprehensive review of studies calculating economic analyses of heart failure telemonitoring systems in the field. Seto found that *all* the studies concluded that e-monitoring was less expensive than usual care in a hospital, with a range of 2-68% cost savings, even before accounting for additional factors such as travel costs and a lower incidence of rehospitalization.

When considering the possible benefits of mobile telemedicine, it is important to note that advanced mobile technology may be particularly suited to such applications. For example, the low latency in LTE networks mean that there is far less delay from data transmission to receipt, compared to previous generation wireless technology.[13] The low latency and high throughput of LTE enable creation of efficient mobile telemedicine applications and complementary services such as VOIP and video conferencing.

[13] See AT&T, Declaration of John Donovan, filed with the FCC on April 21, 2011, available at http://fjallfoss.fcc.gov/ecfs/document/view?id=7021240423.

What might be the overall impact on rural economies from all these factors? In one of the most careful studies of broadband's effect on the rural economy, Stenberg *et al.* (2009) used a quasi-experimental design approach to examine the impact of broadband on rural employment and income. Each of 228 rural counties that had high broadband availability in 2000 was paired with a similar "control" county that had low broadband availability. The matched counties were as similar as possible in terms of local economic structure, population density, income, and other factors. Use of a treatment and control group allows the researchers to focus on differences in employment and income growth when broadband is widely available. Over the years 2002-2006, the "treatment group" of early-adopting counties experienced more job growth, particularly in the nonfarm sector. Broadband-available counties also had more population growth in all years and higher personal income and nonfarm earnings growth in some of the years. The positive association between broadband and personal income, which is significant in 2002, stands in contrast to the finding of no association by Kolko (2010). The difference may be due either to a stronger impact of broadband availability on personal economic welfare in rural areas or the improved study design the quasi-experimental design offers. While not all of the differences Stenberg *et al.* found are statistically significant, the counties with low broadband availability in 2000 never significantly outperformed the treatment group in any year of the study.

3.4. Mobile Broadband and Rural Development

Virtually no studies attempt to quantify the particular impact of mobile broadband on rural development. However, some lessons can be drawn from the closely related literature on mobile telecommunications of any sort on macroeconomic development and growth. As with general broadband technology, the mobile telecommunications and broadband industry contributes to national economic performance through direct and indirect channels. Mobile technology boosts growth directly, through deployment of infrastructure and other direct economic activity. Mobile technology also induces growth indirectly through the positive externalities provided by mobile telecommunications as a general purpose technology. However, as the economy grows, demand for mobile services increases, creating a virtuous cycle of increasing penetration and economic growth. The cycle implies that the simple correlation of GDP with mobile usage reflects two-way causality. Gruber and Koutroumpis (2010) perform one of the most ambitious cross-country studies looking at how mobile telecommunications infrastructure and usage affects growth and productivity. The authors isolate the one-way impact of mobile infrastructure and its externalities on GDP by controlling for increased demand for mobile services due to higher economic output. With a structural econometric model that accounts for reverse causality and the several relationships among GDP, mobile infrastructure, and supply and demand in the mobile industry, the authors find a sizable positive impact of mobile infrastructure on GDP across 192 countries and two recent decades.

Arguing that network effects in the mobile telecommunications market lead to increasing returns in economic output, Gruber and Koutroumpis break down their findings by low, medium, and high mobile penetration countries. In accord with the notion of increasing returns, the authors find that while the impact of mobile infrastructure on GDP is significant for all groups, it rises with the level of penetration. This implies that areas with little mobile infrastructure suffer from compounding disadvantages: not only do low-penetration areas miss out on its direct economic benefits because they have low levels of infrastructure, the little infrastructure they have does not cause as much growth per unit as more highly mobilized countries. The advantages of increasing mobile penetration are further compounded, because with increasing returns, high penetration increases the incentives for further investment and even more GDP growth. The magnitude of mobile infrastructure's contribution to GDP is both statistically significant and sizable. The authors calculate that mobile telecommunications in high-income OECD countries contributed 0.4% to their GDP growth, while in low income countries as a group the contribution was about half that.

Gruber and Koutroumpis also use similar methods and data to estimate the impact of mobile infrastructure on macroeconomic productivity. They find results similar to those for output. Mobile infrastructure increases output per worker-hour, and there again appear to be increasing returns. The contribution from mobile infrastructure to annual productivity growth ranges from 0.3% in the highest penetration countries to about half that in the low-penetration countries.

