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The Broadband Digital Divide and the Benefits of Mobile Broadband for Minorities

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Abstract

This study sets out the facts regarding broadband deployment and usage in the US and the particular promise of mobile broadband for minorities. Fixed broadband is nearly ubiquitous and most people have access to four or more mobile broadband providers. Growth in fixed broadband usage is leveling off, while mobile broadband usage growth remains robust. Blacks and Hispanics generally have fewer fixed broadband options but more mobile broadband providers available. Gaps in broadband usage overall (fixed and mobile combined) for minorities persist and are quite large. Matching estimators show that lagging broadband adoption among minority groups is not fully accounted for by demographic and economic characteristics. Mobile broadband holds particular promise for minorities regarding social, medical, and economic inclusion, and these communities have relatively greater reliance on mobile forms of broadband. Two important findings are that 1) blacks are more likely to access the Internet using a mobile phone than whites (after controlling for demographic differences between the groups), and 2) there is no significant gap in mobile broadband usage between minorities and whites by either of the two measures of usage considered. These results can set the backdrop for discussion of US broadband policy.

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1. Introduction

Mobile broadband has substantially changed how people use the Internet. In the US there were 93 million residential mobile broadband connections in June 2011, more than the number of residential fixed broadband connections (FCC, 2012). With any new technology, particular one whose usage is burgeoning as quickly as mobile broadband, the pace of diffusion may differ among varying groups of the population. This article presents an up to date view of the digital divide facing minorities, showing that significant divides in both availability and usage persist in fixed broadband but not mobile broadband. Mobile broadband thus holds significant potential for minority communities, given the importance of broadband, particularly mobile broadband, for some minorities.

The article proceeds in the next section by examining the state of broadband deployment and usage in the US in general and specifically for minority groups, focusing on African Americans and Hispanics. Both external evidence and a novel examination of the latest FCC and Census data are presented. The data on availability come from the US Federal Communications Commission's (FCC) census of all broadband providers in the US as of June 30, 2011. Data for Internet and broadband usage are from the Computer and Internet Use supplement to the US Census Current Population Survey (CPS), for July 2011.

Section 2.1 documents that fixed broadband is nearly ubiquitous and that most people have access to four or more mobile broadband providers. Section 2.2 shows that fixed broadband usage continues to grow in general, albeit at a slowing rate, while mobile broadband growth is robust with no signs of leveling off yet. Section 2.3 looks at the experience of minorities with broadband. The latest statistics examined show that compared to whites minorities generally have fewer fixed broadband options but more mobile broadband providers available (excepting Native Americans in the latter case). Gaps in broadband usage overall (fixed and mobile combined) for minorities persist and are quite large. Matching estimators presented in section 2.4 show that lagging broadband adoption among minority groups is not fully accounted for by observed individual and household demographic and economic characteristics.

The particular promise that mobile broadband may hold for minorities regarding social, medical, and economic inclusion is discussed in section 3.1. Section 3.2 points out the relatively greater reliance on mobile forms of broadband by these populations. While blacks are less likely overall to access the Internet using a mobile phone than whites, after balancing the covariates between whites and blacks the latter group is slightly more likely to get to the Internet via mobile phone. On the other hand, Hispanics are less likely than whites to access the Internet using a mobile phone than whites. However, there is no significant gap in mobile broadband usage between minorities and whites by either of the two measures of usage considered, either before or after controlling for other demographic and socioeconomic characteristics of the individuals. However, the quality of the official data on mobile broadband usage is lower than that for fixed broadband usage, which limits the extent to which distinctions in mobile broadband usage among racial and ethnic groups can be discerned.

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 particular promise of broadband for minorities, which should set the backdrop for broadband policy discussion.

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

In this section, statistics on broadband availability and usage are presented, with emphasis on mobile broadband.

2.1. Availability

As has been true for several years at least, almost everyone in the US lives in areas where fixed broadband connections are available. The latest FCC Form 477 broadband data, for mid-year 2011, indicate that only 0.11% of individuals live in Census tracts lacking any form of fixed broadband access with transmission speeds of at least 200 kbps in one direction. These fixed broadband access options include DSL, cable modem, satellite, and the relatively rare broadband over power lines (BPL) and fixed wireless sources. An important caveat regarding the FCC data is that there is no guarantee that a broadband provider offers service in the entire tract, which may be problematic in rural areas where tracts are larger.[1] Even when the definition of broadband from the National Broadband Plan (NBP) is used instead (at least 3 mbps downstream and 768 kbps upstream (FCC, 2010), only 1.5% of US residents live in Census tracts lacking fixed broadband access.[2] Given the near ubiquity of fixed broadband access options in the US, the rest of this section focuses on the availability of mobile broadband.

The same data from the FCC show that most areas and almost every individual have access to mobile broadband. Figure 1 is a map of the number of mobile broadband providers in the US by Census tract from the FCC data for June 30, 2011.[3] Darker areas on the map have a greater number of mobile providers in the area. The map shows that most areas have one to three mobile broadband providers. Table 1 presents population-weighted statistics from the same data, showing the probabilities of an individual having access to the various numbers of mobile broadband providers.[4] While the map in

[1] Rural tracts average 198.7 square miles (median = 54.8 mi^2), while non-rural tracts average 13.1 square miles (median = 1.2 mi^2). The definition of rural is from the Economic Research Service (ERS) of the US Department of Agriculture. 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.
[2] Figures are the author's calculations, using tract population estimates from Geolytics.
[3] All figures for mobile broadband from the FCC data use the FCC definition of 200 kbps transmission at least one way. See Prieger and Church (2012) and Prieger (forthcoming) for similar maps with earlier waves of the FCC data.
[4] In the June 2011 data, 85% of reported mobile broadband connections were slower than 3 mbps in the downstream direction (FCC, 2012). Thus, the FCC data include mobile broadband providers offering relatively slow

Figure 1 shows that most *areas* have one to three mobile broadband providers, Table 1 reveals that most *people* live in tracts with four or more providers.

Figure 2 shows that the prevalence of mobile broadband providers has changed little since the end of 2008 in the US. The median individual in the US resides in a tract that had at least four mobile broadband providers during 2008-2011, and the fraction of individuals living in tracts lacking mobile broadband is too minuscule to be seen in the chart.

2.2. Usage

There has been continuing growth in residential broadband usage ever since official statistics were first collected in 1999 by the FCC. Figure 5 shows that residential fixed broadband connections, which include DSL, cable modem, fiber optic, and fixed wireless connections, have grown from fewer than two million lines in December 1999 to almost 80 million in June 2011, for an annualized growth rate of 33.0%. The figures accounting for the increasing population over the period (graphed with dashed lines and scaled according to the right axis in Figure 5) shows nearly as much growth. Fixed connections per 1000 households rose from 17 in 1999 to 658 in 2011, for a growth rate of 31.7% per annum. The implied household subscription rate for fixed broadband of 65.8% in June 2011 from the FCC data accords well with the evidence from the July 2011 CPS, which yields an estimated household fixed broadband subscription rate for the population of 64.1% (95% confidence interval (CI) = [63.76, 64.6]).[5]

As fast as the growth of fixed broadband has been, growth in the provision of mobile broadband has been nothing less than astounding. As recently as June 2005, mobile broadband subscription in the

broadband, but the major wireless carriers in the US are expanding deployment of 4G technology in their service areas.

[5] All estimates from the CPS data are weighted to be unbiased for the US non-institutionalized population. All standard errors are computed with the Taylor series linearization method, account for survey design effects from clustering and stratification, and are robust to heteroskedasticity and clustering within households. The variance estimation takes the survey design approach, where the sampling is assumed to be from a finite population without replacement. Since the CPS does not identify the survey strata, for purposes of variance estimation pseudo-strata were constructed using the method of Prieger and Faltis (2012).

US was a rarity. By June 2011, however, almost 93 million residential mobile connections were served, and that was when mobile broadband connections first outnumbered fixed connections in the US. Calculating from June 2005, the first time the FCC reported mobile connections, the annualized growth rate of residential mobile broadband subscription was 91.2%—subscribership nearly doubled each year. In per capita terms, residential mobile broadband rose from virtually nil in 2005 to 298 per 1000 persons in 2011, for a growth rate of 90.8% per annum. Not only has the growth in mobile broadband outpaced that of fixed broadband, examination of the trends in Figure 5 reveals clearly that while fixed broadband growth is slowing, growth of mobile broadband had not yet reached an inflection point. There is clearly room for much more growth in mobile broadband. While few households would ever consider subscribing to multiple fixed broadband lines, multiple mobile connections per person may be demanded as more personal mobile electronic devices add Internet functionality.

It is difficult to find usage rates in the CPS data that are comparable to the FCC implied mobile subscription rate of 29.8% per capita in June 2011. Several survey questions in the CPS are related to mobile broadband. First, the primary household respondent is asked whether anyone in the household uses the Internet from home, including “using the Internet on mobile devices such as smartphones and laptops” (US Bureau of the Census, 2012). If the answer is affirmative, the respondent is asked about several types of broadband access, including access to the Internet using a “mobile broadband plan (for a computer, cell phone, smartphone, or tablet).” By this measure, only 8.4% (95% CI = [8.1,8.7]) of the population aged 3 and up[6] lived in a mobile-broadband using household in July 2011.[7]

There are two other measures available in the CPS related to mobile broadband. Unrelated to the household mobile broadband question, the following question is asked of each household member

[6] The target population of the survey is non-institutionalized US residents aged 3 years and higher, excluding household members in the armed forces.

[7] The estimates here and in the following paragraph are similar but not identical to the final rows of Table 2 (which is discussed below). Here, the population includes those three years old and up, to conform to NTIA reports on previous waves of the CPS data. In Table 2, the population is restricted to those who are at least 15 years old.

(which is answered on behalf of others by the primary household respondent): "Does [the household member] use a cellular or smartphone to access the Internet?" By this measure, a figure exactly matching the mobile broadband subscription rate from the FCC data is obtained: 29.8% (95% CI = [29.5,30.2]) of the target population uses a mobile phone to access the Internet.[8] Note that this measure is not restricted to broadband speeds, which in any event are not defined for respondents anywhere in the survey. If the previous measure is refined by counting only persons using a mobile phone to access the Internet who reside in households with a stated mobile broadband subscription, a usage rate of a mere 4.2% (95% CI = [4.0, 4.4]) per capita is obtained.

One additional comparison to external estimates is possible. From the CPS data, the estimate of the proportion of cellphone or smartphone users over 18 years of age in the population that use their devices to access the Internet is 45.7% (95% CI = [45.1,46.3]). This figure is similar to a Nielsen estimate for the same month that 40% of mobile consumers over 18 in the US had smartphones (Kellogg, 2011b).

