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The Tribal Digital Divide: Extent and Explanations*

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Abstract

This paper documents home Internet access, types of Internet access, connection speeds, and prices for basic home Internet in tribal areas of the United States. We find that the share of households with Internet access is 21 percentage points lower in tribal areas than in neighboring non-tribal areas. When compared to these non-tribal areas, download speeds, whether measured using fixed or mobile broadband networks, are approximately 75% slower in tribal areas, while the lowest price for basic Internet services in tribal areas is 11% higher. Regression techniques reveal that traditional cost factors such as terrain and population density fully explain the price gap but account for only a fraction of the tribal differences in Internet access and connection speeds. Income differences are strong predictors of Internet access but do not affect connection speeds. A sizable amount of the variation in the access and home connection gap between tribal and non-tribal is left unexplained. We conclude with a discussion of how federal broadband programs have penetrated Indian Country, how tribal-specific factors are related to the variation in Internet access within Indian Country, and the potential policy implications of our findings.

JEL Classification: O33, R11, R12, J15
Keywords: Digital divide, Broadband, Connectivity, Indian Country, American Indians

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1 Introduction

The importance of a reliable Internet connection became painfully clear during the COVID-19 pandemic when public health measures required virtual education, work, and social interaction in many places (Prieger, 2003; Oyana, 2011; Liu et al., 2018; Reddick et al., 2020). Unfortunately, dependable Internet access is not a given for those living in Indian Country – the land within the boundaries of American Indian reservations and the land held in trust by the federal government for the beneficial use of American Indians. This matters for economic development (Czernich et al., 2011; Kolko, 2012; Whitacre et al., 2014a; Ford, 2018), firm location and productivity (Kim and Orazem, 2017; Fabling and Grimes, 2021), local employment (Lehr et al., 2006; Crandall et al., 2007; Van Gaasbeck, 2008; Jayakar and Park, 2013; Atasoy, 2013; Whitacre et al., 2014b; Hjort and Poulsen, 2019; Lobo et al., 2020), the functioning of local markets (Bhuller et al., 2020), and access to financial markets (Evans, 2018).

While it has been noted that Internet access in tribal areas is lower than in non-tribal rural areas (see, e.g., Feir et al., 2019; Federal Communications Commission, 2019), there are still many fundamental, unanswered questions about this divide that are important for public policy. For example, to what extent is the Internet access gap between tribal and non-tribal areas due to factors such as rugged terrain and population density that drive up the cost of providing broadband access? To what extent do income differences between tribal areas and non-tribal areas explain difference in access? Or to what extent is the gap in home-based Internet access due to institutional barriers unique to Indian Country?[1] For example, the complicated management of lands held in trust within tribal jurisdictions may significantly impact broadband access (Henning and Rodman, 2021). Jurisdictional issues between states and tribal governments, many of which are even more pressing on reservations with "checkerboard" land ownership of private and trust lands, can increase the cost of providing broadband (Federal Communications Commission, 2019). Other jurisdictional issues, such as whether

[1]In this paper, the terms "tribal areas" and "Indian Country" are used interchangeably to characterize households located within the boundaries of federally recognized Indian reservations. The race of the heads of households is unobserved in our data; however, our indicator for tribal areas is highly correlated with the proportion of the population that is American Indian.

the state or the tribe has jurisdiction over civil matters under Public Law 83-280, may also play a role (Wellhausen, 2017). Other features of the tribal digital divide, such as connection speeds and prices for basic Internet services, are not well understood.

This paper leverages four broadband penetration datasets to create the first large-scale study of the extent and determinants of the tribal digital divide. We use these data to establish at least three stylized facts about this divide. First, we use public data from the most recent American Community Survey (ACS 2015-2019) to estimate differences in residential Internet access between tribal and neighboring non-tribal areas (Manson et al., 2020).[2] In addition, we measure the difference in how households in tribal and non-tribal areas connect to the Internet when it is used. Second, we characterize the difference in last-mile Internet coverage between households on and off reservation areas by adopting Ookla's measures of connection speed from the first quarter of 2020 to the first quarter of 2021.[3] We complement our last-mile analysis by using 2015-2019 connection speeds from the Measurement Lab (M-Lab) speed tests, which measure Internet performance in the Internet's middle mile. Third, we study the disparities in the lowest prices for basic broadband plans using data compiled in 2020 by BroadbandNow.com, a private company that aggregates local data from Internet service providers (ISPs).

The gap for each outcome is determined by the average difference between households on and off tribal land. We also include geographic, cost, and demand variables for each outcome to determine how these factors may explain the broadband gap between tribal and non-tribal areas.[4] By leveraging these novel scores of data, we are able to contribute to the understanding of tribal broadband coverage and provide further evidence of the systematic price disparities faced by Native people on reservations (Wellhausen, 2017; Cattaneo and Feir, 2020; O'Connell et al., 2011; Romero-Briones

[2]Since we are interested in understanding the role of institutional differences between tribal and neighboring non-tribal areas, we omit Oklahoma Tribal Statistical Areas (OTSAs), Alaska Native Statistical Village Areas (ANVSAs) and Hawaiian Home Lands (HHLs) from the sample.

[3]Terms such as "last mile" refer to the topology of the Internet. Specifically, the "last mile" of service refers to the connection from the local Internet service provider's (ISP) server to the end user's home. The "middle mile" of service refers to the connection between servers outside a local ISP's network.

[4]We recognize that it can be difficult to separate the factors of supply and demand. However, we follow Hauge and Prieger (2015) in using the term "demand" to include factors such as household income and poverty rates.

and Foxworth, 2016; Rivera and Foxworth, 2018) and low-income families in the U.S. as a whole (Myers et al., 2011; Broda et al., 2009; Chung and Myers Jr, 1999). Our results also shed light on which contemporary broadband policies are best designed to address the multiple dimensions of the connectivity divide between tribal and non-tribal areas.

Consistent with some previous studies (Feir et al., 2019; Federal Communications Commission, 2019), we find a large raw gap in Internet access between tribal and non-tribal areas. Specifically, the ACS data show that the average share of households with Internet access in tribal areas is 66%, while the average percentage of households with Internet access in neighboring non-tribal areas is 87%. This gap is approximately four times larger than the urban-rural gap in Internet access, which is about 6% (as reported here). In addition, Fairlie (2017) and Hoffman and Novak (1998) found a gap in home Internet access between non-Hispanic White and Black heads of households between 5% and 10%. Thus, the access gap between tribal and non-tribal areas is the most significant measured disparity in the Internet connectivity literature.

The ACS data also show that the methods by which households access the Internet differ significantly between tribal and non-tribal areas. For example, consistent with Morris and Meinrath (2009) and Howard and Morris (2019), households living predominantly in tribal areas are less likely to have a high-speed broadband subscription (via cable, fiber optic, or DSL) and more likely to use the Internet via cellular data plans or satellite Internet subscriptions. These differences are large. For example, households living in tribal areas are approximately twice as likely to access the Internet exclusively through cellular data plans and five times as likely to access the Internet exclusively through satellite Internet.

We also find significant differences in average Internet connection speeds in the last mile of Internet service. On average, download (upload) speeds over fixed networks in tribal areas are 71% (79%) slower than connection speeds in neighboring, non-tribal areas. Similar results exist for mobile broadband connection speeds. In addition, we find that average middle-mile connection speeds are slower in areas predominantly occupied by reservation land than in neighboring non-reservation land.

After accounting for differences in cost and demand factors, the adjusted differences in average download (upload) speeds of fixed broadband networks in tribal areas are still about 36% (43%) between tribal areas and neighboring non-tribal areas. We do not find that tribal-specific factors are important contributors to the differences in middle-mile connectivity. However, these results cannot draw clear policy conclusions because both last-mile and middle-mile connection data were collected with different levels of geographic precision.

Consistent with previous research (Park, 2020), we find that an ISP's least expensive plan for basic broadband service is about 11% more expensive in predominantly tribal areas than in nearby non-tribal areas. This difference suggests that households in tribal areas have to spend 2% of their annual income on basic service, while those in nearby non-tribal areas would have to pay only 1%. Thus, the budget share for basic Internet services is twice as high for households in tribal areas as in neighboring non-tribal areas. Taken together, these findings paint a bleak picture of the tribal digital divide. Households in predominantly tribal areas have poorer overall access to home Internet and, where available, higher prices and slower average connection speeds than households in neighboring non-tribal areas.

Many of these gaps, particularly the gap in home Internet access and connection speeds, cannot be explained by observed differences in costs and demand factors. This implies policies that allocate funding based solely on standard observable cost and demand factors are unlikely to close the gap in access between tribal and non-tribal areas. For example, while we find median community income is an important predictor lower access, it is unable to fully account for the gap in access. Thus policies such as the Emergency Broadband Benefit (EBB) program, which provides cash transfers to families in Indian Country to support Internet uptake, are unlikely to close the divide on their own.

We conclude this paper by examining the tribe-specific factors that might influence these gaps. In the spirit of Leonard et al. (2020), we find a U-shaped relationship between land held in trust and home Internet access. Other potential factors, such as whether a tribe has jurisdiction over civil matters and the existence of a casino, are not strong predictors of residential Internet access. These findings imply that mixed land tenure on reservations, which is a proxy for checkerboarding, may be a more important barrier to broadband provision than tribal revenue flows from casinos or state versus federal jurisdiction. However, even when census region fixed effects are added, less than half of the total variation of Internet access across reservations can be explained by the combination of institutional, cost, demand, and location factors.

We believe our findings are particularly timely, as the pandemic has brought greater attention to broadband disparities across the country and prompted federal policymakers to act quickly to subsidize broadband in high-cost areas (Federal Communications Commission, 2021) and create an exemption for tribes to extend broadband to tribal lands. Besides the EBB program, these results also suggest that flexibility in spending built into the Department of Commerce's National Telecommunications and Information Administration (NTIA) Tribal Broadband Connectivity Program is highly appropriate since the forms of the tribal digital divide range from inaccessibility, and slower connection speeds to higher prices.[5]

Our paper is organized as follows: In Section 2, we begin by presenting the data we have compiled on access, connection speeds, Internet prices, and costs and demand factors, and explain how we define tribal communities given the limitations in these datasets. In Section 3, we then discuss the empirical framework we use to quantify the broadband gap. We break down our results in Section 4 and explain the different measures of the digital divide that we use (Internet access, subscriptions, connection speeds, and prices). Section 5 provides supplementary data to determine how tribal institutional factors affect the estimated gap in Internet access and usage. We conclude in Section 6 with a discussion of the policy relevance of our findings and suggest important future research directions.

[5]For a description of the NTIA's Tribal Broadband Connectivity Program, see `https://broadbandusa.ntia.doc.gov/resources/grant-programs/tribal-broadband-connectivity-program`.