To the extent that rural areas in the US lag urban areas in the development of ICT infrastructure, some of the lessons from the literature examining the role that mobile broadband can play in the economic growth of developing nations are relevant. The McKinsey report discussed in Buttkerelt *et al.* (2009) estimates the potential economic impact of bringing the developing economies across the world up to the level of broadband deployment and usage of Western Europe. The report projects that world GDP would rise by USD 300-420 billion. The exercise is similar in spirit, if not in numerical detail, to considering the impact of bringing rural areas up to the broadband level of urban areas. The impacts on GDP occur through the channels discussed at the beginning of this section. There are measurable contributions to GDP from direct investment in ICT industries, which are further multiplied as related businesses create new value from equipment, content, and applications enabled by mobile broadband. The report mentions as an example that the ubiquity of mobile broadband in Japan has led to forecasts that applications like mobile music downloads, games, and online video will grow at 6–9% per year in the near future. Deployment of mobile broadband also improves GDP through the indirect channels of increasing firms' productivity and efficiency, attracting investment from outside the area, and improving local human capital through improved healthcare, civic engagement, and education.

It is straightforward to apply all of these notions directly to rural areas in the US, although since the economic gap between rural and urban areas in the US is not as great as the development gaps that exist between lesser developed countries and the West, the scale of the impacts may be lower.

However, given Gruber and Koutroumpis's (2010) finding of increasing returns in the impact of mobile infrastructure deployment, these rural incremental benefits may be substantial.

4. Particular Benefits of Mobile Broadband for Urban Minorities

Turning now from rural to urban areas, this section considers three questions regarding mobile broadband. The first question is, given the advances in broadband access and usage among minorities in recent years, how much of a digital divide remains for minorities? Even though the nation has taken great strides in both the availability of broadband to minorities and their usage of it, there is still a broadband usage gap between most racial and ethnic minority groups and whites.

Second, how can broadband help minorities to participate fully in civic life and to improve their personal lives? Two areas of participation are considered as examples: civic engagement and healthcare. Available research indicates that use of digital and online technology is important to minorities when engaging in civic and political life and accessing government information. Broadband in general and mobile broadband in particular can also help address disparities in health outcomes and access to healthcare that some minorities face. Whether through enhancing prospects for participation in online health communities or through providing the necessary bandwidth to enable mobile health applications and devices, mobile broadband can facilitate access to better health information and care.

The third question pertains to the role of that mobile broadband plays in providing Internet access for minority users. Do minority users in general and African Americans in particular rely more heavily than others do on mobile devices for their broadband Internet access? Available recent evidence suggests this is so. Mobile phone ownership is much more common among minorities than computer ownership, which helps overcome the hardware barrier to broadband usage. Evidence indicates that some minorities are not only more likely to have mobile Internet-capable devices, they are also more likely to use them to access the Internet. Importantly, black and Hispanic users are just as satisfied as others with their online experiences, or more so.

4.1. Minorities are at Greater Risk of Digital Exclusion

In this section, survey evidence from various sources is examined to show that on average, African Americans, Hispanics, and some other minority groups tend to have less access to and usage of broadband. While dealing with averages gives the big picture for the various minorities, looking at the groups as a whole should not obscure the fact that there is much variation among individual experiences within the groups. For example, Gant *et al.* (2010) says that within any particular minority group, those who are younger, more educated, and wealthier tend to be more deeply engaged with broadband.

Broadband Access

Although disparities in access to and usage of broadband between minorities and others have shrunk in recent years, the latest data indicate that gaps may still exist. Gant *et al.* (2010) conducted a national survey of Internet usage in December 2009 and January 2010, focusing on minority access and usage. When individuals who do not use the Internet are asked why, 13% of African Americans and 16% of Hispanics say the reason is that they do not have access. This is the second most commonly given reason, after general lack of interest in the Internet. Only 11% of whites say their reason for not using the Internet at home is lack of access. Compare these results with the latest broadband usage data from the US Census Current Population Survey (CPS). The CPS data for October 2010 show that lack of access (which is defined more broadly as unavailability of broadband *or* lack of a computer to access it) is the main reason stated for not using high-speed Internet at home by about 17% of non-adopting blacks and Hispanics, about the same or slightly higher than for whites (NTIA, 2011, p.23).

It is important to note that surveying non-users on why they do not use broadband at home is not the same as surveying all households to ascertain whether broadband connections are available. The results from the Poisson estimation for the number of mobile wireless broadband providers in Table 2 show that the more minorities are in the Census tract, the *greater* the number of providers. This is likely due to these variables being positively correlated with location in urban cores with maximal wireless coverage. Nonetheless, the results cited previously are suggestive that gaps between minorities and whites in broadband access (broadly defined) may continue to exist.