Why are the mobile broadband usage rates from the CPS so much lower than those calculated from the FCC data? At least part of the discrepancy is no doubt due to respondents' confusion over the wording of the survey question. At least until recently, many subscribers probably did not think of their mobile data packages as a "mobile broadband" plan—a term which is not defined for them in the survey. Furthermore, while respondents may know whether they subscribe to a data plan for their mobile phones, many people do not know whether the data plan uses HSPA+, EDGE, LTE, or other network technology, much less which of these qualify as "broadband" under FCC definitions. Survey sponsors and designers would be well advised to think carefully about how to improve the accuracy of information elicited regarding mobile broadband.

[8] This variable constructed to measure accessing the Internet through a mobile phone is based on the survey question mentioned in the text but refined in the following way. If the individual stated that he "browses the Web" on his cell phone or smartphone, he is counted as using the phone to access the Internet, regardless of his answer to the direct question given in the text. Only 3.3% of respondents answering that they did not access the Internet with a mobile phone contradicted themselves by saying they browsed the Web with a mobile phone.

2.3. Are Minorities are at Greater Risk of Digital Exclusion?

In this section, survey evidence from various sources is examined to show that African Americans, Hispanics, and some other minority groups tend to have fewer options for fixed broadband access than whites, but more options for mobile broadband access. Thus, while less access to broadband may play a role in explaining lower minority adoption of broadband overall, the same cannot be said of mobile broadband. African Americans and Hispanics are less likely to use broadband (fixed and mobile combined) in the home. 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) say that within any particular minority group, those who are younger, more educated, and wealthier tend to be more deeply engaged with broadband.

Broadband Access

Disparities in access to and usage of broadband between minorities and others have shrunk or disappeared in recent years. As recently as the beginning of 2010, some data indicated that access gaps may be greater barriers to adoption for minorities. Gant et al. (2010) conducted a national survey of Internet usage in December 2009 and January 2010. When individuals who do not use the Internet were asked why, 13% of African Americans and 16% of Hispanics said the reason is that they did not have access. This is the second most commonly given reason, after general lack of interest in the Internet. Only 11% of whites said their reason for not using the Internet at home was lack of access. There is no longer any difference between whites and Hispanics in these figures, and blacks are now less likely than whites to cite lack of access as the reason for nonadoption. The CPS data for July 2011 show that lack of access (which is defined as the respondent's stated unavailability of broadband *or* lack of an adequate computer to access it) is the main reason stated for not using high-speed Internet at home by about 11% of non-adopting blacks, 15% of Hispanics, and 14% of non-Hispanic whites. The difference between the proportions for Hispanics and whites is insignificant ($p = 0.17$)). These figures for blacks, Hispanics, and whites have fallen from about 17% of non-adopters in each group in the previous wave of CPS data (NTIA, 2011, p.23).

Surveying non-users on why they do not use broadband at home is not the same as examining where broadband connections are available. Another way to examine broadband availability for minorities is to compare the number of residential broadband providers available to a representative member of each racial or ethnic group. Figure 3 depicts the distribution of providers of residential fixed broadband in the US as of midyear 2011. White non-Hispanics have the greatest chance of having four or more fixed broadband providers, at 64%. Blacks have the lowest probability (46%) of being in a tract with four or more providers, followed by Asians and Pacific Islanders (49%) and Hispanics (53%). If the definition of broadband from the National Broadband Plan (NBP) is used instead (at least 3 mbps downstream and 768 kbps upstream (FCC, 2010); results not shown), then white non-Hispanics still have the greatest chance of being in a tract with four or more providers, except for Asians. However, since about 90% of the time the number of providers meeting this higher speed threshold falls into the censored range of one to three providers, it is difficult to compare among the racial and ethnic groups.

The picture is markedly different for mobile broadband provision. The hatching in Figure 1 shows areas where non-Hispanic whites compose less than half of the population in the tract. Furthermore, given that minorities tend to be concentrated in urban areas, tracts that are “majority minority” (less than half white non-Hispanic, the hatched areas in Figure 1) have more mobile broadband providers available. That is, the distribution of providers in majority minority areas exhibits second-order stochastic dominance over the distribution in other areas.

Referring to Figure 4, we see that Hispanics have the second highest likelihood (92%, after Asians) of having four or more mobile broadband providers and the highest chance of having five or more (52%). Blacks also have more options that white non-Hispanics, with an 88% chance of having four or more mobile providers (vs. 75% for whites) and a 50% chance of having five or more (vs. 38% for whites). Other recent research finds evidence from regressions that the more minorities are in the Census tract, the greater the expected number of mobile broadband providers (Prieger, forthcoming). This is likely due to the fact that minorities are more likely than whites to live in urban cores, where wireless coverage from multiple providers is most likely to be available.

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.[9]

In its review of the 2010 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. The estimates from the CPS for July 2011 for the same population (those aged 3+ years) are nearly identical, meaning that there were no significant adoption gains over the nine month period. This is in contrast to recent growth in broadband use for African Americans and Hispanics as found in CPS data from 2007 to 2009 and from 2009 to 2010. 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 NTIA also found that there could be significant disparities among the sub-groups that make up a racial or ethnic category.

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

Table 2 contains detailed estimates for broadband usage of various types for the population aged 15 years or older, by race and ethnicity, from the July 2011 CPS data. The first set of columns contains results for personal broadband usage in the home of any sort.[10] While overall usage stands at 65%, white non-Hispanics (71%), Asians and Pacific Islanders (72%), and multiracial persons (67%) all have a greater likelihood of home broadband usage. Hispanics and Native Americans have the lowest usage (49%), with usage among blacks only slightly higher (52%). The differences among the usage rates are statistically significant, with the exception that the rate for Asians is indistinguishable from that for whites. Note that these figures do not control for broadband availability in the area. Discussion of the remaining columns in the table, which pertain to mobile Internet and broadband usage, is deferred until section 3.2.

Recent data from non-governmental sources generally confirm that broadband penetration lags among African Americans and Hispanics. As of August 2011, the Pew Research Center estimated Internet usage among whites at 80%, but usage among African Americans to be only 71% (Zickuhr and Smith, 2012).[11] The comparable figures for broadband usage were 66% for whites and 49% for African Americans, a gap of 17 percentage points. While this usage gap between African Americans and whites is smaller than reported in the other sources reviewed above, the authors 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 going online in January 2010, but only 43% of Hispanics do (Gant et al., 2010). Thus, even when restricting attention to low-income individuals, differences in usage crop up between Hispanics and others. For broadband access in

[10] The figures are for persons using the Internet from home who are in a household with broadband access.
[11] 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.

particular, the July 2011 CPS data show that among members of households earning less than $20,000, 31% of blacks and 25% of Hispanics use broadband at home, compared with 43% of white non-Hispanics.[12] Similarly, differences in human capital alone do not explain the entire usage gap between whites and non-whites. Gant et al. (2010) 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%). For July 2011, the estimates for broadband usage at home among those 18 years or older who lack a high-school degree or equivalent is 35% for white non-Hispanics, 23% for blacks and Hispanics. 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.

In summary, the literature cited above along with the investigation of the latest CPS data here show evidence of large adoption gaps remaining in fixed broadband subscription by race and ethnicity. The gaps in fixed broadband usage for minorities do not appear to be caused by lack of access to broadband in the area, because blacks and Hispanics are no more likely than whites to cite lack of access as the main reason for not subscribing to broadband in the home. However, blacks and Hispanics appear to have fewer fixed residential broadband providers available where they live although virtually all areas have access to at least one fixed provider. On the other hand, African-Americans and Hispanics on average have more mobile broadband providers available where they live than do whites. Thus, mobile broadband appears to hold great promise for connecting minority communities to the Internet where they live. As discussed in section 3.2, evidence indicates that some minority groups indeed rely disproportionately on mobile sources for their broadband connections.

[12] See footnote 10.

2.4. Matching Estimators for Broadband Usage Gaps

To explore more intensively whether differences in demographics among racial groups accounts for differing broadband usage, controlling for more than one demographic or economic characteristic at a time is necessary. To illustrate the econometric issues involved, it is useful to draw on the treatment effect literature. When comparing outcomes between a treatment group and a control group, bias can creep into estimates of the treatment effect from three sources (Heckman et al., 1997). The first source of bias (B1) arises because for some in the treatment sample there will be no members of the control group with comparable values of observed characteristics. This is known as the "common support" problem. The second type of bias (B2) happens when the distribution of the observed covariates differs between the groups. The third source of bias (B3) arises when there are unobserved factors influencing outcomes that differ in distribution between the control and treatment groups.

In the present context, the outcome of interest is broadband adoption, the two groups are different racial or ethnic groups, and the observed characteristics are the sociodemographic data available in the CPS. The unobserved factors include (U1) sociodemographic factors not adequately measured in the data, (U2) unobserved differences in broadband availability, quality, or pricing, and (U3) cultural factors influencing broadband adoption. Removing the first two sources of bias, B1 and B2, will leave an adjusted estimate of the difference in broadband adoption rates between the two groups, where the remaining difference in outcomes is due solely to unobservables. Since we are able to control for an extensive array of observed characteristics, factor U1 is not likely to be important,[13] and we can interpret the difference in broadband usage as stemming from U2 and U3. If we are further able to refine our comparison of individuals between the two groups by comparing only within the same geographic area, then factor U2 is not likely to be important either. Thus we arrive at an estimate of the

[13] The exception to this statement is the impact of primary language spoken when the minority group is Hispanics, as discussed below.

difference in demand for broadband coming from the "pure group effect", as it is known in the regression decomposition literature.

The two main approaches in econometrics to dealing with bias from sources B1 and B2, both related to imbalance among the covariates, are multiple regression and matching estimators. While multiple regression is the more familiar and commonly applied technique to balance covariates, and has been applied often to broadband adoption (e.g., Prieger and Hu, 2008; Flamm and Chaudhuri, 2007), it does not correct for bias stemming from B1. To correct for bias B2, regression also requires that the functional form chosen for the conditional mean in the dependent variable be linear in the regressors (or in transformations of them) and otherwise correctly specified. Matching estimators, on the other hand, allow one to enforce a requirement of common support in the comparisons, removing B1.[14] Furthermore, by matching on the propensity scores (the probability of being in the treatment group conditional on the covariates), the need for correct specification of the regression function is removed.[15] The method of propensity score matching (Rosenbaum and Rubin, 1983) is thus pursued here, and appears to be the first application of matching methods to investigate broadband digital divides.

Propensity score matching proceeds in three steps. First, the likelihood of an individual being in the minority group instead of the white non-Hispanic (WNH) group, conditional on other observed covariates, is estimated to yield a propensity score (PS) for each individual. Second, after discarding observations in the WNH group whose PS's are not in the range of the PS's for the minority group, each minority individual is matched to one or more WNH observations that have similar PS's. Details on the matching procedure are in the Appendix. Finally, the difference in the average outcomes (broadband

[14] Guo and Fraser (2010) provide an accessible introduction to matching methods for the practitioner.