2 Data and Measurement

To calculate the gap between tribal and non-tribal areas in Internet-related outcomes, one would ideally have detailed geographic information. Unfortunately, public data on Internet usage and access do not include precise coordinates, so we establish a decision rule to define whether a household is located on or just outside a federally recognized reservation. Therefore, our unit of observation in the main sample is the census block group, the smallest geographic unit containing broadband-related outcomes in the ACS. Some Internet outcomes, such as minimum basic broadband price and middle-mile connection speeds, can only be measured in less precise geographic units such as ZIP code translation areas (ZCTAs). In both cases, we characterize a census block group or ZCTA as "tribal" and "non-tribal." We assign geographic units to tribal areas by overlapping the TIGER/Line shapefiles of recognized federal reservations on both census geographies. Once those overlap percentages are calculated (see Figure 1), we identify "tribal" areas where more than 50% of the geographic unit overlaps with federal reservation land. To limit our sample for "non-tribal" to nearby areas, they must satisfy two conditions: (1) 50% or less of the geographic unit's area consists of federal reservation land, and (2) the center of the geographic unit is within 25 kilometers of the nearest centroid of the "tribal" area.[6]

To get a better sense of the sample, see Figure 2. Using Minnesota as an example, Panel A shows the location of Indian reservations within the state, while Panel B contains the "tribal" block groups (in yellow) and the "non-tribal" block groups (in blue) using our assignment rule. Fortunately, our tribal assignment rule appears to reflect the location of large, contiguous reservations. The non-tribal areas are relatively uncovered by reservation land.

We work with four main sources of data in this paper: (1) the latest release of the ACS, (2) Ookla speed tests, (3) M-Lab speed tests, and (4) BroadbandNow.com (BBN). We briefly describe the benefits and limitations associated with each dataset below.

The ACS data was collected over five years from 2015 to 2019 and released to the public in De-

[6] For the list of reservations in our sample, see Online Appendix Table 2.

cember 2020 (Manson et al., 2020).[7] This dataset is a nationally representative sample and includes questions about household Internet access and the type of Internet subscriptions. As mentioned above, the unit of observation is the census block group. Unfortunately, the ACS does not provide Internet-related outcomes by race at a granular level, so we use all households within a census block group to determine the proportion of households with Internet access.[8]

We use two self-administered Internet speed tests to measure the connectivity gap between the tribes. First, we use data collected by Ookla's Speedtest.net, a free web service that provides cross-device performance metrics. Specifically, we measure Internet quality by averaging upload and download speeds of fixed and mobile broadband networks from the first quarter of 2020 to the first quarter of 2021. While the exact accuracy of the Ookla data varies by location, local speeds are accessible as shapefiles with tiles of approximately 610.8 meters by 610.8 meters at the equator.[9] These speed tests measure the connection of the "last mile" of the Internet, i.e., the speed at which information is transmitted to the customer's device from the nearest local server. To be consistent with the ACS data, we aggregate these data up to the level of the census block group.

We also adopt connection speeds collected by M-Lab, an open-source project that uses a single-stream diagnostic tool to measure a device's Internet performance. M-Lab's speed tests come from "off-net" servers, meaning that the test calculates the connection from home to off-network servers (and back). Unlike the Ookla tests, these connection speeds inform the consumer of the "middle mile" connection to the Internet and are typically slower. For our purposes, the M-Lab data offer two advantages over Ookla data: (1) the M-Lab speed data represent the full user experience, and (2) these connection speeds can be calculated over a longer period of time (i.e., we adopt data from 2015

[7]There are some limitations in the ACS data. First, the ACS does not ask questions about the quality of the Internet when it is available. Second, several studies have questioned the quality of the ACS data in Indian Country (DeWeaver, 2010, 2013a,b,c; Villega et al., 2016). These studies have highlighted underreporting of the American Indian, Alaska Native (AIAN) population, particularly in years prior to 2011 when interviews were conducted by email or telephone. The U.S. Census Bureau changed its procedures in 2011 to address this issue by conducting in-person interviews in areas of Indian Country where 10% of the population participated in the 2010 Census (U.S. Census Bureau, 2020). The only way to assess Internet access and other demographic and economic variables in very rural areas, such as most Indian reservations, is to use the five-year average, which smooths out year-to-year changes in these variables.

[8]For a discussion of the differences between ACS and FCC Internet data, see the online Appendix.

[9]See `https://www.ookla.com/ookla-for-good` and `https://github.com/teamookla/ookla-open-data`. Last accessed May 13, 2021.

to 2019), which should reduce the role of outliers. However, the main limitation with the M-Lab data is the geographic identification of the speed tests at the location of the local server, which can be many miles from home in rural areas. For this reason, we aggregate these speed tests at the ZCTA level.

The Ookla and M-Lab data have one major limitation: Both are based on individuals who voluntarily perform speed tests. Therefore, the observed speed tests may not be representative of the general distribution of connection speeds. For example, the speed test data likely suffer from positive selection (i.e., higher-income households are more likely to conduct speed tests), which may affect the accuracy of speed measurements in tribal areas (McMahon et al., 2011). In addition, speed tests are often conducted at times of extreme congestion. However, there is no a priori information that households in tribal areas are more likely to conduct a speed test during times of unusually poor connectivity; thus, the direction of sample selection bias is unclear. Future research will hopefully address the non-representative nature of connection speed data.

We measure the minimum price for basic broadband services using BBN data. BBN collected price plans from more than 2,000 ISPs by ZIP code in the third quarter of 2020.[10] These prices reflect the lowest regular monthly fixed broadband rate for residential customers, whose minimum requirement is download and upload speeds of 25 Mbps download and 3 Mbps, respectively (Zimmer, 2018).[11] The price data are collected at the ZIP code level and converted to the ZCTA level using the HUD crosswalk.[12]

We incorporate additional data from several sources to account for differences in broadband deployment costs between tribal and non-tribal areas. First, because high-speed fiber-optic infrastructure often runs along major roads, we measure both the distance to the nearest highway and the

[10] These data are available on Github (`https://github.com/BroadbandNow/Open-Data`).

[11] There is a surprising amount of variation in minimum prices across the U.S. The mean price is $55 but the standard deviation is $20, which is approximately half the mean. The price at the 25% percentile is $40 while the price at the 75% percentile is $70.

[12] For the most part, the ZIP codes match the ZCTAs perfectly. However, for completeness, the HUD's UDS Mapper crosswalk links all ZIP codes to the ZCTAs. For more information, see `https://udsmapper.org/zip-code-to-zcta-crosswalk/`.

distance to the nearest urban area using Census TIGER/Line Shapefiles.[13] Second, we measure topographic differences by calculating the mean slope of the terrain from a 1/3 arc-second resolution elevation change map from the National Elevation Dataset (NED) and the percentage of tree canopy cover from the National Land Cover Database (NLCD). Population density and block group area are from the ACS and Census TIGER/Line Shapefiles. We also control for income and demographic differences by taking the ACS data on median household income, poverty rate, and median age.

Table 1 presents the mean difference between tribal and non-tribal areas for each variable used in this study. Column 1 provides the mean for each variable in tribal areas, which we define as "tribal" if at least 50% of the geographic unit's area overlaps with federally recognized American Indian Reservation land. Column 3 contains the mean for the non-tribal sample, including all "non-tribal" geographical units whose centroid is within 25 kilometers of a "tribal" unit. Because census geographic units (i.e., census block groups and ZCTAs) are spatially correlated, we report robust standard errors and errors clustered at the county level in Column 3.

Table 1 shows that the deficit in Internet access in tribal areas compared to non-tribal areas is 21%, while for households with Internet access, the deficit is 19% for households with fixed broadband subscriptions. Given that satellite Internet and cell phone-only home Internet use are often associated with living in very rural areas, the differences in the proportion of households with cellphone-only plans and satellite Internet contracts are stark. Households in tribal areas are twice as likely to use cell-phone only home Internet and five times as likely to use satellite Internet for home Internet.

There is a significant difference in Internet connection speeds between tribal and neighboring non-tribal areas. For example, the average download speed in Ookla speed tests is about twice as fast in neighboring non-tribal areas. Speeds obtained with the M-Lab performance tests are consistently

[13]Ideally, we would have used actual data on fiber-optic infrastructure, but the only official, publicly available data are reported by ISPs to the FCC on Form F477, which, as noted above, may overrepresent coverage. Other attempts, such as Durairajan et al. (2015) and Durairajan et al. (2013), to construct fiber-optic maps were made using data from the Internet Atlas project (no longer available), while Knight et al. (2012) collected data from The Internet Topology Zoo. Both initiatives collected and processed public data from major ISP websites with various accuracy. Regarding the accuracy of the map and the data provided by ISPs, Knight et al. (2012) explicitly states: "The map is the idealization of their network they wished to publicize." In the absence of accurate data on fiber-optic infrastructure, we use the distance to the nearest highway.

slower in tribal areas. However, these differences are smaller than for last-mile connections obtained with Oookla data. One potential reason for this is that the M-Lab data confirm different privacy protocols, so the exact locations of these tests are unclear, which may attenuate these differences.

Table 1 reveals that the deficiency in Internet access in tribal areas relative to non-tribal areas is 21 percentage points, while, among the households with access to the Internet, the deficiency in households with fixed broadband subscriptions is 19 percentage points. Given that satellite Internet and exclusive use of cell phones for home Internet are often functions of living in highly rural areas, the differences in the share of households with only cellular data plans and with only satellite Internet plans is stark: Households in tribal areas are twice as likely to exclusively use cell phones for home Internet and five times as likely to use satellite Internet for home Internet.

The average price for basic Internet in "tribal" ZIP codes is $65 per month compared to $60 per month in neighboring "non-tribal" ZIP codes. This $5 per month premium leads to larger differences in the annual cost of basic Internet as a share of income because median household income is substantially lower in tribal areas (see Panel B). As a result, the spending on basic Internet for households in tribal areas is twice the share of spending for households in neighboring areas.

With respect to the cost and demand factors, there is a statistically significant difference between tribal and non-tribal areas for every control variable except for the proportion of tree cover. In particular, median household income and population density are substantially lower on tribal lands than neighboring non-tribal areas. Tribal areas also have a younger population than non-tribal areas.

The distance between the centroid of tribal areas and the center of the nearest city is much greater for tribal areas than for non-tribal areas, even though the two are contiguous. However, this result is purely mechanical: The size of census block groups is defined by population, and given the difference between tribes in population density, the size of census block groups classified as "tribal" is much larger than neighboring non-tribal block groups. Other control variables (the major highways indicator, the poverty rate, and the average slope of the terrain) suggest large differences between tribal and non-tribal areas, even when the non-tribal areas are nearby.

One final note is worth mentioning. Our sample restriction and tribal assignment rule, i.e., assigning units as "tribal" if 50% of their area contains Indian reservation land, works well with the block group data. Using both criteria, the overlap percentage of "tribal" block groups is 96%, while the overlap percentage of "non-tribal" block groups is 3%. We are therefore confident that most households in our "tribal" units live on reservation land, whereas the large majority of households in our "non-tribal" units live off reservation land. The sampling relationship holds for "tribal" and "non-tribal" ZIP codes.

3 Empirical Framework

To measure the digital divide between the tribes in their different forms, we use the following empirical framework:

$$\text{Y}_i = \alpha + \beta\text{tribal}_i + \textbf{Cost}_i'\psi + \textbf{Demand}_i'\pi + \epsilon_i \tag{1}$$

where Y_i is the outcome variable of interest in geographical unit i, and "tribal" equals one if at least x% of the unit's area overlaps with federal Indian reservation land, and zero otherwise. We allow x≥ 50 for the bulk of specifications. However, to illustrate how the gaps between tribal and non-tribal areas vary by the overlapping percentage, we allow x to vary across all possibilities (i.e., we allow x to vary from $x \geq 1$ to $x \geq 99$) and report the $\hat{\beta}$ for each x when we measure the raw gaps.