Broadband Usage

Regardless of whether there is unequal access to broadband for minorities, the data show clearly that there are still disparities in broadband usage between minorities and others. A sizable body of empirical literature has explored reasons for lower broadband usage by minorities. Explanations proposed for the broadband gap include lack of computer ownership, low income, and (particularly in earlier years) lack of broadband availability.[14]

In its review of the latest official CPS figures, the NTIA (2011) concluded that when compared with whites, "[s]ignificant disparities … remained among other race and ethnic groups [excepting Asian and white non-Hispanics], with none exceeding broadband use of greater than 50 percent" (p.11). In October 2010, 50% of African Americans and 45% of Hispanics used broadband in the home, but over 68% of whites and Asian Americans did. Another recent survey by the FCC from late 2009 shows higher but still lagging usage rates for African Americans and Hispanics. The FCC survey (Horrigan, 2010) found broadband usage to be 69% for whites, 59% for African Americans, and 49% for Hispanics. The trend appears to be promising, however, since in the CPS data the growth rate in broadband use for African Americans and Hispanics is higher in the most recent data than it was in the 2007 to 2009 period. The NTIA also found that there could be significant disparities among the sub-groups that make up a racial or ethnic category.

Recent data from non-governmental sources generally confirm that broadband penetration lags among African Americans and Hispanics. As of May 2010, the Pew Research Center estimated Internet

[14] See Prieger and Hu (2008) for a review of the literature on minorities and broadband usage and access.

usage among whites at 80%, but usage among African Americans to be only 71% (Smith, 2010a).[15] The comparable figures for broadband usage were 67% for whites and 56% for African Americans, a gap of 11 percentage points. While this usage gap between African Americans and whites is smaller than reported in the other sources reviewed above, the author notes that the gap persists despite strong growth in broadband adoption by African American households.

Although some of the broadband gaps for minorities are caused by lower incomes, income alone does not fully explain the broadband digital divide. For example, among those earning less than $20,000 per year, 56% of African Americans and 58% of whites report being online in January 2010, but only 43% of Hispanics (Gant *et al.*, 2010). Thus, even when restricting attention to low-income individuals, differences in usage crop up between Hispanics and others. Similarly, differences in human capital alone do not explain the entire usage gap between whites and non-whites. The same report found that among high-school dropouts, 33% of Hispanics, and 37% of African Americans used the Internet, which lags greatly usage by white dropouts (51%). Gant *et al.* (2010) also shows that the differential Internet adoption rates of minorities are not explained solely by rural versus non-rural location, for blacks and Hispanics lagged whites in both areas. Furthermore, African Americans are more likely to live in non-rural areas, where their Internet adoption rates are higher than in rural areas (69% vs. 65%). Thus, favorable geographical composition tends to reduce somewhat the overall usage gap for blacks. The same is true for Hispanics.

The exploration of the FCC broadband subscription data in Table 2 confirms that income does not fully explain the broadband digital divide between non-whites and whites. The ordered logit regressions discussed in section 2.2 also control for race and ethnicity. Consider first *Ordered Logit Estimation 1* in Table 2. The odds ratios are all significant, and show that subscription is higher in areas

[15] The Pew data did not find any disparity in usage between whites and Hispanics. However, the Pew survey does not include non-English speaking Hispanics, which may account for the discrepancy between its results and survey results from other sources.

with higher income. Despite separately controlling for income and rural location, the non-white and Hispanic odds ratios are all less than one, implying that the more the population in a tract is composed of these groups, the lower the subscription rate. The odds ratios for the fraction of people living in the tract that are black is 0.156, implying that (for example) the odds of having a subscription rate higher than 40% in an all-black area is only 15.6% of the same odds in an all-white area. The odds ratios for Native Americans, other race, and Hispanics are even lower than for blacks. The odds ratio for Asians is 0.24. All of these are highly statistically significant.[16]

The same results concerning race and ethnicity hold with few changes in *Ordered Logit Estimation 2*, which controls for the number of providers. Thus controlling for income and broadband competition does not explain the racial digital divide in broadband adoption. With the *Ordered Logit Estimation 3*, which uses the stricter definition of broadband, the results remain about the same.[17]

In summary, the literature cited above along with the investigation of the latest official data here show evidence of large adoption gaps remaining in fixed broadband subscription by race and ethnicity, and the gaps are not solely due to income or rural/urban location. As noted above, similar estimations cannot be performed on mobile broadband subscription rates, due to lack of data. However, as discussed in the following section, available evidence indicates that some minority groups rely disproportionately on mobile sources for their broadband connections.