[15] Since the propensity scores are unknown, they must be estimated, which requires specification of the conditional mean for assignment to the treatment group in terms of the observables in the first step estimation. However, in practice it is not difficult to determine whether the propensity scores have been accurately estimated, since one only need check whether the resulting matched samples are indeed balanced on the covariates. On the other hand, when taking the multiple regression approach instead of matching, it is difficult ever to know whether the "right" regression specification for the outcomes has been chosen.

usage, in the present application) between the minority group and the matched set of observations from the WNH group is the estimated "pure group effect" on broadband usage described above.

Given the numerical importance of African Americans and Hispanics in the US, their historical gaps in broadband usage, and the significant attention paid to these gaps by policymakers, we focus on comparing these two groups to non-Hispanic whites. The results of four different matching estimators of the home broadband usage gaps are in Table 3. The estimated population difference between the non-Hispanics blacks and whites in home broadband subscription is 18.6 percentage points (see the first row in the table). This figure is the difference in the subpopulation usage estimates for whites and blacks in Table 2. The estimates of the usage gap calculated by various methods of covariate balancing are in the following four rows of Table 3. Removing biases B1 and B2 lowers the estimate of the broadband adoption gap by 31% to 47%, depending on the matching method. The first three matching methods (one-to-one matching and two variants of kernel matching; see Appendix for details) balance on a host of demographic, socioeconomic, and area characteristics, as detailed in the Appendix, but do not require matches to be in the same geographic area. Thus, these estimates are still susceptible to bias due to factor U2, unobserved differences in broadband availability, quality, or pricing. The estimates of the gap between blacks and whites are in the range of 11.9 to 12.7 percentage points, and are statistically significant. The fourth reported matching estimator, labeled "nearest neighbor matching 2" in Table 3, restricts matches to come from the same survey stratum, which is the usually the metropolitan area of residence (the CBSA) for urban respondents. Therefore, this matching estimator will be less susceptible to bias from factor U2.[16] This estimate of the home broadband adoption gap is the smallest, at 9.8 percentage points. The results for the home broadband adoption gap for Hispanics, shown in the rightmost columns of Table 1, are similar. The gap in the population of

[16] However, given the smaller number of available whites for matching within the stratum, the potential for bias due to lower quality matching increases. Despite this potential, however, the confidence interval for the within-stratum matching estimate is not much larger than those for the other methods.

22.1 percentage points is reduced by 36% to 39% after matching, and again the within-strata matching estimate yields to smallest gap.

Thus, while controlling for factors like income, education, and geography greatly reduce the broadband adoption gap for blacks and Hispanics, they do not vanish. The remaining gaps would appear to be driven mainly by the pure group effects (factor U3), differences in cultural attitudes toward the perceived usefulness of subscribing to broadband.[17] Such differences among racial groups have been posited (Porter and Donthu, 2006) but not generally found in the literature. In fact, recent evidence suggests that black and Hispanic individuals are more likely than whites to view the lack of broadband access in the home as a major disadvantage (Smith 2010a). In a related vein, Mossberger et al. (2003) find that African-Americans, and to a lesser extent, Hispanics, hold more positive attitudes toward information technology than whites, after controlling for income, education, age, and gender.

In the case of Hispanics, lack of proficiency in reading English may also contribute toward the remaining broadband gap, since the matching estimators could not balance on language skills.[18] Fox and Livingston (2007) find that English proficiency is a substantial determinant of home Internet subscription by Latinos in the US. Fairlie (2004) finds that after controlling for income and education, Mexican-Americans in Spanish-speaking households are less likely than both Mexican-Americans in English-speaking households and whites to use the Internet, and concludes that "language barriers limit computer and Internet use among Mexican-Americans."

[17] Some work has shown that lack of a computer in the household is a barrier to broadband adoption by minorities (Gant et al., 2010; Smith, 2010b; NTIA, 2011). However, the matching estimators control for income. If a minority household chooses not to own a computer when a white but otherwise similar household of equal income does, that choice is part of the pure group effect affecting broadband adoption.

[18] There are few non-Hispanic individuals with Spanish as their first language, and so this factor cannot be added usefully to the set of covariates on which to balance.

3. Particular Benefits of Mobile Broadband for Urban Minorities

This section considers two questions regarding mobile broadband. The first question is how broadband can 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 second 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.

3.1. 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 (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 highly important. 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 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 set of resources and skills that includes 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 some minorities are more likely to use mobile instead of fixed broadband, compared to other groups,[19] any policy that encourages the spread of mobile technology may foster digital citizenship by making available high quality access to the Internet.

[19] Estimates from the July 2011 CPS data indicate that among individuals aged 15+ using broadband in the home, blacks are 13.5% more likely than whites to access the Internet from their mobile phones (95% CI = [9.0%,17.9%]) (where the later variable is defined as in footnote 8). Native Americans are 21.1% [4.8%,37.4%] more likely, Asians/Pacific Islanders are 5.4% [0.1%,10.7%] more likely, multiracial non-Hispanics are 12.5% [2.8%,22.2%] more likely, and Hispanics are 7.2% [3.1%,11.3%] more likely (author's calculations).

E-health and M-health

Greater broadband access can provide minority individuals 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 US Department of Health and Human Services (AHRQ, 2011) 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 mobile 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." Another study found that people with mobile Internet access are more than twice as likely as those with wired connections to seek health information online (Sarasohn-Kahn, 2009). 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.

The data from the July 2011 CPS also show that individuals in households using mobile broadband engage in more healthcare-related Internet use than any other group. Table 4 shows results for the three questions regarding health-related Internet use in the survey, broken out by the type of Internet access available to the home. Adults lacking broadband access at home are least likely to research health plans or practitioners on the Internet, or to use the Internet to aid in self-diagnosis of health problems. Individuals with dialup access in the home (about 2% of the adult population) are about four times as likely as the previous group to engage in these activities. Those with fixed broadband in the home, but not mobile broadband, are about 50% more likely than dialup users to search for such health information on the Internet, and persons in mobile broadband using households are about ten percent more likely than fixed broadband users. The same general pattern of increasing usage in the progression from no Internet access to mobile broadband access in the home also holds for using the Internet to access medical records or consult with physicians (the third set of rows in Table 4). However, when mobile broadband users in 2011 are compared to all other individuals, they are only half again as likely to engage in the types of healthcare-related Internet use measured in Table 4 (see results in final column).

To the extent that some minorities rely more heavily on smartphones to access the Internet (as documented 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." African Americans who use mobile phones are more than twice as likely as whites to use mobile health applications on their phones (Fox, 2010). Fox also finds that blacks and Hispanics owning mobile phones are more likely than whites to search for health and medical information via their phone, although only the latter comparison is statistically significant.

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.[20] 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 more likely to live in areas 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 minority communities.

3.2. Some Minorities Rely Heavily on Mobile Broadband

Evidence from the Literature

In the increasingly mobilized world of Internet access, mobile broadband is growing as the channel of choice for many Americans, particularly minorities. As Julius Genachowski, the chairman of the FCC, has noted, "The spectrum crunch is a particular concern for minority communities. Mobile

[20] 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).

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. In July 2011, 85% of non-Hispanic whites had a desktop, laptop, netbook, notebook, and tablet computer at home, compared to only 68% of non-Hispanic blacks and 68% of Hispanics.[21] Compare these figures with Gant et al.'s (2010) finding that 62% of whites had a working desktop computer at home, but only 54% of blacks and 49% of Hispanics. Another recent survey found the desktop computer ownership gap between blacks and whites to be 14 percentage points (Smith, 2010b). Lower computer ownership among some minorities translates into greater barriers to Internet adoption. In July 2011, not having an adequate computer was the main reason for not using high speed Internet at home for 11% of non-Hispanic blacks, 18% of non-Hispanic Native Americans, 15% of Hispanics, but by only 11% of non-Hispanic whites (NTIA, 2011). These figures show small improvement over a year earlier, when lack of a computer was the main reason for non-use for 16% of blacks, 20% of Native Americans, 16% of Hispanics, and 13% of whites (NTIA, 2011).

[21] In this section, all statistics from July 2011 are calculated from the CPS by the author.

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. However, this differential is narrowing. In July 2011, non-Hispanic blacks were 22% more likely to use a cell phone or smartphone than to have a computer in their household, and Hispanics were 19% more likely. 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, 2011a). 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.[22]

Not only are minorities more likely to have mobile Internet-capable smartphones, until recently they were more likely than whites to use them to access the Internet. A few years ago, while 30% of whites used their cell phone to access the Internet, half of all blacks and 42% of Hispanics surfed the net through their phones (Gant et al., 2010). These patterns of usage revealed 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 (Gant et al., 2010). In fact, minorities led whites in using a wide range of their smartphones' capabilities. Smith (2010b) finds

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

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. Whether this is still true is examined in the next section.

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 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."

Finally, the importance of mobile broadband for minorities can also be seen from examining the reasons why households do not have broadband in the home. In July 2011, 14.1% of households which do not subscribe to broadband say they do not because broadband is unavailable.[23] Among such households, Figure 6 shows what type of unavailable broadband is the perceived barrier to access. The figure shows that blacks are more than twice as likely as whites (12.3% vs. 5.7%), Asians are more than five as likely as whites (30.7% vs. 5.7%), and Hispanics are seven times as likely as whites (40.0% vs. 5.7%) to cite the lack of mobile broadband as the barrier.

New Evidence from the CPS

In this section, the CPS data from 2011 are examined to compare African Americans and Hispanics with whites regarding usage of mobile phone data applications, mobile Internet, and mobile broadband. The CPS data allows for an updating of estimates regarding minority usage of cellphones' capabilities, to compare with the findings of Smith (2010b) discussed above. The results are in Table 5.[24] In July 2011, the proportion of cell phone users accessing the Internet from their phones was similar among non-Hispanic whites (54%), non-Hispanic blacks (52%), and Hispanics (55%).[25] Similarly, there is no difference among these groups for the more specific activity of "browsing the Web." Several other mobile phone activities are listed in Table 5. African Americans use their phones to play games, access social networking sites, and listen to music or other audio more than whites, but use their phones less to take pictures or video (the latter in contrast to evidence from Smith (2010b)). Hispanics listen to music on their phones more than non-Hispanic whites, but are less likely to download apps or take photos or videos with their phones. There are no significant differences among the subpopulations in usage of

[23] As with all the statistics calculated from the CPS data, the figure is weighted to reflect the census population quantity. The 95% confidence interval is (0.135,0 .148). It is also important to note that the survey did not verify that broadband was unavailable at the location of the household.

[24] The question regarding cell phone or smartphone use was asked only of primary respondents in the CPS. Statistics cited in this section are for the subpopulation of those answering yes to this question. If household members other than the primary respondent (who tend to be younger) use mobile phones to access the Internet at a different rate than primary respondents, and these differences vary by race, then the statistics here may not be representative of the population of mobile phone users.