The control variables are grouped into two categories. Because many Indian reservations are located in remote areas with high broadband costs, $\textbf{Cost}_i$ contains geographic variables such as distance to an urban area, distance to a primary major road, mean slope (and its standard deviation) of the terrain, percentage the of proportion of tree cover, land area, and population density. We also use state fixed effects to account for cost differences shared within states, but that vary across states. These controls allow us to identify the mean difference in Y, while accounting for the cost of deploying broadband due to traditional cost differences.

We also add factors in $\mathbf{Demand}_i$ such as median household income, poverty rate, and median age to account for demand differences. However, there is one thing to note when using household income as a control variable. Since median household income affects the profitability in service areas and is substantially lower in tribal areas (see Table 1), income could be considered a confounding factor. However, using income as a control variable may mediate the OLS coefficient on the tribal indicator since tribal-specific factors may also influence incomes itself. In this sense, income may be considered a "bad control" (Cinelli et al., 2020). If income mediates the impact of tribal-specific factors on broadband outcomes, then our estimated adjusted gap between tribal and non-tribal areas will only partially reveal the impact of tribal-specific factors on broadband. As a result, overcontrolling would bias the results against the hypothesis that tribal-specific factors contribute to gaps between tribal and non-tribal areas.

We also apply a common strategy used in spatial regression discontinuity to compute the tribal digital divide. First, following Gelman and Imbens (2019), Dell et al. (2018), and Dell and Olken (2020), we weight each observation such that the weighting of a given unit decreases with distance from the boundary of a federal Indian reservation. This weighting scheme gives more weight to geographic areas just within and outside the boundaries of federal reservations and makes the results less sensitive to changes in sampling restrictions. Second, to account for spatial autocorrelation, the standard errors of the block group sample are clustered at the county level, while the standard errors of the ZCTA sample are clustered at the state level.

4 Main Results

4.1 Home Internet Access and Subscriptions

We first use ACS data to investigate the extent of tribal disparity in home Internet access and, when the Internet is available, the gap in types of Internet subscriptions (i.e., differences in the share of households with fixed broadband, cellphone-only, and satellite-only Internet service plans) between tribal and non-tribal areas. In the ACS, a household is classified as having Internet access if a household member has an Internet subscription or non-subscription Internet access via a municipal wireless network (Ryan and Lewis, 2017). Therefore, under the ACS definition of Internet access, a household may not have Internet access if an ISP does not provide Internet in its service area (i.e., a supply-side reason), or if Internet is available but the household is unwilling to purchase an Internet subscription at the market price (i.e., a demand-side reason).

Figure 3 shows four unconditional gaps between tribal and non-tribal areas in Internet access and subscriptions in the ACS. Panel A shows the 95% confidence interval for β in Equation (1) for all possible overlapping percentages, where Y is the proportion of households with Internet access. Panel B shows the 95% confidence intervals using the share proportion of households with broadband subscriptions, conditional on having Internet access. Panels C and D show the 95% confidence intervals using the share of internet-subscribing households with only cellular data plans and only satellite Internet, respectively.

Figure 3, Panel A shows that the raw access gap is highly statistically significant for all values of x, ranging in size from 18.9 percentage points (when $x \geq 1$) to 22.2 percentage points (when $x \geq 99$). This finding is consistent with Tanberk and Cooper (2021), who find an 18% difference in tribal Internet access when comparing ZIP codes that overlap with reservations to non-reservation ZIP codes. The point estimates of the raw gap between tribal and non-tribal areas for households with a broadband subscription in Panel B are stable across all overlapping percentages, ranging between 18 and 20 percentage points. Panel C shows that the share of Internet-subscribing households with cellphone-only data plans only is between 9 and 10 percentage points higher on tribal lands. Finally, Panel D shows that the share of Internet-subscribing households with satellite Internet only is between 3 and 4 percentage points higher on tribal lands.

To better understand how specific factors affect the access and subscription type gaps, we estimate the adjusted gaps and report the OLS results in Table 2. For simplicity, we define a block group as a tribal area for these regressions if 50% of its area overlaps with reservation land and as zero otherwise. However, Figure 3 shows that the estimated gaps are insensitive to assignment, largely due to the relative alignment of block group boundaries with reservation borders.

For each outcome, we report the results in three ways. First, we simply report the unconditional gap between tribal and non-tribal areas for each outcome. This is identical to the raw gaps measured at $x \geq 50$ in Figure 3. Second, we report the adjusted gaps between tribal and non-tribal areas by controlling for cost factors. Third, we add demographic and income controls to test the stability of the tribal coefficient.[14]

According to the first set of columns in Table 2, the raw gap in Internet access decreases from 21 to 16 percentage points after cost factors are added. Thus, using standard regression techniques, standard cost factors account for approximately a quarter of the difference. Column 3 shows that income inequality and demographic differences explain a substantial portion of the raw access gap (about 30% of this gap). This result suggests that recent policies such as the EBB program, which provides cash transfers to households in tribal areas (and smaller cash transfers to households in rural non-tribal areas), will partially reduce the access gap. However, the adjusted gap between tribal and non-tribal areas is still 9.5% and is highly significant after controlling for cost and income differences, meaning that roughly half of the raw access gap remains unexplained.

Table 2, Column 4 shows that the share of households with broadband subscriptions is 19 percentage points lower in tribal areas if they have Internet. However, unlike Column 2, the adjusted gap is highly influenced by cost controls (i.e., approximately 43% of the gap is explained by cost factors). Controlling for household income, poverty rate, and median age further reduces the gap between the tribes, accounting for about 30% of the raw gap. As a result, income and cost factors explain three-quarters of the gap in broadband subscriptions.

[14] As indicated in Table 1, there are not only differences in the socioeconomic characteristics of tribal and non-tribal areas but also the socioeconomic characteristics of people with and without Internet access in general. See Table 4 in the online Appendix for summary statistics from the ACS microdata of people with and without Internet access. This table shows that those without Internet access tend to be slightly older, are less likely to be White, married, or college-educated. They also have much lower incomes, both individually and at the household level, are less likely to be employers or out of the labor force. Finally, they are more likely to live in the central Southwest. This confirms that adjusting for socioeconomic differences in and outside tribal areas is relevant for understanding the nature of the tribal broadband gap.

Since previous work has shown that consumers rely more heavily on cell phones in Indian Country (Howard and Morris, 2019) and on satellite subscriptions in rural areas in general (Rawls et al., 2020), we generate some stylized facts regarding the extent to which households on tribal lands use only cell phones (Columns 7-9) or satellite Internet plans for home Internet access (Columns 10-12). Column 7 shows that households on tribal lands are twice as likely to access the Internet exclusively from cellular data plans. The observed cost factors account for about one-fifth of the gap between tribal and non-tribal areas. As a result, income and demographic factors explain a much larger share (approximately half) of the raw gap.

The difference between the share of households with satellite Internet subscriptions in tribal and non-tribal areas, conditional on having Internet, is also very large (see Column 10). Households with Internet access in tribal areas are five times more likely to have only satellite Internet subscriptions than non-tribal households with home Internet. Unlike the cellular data plan gap, cost factors account for over 60% of the discrepancy (Column 11), while demand factors account for only 7% of the gap (Column 12).[15]

These results mask the heterogeneity of the tribal digital divide across states. To illustrate some of these differences, Figure 4 shows the state-by-state variation in of the conditional access gap between tribal and non-tribal areas. These state-level gaps are estimates of β from Equation (1) using a full set of controls. We also report state-level access gaps only when there are at least 10 "tribal" block groups in a state.

Figure 4 reveals that the greatest lack of Internet access in tribal areas (compared to neighboring non-tribal areas) is in Wyoming, Arizona, and New Mexico. Arizona and New Mexico are home to most of the Navajo Nation, whose lack of digital inclusion has been well documented in press articles and recent congressional hearings (Nez, 2020; Park, 2020).[16] The states with the smallest gap in Internet access for tribes are in the Upper Midwest, where the gap in Internet access for tribes is

[15] We show that these adjusted gaps between tribal and non-tribal areas in Internet access and adoption methods are robust to bandwidth choice and the tribal assignment rule (see the Online Appendix, Figure 5).

[16] As a robustness check, we estimate Table 2 without the Navajo Nation and its non-tribal neighbors and the results do not change greatly. See the online Appendix for more details.

nearly zero.

4.2 Connection Speeds

We now establish some stylized facts about the tribal differential in residential Internet connections. We simplify the measurement of Internet connections by focusing on the average difference in upload and download speeds over a relatively long period of time. Figure 5 shows the raw gap in Ookla's last-mile download and upload speeds between fixed and mobile broadband networks in all overlapping percentages. Panels A and B show the raw gaps between tribal and non-tribal areas in download and upload speeds from fixed networks, while Panels C and D show the raw gaps between tribal and non-tribal areas in download and upload speeds from mobile networks. Across all possible tribal assignments (i.e., over the range of $x \geq 1$ to $x \geq 99$), the mean download/upload speeds in "tribal" areas are substantially lower than in neighboring "non-tribal" areas.

We determine the role of observed cost and demand factors on the tribal connectivity gap in Table 3. As before, the tribal indicator in Equation (1) equals one if 50% or more of a block group's area overlaps with federal Indian reservation land and zero otherwise. The sample is limited to block groups with centroids within 25 kilometers of the centroid "tribal" census block group. The results are as follows: Columns 1-3 use log mean download speeds of fixed networks, Columns 4-6 use log mean upload speeds of fixed networks, Columns 7-9 use log mean download speeds of mobile networks, and Columns 10-12 use log mean upload speeds of mobile networks. Columns 1, 4, 7, and 10 all correspond to the midpoint of the respective graph in Figure 5.

Cost factors explain much of the gaps in connection speeds of mobile networks (Columns 8 and 11) than fixed networks (Columns 2 and 5). Across all outcomes, however, median household income, median age, and poverty rate account for less than 5% of the raw tribal differences in connection speeds. This is interesting, as one might assume that Internet upgrades (and subsequent speed testing) are correlated with income. However, these results suggest that income factors are not an important predictor of self-measured connectivity speeds. Thus, while helpful to individuals, programs such as EBB would not necessarily result in equalizing disparities in tribal area connectivity.[17]

Using alternative measures of Internet speeds, Figure 6 shows that the raw gaps between tribes in middle-mile connection speeds are substantial and vary by the tribal assignment rule because ZCTAs are not precisely aligned with tribal boundaries. However, regardless of the tribal assignment rule, there is a large and statistically significant difference in download/upload speeds using M-Lab speeds between tribal and non-tribal ZIP codes.

Table 4 shows that much of the difference in M-Lab speeds is due to observed cost differences between tribal and non-tribal areas. When income differences are accounted for, the connection speed gap is still negative but less accurately measured. Since the M-Lab speed data are measured with less precise geographic identification than the Ookla tests, we cannot claim that barriers unique to Indian Country affect only the "last mile" of connectivity.

4.3 Internet Prices

Finally, we measure price differences in basic Internet service plans by comparing the cheapest monthly residential Internet rates on and off tribal lands. Figure 7 indicates 95% confidence intervals of this difference using the natural log of the cheapest broadband plan available in each ZCTA as the outcome. As with the previous results, we begin by estimating Equation (1) without controls for all possible overlapping thresholds and restrict the sample to ZCTAs whose centroid is within 25 kilometers of the nearest centroid of the "tribal" ZCTA.

The confidence intervals in Figure 7 show a positive, statistically significant difference in prices for basic residential broadband services between tribal and non-tribal areas in all overlapping percentages. The estimated range suggests that the cheapest ISP plans are between 11% and 14% higher on tribal lands than near non-tribal areas.