4.2. Urban Minorities and Digital Connectedness

Digital connectedness has become very important for full participation in the social, economic, and civic spheres of human interaction. Broadband, and increasingly *mobile* broadband in particular, are the central components of digital connectedness in modern life. Geographers speak of the integration of cyberspace and physical space as mobile Internet-capable devices gain widespread use

[16] Even if the standard errors are clustered by state, which may be appropriate due to the state fixed effects in the specification, all the racial and Hispanic estimates remain significant at the 1% level, with the exception of "other race".
[17] The lone exception is that the "other race" odds ratio is no longer significant (but is still less than one).

(Kellerman, 2010). The more important broadband becomes to society, the greater the potential cost of failing to connect all Americans. The FCC's National Broadband Plan calls the cost of digital exclusion "large and growing" and goes on to state:

> For individuals, the cost manifests itself in the form of lost opportunities. As more aspects of daily life move online and offline alternatives disappear, the range of choices available to people without broadband narrows. Digital exclusion compounds inequities for historically marginalized groups. (*FCC, 2010, p.129)*

The National Broadband Plan goes on to assert that broadband can facilitate the narrowing of social and digital divides, helping "…low-income, minority and other communities overcome other persistent socioeconomic or geographic disparities" (FCC, 2010, p.171). The rest of this section looks at some examples of the role broadband can play in furthering digital inclusion.

Broadband Can Help Overcome Disparities

How does broadband help minorities to participate fully in civic life and to improve their lives? Academics and advocates have argued that broadband Internet access and other forms of "digital literacy" are key. Many programs have been aimed at promoting digital literacy and broadband usage among minorities and other disadvantaged groups. Digital literacy programs often have specific goals such as enhancing employment opportunities, integrating immigrants into civic life, fostering social cohesion and interaction among neighborhoods, or building social and human capital by developing ICT skills in the community (Hilding-Hamann *et al.,* 2009; Hauge and Prieger, 2009, 2010).

The views of those at risk of ending up on the wrong side of the digital divide are perhaps even more compelling than the opinions of the experts. Survey evidence shows that minorities—more than whites—view a lack of broadband as creating detrimental consequences for themselves. A recent Pew report found that minorities in the US are among the groups that are "most attuned to the need for a home broadband connection" (Smith, 2010a, p. 14). When looking for employment, African Americans and Hispanics are significantly more likely than whites (51% versus 39%) to say that a lack of broadband access presents a "major disadvantage." Similarly, blacks and Hispanics also view not having access to broadband as a major disadvantage when it comes to getting healthcare information, learning new things to improve and enrich their lives, using government services, and keeping up with news and happenings in the community (Smith, 2010a).

Some evidence indicates that minorities use broadband Internet access to address and remedy deficiencies in human capital. For example, a survey conducted by the FCC found that African Americans are significantly more likely to take online classes than whites by a margin of 37% to 22% (Horrigan, 2010). The importance of the Internet for finding employment is also greater for African Americans, with African Americans being more likely than whites (83% versus 55%) to go online to get information about or apply for a job.

Of course, broadband is not a panacea for all social ills, and some proponents are too glib when expounding its benefits. When considering digital inclusion, the availability of broadband is only one element of a package that includes other elements such as digital literacy, relevancy of online content, and the personal financial resources to embrace available devices and service offerings. Furthermore, convincing measurement of the personal benefits caused by programs to stimulate broadband adoption or digital inclusion are nearly nonexistent (Hauge and Prieger, 2009, 2010). However, broadband can be an important tool for individuals and policymakers alike. In the remainder of this section, two particular areas that demonstrate the potential of broadband to enrich the lives of disadvantaged users are reviewed: civic engagement and healthcare.

Civic Engagement

Reinvigorating civic participation in American life is vital to sustaining the culture of democracy upon which the nation was founded. As important aspects of civic life move online, "digital citizenship" becomes an indispensable element of civic engagement. Available data indicate that, in some aspects, minority Americans are leading the way in this regard. Research also finds that minorities hold different attitudes toward social media than whites. For example, Smith (2010b) finds from a recent large-scale survey that

> …minority Americans were very active using social technologies to share information during the 2008 election campaign. And when we asked about government outreach using social media, minority respondents were significantly more likely than whites to say that this type of outreach "helps people be more informed about what government is doing" and "makes government more accessible." They are also much more likely than whites to say it is "very important" for government agencies to post information and alerts on social networking sites.