[25] This variable is defined as discussed in footnote 8. Unlike the statistics presented in footnote 19, those here are not conditional on using broadband at home.

mobile phones for text messaging, email, or maps and GPS applications (estimates not shown in Table 5).

Returning to Table 2 and Table 3, we can examine several measures of mobile Internet and broadband usage among minorities aged 15+ from the July 2011 CPS data. The first is whether the individual uses a cell phone or smartphone to access the Internet.[26] These individuals do not necessarily have data speeds high enough to qualify as broadband. Mobile Internet usage by blacks is 1.4 percentage points lower than whites (with a *p*-value for the difference of 0.055), and mobile Internet usage by Hispanics is 5.6 percentage points lower than whites (*p*-value = 0.000). The mobile Internet usage rates for Native Americans and Asians are not significantly different than that for whites. After matching to balance the covariates, however, the usage rate for blacks is higher than that for whites, by 1.1 to 1.5 percentage points. The 95% confidence intervals for the difference excludes zero for the two largest estimates. Thus, after matching, blacks are more likely to use their mobile phones to access the Internet than observably similar whites. Even though the difference in usage rates is not large—blacks are about 5% more likely than similar whites to access the Internet on their mobile phone—the results here corroborate the evidence from the literature discussed above that mobile devices are an important avenue to the Internet for some minorities in the US. The mobile Internet access gap for Hispanics shrinks from 5.6 percentage points in the unbalanced comparison to 2.0-2.5 percentage points after matching, and remains statistically significant.

The other two measures discussed in section 2.2 above, the availability of mobile broadband at home and the coincidence of home mobile broadband and smartphone usage, are in the final two sets of columns in Table 2. Black and Hispanic individuals lag white individuals in the available of mobile broadband in the household, but the differences are too slight to be statistically significant whether tested individually or jointly. After matching, the difference in usage rates remains insignificant (results

[26] This variable is defined as explained in footnote 8.

not shown in Table 3). The same is true of both the unbalanced and matched comparisons for the variable measuring smartphone usage by individuals in households with mobile broadband access.

4. Conclusions

The expansion of mobile broadband in the US will create important benefits for users. Mobile broadband is important to many minorities, given the role that it appears to play in closing broadband access gaps for minority users. Benefits to users of mobile broadband include furthering of digital citizenship and an expanded scope for mobile health participation and applications, not to mention the consumer surplus gained by usage of the service. Thus, any policy affecting mobile broadband diffusion is highly important. Antitrust scrutiny of proposed wireless mergers, spectrum policy, and universal service support for broadband and wireless subscription are just a few of the current public policy issues related to broadband.

In the end, two themes arise from the empirical results. The first message is an encouraging one for advocates of digital inclusion for minorities. Despite the absence of any large-scale subsidies for broadband, mobile broadband use appears to be at least as high among blacks and Hispanics as among similar whites, and many minorities have substituted mobile Internet access for fixed access when lacking a computer in the home.[27] The second message highlights the progress yet to be made. Despite strong growth rates in mobile broadband usage, such usage still appears to be far from full diffusion for all racial and ethnic groups. Policymakers interested in stimulating the use of mobile broadband thus have ample scope to do so, although the success of programs designed to encourage broadband adoption remains largely unproven in the literature (Hauge and Prieger, 2009, 2010).

[27] While the FCC has since added broadband to its list of services supported by the Universal Service Fund, no such federal support was in place in July 2011.

References

Agency for Healthcare Research and Quality (AHRQ), US Department of Health and Human Services (2011). *National Healthcare Disparities Report 2010*, AHRQ Publication No. 11-0005, February. Accessed online April 1, 2013 at http://www.ahrq.gov/qual/qrdr10.htm.

Brodie, M., R.E. Flournoy, D.E. Altman, R.J. Blendon, J.M. Benson and M.D. Rosenbaum (2000). "Health Information, the Internet, and the Digital Divide," *Health Affairs* 19(6): 255-265.

Center for Disease Control (CDC) (2008). "Racial/Ethnic Disparities in Self-Rated Health Status among Adults with and without Disabilities–United States, 2004-2006," *Morbidity and Mortality Weekly Report,* October 3, 57(39):1069-1073.

Cotten, S.R. and S.S. Gupta (2004). "Characteristics of Online and Offline Health Information Seekers and Factors That Discriminate between Them," *Social Science & Medicine* 59(9):1795-1806.

Eggerton, John (2011). "ITU, UNESCO Push for Affordable Broadband Everywhere by 2015," *Broadcasting & Cable*, October 25. Accessed online April 1, 2013 at http://www.broadcastingcable.com/article/475714-ITU_UNESCO_Push_for_Affordable_Broadband_Everywhere_by_2015.php.

Ekeland, A.G., A. Bowes, and S. Flottorp (2010). "Effectiveness of Telemedicine: A Systematic Review of Reviews," *International Journal of Medical Informatics* 79:736–771.

Fairlie, R.W. (2004). "Race and the Digital Divide," *Berkeley Electronic Journals, Contributions to Economic Analysis and Policy*, 3(1), Article 15.

Federal Communications Commission (FCC) (2010). *Connecting America: The National Broadband Plan*. Accessed online April 1, 2013 at http://www.broadband.gov/download-plan.

Federal Communications Commission (FCC) (2012). *Internet Access Services: Status as of June 30, 2011.* Industry Analysis and Technology Division, Wireline Competition Bureau, June. Accessed online April 1, 2013 at http://www.fcc.gov/reports/internet-access-services-63011.

Flamm, K. (2005). "The Role of Economics, Demographics, and State Policy in Broadband Availability," paper presented at the PURC/London Business School Conference on "The Future of Broadband: Wired and Wireless, 2005," Gainesville, Florida, February.

Flamm, K. and A. Chaudhuri (2007). "An Analysis of the Determinants of Broadband Access," *Telecommunications Policy*, 31:312–326.

Fox, S. (2010). *Mobile Health 2010.* Pew Research Center's Internet & American Life Project, October 19. Accessed online April 1, 2013 at http://www.pewInternet.org/~/media//Files/Reports/2010/PIP_Mobile_Health_2010.pdf.

Fox, S. (2011). *Americans Living with Disability and Their Technology Profile*. Pew Research Center's Internet & American Life Project, January 21. Accessed online April 1, 2013 at http://pewInternet.org/Reports/2011/Disability.aspx.

Fox, S. and G. Livingston (2007). *Latinos Online*. Pew Research Center's Internet & American Life Project, March 14. Accessed online April 1, 2013 at http://www.pewInternet.org/~/media//Files/Reports/2007/Latinos_Online_March_14_2007.pdf.pdf.

Gant, J.P., N. Turner-Lee, Y. Li and J.S. Miller (2010). *National Minority Broadband Adoption: Comparative Trends in Adoption, Acceptance and Use.* Joint Center for Political and Economic Studies, February. Accessed online April 1, 2013 at http://www.jointcenter.org/sites/default/files/upload/research/files/MTI_BROADBAND_REPORT_WEB.pdf.

Genachowski, J. (2011). "Prepared Remarks for the Minority Media & Telecom Council Broadband and Social Justice Summit," Washington, DC, January 20. Accessed online August 17, 2011 at http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-304191A1.pdf.

Guo, S. and M.W. Fraser (2010). *Propensity Score Analysis: Statistical Methods and Applications*. Thousand Oaks, CA: Sage Publications.

Hauge, J.A. and J.E. Prieger (2009). "Demand-Side Programs to Stimulate Adoption of Broadband: What Works?" SSRN Working Paper. Accessed online April 1, 2013 at http://ssrn.com/abstract=1492342.

Hauge, J. and J.E. Prieger (2010). "Demand-Side Programs to Stimulate Adoption of Broadband: What Works?" *Review of Network Economic* 9(3): Article 4.

Heckman, J.J., H. Ichimura, and P.E. Todd, (1997). "Matching as an Econometric Evaluation Estimator: Evidence from Evaluating a Job Training Program," *Review of Economic Studies* 64:605-654.

Hilding-Hamann, K.E., M. Meyerhoff Nielsen, J. Overgaard and K. Pedersen (2009). *Supporting Digital Literacy: Analysis of Good Practice Initiatives, Topic Report 3: Final Report*. Danish Technological Institute, Centre for Policy and Business Analysis, February. Accessed online August 17, 2011 at http://ec.europa.eu/information_society/eeurope/i2010/docs/benchmarking/dl_topic_report_3.pdf.

Horrigan, J. (2010). "Broadband Adoption and Use in America," Federal Communications Commission OBI Working Paper Series No. 1. Accessed online April 1, 2013 at http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-296442A1.pdf.

Johnson, G.K. and P.J. Ambrose (2006). Neo-Tribes: The Power and Potential of Online Communities in Health Care," *Communications of the ACM* 49(1):107-113.

Kellerman, A. (2010). "Mobile Broadband Services and the Availability of Instant Access to Cyberspace," *Environment and Planning A* 42:2990-3005.

Kellogg, D. (2011a). "Among Mobile Phone Users, Hispanics, Asians Are Most-Likely Smartphone Owners in the U.S.," NielsenWire, February 1. Accessed online April 1, 2013 at http://blog.nielsen.com/nielsenwire/consumer/among-mobile-phone-users-hispanics-asians-are-most-likely-smartphone-owners-in-the-u-s/.

Kellogg, D. (2011b). "40 Percent of U.S. Mobile Users Own Smartphones; 40 Percent are Android," NeilsenWire, September 1. Accessed online April 1, 2013 at http://blog.nielsen.com/nielsenwire/online_mobile/40-percent-of-u-s-mobile-users-own-smartphones-40-percent-are-android/.

Kirby, J.B. (2008). "Poor People, Poor Places and Access to Health Care in the United States," *Social Forces* 87(1):326-354.

Leuven, E. and B. Sianesi (2003). "PSMATCH2: Stata Module to Perform Full Mahalanobis and Propensity Score Matching, Common Support Graphing, and Covariate Imbalance Testing." Accessed online April 1, 2013 at http://ideas.repec.org/c/boc/bocode/s432001.html.

Mossberger, K., C.J. Tolbert, and M. Stansbury (2003). *Virtual Inequality: Beyond the Digital Divide*. Washington, DC: Georgetown Univ. Press.

National Telecommunications and Information Administration (NTIA), US Department of Commerce (2011). *Digital Nation: Expanding Internet Usage: NTIA Research Preview*, February. Accessed online April 1, 2013 at http://www.ntia.doc.gov/reports/2011/NTIA_Internet_Use_Report_February_2011.pdf.

Porter, C.E. and N. Donthu (2006). "Using the Technology Acceptance Model to Explain How Attitudes Determine Internet Usage: The Role of Perceived Access Barriers and Demographics," *Journal of Business Research* 59:999-1007.