Next, we estimate the determinants of this gap by adding cost factors associated with broadband deployment. Similar to the previous specifications, we designate a ZCTA as tribal if at least 50% of its

[17] We show that these adjusted gaps between tribal and non-tribal areas in connection speeds are robust to bandwidth choice and the tribal assignment rule in the Online Appendix, Figure 6.

area overlaps with reservation land. Table 5 shows these results. The models follow the same schema as in Table 2. The first model shows the raw gap, the second model adjusts the gap for observed cost factors, and the third model adds income and demographic factors. In terms of the cheapest Internet service plan for basic broadband, the estimated price gap between tribal and non-tribal areas in Column 1 is roughly 11%. Adjusting for geographic and cost factors reduces the estimated gap to 0.3%, and the gap becomes statistically insignificant. Income and demographic factors further reduce the price gap. Thus, unlike access and connection speeds, the direct effects of factors unique to Indian Country are not significant in the higher prices that tribal households pay for basic broadband services. Rather, the higher prices appear to be entirely due to the higher cost of broadband deployment in tribal areas.

5 Digging Deeper into the Tribal Digital Divide

So far, we have found a statistically significant and economically large lack of Internet connectivity in tribal areas compared to their neighboring non-tribal areas. We have also shown that observed cost and demand differences do not fully explain this gap. While there is no definitive report on the specific barriers to Internet access in tribal areas (see, e.g., Henning and Rodman, 2021), several government documents provide compelling anecdotal evidence on the factors that increase the cost of deployment in tribal areas. This section provides an overview of the suspected causes of the tribal digital divide and, where possible, examines whether these claims can be substantiated with available data.[18]

The Federal Communications Commission (2019)'s Report on Broadband Deployment in Tribal Areas highlights several factors that contribute to the high cost of deployment. First, the rugged terrain, high poverty rates, and low population density in many reservation areas increase the cost of broadband deployment. As these factors are controlled in our analysis, we have effectively shown

[18] Several potentially important factors are not testable due to a lack of data; therefore, our analysis of the importance of tribal-specific factors is inherently limited.

that other factors are equally important. In this context, the FCC report also underscores the complicated permitting processes that apply to trust status lands on reservations, as well as jurisdictional issues involving state and tribal governments. In the case of fiber-optic Internet deployment, these permitting processes include federal environmental reviews and rights-of-way through trust status lands. Jurisdictional issues between states and tribes are likely to be more problematic on reservations with a "checkerboard" pattern that occurs when fee lands (i.e., lands within a reservation in private ownership) and trust lands on a reservation are close to each other.

A report by Native Nations Communications Task Force (2019) also emphasizes the economic barriers that increase deployment costs and decrease adoption rates. In contrast to the Federal Communications Commission (2019), this report highlights requirements in federal broadband funding programs that have hindered tribal participation and deployment in tribal areas. For example, the FCC's E-rate program, which provides affordable broadband services to schools and libraries, has not been adopted by many tribal libraries because of the complexity of the application process, low staff capacity, and lack of resources. In addition, many tribally owned ISPs have not been direct recipients of grants from the FCC and USDA's Rural Utilities Service (RUS), both of which are commonly used to provide broadband in rural areas (U.S. Government Accountability Office, 2018). Finally, the Native Nations Communications Task Force (2019) also highlights that tribal areas are often the last to be served under the FCC's Universal Service High-Cost program, which allows the ISP to meet the build-out obligations of the grant before serving a tribal community.

5.1 Tribal Institutional Factors

We examine the influence of a number of institutional factors on Internet access and use in Indian Country. As noted earlier, our analysis is hampered by data gaps. For example, we do not observe fractionation or checkerboarding in our data, so we will use proxies for these potentially important factors. Thus, this analysis is exploratory in nature. To this end, our goal is to determine the relationship between Internet access on a reservation (and type of use) and potentially influential tribal institutional factors.

We focus on three observable institutional factors: (1) the extent of trust status land on a reservation, (2) whether a tribe is exempt from Public Law 83-280 (PL280), and (3) the presence of a tribally owned casino. Each variable is measured at the reservation level. If casino profits, which are unobservable to the public, are used to provide the necessary infrastructure to support broadband deployment, then the presence of a casino should be positively related to broadband access and negatively related to substitutes for reliable Internet such as exclusive use of cellular data plans and satellite Internet. If checkerboarding is problematic, then reservations with a mixture of fee simple and trust status land should have less Internet access, all else being constant, compared to reservations completely comprised of trust land.[19] However, if transaction costs related to permitting increase with the amount of land held in trust, then reservations with more land held in trust will have less Internet access, all else being constant.

We examine the correlation between PL280 status and Internet connectivity because the readiness of non-tribal ISPs, some of which may be smaller "rate-of-return" providers, may be affected by whether a state or tribe has jurisdiction over civil matters. For PL280 tribes, civil matters are adjudicated by state courts rather than tribal courts.[20] Anderson and Parker (2008) finds evidence that state jurisdiction over civil matters on tribal lands stabilizes contract enforcement; however, the causal relationship depends on the exogeneity of PL280 status concerning the economic activity, which is in dispute.

To calculate the proportion of reservation land held in trust and as a restricted fee property, we adopt data on six forms of land ownership (individual trust, individual restricted fee, individual fee, tribal trust, tribal restricted fee, and tribal fee) from a 2019 Freedom of Information Act request to the BIA and published publicly by Native Land Information Systems. These six categories are grouped

[19] In an ideal setting, we would have spatial data on the types of property rights within reservations. Thus, we are not directly testing for checkerboarding. If such data become available, future research will be able to directly isolate the role of checkerboarding.

[20] PL280 was passed in the early 1950s and transferred federal legal jurisdiction over civil and criminal matters on reservations to the states of California, Minnesota, Nebraska, Oregon, and Wisconsin, and then to Alaska. PL280 also allowed states to assume jurisdiction at their discretion with tribal consent. For a more detailed discussion of PL 280, see Goldberg (1974), Goldberg and Champagne (2005), and Harvey (2020).

by tribal name and hand-linked to American Indian reservations and off-reservation trust land. As a result, we find 313 individual Indian reservations (and off-reservation trust land) with available BIA land, 238 of which contain ACS data on Internet outcomes.[21] We define the proportion of land with trust status as the total acreage held in these six categories divided by the total acreage held as trust land and a restricted fee for individuals and tribes. This results in an average of about 91% of all land held as trust status land in the entire sample.

We identify the current federally recognized tribes (and thus reservations) subject to PL280 jurisdiction (i.e., state jurisdiction) using the National Indian Justice Center's comprehensive list found here. This list includes tribes located in mandatory PL280 states, optional PL280 states, tribes signed up after PL280 was enacted, tribes excluded from PL280, and tribes located in states that relinquished jurisdiction. We construct a PL280 indicator equal to one if a reservation is under state jurisdiction and zero otherwise.[22]

Table 6 shows the correlations between these factors and reservation Internet access (Column 1) and reservation Internet usage rates (Columns 2–4). Each model includes the same set of controls as in Table 2, except that BIA census region fixed effects are used instead of state fixed effects. With respect to home-based Internet access, our results show a U-shaped relationship with trust status land: Reservations with a mix of trust status land and fee land have the lowest proportion of home-based Internet access. Neither PL280 status nor the presence of a casino is related to Internet access from home on a reservation.

Table 6, Columns 2–4 show the relationship between institutional factors and type of Internet use. Column 2 shows that the presence of casinos is positively correlated with the share of households with broadband subscriptions and that there is a U-shaped relationship in holds with respect to trust

[21]In Table 6 in the Appendix, we compare how representative these 238 variables are of those excluded from the analysis. We have enough other indicators for a total of 303 reservations. From the summary statistics presented in the table, we can see that our sample is comparable to the reservations not included in the sample in terms of the proportion of land held in tribal trust, presence of casinos, elevation, tree cover, and distance to the nearest urban center. However, the reservations in our sample tend to be more densely populated and larger in area (which is to be expected since our sample was selected due to confidentiality issues in the ACS). They are also somewhat closer to a major road and slightly less likely to be covered under PL280.

[22]For further details on the construction of the PL280 indicator, see Section 1.5 of the Online Appendix.

status land and the share of households that have only a cellular plan subscription. The last column shows that, for the proportion of Internet-subscribing households that use only satellite Internet, the relationship with trust status land becomes an inverted U-shaped relationship. The coefficient on the casino indicator is negative and significant. Thus, in reservations with casinos, the proportion of households using only satellite Internet is lower than in reservations without casinos, holding all other factors constant. In all specifications, there is no relationship between PL280 status and any of the Internet outcomes.[23]

These findings confirm that certain institutional factors drive up the cost of broadband deployment and subsequently affect how households adopt the Internet. The FCC recognizes the higher costs of broadband deployment in tribal areas and provides special credits to telecommunications providers in Auction 904, the Rural Digital Opportunity Fund (RDOF). However, there is no clear indication that these additional costs are due to checkerboarding. It is also unclear whether tribal bidding credits are large enough to incentivize broadband deployment.

6 Discussion and Conclusions

We use empirical strategies to determine the extent of the tribal digital divide in its various forms and then to determine the extent to which standard cost and demand factors are responsible for this divide. We first find strong evidence that the gap between tribal and non-tribal areas in Internet access, connection speeds, and basic Internet prices is statistically and economically significant. We also find that standard cost differences in broadband deployment, such as rugged terrain and low population density, are important factors driving the access, connection speed, and price gaps. However, in some cases, such as home Internet access, about half of the gap remains unexplained.

However, income inequality plays a more nuanced role in the tribal digital divide. Median house-

[23] We also find no relationship between the share of land held in individual trust and each of these Internet outcomes. To the extent to which reservations with greater shares of individual trust land deal with more issues pertaining to fractionation, we do not find a relationship between connectivity and fractionation. Of course, direct measures of fractionation and more granular Internet data would better suited to identify this potential mechanism.

hold income is a significant predictor of the access gap and the decision to access the Internet via cable, fiber optic, DSL, or a cellular data plan. But income inequality itself is not a strong predictor of satellite Internet use of connection speed. This implies that subsidizing Internet payments along the lines of the FCC's EBB program should increase home Internet use and reduce reliance on the exclusive use of cell phones for home Internet access. For households using satellite Internet, however, limited competition may affect the extent to which FCC subsidies can improve the quality of home Internet. Thus, revenue subsidies are not expected to improve several features of the tribal digital divide.

Of the institutional factors considered, we find evidence of a U-shaped relationship between home Internet access and the share of reservation held as trust status land. Other factors, such as the limited ability of tribal governments to operate their own ISPs, the lack of ISPs for tribes in previous federal broadband programs, and potential grant requirements from the FCC and RUS—which may have left tribal areas without Internet after build-out requirements were met—are all additional factors in the tribal digital divide. Unfortunately, we cannot test each of these factors due to data limitations.

Recent federal programs such as the National Telecommunications and Administration Tribal Connectivity Program, the RDOF, and the EBB program are creating new sources of federal funds or subsidies that directly address digital inequities between tribal and non-tribal areas. Across all measurements of the tribal digital divide, our results suggest that flexibility in federal broadband grant programs will necessitate closing this gap since the connectivity gaps are large between tribal and non-tribal areas as well as within Indian Country.