Smith's research also uncovered that minorities are more likely to substitute digital technology for face-to-face interaction to keep up with neighborhood happenings and events. Such substitution was found to be especially important for residents less likely to know their neighbors by name, which may be more prevalent in the crowded, relatively less safe urban neighborhoods in which many minorities reside.

While minorities are at greater risk of digital exclusion because of lower access to and usage of broadband, as documented below, this may be ameliorated as mobile broadband usage continues to diffuse. Given that minorities are heavier users of *mobile* broadband than other groups, any policy that encourages the spread of mobile technology may foster digital citizenship by making available high quality access to the Internet.

E-health and M-health

Greater broadband access can provide minorities greater access to the world of online healthcare—e-health—and its relatively new aspect, mobile health, or m-health. Two of the "socioeconomic disparities" mentioned in the National Broadband Plan afflicting low-income minority communities are access to quality healthcare and health outcomes in general. It is well documented that minorities and low-income Americans receive lower quality of healthcare on average than do whites and members of higher-income households. A recent report from the Agency for Healthcare Research and Quality (AHRQ, 2011), an agency of the US Department of Health and Human Services, found evidence of significant disparities in access to healthcare. AHRQ found blacks to have worse access than whites for one-third of the core measures of the study, and Hispanics to have worse access than non-Hispanic whites for all but one of the core measures. Not only access to, but also the quality of healthcare differs for the average minority healthcare consumer. AHRQ found that African Americans, Native Americans, and Hispanics receive lower quality healthcare for between 40 to 60% of core measures. Worse access to and quality of healthcare translates into worse health outcomes. Only 44% of African Americans and 34% of Hispanics rate their health as very good or excellent, compared with 59% of whites (CDC, 2008).

The nexus of healthcare and mobile broadband has at least two aspects. The first is that users with wireless Internet access participate more in certain forms of healthcare-oriented online media. Fox (2011) finds that mobile Internet users are more likely than others are "to post their own health experiences online or to access the health information created by other people in online forums and discussion groups." To the extent that some minorities rely more heavily on smartphones to access the Internet (as we document below), mobile broadband helps level access to e-health among demographic groups, for as Brodie *et al*. (2000) found, "once people have access to the Internet, the health information digital divide tends to disappear." Furthermore, for some diseases, education and self-management is critical to help patients to understand their symptoms and treatment options, and online information can play an important role (Schatell *et al.*, 2006). Johnson and Ambrose (2006) discuss how participation in online health communities for patients with complicated treatment plans can help them understand the regimen by their physicians, increasing the likelihood that they stick with their treatments and heal.

Of course, e-involvement alone does not substitute for medical care from a physician, and there may be some limitations with online healthcare, such as misinformation or inadequate security of personal medical information (Johnson and Ambrose, 2006). Furthermore, large-scale studies quantifying specific, measurable benefits from participation in online health communities for individuals, particularly with regard to concrete physical health outcomes, are scarce.[18] However, at least one study finds a positive correlation between better health, personal happiness, and looking online for health information (Cotten and Gupta, 2004).

The other aspect of the nexus of healthcare and broadband is the field of m-health medical technology. Clearly, we have seen only the first fruits of this linkage. More and more m-health technology will rely on high-speed wireless networks. The National Broadband Plan mentions m-health applications, devices, and networks that allow "clinicians and patients to give and receive care anywhere at any time." Some m-health applications such as downloading diagnostic data and lab results to smartphones are feasible today, provided adequate mobile network bandwidth is available. Other m-health applications are just coming over the horizon of cost-effectiveness, such as non-invasive personal networks of implanted body sensors. Since some minorities are at greater risk of living in areas that are underserved by local healthcare facilities (Kirby, 2008; AHRQ, 2011), medical technology that allows remote monitoring or otherwise removes the limitations of distance in healthcare may greatly benefit their communities.

4.3. Some Minorities Rely Heavily on Mobile Broadband

In the increasingly mobilized world, Internet access through mobile broadband devices is growing as the channel of choice for many Americans, particularly minorities. As the chairman of the

[18] The same does not apply to telemedicine, which numerous studies in the medical literature have shown to be effective for specific healthcare applications (Ekeland, *et al.*, 2010).