Prieger, J.E. (2003). The Supply Side of the Digital Divide: Is There Equal Availability in the Broadband Internet Access Market? *Economic Inquiry* 41(2):346-363.

Prieger, J.E. (forthcoming). "The Broadband Digital Divide and the Economic Benefits of Mobile Broadband for Rural Areas," *Telecommunications Policy*.

Prieger, J.E. and K.M. Faltis (2012). "Civic Engagement in California: Why Do We Lag?" Pepperdine University, School of Public Policy Working Papers, paper 37.

Prieger, J.E. and T.V. Church (2012). "Deployment of Mobile Broadband Service in the United States," in I. Lee (ed), *Mobile Services Industries, Technologies, and Applications in the Global Economy.* Hershey, PA: IGI Global.

Prieger, J.E. and W.-M. Hu (2008). "The Broadband Digital Divide and the Nexus of Race, Competition, and Quality," *Information Economics and Policy* 20(2):150-167.

Prieger, J.E., and S. Lee (2008). "Regulation and the Deployment of Broadband," in Dwivedi et al. (eds), *Handbook of Research on Global Diffusion of Broadband Data Transmission*. Hershey, PA: IGI Global.

Rosenbaum, P. and D.B. Rubin (1983). "The Central Role of the Propensity Score in Observational Studies for Causal Effects," *Biometrika* 70:41-55.

Rosenbaum, P. and D.B. Rubin (1984). "Constructing a Control Group Using Multivariate Matched Sampling Methods That Incorporate the Propensity Score," *The American Statistician* 39(1):33-38.

Sarasohn-Kahn, J. (2009). *Participatory Health: Online and Mobile Tools Help Chronically Ill Manage Their Care*. California HealthCare Foundation, September. Accessed online April 1, 2013 at http://www.chcf.org/resources/download.aspx?id=%7bEF90BA22-1A70-4148-BDEB-D7ECEB17D934%7d.

Schatell, D., M. Wise, K. Klicko and B.N. Becker (2006). "In-Center Hemodialysis Patients' Use of the Internet in the United States: A National Survey," *American Journal of Kidney Diseases* 48(2):285-291.

Smith, A. (2010a). *Home Broadband 2010*. Pew Research Center's Internet & American Life Project, August 11. Accessed online April 1, 2013 at http://pewInternet.org/Reports/2010/Home-Broadband-2010.aspx.

Smith, A. (2010b). *Technology Trends among People of Color* Pew Research Center's Internet & American Life Project, Commentary, Sept. 17. Accessed online April 1, 2013 at http://www.pewInternet.org/Commentary/2010/September/Technology-Trends-Among-People-of-Color.aspx.

US Bureau of the Census (2012). *Current Population Survey, July 2011: Computer and Internet Use File: Technical Documentation*, *CPS—11*. Washington, DC: Bureau of the Census. Accessed online April 1, 2013 at www.census.gov/apsd/techdoc/cps/cpsjul11.pdf.

Zickuhr, K. and A. Smith (2012). *Digital Differences*. Pew Research Center's Internet & American Life Project, April 13. Accessed online April 1, 2013 at http://pewInternet.org/Reports/2012/Digital-differences.aspx.

Appendix

This appendix contains details on the matching methods used. Table 3 contains results from four variations on the matching estimator. Each method begins with estimation of the propensity score. Let W = 1 when the individual is in the minority group at issue (group 1), and let W = 0 for non-Hispanic whites (group 0). The Stata user-written command `psmatch2` (Leuven and Sianesi, 2003), version 4.0.6, was used to implement the following procedure.

Step One: Estimation of the Propensity Score

The estimated propensity score is $\hat{W}$, the predicted probability that W = 1 from a logit regression of W on the following household, family, and individual-level regressors found in the CPS: family income, type of living quarters, type of household tenure (own, rent, or occupy without payment), number of household members, familial structure of household (two-parent household, single parent, etc.), presence of a household business, labor force status, age, marital status, education, gender, disability status, metropolitan status, and size of metropolis.

Step Two: Matching

One of the four methods matches on $\hat{W}$ (labeled "P-score" in the "Match on" column in Table 3). The other methods match on the linear index $q(X_i) = X_i'\hat{\beta}$ $(= \ln[\widehat{W}/(1-\widehat{W})]$; labeled "Q-score"), where X_i is the vector of regressors for observation *i* and $\hat{\beta}$ is the coefficient vector from the propensity score estimation. Guo and Fraser (2010, p.134) suggest matching on the q-score, stating that it has distributional properties that make it more desirable than the propensity score.[28] Regardless of whether matching occurs on the propensity score or q-score, the common support requirement is enforced: observations in group 1 are dropped whose score is higher than the maximum or less than the minimum score of group 0.

The matching uses either a nearest neighbor with caliper method or a kernel method. In the nearest neighbor method, the propensity score or q-score of each observation in group 1 is matched (with replacement) to the closest score in group 0. If no group 0 score is within the distance defined by the caliper, however, no match is made. The caliper is listed in Table 3 in the column headed "Caliper or Bandwidth". With kernel matching, each observation in group 1 is matched to all observations in group 0 falling into the given bandwidth (Heckman et al., 1997). Matched group 0 observations are given weights determined from the Epanechnikov kernel.

In one of the matching methods, matches are restricted to observations coming from the same survey stratum. For individuals residing in a CMSA, the stratum is the CMSA. For other individuals, strata are defined based on less-specific geography, but no stratum crosses state lines (refer to Prieger and Faltis, forthcoming, for details on defining pseudo-strata for CPS data).

The quality of the matching can be assessed by various means. For binary and categorical covariates, the Pearson chi-square test for the independence of the covariate and the groups in a contingency table was used.[29] The categorical covariates are family income, type of living quarters, type of household tenure (own, rent, or occupy without payment), familial structure of household, presence of a household business, unemployed, self-employed, marital status, education, gender, disability status, metropolitan status, and size of metropolis. When group 1 is non-Hispanic Blacks, none of the

[28] Rosenbaum and Rubin (1984) state that the decision to match on Q-scores rather than on propensity scores probably has negligible effect, but avoids compression of the propensity scale near 0 and 1, which makes the use of a fixed caliper size or bandwidth more appropriate.

[29] Survey weights were not employed in the hypothesis tests, since the tests were for the comparability of the matched subsamples, not the subpopulations.

categorical covariates had a p-value of the Pearson chi-square statistics that was less than 0.12, and most had p-values that were much higher, signifying that there is no evidence that the matching failed to balance these covariates between groups 0 and 1. For the two continuous variables, number of household members and age, Wald tests for comparability of the means between groups failed to reject the null hypothesis of a common mean. Similar results obtain when group 1 is Hispanics: none of the tests reject comparability of the matched subsamples.

Another way to assess the quality of the covariate balancing is examine the imbalance before and after matching. Table A1 shows the absolute differences in the means of the covariates between the non-Hispanic black and non-Hispanic white subsamples before and after balancing with the nearest neighbor method. The test for equality of the means (which is a test for equality of proportions in the case of a binary covariate) between groups nearly always rejects before the balancing is performed. However, after matching, the absolute differences in means are small and the hypothesis that the difference is zero is never rejected at the 5% level. Furthermore, after balancing, the bias between the subsamples is usually less than 2% and less than 3% in all but three cases. It can thus be concluded that matching worked well to balance the covariates. Results are similar when group 1 is Hispanics (see Table A2), although the bias after matching is a bit larger in general and some of the p-values are lower.

Step Three: Estimation of the Difference in Outcomes

With a subset of group 0 matched to the observations in group 1 remaining after trimming to the common support, the difference in outcomes can be calculated. Let w_i be the survey weight of observation i in trimmed group 1, and let v_{ij} be the matching weight between observation i in group 1 and observation j in group 0. For nearest neighbor matching with replacement, $v_{ij} = 1$ for the single j matched to i, and zero otherwise. For kernel matching, v_{ij} is calculated as the kernel weight based on the distance in propensity or q-scores between observations i and j. A property of kernel weighting is that $\sum_{j \in G_0} v_{ij} = 1 \; \forall \; i$, where G_0 is the set of observations in group 0. Let Y_k be the outcome of interest (e.g., the presence of broadband in the home) when the individual is in group k = 0,1. Then the estimates of $E(Y_1 - Y_0|W = 1)$ in Table 3, $\hat{\tau}$, are calculated as

$$\hat{\tau} = \frac{\sum_{i \in G_1} w_i \left(Y_{1i} - \sum_{j \in G_0} v_{ij} Y_{0j}\right)}{\sum_{i \in gG_1} w_i}$$

where G_1 is the set of observations in group 1 after trimming to the common support. In the treatment effects literature, $\hat{\tau}$ is called the *average treatment effect on the treated* (ATT). The formula used here is a straightforward adaptation of equation (10) in Heckman et al. (1997) to include survey weights. Thus, $\hat{\tau}$ is the ATT estimated for the subpopulation pertaining to group 1, not just the group 1 subsample.

Table 1: Mobile Broadband Providers for US Population, Midyear 2011

	Mobile Broadband Providers						
Tract Population	0	1-3	4	5	6	7+	Total
≥ 50% white non-Hispanic	0.3%	24.4%	37.8%	30.4%	6.9%	0.2%	100.0%
< 50% white non-Hispanic (“majority minority”)	0.1%	6.9%	39.6%	46.8%	6.6%	0.0%	100.0%
Total	0.2%	19.3%	38.3%	35.1%	6.8%	0.2%	100.0%

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 June 30, 2011. The FCC definition of broadband is 200+ kbps at least one way.

Table 2: Broadband and Internet Usage by Race and Ethnicity, July 2011

	Home Broadband Usage of Any Kind		Access Internet on Mobile Phone		Home Mobile Broadband Available		Home Mobile BB Available & Uses Smartphone	
	Proportion [95% CI]	p-value	Proportion [95% CI]	p-value	Proportion [95% CI]	p-value	Proportion [95% CI]	p-value
White non-Hispanic	0.7075		0.3480		0.0826		0.0480	
	[0.703,0.712]	-	[0.343,0.353]	-	[0.079,0.086]	-	[0.046,0.050]	-
Black non-Hispanic	0.5216		0.3343		0.0783		0.0488	
	[0.507,0.536]	0.000*	[0.321,0.348]	0.055*	[0.070,0.088]	0.371*	[0.043,0.056]	0.799*
Native American	0.4856		0.3300		0.1043		0.0521	
non-Hispanic	[0.431,0.541]	0.000*	[0.285,0.379]	0.458*	[0.073,0.148]	0.252*	[0.035,0.078]	0.697*
Asian/Pacific	0.7186		0.363		0.0786		0.0482	
Islander non-Hisp.	[0.699,0.737]	0.268*	[0.344,0.382]	0.129*	[0.067,0.093]	0.554*	[0.040,0.058]	0.956*
Multiracial non-	0.6719		0.3815		0.0847		0.0553	
Hispanic	[0.636,0.706]	0.045*	[0.348,0.417]	0.058*	[0.067,0.107]	0.840*	[0.042,0.073]	0.347*
Hispanic	0.4865		0.2921		0.0782		0.0434	
	[0.473,0.500]	0.000*	[0.281,0.303]	0.000*	[0.070,0.087]	0.327*	[0.038,0.049]	0.121*
Total	0.6524		0.3393		0.0814		0.0475	
	[0.648,0.657]	0.000**	[0.335,0.344]	0.000**	[0.079,0.084]	0.583**	[0.046,0.050]	0.539**

*P-values are for the two-sided Wald test that the proportion for the row subpopulation differs from the proportion for the white non-Hispanic subpopulation.