In addition, large amounts of discretionary COVID-19 relief funds from the Coronavirus Aid, Relief, and Economic Security (CARES) Act and the American Rescue Plan Act (ARPA) provide an additional source of funds.[24] Over time, future research should be able to determine the extent to which these federal programs have closed the tribal connectivity gap. Additional research is also

[24]However, tribes with more employees receive a larger share from these formula-based funds. As a result, there is a positive correlation (r = 0.248) between reservations with Internet access and the combined CARES Act/ARPA allocations per tribal citizen. Data on combined CARES Act and ARPA allocations can be found at https://hpaied.org/.

needed to dig deeper into the unexplained portion of the large disparities in connectivity between tribal and non-tribal areas.

References

Anderson, T. L. and Parker, D. P. (2008). Sovereignty, credible commitments, and economic prosperity on American Indian reservations. *Journal of Law and Economics*, 51(4):641–666.

Atasoy, H. (2013). The effects of broadband Internet expansion on labor market outcomes. *ILR Review*, 66(2):315–345.

Bhuller, M., Kostol, A., and Vigtel, T. (2020). How broadband Internet affects labor market matching. *IZA Discussion Paper Series*, (12895).

Broda, C., Leibtag, E., and Weinstein, D. E. (2009). The role of prices in measuring the poor's living standards. *Journal of Economic Perspectives*, 23(2):77–97.

Cattaneo, L. and Feir, D. (2020). The price of mortgage financing for Native Americans. *Journal of Economics, Race, and Policy*, pages 1–18.

Chung, C. and Myers Jr, S. L. (1999). Do the poor pay more for food? an analysis of grocery store availability and food price disparities. *Journal of Consumer Affairs*, 33(2):276–296.

Cinelli, C., Forney, A., and Pearl, J. (2020). A crash course in good and bad controls. *Available at SSRN*, 3689437.

Crandall, R., Lehr, W., and Litan, R. (2007). The effects of broadband deployment on output and employment: a cross-sectional analysis of U.S. data. *Issues in Economic Policy*, 6(6):1–34.

Czernich, N., Falck, O., Kretschmer, T., and Woessmann, L. (2011). Broadband Infrastructure and Economic Growth. *Economic Journal*, 121(552):505–532.

Dell, M., Lane, N., and Querubin, P. (2018). The Historical State, Local Collective Action, and Economic Development in Vietnam. *Econometrica*, 86(6):2083–2121.

Dell, M. and Olken, B. A. (2020). The Development Effects of the Extractive Colonial Economy: The Dutch Cultivation System in Java. *Review of Economic Studies*, 87(1):164–203.

DeWeaver, N. (2010). The American Community Survey: Serious Implications for Indian Country. *NCAI Policy Research Center*. http://www.ncai.org/policy-research-center/initiatives/ACS_Serious_Implications.PDF.

DeWeaver, N. (2013a). American Community Survey Data On the American Indian/Alaska Native Population: A Look Behind the Numbers. *NCAI Policy Research Center*. https://www.ncai.org/policy-research-center/initiatives/ACS_data_on_the_AIAN_Population_paper_by_Norm_DeWeaver.pdf.

DeWeaver, N. (2013b). Comments on Census Bureau Evaluation Report on ACS Coverage Measured by Comparison with the 2010 Decennial Census. https://www.ncai.org/policy-research-center/initiatives/Census_Evaluation_of_ACS_coverage_-_DeW_comments.docx.

DeWeaver, N. (2013c). Trends in Size of AI/AN Alone Youth Population by Type of Land Area - 1990 to 2010. Technical report. https://www.ncai.org/policy-research-center/initiatives/Declining_AI-AN_Alone_Youth_Population.docx.

Durairajan, R., Barford, P., Sommers, J., and Willinger, W. (2015). Intertubes: a study of the U.S. long-haul fiber-optic infrastructure. *SIGCOMM Comput. Commun. Rev.*, 45(4):565–578.

Durairajan, R., Ghosh, S., Tang, X., Barford, P., and Eriksson, B. (2013). Internet atlas: A geographic database of the Internet. In *Proceedings of the 5th ACM Workshop on HotPlanet*, HotPlanet '13, page 15–20, New York, NY, USA. Association for Computing Machinery.

Evans, O. (2018). Connecting the poor: the Internet, mobile phones and financial inclusion in Africa. *Digital Policy, Regulation and Governance*, (6):568–581.

Fabling, R. and Grimes, A. (2021). Picking up speed: does ultrafast broadband increase firm productivity? *Information Economics and Policy*, page 100937.

Fairlie, R. W. (2017). Have we finally bridged the digital divide? Smart phone and Internet use patterns by race and ethnicity.

Federal Communications Commission (2019). Report on Broadband Deployment in Indian Country. 8(5):20. https://www.fcc.gov/document/fcc-adopts-report-and-order-emergency-broadband-benefit-program-0.

Federal Communications Commission (2021). FCC adopts report and order for Emergency Broadband Benefit Program. https://www.fcc.gov/document/fcc-adopts-report-and-order-emergency-broadband-benefit-program-0.

Feir, D., Todd, R. M., and Weyrauch, K. (2019). The digital divide in Indian Country. *Center for Indian Country Development, The Federal Reserve Bank of Minneapolis*.

Ford, G. S. (2018). Is faster better? Quantifying the relationship between broadband speed and economic growth. *Telecommunications Policy*, 42(9):766–777.

Gelman, A. and Imbens, G. (2019). Why High-Order Polynomials Should Not Be Used in Regression Discontinuity Designs. *Journal of Business & Economic Statistics*, 37(3):447–456.

Goldberg, C. and Champagne, D. (2005). Is Public Law 280 fit for the twenty-first century-some data at last. *Connecticut Law Review*, 38:697.

Goldberg, C. E. (1974). Public Law 280: The limits of state jurisdiction over reservation Indians. *UCLA L. Rev.*, 22:535.

Harvey, M. (2020). Fatal encounters between native americans and the police. *The Center for Indian Country Development, Federal Reserve Bank of Minneapolis*.

Hauge, J. A. and Prieger, J. E. (2015). Evaluating the impact of the American Recovery and Reinvestment Act's BTOP on broadband adoption. *Applied Economics*, 47(60):6553–6579.

Henning, S. and Rodman, A. (2021). *National Tribal Broadband Strategy*. Bureau of Indian Affairs. https://www.bia.gov/sites/bia.gov/files/assets/as-ia/doc/2020.%20December.%20National%20Tribal%20Broadband%20Strategy%20FINAL-cover%20change.pdf.

Hjort, J. and Poulsen, J. (2019). The arrival of fast Internet and employment in africa. *American Economic Review*, 109(3):1032–1079.

Hoffman, D. L. and Novak, T. P. (1998). Bridging the racial divide on the Internet.

Howard, B. and Morris, T. (2019). *Tribal technology assessment: The state of internet service on tribal lands*. American Indian Policy Institute, Arizona State University.

Jayakar, K. and Park, E.-A. (2013). Broadband Availability and Employment: An Analysis of County-Level Data from the National Broadband Map. *Journal of Information Policy*, 3:81.

Kim, Y. and Orazem, P. F. (2017). Broadband Internet and new firm location decisions in rural areas. *American Journal of Agricultural Economics*, 99(1):285–302.

Knight, S., Falkner, N., Nguyen, H. X., Tune, P., and Roughan, M. (2012). I can see for miles: Re-visualizing the Internet. *IEEE Network*, 26(6):26–32.

Kolko, J. (2012). Broadband and local growth. *Journal of Urban Economics*, 71(1):100–113.

Lehr, W. H., Osorio, C. A., Gillett, S. E., Sirbu, M. A., Lehr, W. H., and Gillett, S. E. (2006). Measuring Broadband's Economic Impact. *Massachusetts Institute of Technology Engineering Systems Division Working Paper Series*. ES-WP-2006-02.

Leonard, B., Parker, D. P., and Anderson, T. L. (2020). Land quality, land rights, and indigenous poverty. *Journal of Development Economics*, 143:102435.

Liu, Y.-H., Prince, J., and Wallsten, S. (2018). Distinguishing bandwidth and latency in households' willingness-to-pay for broadband Internet speed. *Information Economics and Policy*, 45:1–15.

Lobo, B. J., Alam, M. R., and Whitacre, B. E. (2020). Broadband speed and unemployment rates: Data and measurement issues. *Telecommunications Policy*, 44(1):101829.

Manson, S., Schroeder, J., David Van Riper, T. K., and Ruggles, S. (2020). Ipums national historical geographic information system: Version 15.0 [dataset]. *Minneapolis, MN: IPUMS. 2020*.

McMahon, R., O'Donnell, S., Smith, R., Walmark, B., Beaton, B., and Simmonds, J. (2011). Digital divides and the 'first mile': Framing First Nations broadband development in Canada. *International Indigenous Policy Journal*, 2(2).

Morris, T. L. and Meinrath, S. D. (2009). New media, technology, and Internet use in Indian Country: Quantitative and qualitative analyses. *Native Public Media and New America Foundation*.

Myers, C. K., Close, G., Fox, L., Meyer, J. W., and Niemi, M. (2011). Retail redlining: Are gasoline prices higher in poor and minority neighborhoods? *Economic Inquiry*, 49(3):795–809.

Native Nations Communications Task Force (2019). Improving and Increasing Broadband Deployment on Tribal Lands. *Report to the Federal Communications Commission from the Tribal Members of the Task Force*.

Nez, J. (2020). Addressing the urgent needs of our tribal communities. *United States House of Representatives Committee on Energy and Commerce*.

O'Connell, M., Buchwald, D. S., and Duncan, G. E. (2011). Food access and cost in American Indian communities in Washington State. *Journal of the American Dietetic Association*, 111(9):1375–1379.

Oyana, T. J. (2011). Exploring geographic disparities in broadband access and use in rural southern Illinois: Who's being left behind? *Government Information Quarterly*, 28(2):252–261.

Park, C. (2020). The Cost of Connectivity in the Navajo Nation. Technical Report October.

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.

Rawls, M. L., Thiemann, H. B., Chemin, V., Walkowicz, L., Peel, M. W., and Grange, Y. G. (2020). Satellite constellation internet affordability and need. *Research Notes of the AAS*, 4(10):189.

Reddick, C. G., Enriquez, R., Harris, R. J., and Sharma, B. (2020). Determinants of broadband access and affordability: An analysis of a community survey on the digital divide. *Cities*, 106:102904.

Rivera, Y. and Foxworth, R. (2018). Indian Country Food Price Index: Exploring Variation in Food Pricing Across Native Communities - A working paper II. *First Nations Development Institute*.

Romero-Briones, A.-d. and Foxworth, R. (2016). Indian Country Food Price Index: Exploring Variation in Food Pricing Across Native Communities - A working paper. *First Nations Development Institute*.

Ryan, C. L. and Lewis, J. M. (2017). *Computer and Internet use in the United States: 2015*. U.S. Department of Commerce, Economics and Statistics Administration.

Tanberk, J. and Cooper, T. (2021). 82% of Residents in Tribal ZIP Codes Have Broadband Internet Access, Compared to 94% of Non-Tribal Residents. *Broadband Now Research*. `https://broadbandnow.com/research/tribal-broadband`.

U.S. Census Bureau (2020). Understanding and using American Community Survey data: What all data users need to know. *United States Census Bureau*, (July):1–84.

U.S. Government Accountability Office (2018). Tribal broadband: Few partnerships exist and the rural utilities service needs to identify and address any funding barriers tribes face. (September 28).

Van Gaasbeck, K. A. (2008). A rising tide: Measuring the economic effects of broadband use across California. *Social Science Journal*, 45(4):691–699.