FCC, Julius Genachowski, has noted, "The spectrum crunch is a particular concern for minority communities. Mobile devices are now the primary pathway to the Internet for minority Americans, as African-Americans and Latinos have adopted mobile broadband at a faster rate than the general population" (Genachowski, 2011). A major reason for the growing popularity of mobile broadband among minorities, who have lower income than whites on average, is the lower cost of a wireless device than traditional desktop PCs (smartphones are often heavily subsidized by the service provider). As a Commerce Department official stated when discussing President Obama's National Wireless Initiative, "a significant number of households do not subscribe to broadband because they have inadequate computers or no computers at all. The initiative will help eliminate this access barrier by expanding 4G and facilitating the proliferation of mobile devices with computing capability. These mobile devices are significantly less expensive than computers, but still provide a means through which individuals can access the Internet, web applications, and other web services" (Lawrence Strickling, in NTIA (2011), p.3).

Available statistics support these statements that minorities are less likely to own computers but more likely to have mobile devices. Gant *et al*. (2010) found that 62% of whites had a working desktop computer at home, but only 54% of blacks and 49% of Hispanics. A slightly more recent survey found the desktop computer ownership gap between blacks and whites to be a bit larger, at 14 percentage points (Smith, 2010b). Lower computer ownership among some minorities translates into greater barriers to Internet adoption. In a survey of individuals who do not use high speed Internet at home, not having a computer was the main reason given for non-use by 16% of blacks, 20% of Native Americans, 16% of Hispanics, but by only 13% of whites (NTIA, 2011).

Mobile phone ownership is much more common among minorities than computer ownership. Gant *et al*. (2010) found that African Americans and Hispanics are about 30 percentage points more likely to own a cell phone than a computer. In fact, a Nielsen survey showed that when it comes to smartphones (defined in the survey as mobile phones with "app-based, web-enabled operating systems"), usage is higher among Hispanics (45%) and African Americans (33%) than among whites (27%) (Kellogg, 2011). Among new purchasers of mobile phones, the differences in smartphone adoption among groups are even starker. Kellogg reports that "[a]lthough only 42 percent of Whites who purchased a mobile phone in the past six months chose a smartphone over a feature phone, 60 percent of Asians/Pacific Islanders, 56 percent of Hispanics, and 44 [percent] of African Americans who recently bought cellphones chose smartphones."

Mobile Internet access can also be through a laptop computer. Evidence from Smith (2010b) reveals that although African Americans and Hispanics are less likely to have a desktop computer in the home, they are just as likely as whites to have a laptop computer.[19]

Minorities are not only more likely to have mobile Internet-capable devices, they are more likely than whites to use them to access the Internet. While 30% of whites use their cell phone to access the Internet, half of all blacks and 42% of Hispanics surf the net through their phones.[20] These patterns of usage reveal their consumers' preferences. African Americans are more than twice as likely as whites to say their cell phone is their preferred device to access the Internet, and Hispanics are 60% more likely to say this than whites. In fact, minorities lead whites in using a wide range of their smartphones' capabilities. Smith (2010b) finds that African Americans and Hispanics are more likely than white cell phone owners to use their mobile device to text, use social networking sites, surf the Internet, email, play games, post multimedia content online, and even make charitable donations via text messaging.

A criticism sometimes leveled, particularly in the 3G era of mobile Internet access, was that limitations in wireless devices and connection speeds led to a "second class" experience for mobile users. Continual improvement in mobile devices and technology makes this much less of a concern. Smartphones get ever "smarter," and with the latest mobile broadband technology such as LTE, data

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[19] The parity in laptop computer ownership for blacks appears to be very recent, as a survey from earlier in 2010 by Gant *et al*. found that laptop ownership for blacks and Hispanics lagged white ownership by about ten percentage points.

[20] All statistics in this section, unless otherwise noted, are from the report by Gant *et al.* (2010).

transmission rates satisfy any official definition of broadband. To quote Chairman Genachowski (2011) again:

> Increasing broadband adoption rates for minority communities is very important, no matter how the Internet is being accessed. And with new mobile devices like tablets hitting the market, and wireless carriers beginning to roll out 4G networks, which will offer a high-speed Internet experience comparable to what many enjoy on desktops, the mobile broadband experience will only get richer.

Despite the relatively greater reliance of African Americans on mobile devices to access the Internet, as a group blacks are even more satisfied with their online experiences than others. Gant *et al.* (2010) find that 65% of African American Internet users responded that they are "very satisfied" with their broadband service, compared to 61% of Hispanics and 57% of whites. At the other end of the spectrum, African Americans are less likely than others to report that they are either "not too satisfied" or "not satisfied at all."

5. Conclusions

The expansion of mobile broadband in the US will have important economic and social benefits. The evidence suggests that as mobile and other forms of broadband diffuse in rural areas, they will stimulate local economic growth, although estimates vary concerning the magnitude of the causal impact. Mobile broadband is also important to urban individuals, given the role that mobile broadband can play in closing broadband access gaps for minority users.