**P-values are for the Pearson design-based chi-square test for differing proportions among the entire set of subpopulations.

Notes: all proportions represent estimates for the US population of individuals age 15+. Data are from the CPS Computer and Internet Use Supplement, July 2011.

Table 3: Differences in Broadband and Internet Usage by Race and Ethnicity

Measure of Usage and Method	Match on	Caliper or Bandwidth	Match within Strata	Non-Hispanic Blacks vs. Non-Hispanic Whites		Hispanics vs. Non-Hispanic Whites	
				Difference (in %age points)	95% Confidence Interval	Difference (in %age points)	95% Confidence Interval
Home Broadband Usage of Any Kind							
Unbalanced sample	NA	NA	NA	-18.59	[-20.14,-17.04]	-22.10	[-23.53,-20.67]
Nearest neighbor matching 1	Q-score	0.1	no	-12.74	[-14.48,-11.00]	-14.21	[-15.79,-12.64]
Kernel matching 1	Q-score	0.15	no	-11.94	[-13.40,-10.48]	-13.64	[-14.94,-12.34]
Kernel matching 2	P-score	0.06	no	-12.20	[-13.65,-10.74]	-14.04	[-15.34,-12.75]
Nearest neighbor matching 2	Q-score	0.1	yes	-9.80	[-11.61,-7.98]	-13.38	[-15.08,-11.68]
Access Internet on Mobile Phone							
Unbalanced sample	NA	NA	NA	-1.37	[-2.77,0.03]	-5.59	[-6.78,-4.39]
Nearest neighbor matching 1	Q-score	0.1	no	1.07	[-0.60,2.74]	-2.43	[-3.84,-1.02]
Kernel matching 1	Q-score	0.15	no	1.49	[0.18,2.79]	-2.48	[-3.57,-1.39]
Kernel matching 2	P-score	0.06	no	1.45	[0.14,2.75]	-2.47	[-3.56,-1.39]
Nearest neighbor matching 2	Q-score	0.1	yes	1.34	[-0.40,3.07]	-2.02	[-3.62,-0.42]

Notes: Nearest neighbor method is one to one matching with replacement. Kernel method uses the Epanechnikov kernel. Figures in second column are caliper widths for nearest neighbor matching and bandwidth for kernel matching. All matching methods enforce a restriction of common support. Confidence interval does not account for first-step estimation error of the propensity or q-score. All estimates use survey weights. NA = not applicable.

Table 4: Healthcare-Related Internet Use by Type of Household Internet Access, July 2011

	No Internet Access in Household	Dialup Internet Access in HH	Fixed Broadband Only in HH	Mobile Broadband in Household		
	Proportion [95% CI]	Proportion [95% CI]	Proportion [95% CI]	Proportion [95% CI]	*P*-value (vs. Fixed BB)*	Relative Incidence** (vs. Others)
Use Internet to research health plans or practitioners?	0.048 [0.043,0.053]	0.206 [0.178,0.233]	0.344 [0.338,0.351]	0.385 [0.366,0.404]	0.000	1.527
Use Internet to research health info for self-diagnosis?	0.071 [0.065,0.077]	0.290 [0.259,0.321]	0.409 [0.402,0.416]	0.454 [0.434,0.473]	0.000	1.488
Use Internet to access medical records or consult doctor?	0.010 [0.008,0.012]	0.031 [0.020,0.041]	0.070 [0.066,0.073]	0.076 [0.066,0.086]	0.285	1.483
Use Internet for any of the above?	0.089 [0.082,0.095]	0.353 [0.320,0.386]	0.498 [0.491,0.504]	0.549 [0.529,0.568]	0.000	1.476

*P-values are for the two-sided Wald test that the proportion for the mobile broadband subpopulation differs from the proportion for the fixed broadband only subpopulation.

**Relative incidences are the ratio of the proportion for the mobile broadband subpopulation to the proportion for all other individuals.

Notes: all proportions represent estimates for the US population of individuals age 18+. Data are from the CPS Computer and Internet Use Supplement, July 2011. The subpopulations are not limited to Internet users.

Table 5: Mobile Phone Owners' Usage of Mobile Data Applications by Race and Ethnicity, July 2011

	White non-Hispanic	Black non-Hispanic		Hispanic	
Mobile data application	Proportion [95% CI]	Proportion [95% CI]	*P*-value*	Proportion [95% CI]	*P*-value*
Accessing the Internet	0.456 [0.449,0.463]	0.475 [0.456,0.493]	0.073	0.450 [0.432,0.467]	0.485
Web browsing	0.371 [0.364,0.378]	0.384 [0.365,0.402]	0.214	0.362 [0.345,0.380]	0.367
Playing games	0.221 [0.214,0.227]	0.250 [0.232,0.268]	0.002	0.220 [0.204,0.235]	0.892
Accessing social networking sites	0.258 [0.252,0.265]	0.280 [0.261,0.298]	0.031	0.256 [0.240,0.272]	0.798
Downloading apps	0.257 [0.251,0.264]	0.251 [0.234,0.269]	0.542	0.226 [0.211,0.242]	0.000
Listening to music or other audio	0.234 [0.228,0.241]	0.280 [0.262,0.298]	0.000	0.261 [0.244,0.277]	0.004
Taking photos or videos	0.447 [0.440,0.454]	0.417 [0.399,0.436]	0.003	0.413 [0.396,0.431]	0.000

*P-values are for the two-sided Wald test that the proportion for the column subpopulation differs from the proportion for the non-Hispanic white subpopulation.

Notes: all proportions represent estimates for the US population of individuals age 18+. "Accessing the Internet" is defined as discussed in footnote 8. Data are from the CPS Computer and Internet Use Supplement, July 2011. The subpopulations are limited to cellphone or smartphone users.

Table A1: Comparability of the Black and White Subsamples before and after Matching

Covariate	Original Subsamples: Absolute Δ mean	p-value for Δ mean	Standard-ized % bias	Balanced subsamples: Absolute Δ mean	p-value for Δ mean	Standard-ized % bias
Rent home	0.255	0.000	56.1	0.013	0.247	2.5
Occupy home w/o pay	0.001	0.446	1.1	0.000	0.845	0.4
House or apartment	0.011	0.000	5.7	0.004	0.326	2.0
Mobile home	0.012	0.000	6.3	0.002	0.525	1.2
Family income cat. 2	0.024	0.000	15.4	0.000	0.965	0.1
Family income cat. 3	0.027	0.000	15.7	0.000	0.917	0.2
Family income cat. 4	0.028	0.000	14.3	0.003	0.568	1.3
Family income cat. 5	0.015	0.000	8.5	0.002	0.651	0.9
Family income cat. 6	0.026	0.000	11.5	0.001	0.787	0.6
Family income cat. 7	0.025	0.000	10.3	0.003	0.566	1.3
Family income cat. 8	0.011	0.003	4.7	0.003	0.540	1.3
Family income cat. 9	0.018	0.000	7.4	0.001	0.822	0.5
Family income cat. 10	0.002	0.671	0.7	0.004	0.441	1.7
Family income cat. 11	0.001	0.836	0.3	0.003	0.594	1.1
Family income cat. 12	0.022	0.000	7.8	0.002	0.739	0.7
Family income cat. 13	0.032	0.000	11.0	0.005	0.351	1.9
Family income cat. 14	0.057	0.000	18.4	0.007	0.203	2.6
Family income cat. 15	0.059	0.000	19.9	0.004	0.469	1.5
Family income cat. 16	0.050	0.000	20.5	0.003	0.485	1.5
# HH members	0.173	0.000	11.1	0.010	0.824	0.6
Unmarried male + family	0.024	0.000	10.4	0.005	0.337	2.2
Unmarried female + family	0.210	0.000	54.2	0.001	0.950	0.1
Unmarried male, ind.	0.002	0.621	0.6	0.003	0.585	1.0
Unmarried female, ind.	0.017	0.000	5.1	0.002	0.690	0.7
Other familial structure	0.000	0.903	0.2	0.002	0.084	3.1
Business in HH	0.105	0.000	34.9	0.001	0.766	0.6
Unemployed	0.053	0.000	20.5	0.001	0.859	0.3
Self-employed	0.045	0.000	20.0	0.004	0.158	2.2
Age category 2	0.032	0.000	11.1	0.007	0.158	2.5
Age category 3	0.020	0.000	7.3	0.004	0.428	1.4
Age category 4	0.013	0.000	4.7	0.004	0.446	1.3
Age category 5	0.018	0.000	5.1	0.014	0.044	3.7
Age category 6	0.004	0.318	1.1	0.010	0.127	2.7
Age category 7	0.017	0.000	4.3	0.004	0.526	1.1
Age category 8	0.027	0.000	8.1	0.002	0.709	0.6

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Continuation of table…	Original Subsamples			Balanced subsamples		
Covariate	Absolute Δmean	p-value for Δmean	Standard -ized % bias	Absolute Δmean	p-value for Δmean	Standard-ized % bias
Age category 9	0.019	0.000	7.2	0.007	0.101	2.9
Age category 10	0.023	0.000	11.6	0.000	0.862	0.3
Married, spouse absent	0.009	0.000	7.8	0.001	0.579	1.0
Widowed, div., or sep.	0.034	0.000	8.5	0.006	0.437	1.4
Never married	0.192	0.000	41.1	0.015	0.091	3.0
Female	0.041	0.000	8.2	0.012	0.129	2.3
Education category 2	0.035	0.000	7.6	0.011	0.182	2.4
Education category 3	0.011	0.017	2.8	0.005	0.494	1.2
Education category 4	0.013	0.000	4.4	0.002	0.733	0.6
Education category 5	0.077	0.000	21.3	0.006	0.240	1.9
Education category 6	0.043	0.000	15.6	0.001	0.728	0.6
Disabled	0.030	0.000	14.3	0.003	0.561	1.2
Nonmetro location	0.143	0.000	38.5	0.008	0.154	2.8
Metro status unidentified	0.006	0.000	6.8	0.000	0.748	0.6
MSA size category 1	0.031	0.000	11.8	0.004	0.383	1.8
MSA size category 2	0.015	0.000	5.3	0.003	0.571	1.1
MSA size category 3	0.006	0.193	2.1	0.001	0.849	0.4
MSA size category 4	0.010	0.097	2.6	0.001	0.900	0.3
MSA size category 5	0.123	0.000	31.1	0.008	0.404	1.9
MSA size category 6	0.108	0.000	30.1	0.005	0.580	1.3

Notes: Balancing was performed with the nearest neighbor method using the Q-score and a caliper of 0.1, without restricting matches to lie within the same stratum. “Δmean” refers to differences in the mean of the covariate between non-Hispanic blacks and non-Hispanic whites. P-values are for t-tests of the null hypothesis that Δmean = 0, where the s.e. for the test statistic accounts for clustering at the household level. The standardized % bias is a studentized form (on a 100 point scale) of the absolute Δmean, using the formula of Rosebaum & Rubin (1985). All figures are for the samples, not the population.