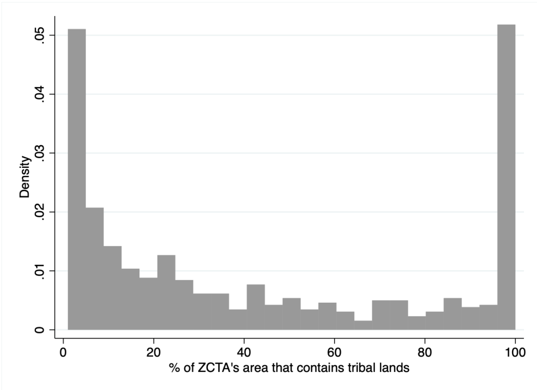
Villega, M., Ebarb, A., Pytalski, S., and Roubideaux, Y. (2016). Disaggregating American Indian & Alaska Native Data: A Review of Literature. Technical report. *A Report to the National Congress* *of American Indians to the Robert Wood Johnson Foundation* https://www.policylink.org/sites/default/files/AIAN-report.pdf.

Wellhausen, R. L. (2017). Sovereignty, law, and finance: Evidence from American Indian reservations. *Quarterly Journal of Political Science*, 12(4):405–436.

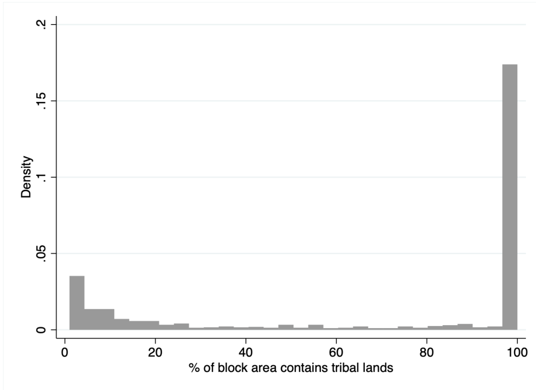
Whitacre, B., Gallardo, R., and Strover, S. (2014a). Broadband's contribution to economic growth in rural areas: Moving towards a causal relationship. *Telecommunications Policy*, 38(11):1011–1023.

Whitacre, B., Gallardo, R., and Strover, S. (2014b). Does rural broadband impact jobs and income? Evidence from spatial and first-differenced regressions. *Annals of Regional Science*, 53(3):649–670.

Zimmer, J. (2018). What is broadband: FCC broadband definition has changed before and will change again. *Broadband Now Research*, 10. https://broadbandnow.com/report/fcc-broadband-definition/.



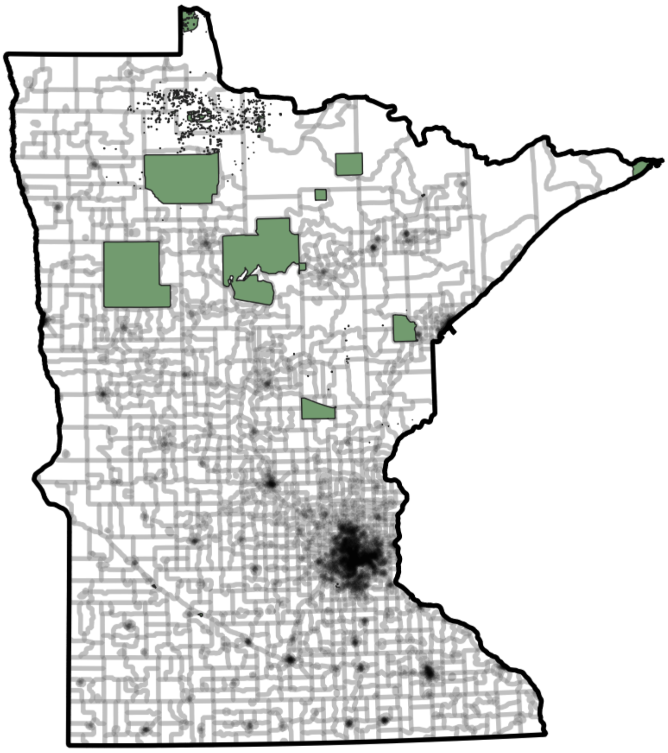
(a) Overlapping ZCTAs with Reservations



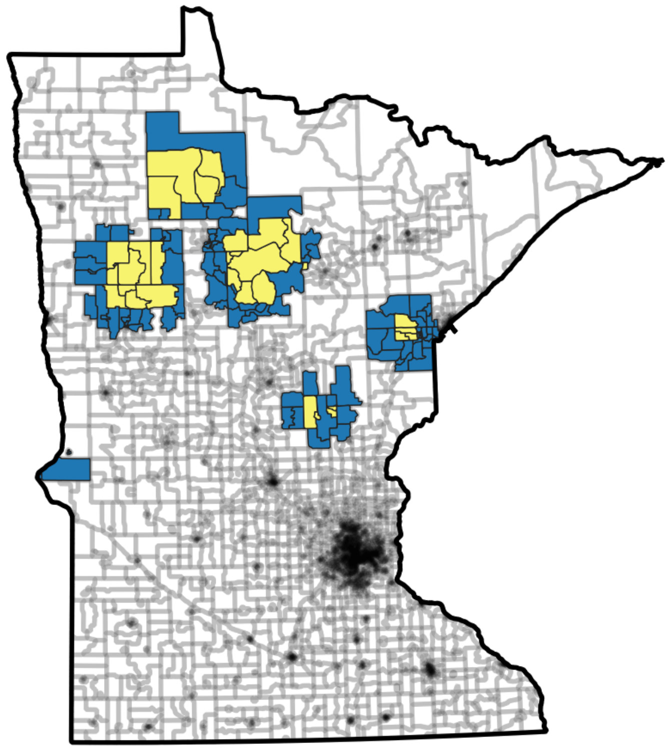
(b) Overlapping Census Block Groups with Reservation

Figure 1: Distribution of Geographical Units by percent on reservation land

Notes: In each histogram, we drop all geographical units with an overlap percent less than 1% as those overlaps are likely due to slight mapping errors in the original shapefiles.



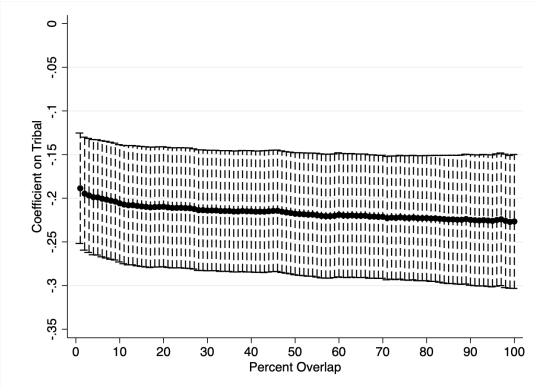
(a) Minnesota Indian Reservations



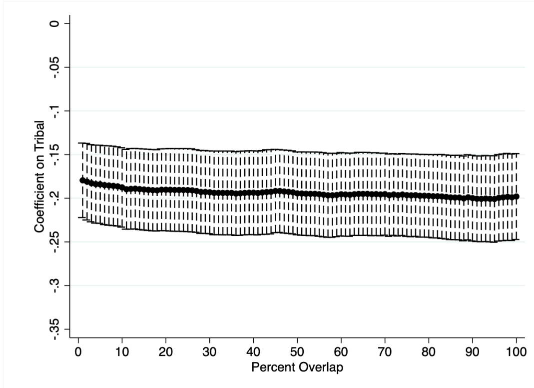
(b) "Tribal Areas" in yellow, "Non-Tribal Areas" in blue

Figure 2: Example of Sample Creation

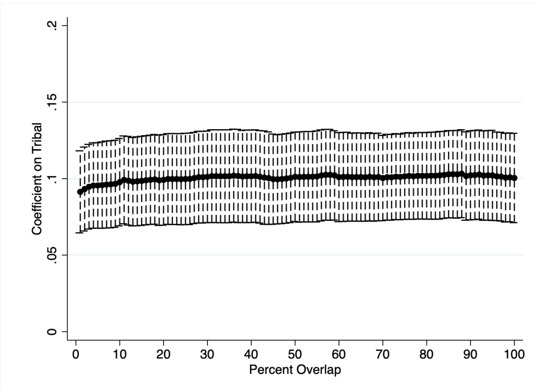
Notes: The first panel shows the location of each Minnesota Indian reservation. The second panel shows the census block groups, which are treated as "tribal areas" since 50% or more of its area contains federally recognized Indian reservation land. The "non-tribal areas" are block groups whose centroid is within 5 kilometers of the centroid of the nearest "tribal area."



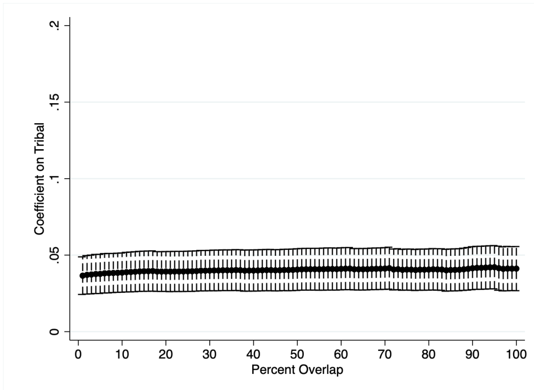
(a) Internet Access



(b) Broadband Subscription



(c) Only Cellular Data Plans



(d) Only Satellite Internet Subscriptions

Figure 3: The Gap in Internet Access and Subscriptions between Tribal and Non-Tribal Areas

Notes: Each panel shows the coefficient and 95% confidence interval for separate regressions of the proportion of households with Internet access, broadband subscriptions, only cellular data plans and only satellite Internet subscriptions, respectively, on an indicator equal to 1 if at least x% of a block group's area overlaps with reservation land where x∈ [1,99]. The sample is restricted to all block groups whose centroid is within 25 kilometers of a "tribal" block group's centroid. Each observation is weighted such that the weight decays as the distance to a reservation border increases. The standard errors are clustered at the county level.