These potential benefits to users of mobile broadband, including increased digital citizenship and an expanded scope for mobile health participation and applications, not to mention the general economic consumer benefits gained by usage of the service, suggest that any policy affecting broadband diffusion is highly important. Antitrust scrutiny of proposed wireless mergers, spectrum policy, and universal service support for broadband subscription are just a few current public policy issues in the area. Regardless of the details of the particular policy being debated, the participants in the discussion should be cognizant that the stakes are large.

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Table 1: Residential and Mobile Broadband Providers for US Population, Year End 2010

	Mobile Broadband Providers (200+ kbps one way)						
Residential Broadband Providers (3+ mbps up/ 768+ kbps down)	0	1-3	4	5	6	7+	Total
0	3.2%	68.3%	16.7%	6.4%	5.2%	0.2%	100%
1-3	0.3%	21.7%	22.4%	36.0%	16.0%	3.8%	100%
4	0.1%	16.6%	16.7%	37.8%	23.2%	5.5%	100%
5+	0.2%	17.0%	17.1%	39.9%	22.9%	3.1%	100%
Total	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100%

Notes: each cell is the percentage of mobile broadband providers within the row falling into the category given by the column heading. The figures are population weighted. The data are from FCC Form 477 broadband data for December 21, 2010.

Table 2: Regression Analysis of the Number of Mobile Broadband Providers and Fixed Broadband Subscription Rates

	Poisson Estimation		**Ordered Logit Estimation 1**		**Ordered Logit Estimation 2**		**Ordered Logit Estimation 3**	
	Y = # mobile broadband providers in Census tract		Y = residential fixed BB subscription rate categories		Y = residential fixed BB subscription rate categories		Y = residential fixed BB subscription rate categories (BTOP)	
	Coefficient (×100)	s.e.	Odds Ratio	s.e.	Odds Ratio	s.e.	Odds Ratio	s.e.
rural	-41.49*	(0.49)	0.693*	(0.017)	0.682*	(0.017)	0.622*	(0.016)
population density (log)	7.02*	(0.08)	1.115*	(0.006)	1.148*	(0.007)	1.244*	(0.008)
income (log)	11.71*	(0.34)	18.747*	(0.602)	18.714*	(0.600)	18.847*	(0.593)
# households (log)	-2.18*	(0.15)	0.696*	(0.012)	0.655*	(0.012)	0.676*	(0.012)
race, fraction black	12.62*	(0.42)	0.156*	(0.007)	0.156*	(0.007)	0.172*	(0.007)
race, fraction native american	0.58	(4.57)	0.025*	(0.006)	0.029*	(0.007)	0.033*	(0.008)
race, fraction asian	8.75*	(0.77)	0.244*	(0.029)	0.234*	(0.028)	0.183*	(0.020)
race, fraction other	25.19*	(6.49)	0.079*	(0.058)	0.089*	(0.066)	0.621	(0.448)
ethnicity, fraction hispanic	9.77*	(0.51)	0.101*	(0.005)	0.098*	(0.005)	0.090*	(0.005)
# fixed BB providers > 3					1.372*	(0.023)	1.303*	(0.022)
Wald Chi-Square stat (df)	87,118.0 (59)		23,562.9 (59)		23,947.2 (60)		25,305.8 (60)	
P-value of Chi-Square statistic	0.000		0.000		0.000		0.000	
Log Likelihood	-96,392.2		-78,531.5		-78,366.6		-80,640.0	

*Estimate is significant at the 1% level.

Notes: sample size is 64,918 in all estimations. The unit of observation is a Census tract. The dependent variables are from FCC Form 477 broadband data for December 21, 2010. Broadband is defined to be at least 200 kbps in at least one direction in the Poisson and first two ordered logit estimations. Broadband is defined to be 3 mbps downstream and 768 kbps upstream (or higher) in ordered logit estimation 3. Estimated standard errors used to calculate *p*-values are robust to heteroskedasticity. Odds ratios are exponentiated coefficients. All estimations include state fixed effects.