Table A2: Comparability of the Hispanic and Non-Hispanic White Subsamples before and after Matching

	Original Subsamples			Balanced subsamples		
Covariate	Absolute Δ mean	p-value for Δ mean	Standard -ized % bias	Absolute Δ mean	p-value for Δ mean	Standard-ized % bias
Rent home	0.258	0.000	56.8	0.023	0.087	4.6
Occupy home w/o pay	0.004	0.007	3.7	0.001	0.452	1.5
House or apartment	0.009	0.010	4.1	0.002	0.708	0.9
Mobile home	0.010	0.005	4.5	0.002	0.665	1.1
Family income cat. 2	0.013	0.000	9.6	0.002	0.653	1.2
Family income cat. 3	0.010	0.000	6.9	0.002	0.633	1.1
Family income cat. 4	0.018	0.000	10.0	0.004	0.583	1.9
Family income cat. 5	0.013	0.000	7.1	0.003	0.565	1.4
Family income cat. 6	0.031	0.000	13.6	0.010	0.093	4.3
Family income cat. 7	0.029	0.000	11.5	0.001	0.895	0.4
Family income cat. 8	0.030	0.000	11.7	0.000	0.960	0.1
Family income cat. 9	0.025	0.000	9.8	0.004	0.624	1.5
Family income cat. 10	0.025	0.000	10.4	0.002	0.791	0.8
Family income cat. 11	0.008	0.115	2.6	0.007	0.326	2.5
Family income cat. 12	0.011	0.017	3.8	0.001	0.857	0.5
Family income cat. 13	0.020	0.000	6.6	0.003	0.622	1.2
Family income cat. 14	0.059	0.000	19.3	0.002	0.711	0.8
Family income cat. 15	0.067	0.000	23.0	0.002	0.738	0.7
Family income cat. 16	0.057	0.000	24.0	0.004	0.264	2.1
# HH members	1.125	0.000	66.8	0.023	0.704	1.2
Unmarried male + family	0.052	0.000	20.3	0.001	0.914	0.3
Unmarried female + family	0.089	0.000	25.7	0.003	0.753	0.9
Unmarried male, ind.	0.035	0.000	12.3	0.007	0.169	2.7
Unmarried female, ind.	0.061	0.000	22.4	0.004	0.351	1.9
Other familial structure	0.001	0.412	0.9	0.000	0.861	0.3
Business in HH	0.077	0.000	24.3	0.010	0.139	3.6
Unemployed	0.030	0.000	12.7	0.001	0.792	0.6
Self-employed	0.028	0.000	11.5	0.004	0.386	1.8
Age category 2	0.059	0.000	19.4	0.006	0.383	1.7
Age category 3	0.039	0.000	13.9	0.001	0.853	0.4
Age category 4	0.035	0.000	12.3	0.004	0.569	1.2
Age category 5	0.080	0.000	20.7	0.002	0.805	0.6
Age category 6	0.013	0.001	3.5	0.009	0.239	2.4
Age category 7	0.072	0.000	19.9	0.001	0.884	0.3

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Continuation of table…	Original Subsamples			Balanced subsamples		
Covariate	Absolute Δmean	p-value for Δmean	Standard -ized % bias	Absolute Δmean	p-value for Δmean	Standard-ized % bias
Age category 8	0.046	0.000	19.6	0.005	0.280	2.7
Age category 9	0.035	0.000	18.9	0.009	0.083	5.8
Married, spouse absent	0.017	0.000	13.1	0.004	0.492	2.4
Widowed, div., or sep.	0.053	0.000	14.3	0.013	0.070	3.8
Never married	0.122	0.000	26.5	0.004	0.697	0.8
Female	0.001	0.793	0.2	0.000	1.000	0.0
Education category 2	0.013	0.013	2.8	0.005	0.589	1.1
Education category 3	0.039	0.000	10.6	0.008	0.206	2.2
Education category 4	0.035	0.000	13.2	0.004	0.304	1.6
Education category 5	0.115	0.000	33.9	0.002	0.702	0.6
Education category 6	0.071	0.000	28.0	0.000	0.880	0.2
Disabled	0.001	0.517	0.7	0.004	0.285	2.4
Nonmetro location	0.165	0.000	45.8	0.004	0.490	1.4
Metro status unidentified	0.001	0.366	1.5	0.002	0.145	2.9
MSA size category 1	0.032	0.000	12.0	0.002	0.774	0.6
MSA size category 2	0.018	0.000	6.3	0.001	0.939	0.2
MSA size category 3	0.035	0.000	11.3	0.001	0.903	0.3
MSA size category 4	0.004	0.460	1.1	0.002	0.802	0.6
MSA size category 5	0.036	0.000	9.8	0.005	0.626	1.3
MSA size category 6	0.193	0.000	49.7	0.005	0.704	1.1

Notes: "Δmean" refers to differences in the mean of the covariate between Hispanics and non-Hispanic whites. See notes to previous table. In additional to the covariates shown in the table, the logit estimation for the propensity score also includes interaction terms between household type (head and family/individual), age, and age squared as regressors.

Figure 1: Mobile Providers of Broadband in the US, Midyear 2011

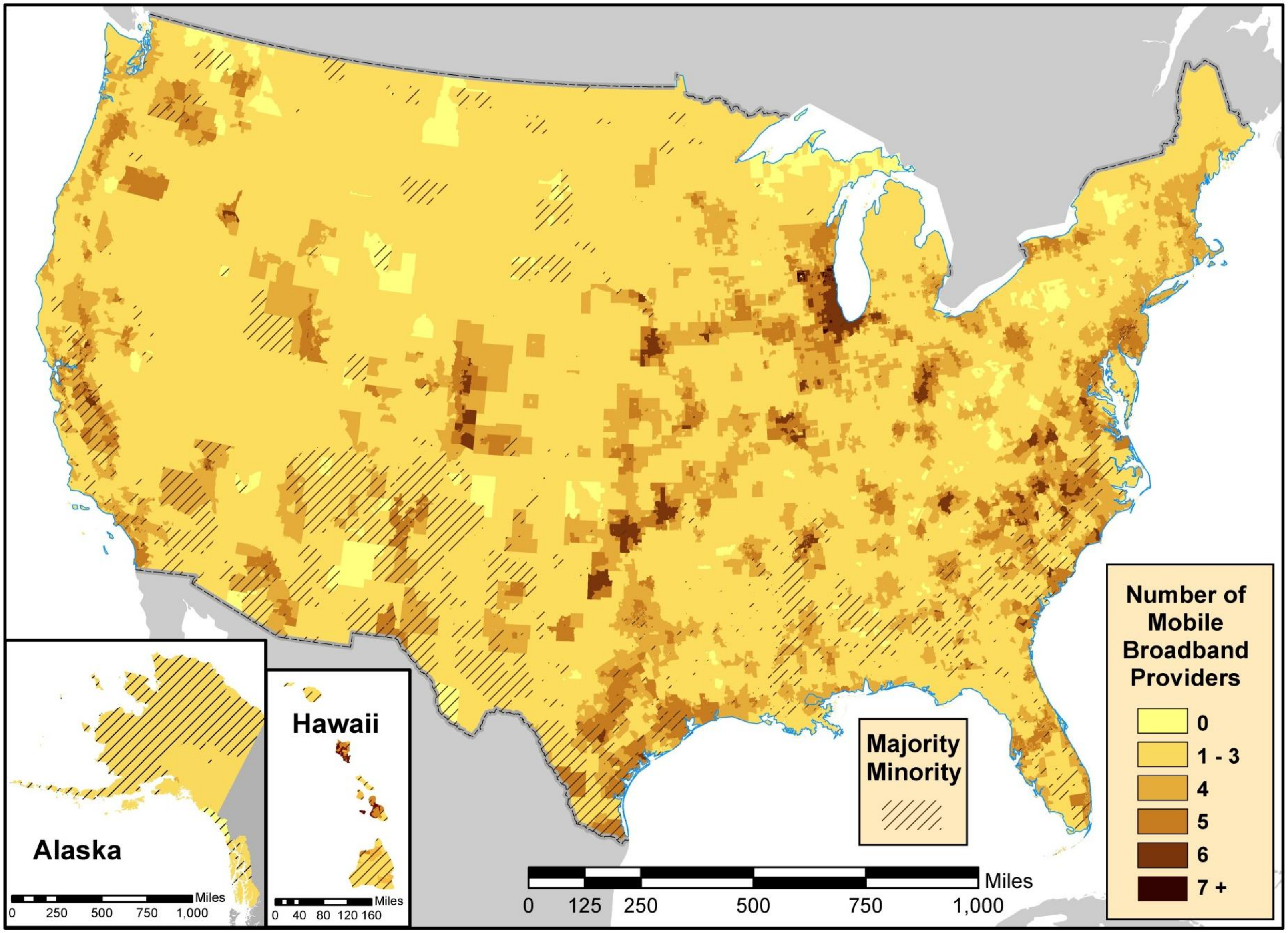


Figure 2: Distribution of Mobile Providers of Residential Broadband, 2008-2011

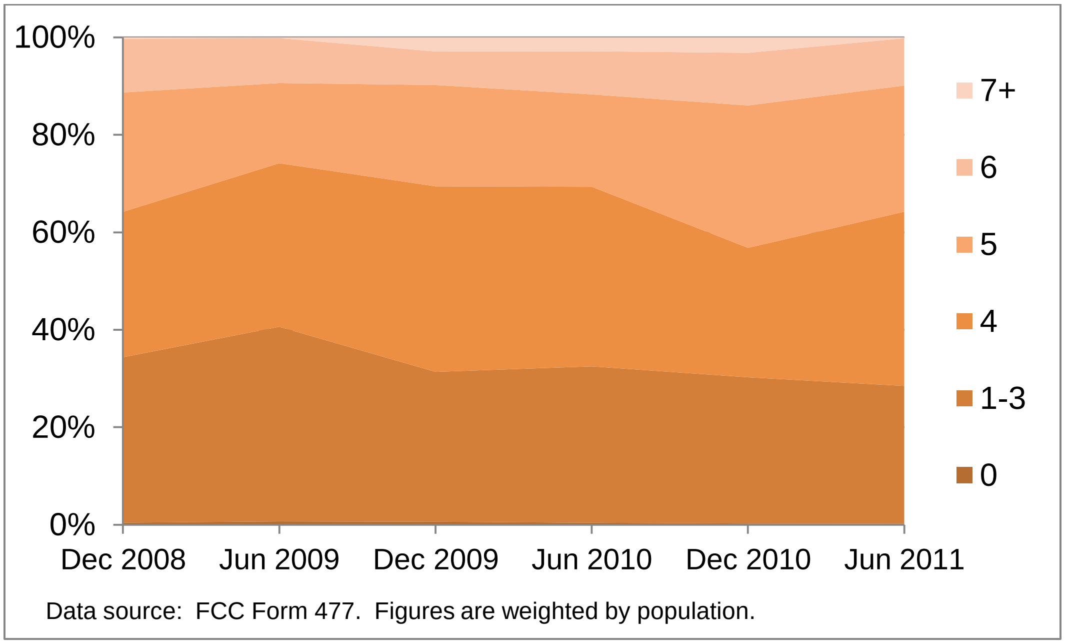


Figure 3: Distribution of Fixed Providers of Residential Broadband by Race/Ethnicity, Midyear 2011