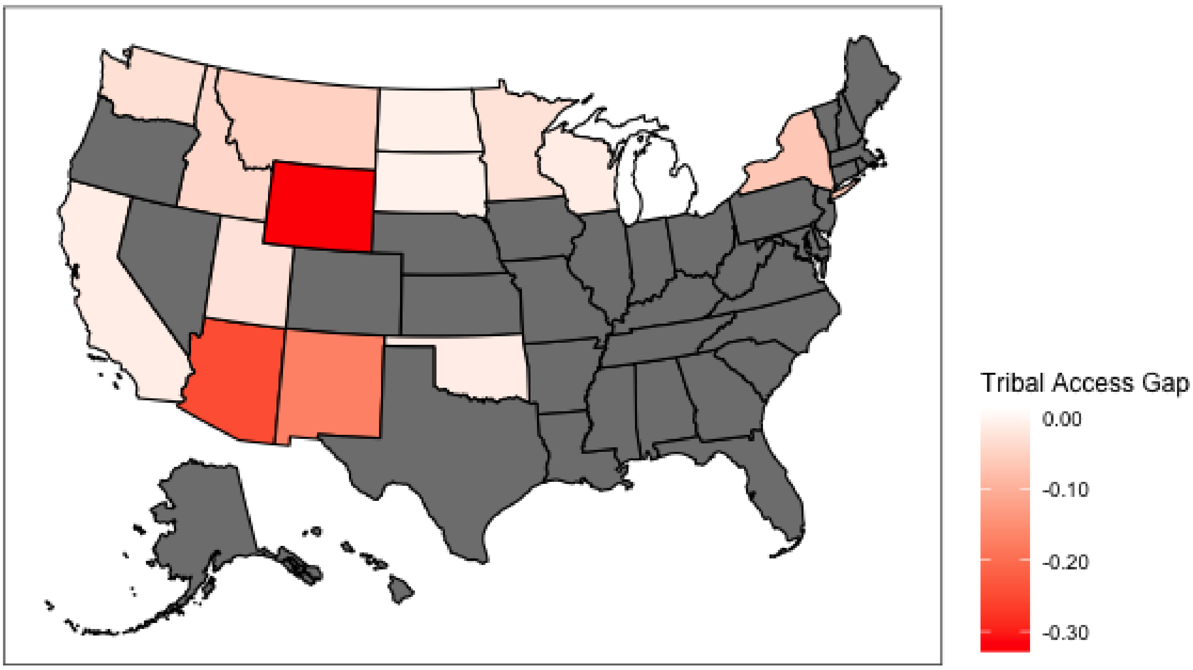
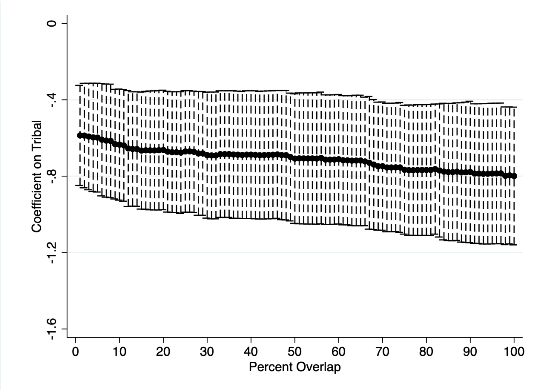
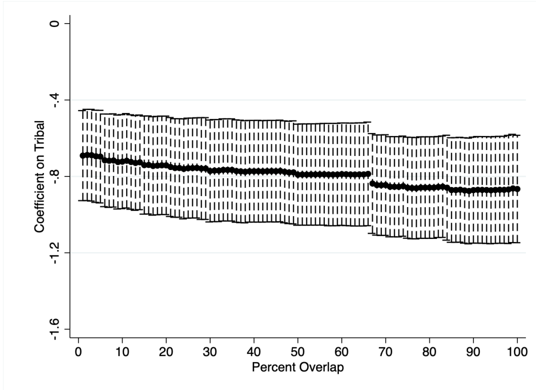


Figure 4: Internet Access Gap across States

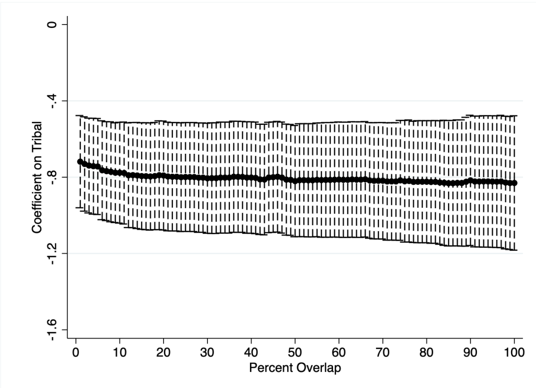
Notes: For each state with at least 10 "tribal" census block groups, we estimate the Internet access gap using Table 2, Column 3, and plot the estimated gaps. The more negative the gap, the larger the deficiency in home Internet access on tribal land when compared to their non-tribal neighbors. States without federally recognized reservations or fail to meet our sampling threshold are in gray.



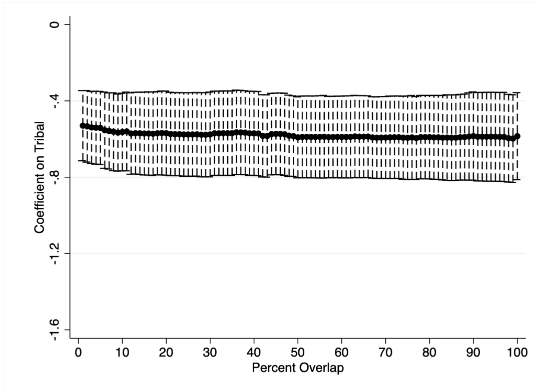
(a) Mean Download Speed (from fixed broadband networks)



(b) Mean Upload Speed (from fixed broadband networks)



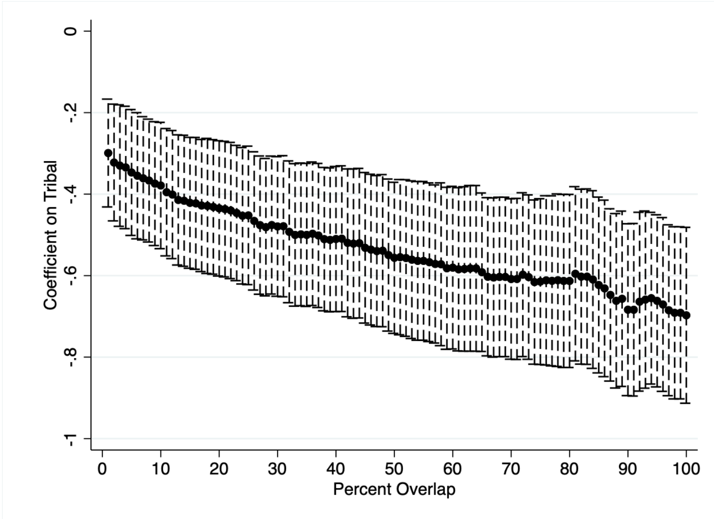
(c) Mean Download Speed (from mobile broadband networks)



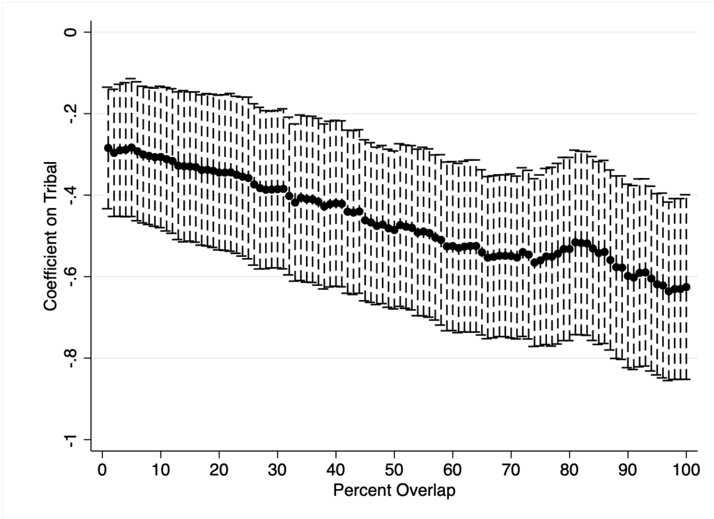
(d) Mean Upload Speed (from mobile broadband networks)

Figure 5: Gap in Connection Speeds: Ookla Data, 2020-2021

Notes: Each panel shows the coefficient and 95% confidence interval for separate regressions of the outcome of interest on the percent of census block group that overlaps with federal Indian reservation land. The outcomes are the following: in Panel A, the log of the mean download speed from fixed broadband networks; in Panel B, the log of the mean upload speed from fixed broadband networks; in Panel C, the log of the mean download speed from mobile broadband networks; in Panel D, the log of the mean upload speed from mobile broadband networks. Each regression is weighted by the number of tests. The sample is restricted to all block groups whose centroid is within 25 kilometers of a "tribal" block group's centroid. The standard errors are clustered at the county level.



(a) Median Download Speed



(b) Median Upload Speed

Figure 6: Gap in Connection Speeds: M-Lab: 2015-2019

Notes: Each panel shows the coefficient and 95% confidence interval for separate regressions of the outcome of interest on the percent of ZIP code tabulation area (ZCTA) that overlaps with federal Indian reservation land. The outcomes are the following: in Panel A, the log of the median download speed; and, in Panel B, the log of the median upload speed. Each observation is weighted such that the weight decays as the distance to a reservation border increases. The sample is restricted to all ZCTAs whose centroid is within 25 kilometers of a "tribal" ZCTA's centroid. The standard errors are clustered at the state level.

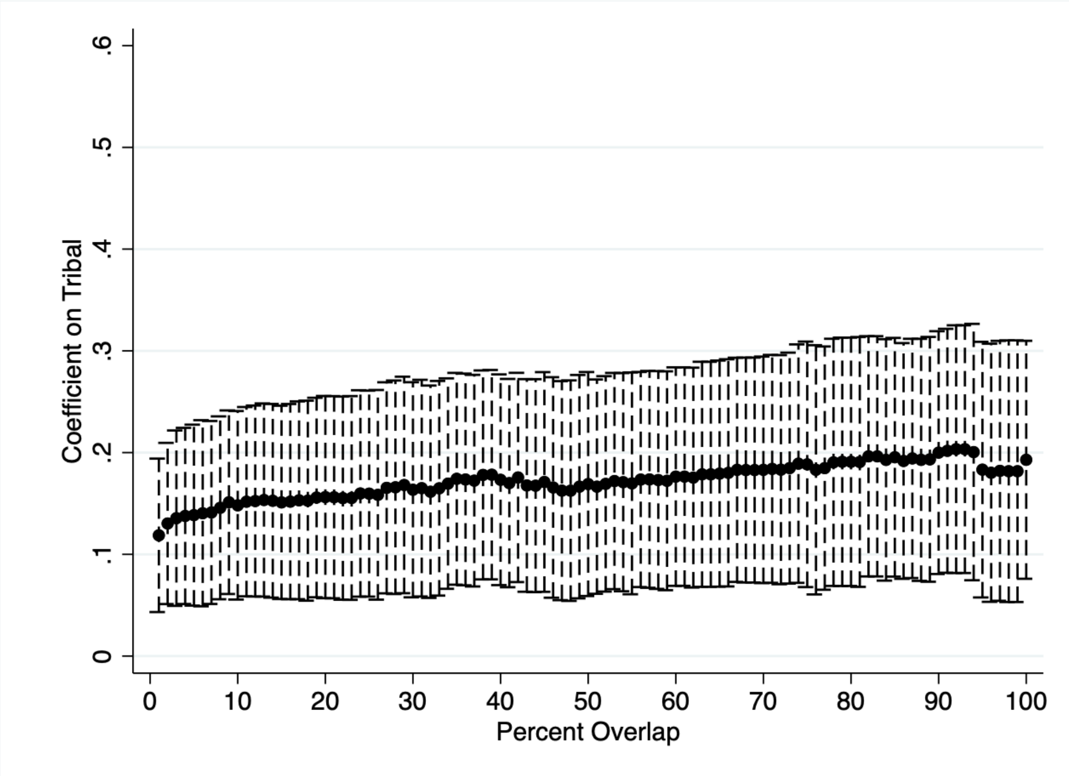


Figure 7: Gap in Lowest-Priced Internet Service Plan

Notes: The figure shows coefficient and 95% confidence interval for separate regressions of the outcome of interest on the percent of ZIP code tabulation area (ZCTA) that overlaps with federal Indian reservation land. The sample is restricted to all ZCTAs whose centroid is within 25 kilometers of a "tribal" ZCTA's centroid. Each observation is weighted such that the weight decays as the distance to a reservation border increases. The standard errors are clustered at the state level.