Figure 1: Fixed Providers of Residential Broadband (NBP Definition) by Rural and Non-Rural Population, Year End 2010

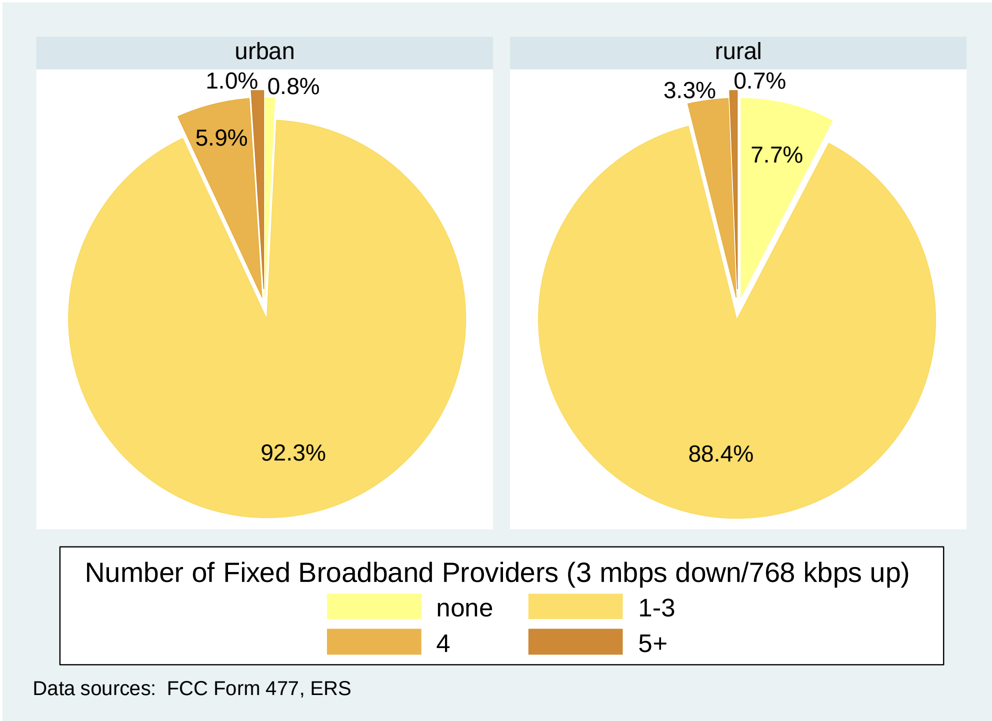

Figure 2: Mobile Providers of Broadband by Rural and Non-Rural Population, Year End 2010

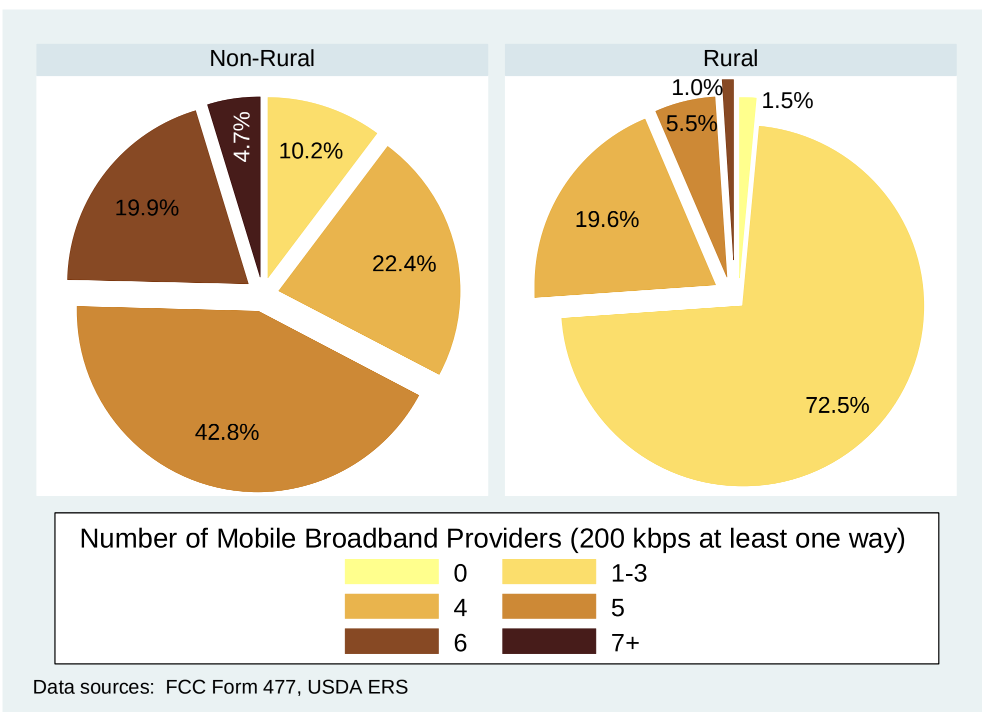

Figure 3: Mobile Providers of Broadband in the US, Year End 2010