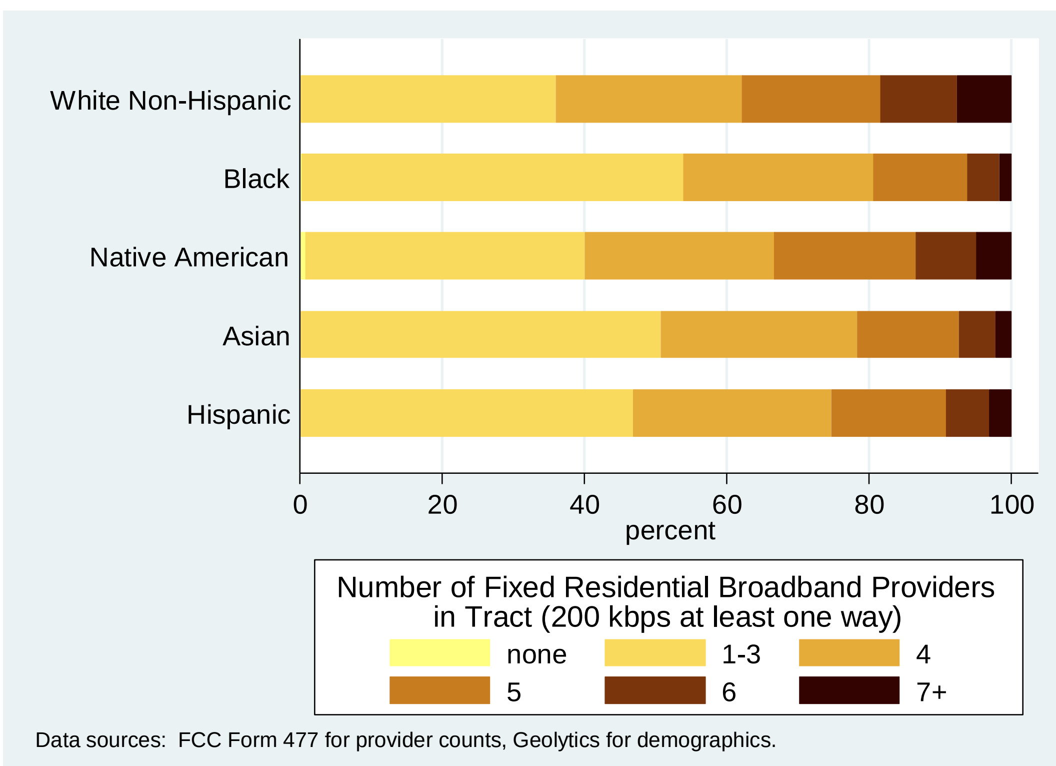
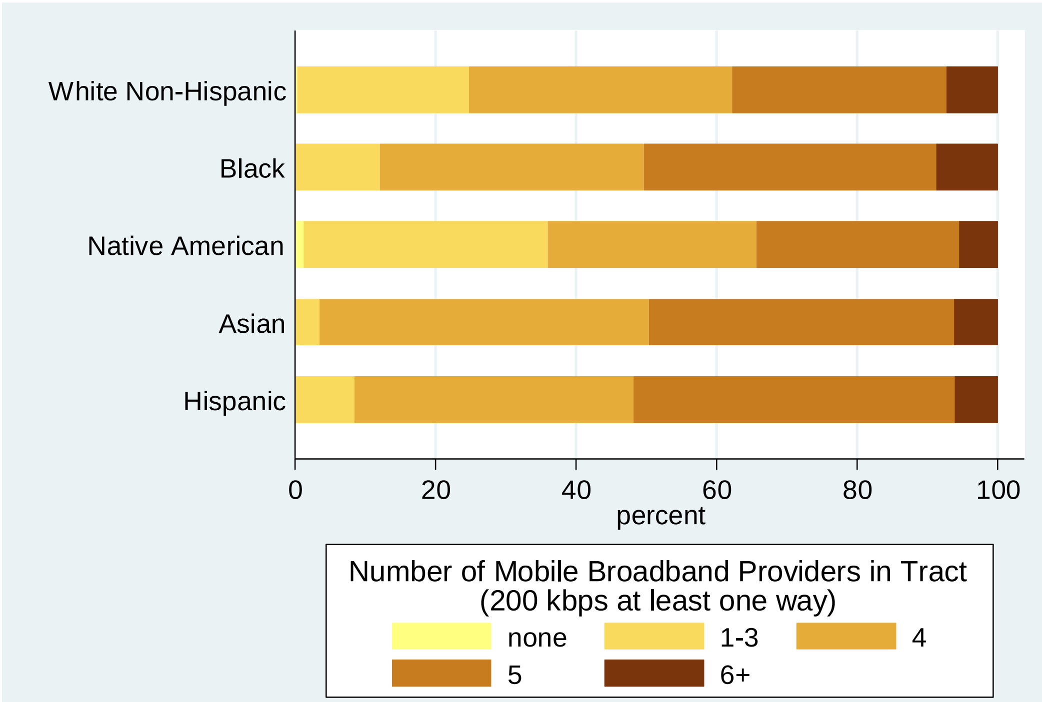


Figure 4: Distribution of Mobile Providers of Residential Broadband by Race/Ethnicity, Midyear 2011



Data sources: FCC Form 477 for provider counts, Geolytics for demographics.

Figure 5: Growth in US Residential Broadband Usage, 1999-2011

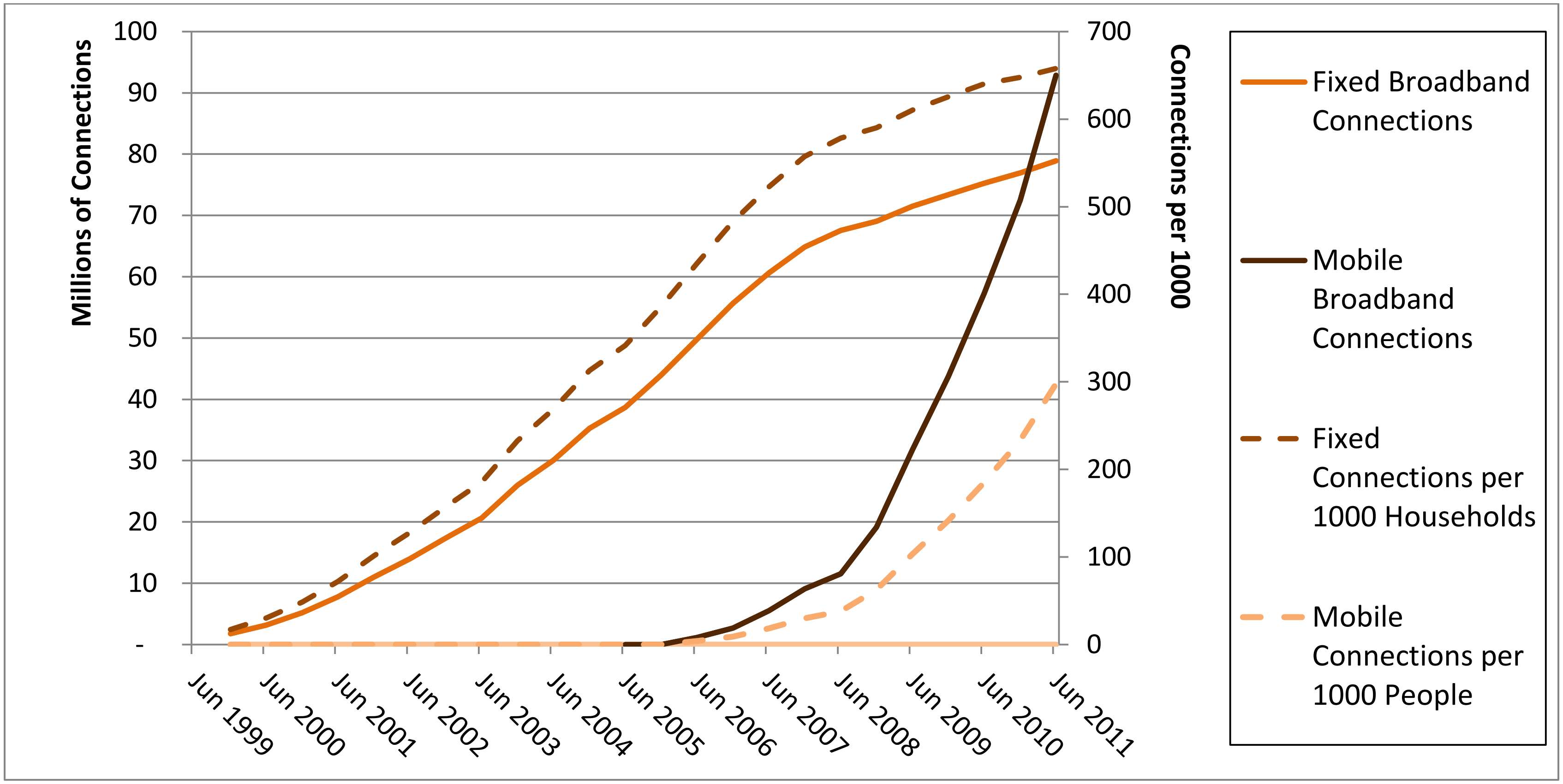


Figure notes: only residential connections are included. Data source: FCC *High-Speed Services for Internet Access* and *Internet Access Services* reports, various years. Population and household figures are from the US Census Bureau.

Figure 6: Type of Broadband Unavailable Among Households Not Subscribing Due to Unavailability