Table 1: Summary Statistics, block group and ZIP code variables

	Tribal	Non-Tribal	s.e. (of diff.)
Panel A: Outcomes			
Home Internet Share	0.649	0.866	(0.008)***
			[0.036]***
Broadband Subscriber Share	0.634	0.827	(0.008)***
			[0.024]***
Share with only Cellular Data Plans	0.226	0.125	(0.003)***
			[0.007]***
Share with only Satellite Internet	0.052	0.012	(0.006)***
			[0.015]***
Mean Download Speed (Mbps, fixed)	52.233	130.049	(1.807)***
			[6.232]***
Mean Upload Speed (Mbps, fixed)	17.586	32.763	(0.937)***
			[3.291]***
Mean Download Speed (Mbps, mobile)	27.830	57.186	(0.896)***
			[4.021]***
Mean Upload Speed (Mbps, mobile)	7.565	12.994	(0.196)***
			[0.657]***
Median Download Speed (Mbps, M-Lab)	7.079	10.229	(0.738)***
			[1.078]**
Median Upload Speed (Mbps, M-Lab)	3.918	4.454	(0.702)
			[0.961]
Mean Price of Basic Home Internet ($)	65.830	59.506	(1.969)***
			[2.326]***
Panel B: Controls			
Household Income ($)	45071.981	67877.903	(795.889)***
			[3858.875]***
Poverty Rate	0.257	0.143	(0.006)***
			[0.017]***
Land Size (km^2).	357.377	16.847	(25.312)***
			[38.199]***
Population Density (people/km^2)	212.764	2,030.528	(29.547)***
			[259.107]***
Median Age (years)	37.571	40.385	(0.385)***
			[1.075]***
Distance to Urbanized Area (km)	25.879	17.500	(0.790)***
			[3.360]**
Distance to Primary Road (km)	79.049	21.893	(2.869)***
			[7.484]***
Tree Cover Share	0.126	0.107	(0.007)***
			[0.024]
Mean Slope (∠)	4.159	1.859	(0.159)***
			[0.441]***
Std. Dev. of Slope (∠)	4.294	1.743	(0.121)***
			[0.374]***
Overlap Share (block groups)	0.962	0.031	(0.005)***
			[0.011]***
Overlap Share (ZIP codes)	0.926	0.027	(0.014)***
			[0.022]***
Observations (block groups)	756	10491	
Observations (ZIP codes)	329	1844	

Notes: The sample contains all block groups whose centroid is within 25 kilometers of a "tribal" block group's centroid. A block group is considered a tribal area if 50% or more of its area contains federally recognized Indian reservation land. The non-tribal block groups comprise the remainder of the sample. The sample logic is used for the ZIP-code level variables (M-Lab and lowest price). Robust standard errors of the mean differences are in parentheses and clustered standard errors at the county level are in brackets. ***, **, *: significant at the 1%, 5%, 10% levels.

Table 2: Internet Access and Uptake Regressions using ACS Data

	The Dependent Variable is the Share of Households with:											
	Internet Access			Broadband Subscription			Only Cellular Data Plan Subscription			Only Satellite Internet Subscription		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Tribal	-0.217	-0.164	-0.095	-0.193	-0.109	-0.051	0.101	0.085	0.034	0.040	0.016	0.013
	(0.036)***	(0.029)***	(0.020)***	(0.024)***	(0.019)***	(0.014)***	(0.015)***	(0.013)***	(0.009)***	(0.007)***	(0.005)***	(0.005)***
Cost Factors	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Demand Factors	No	No	Yes	No	No	Yes	No	No	Yes	No	No	Yes
State Fixed Effects	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
R2	0.15	0.28	0.59	0.10	0.28	0.45	0.05	0.15	0.36	0.07	0.21	0.23
N	11,247	11,240	11,008	11,245	11,238	11,008	11,245	11,238	11,008	11,245	11,238	11,008

Notes: The tribal indicator takes the value of one if at least 50% of its area overlaps with federal Indian reservation land, zero otherwise. Columns 1 through 3 use the proportion of households with Internet access. Columns 4 through 6 use the proportion of Internet-subscribing households with a broadband service plan (cable, DSL, or fiber optic). Columns 7 through 9 use the proportion of Internet-subscribing households with only a cellular data plan as the dependent variable. Columns 10 through 12 use the proportion of Internet-subscribing households with only cell phone subscriptions as the dependent variable. For each set of columns, the first model is the unconditional gap. The controls in the second model of each set of columns contain distance to the nearest urbanized area, mean terrain, standard deviation of terrain, proportion of tree canopy, population density, distance to the nearest primary road, block group area, and state fixed effects. The third model of each set of columns adds demographic and income controls: median age, poverty rate, and median household income. The sample is restricted to all block groups whose centroid is within 25 kilometers of a "tribal" block group's centroid. Each regression is weighted by the distance to the nearest reservation border. Standard errors are clustered at the county level. ***, **, *: significant at the 1%, 5%, 10% levels.

Table 3: Internet Connectivity using Ookla Data

	The Dependent Variable: log(Download Speed, fixed)			log(Upload Speed, fixed)			log(Download Speed, mobile)			log(Upload Speed, mobile)		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Tribal	-0.708	-0.394	-0.357	-0.792	-0.530	-0.434	-0.820	-0.256	-0.293	-0.658	-0.143	-0.183
	(0.174)***	(0.104)***	(0.108)***	(0.135)***	(0.108)***	(0.100)***	(0.149)***	(0.092)***	(0.096)***	(0.082)***	(0.048)***	(0.055)***
Cost Factors	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Demand Factors	No	No	Yes	No	No	Yes	No	No	Yes	No	No	Yes
State Fixed Effects	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
R2	0.08	0.39	0.43	0.02	0.27	0.33	0.06	0.26	0.28	0.08	0.28	0.29
N	11,279	11,271	10,996	11,279	11,271	10,996	11,278	11,269	10,998	11,278	11,269	10,998

Notes: The tribal indicator takes the value of one if at least 50% of its area overlaps with federal Indian reservation land, zero otherwise. Columns 1 through 3 use the log of mean download speed from fixed broadband networks across five quarters starting in January 2020, and Columns 4 through 6 use the log of mean upload speed from fixed broadband networks across those same five quarters. For each outcome, the first model is the unconditional gap. The second model contains the following controls: distance to the nearest urbanized areas, distance to the nearest primary road, mean elevation, standard deviation of elevation, percent of tree cover, population density, block group area and state fixed effects. The last column adds income and demographic controls, median household income, poverty rate, and median age. The sample is restricted to all block groups whose centroid is within 25 kilometers of a "tribal" block group's centroid. We weight each observation by the number of tests. Standard errors are clustered at the county level. ***, **, *: significant at the 1%, 5%, 10% levels.

Table 4: Internet Connectivity using M-Lab Data

	The Dependent Variable is:					
	log(Median Download Speed)			log(Median Upload Speed)		
	(1)	(2)	(3)	(4)	(5)	(6)
Tribal	-0.649 (0.104)***	-0.215 (0.055)***	-0.111 (0.062)*	-0.532 (0.118)***	-0.139 (0.072)*	-0.025 (0.068)
Cost Factors	No	Yes	Yes	No	Yes	Yes
Demand Factors	No	No	Yes	No	No	Yes
State Fixed Effects	No	Yes	Yes	No	Yes	Yes
R2	0.09	0.32	0.34	0.05	0.30	0.32
N	1,163	1,153	1,104	1,164	1,154	1,105

Notes: The tribal indicator takes the value of one if at least 50% of a ZCTA's area contains federal Indian reservation land. For each set of columns, the first model is the unconditional gap. The controls in the second model of each set of columns contain distance to the nearest urbanized area, distance to nearest primary road, mean terrain, standard deviation of terrain, proportion of tree canopy, population density, ZCTA area, and state fixed effects. The third model of each set of columns adds income/demographic controls: median age, poverty rate, and median household income. The sample is restricted to all ZCTAs whose centroid is within 25 kilometers of a "tribal" ZCTA's centroid. We weight each observation such that the weight given to a specific unit decays with distance from the border of a federal Indian reservation. Robust standard errors are in state level. ***, **, *: significant at the 1%, 5%, 10% levels.

Table 5: OLS Regressions with BBN Data

	The Dependent Variable is: log (Minimum Priced Internet Plan)		
	(1)	(2)	(3)
Tribal	0.113	0.003	0.004
	(0.039)***	(0.032)	(0.028)
Cost Factors	No	Yes	Yes
Demand Factors	No	No	Yes
State Fixed Effects	No	Yes	Yes
R2	0.02	0.34	0.37
N	712	709	690
Clusters	152'	152'	151'

Notes: The tribal indicator takes the value of one if at least 50% of its area overlaps with federal Indian reservation land, zero otherwise. Columns 1 through 3 use the log of the minimum price for basic broadband as the outcome. The first model is the unconditional gap. The second model contain the following controls: distance to the nearest urbanized area, distance to the nearest primary road, mean elevation, standard deviation of elevation, percent of tree cover, population density, ZIP area, and state fixed effects. The last column adds demographic and income controls: median household income, poverty rate, and median age. The sample is restricted to all ZCTAs whose centroid is within 25 kilometers of a "tribal" ZCTA's centroid. We weight each observation such that the weight given to a specific unit decays with distance from the border of a federal Indian reservation. Standard errors are clustered at the state level. ***, **, *: significant at the 1%, 5%, 10% levels.

Table 6: Institutional Determinants of Internet Gaps

	The Dependent Variable is the Share of Households with:			
	Internet Access	Broadband Subscription	Only Cellular Plan Subscription	Only Satellite Internet Subscription
	(1)	(2)	(3)	(4)
Trust Status Share	-0.274	-0.359	-0.332	0.497
	(0.103)**	(0.173)**	(0.115)***	(0.122)***
Trust Status Share^2	0.198	0.387	0.299	-0.509
	(0.094)**	(0.120)***	(0.101)***	(0.106)***
PL280	0.027	-0.014	0.014	0.001
	(0.017)	(0.030)	(0.018)	(0.007)
Casino	0.034	0.112	-0.037	-0.044
	(0.029)	(0.025)***	(0.033)	(0.012)***
Cost Controls	Yes	Yes	Yes	Yes
Demand Controls	Yes	Yes	Yes	Yes
Census Region Fixed Effects	Yes	Yes	Yes	Yes
R2	0.50	0.27	0.29	0.23
N	238	238	238	238

Notes: The unit of observation in these regressions is set at the American Indian reservation level. Trust status share is the share of reservation land held as either trust land or restricted fee land. PL280 is equal to one if all parts of the reservation fall under PL280 jurisdiction, zero otherwise. Reservations that overlap with PL280 states and non-PL280 states are dropped from the sample. The Casino indicator is equal to one if a reservation contains a tribally owned casino of any type (Class II or III), zero otherwise. Column 1 uses the proportion of households with Internet access, Column 2 uses the proportion of Internet-subscribing households with a broadband service plan (cable, DSL, or fiber optic), Column 3 uses the proportion of Internet-subscribing households with only a cellular data plan, and Column 4 uses the proportion of Internet-subscribing households with only cell phone subscriptions as the dependent variable. Each model contains the following controls: distance to the nearest urbanized area, mean terrain, standard deviation of terrain, proportion of tree canopy, population density, distance to the nearest primary road, reservation land area, median household income, median age, poverty rate, and BIA census regions fixed effects. Standard errors are clustered at the state level and shown in parentheses. ***, **, *: significant at the 1%, 5%, 10% levels.