The Tribal Digital Divide: Extent and Explanations*

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Abstract

We document systematic differences in connection speeds, prices for basic broadband service, and home internet access between American Indian Reservations and neighboring areas. Consistent with past studies, we find large raw tribal gaps in these broadband outcomes. Regression techniques and Oster (2019)'s method reveal that traditional cost factors, similar to those used in FCC's Connect American Cost Model, fully explain the price gap but explain only a fraction of the tribal gaps in access and connection speeds. Income differences are strong predictors on internet access but do not affect the tribal gap in connectivity. We conclude with a discussion of the factors specific to Indian County that might drive the unexplained gap in access and connectivity.

JEL Classification: O33, R11, R12, J15

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1 Introduction

The importance of a reliable internet connection became painfully apparent during the COVID-19 pandemic as public health measures necessitated virtual education, work, and social interaction in many places (Prieger, 2003; Oyana, 2011; Liu et al., 2018; Reddick et al., 2020). Unfortunately, reliable internet access in Indian Country is not a given for many households. This matters for economic development (Czernich et al., 2011; Kolko, 2012; Whitacre et al., 2014a; Ford, 2018), firm location (Kim and Orazem, 2017), firm productivity (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 the existence of a tribal digital divide needs no further quantification (see, e.g., Feir et al., 2019; Federal Communications Commission, 2019), there are still many basic, unanswered questions about the divide. For example, to what extent is the tribal digital divide driven by factors such as terrain and population density which affect the cost of deploying broadband in rural communities? Alternatively, how much of the tribal gap in home internet is driven by barriers unique to Indian County?[1] Conditional on having internet, do cost and income differences explain the slower internet connections on tribal areas? Are basic service plans more expensive in tribal areas?[2]

This paper leverages four datasets concerning broadband coverage to provide the first, large-scale study of the determinants of the tribal digital divide. First, we use

[1] There are several factors unique to land held in trust on behalf of Native Nations that may deter the supply of broadband in tribal areas. Henning and Rodman (2021), Native Nations Communications Task Force (2019), and United States Government Accountability Office (2018) identify complicated permitting processes on tribal lands which is a result of land fractionation and checkerboarding, a lack of carve-outs for tribes in past broadband grants, and statutory requirements in past funding programs are may impact tribal broadband coverage.

[2] Throughout the paper, we use the term "tribal area" to characterize households located within the boundaries of federally recognized Indian reservations. These households will be comprised of households of all races. We omit households located within the boundaries of the Five Tribes in Oklahoma and households located on state-recognized Indian reservations from the main sample.

data from the latest release of the American Community Survey (ACS 2015-2019) to estimate the tribal gap in home internet access and, if internet is available, the tribal gap in internet subscription types.[3] Second, we characterize differences in last-mile internet service between households located on and just off reservation areas by adopting Ookla connection speed measurements from 2020Q1 to 2021Q1.[4] Third, we complement our last-mile analysis by using connection speeds averaged across 2015-2019 from Measurement Lab (M-Lab) speed tests which measure internet performance over the Internet's middle mile. Fourth, we study the disparities in the lowest prices for basic broadband plans by using data compiled in 2020 by BroadbandNow.com, a private company that aggregates local data from ISPs. The tribal gap for each outcome is subsequently determined by the mean difference between households located on- and just off-tribal lands. In addition, for each outcome, we also incorporate geographic, cost and demand variables to determine the extent to which those factors can account for the tribal broadband gap.

Consistent with past studies, we find a large raw tribal gap in internet access. In particular, the ACS data show that the average share of households with home Internet in tribal areas is 66 percent, while the average share of households with home Internet in neighboring non-tribal areas is 87 percent. After controlling for proxies for FCC (2014)'s Connect America Cost Model (CACM)[5], the adjusted gap is 15.0 percentage points while

[3]ACS data contain a few limitations. First, the ACS does not ask questions about the quality of 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). Those studies have emphasized the undercounting of the American Indian, Alaska Native (AIAN) population, especially in the years prior to 2011 when interviews were done by email or phone. The US Census Bureau changed its procedures in 2011 to account for this issue by conducting in-person interviews in Indian Country areas, in which 10% of the population responded to the 2010 Census (US Census Bureau, 2020). The only way to evaluate internet access and other demographic and economic variables in highly rural areas, such as most Indian reservations, is to use the five-year average, which will smooth over yearly changes in these variables.

[4]Terms like "last mile" speak to the topology of the Internet. In particular, 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 of an local ISP's network.

[5]The CACM "estimates the cost to provide voice and broadband-capable network connections to all locations in the country" (FCC, 2014). Current official cost estimates are not publicly available at a granular level so we use publicly-available the Rural Digital Opportunity Fund's reserve prices which were generated from the CACM to determine the extent to which our cost proxies predict CACM

the adjusted gap using Oster (2019)'s bias-adjusted approach is 8.1 percentage points. Thus, standard cost factors predict at most 60 percent of the raw tribal gap. When income differences are accounted for, the tribal gap is still large and highly significant.

The ACS also reveals that when home internet is available, methods to access the internet vary between households located on and just of reservations vary. Consistent with (Morris and Meinrath, 2009), among households with home internet subscriptions, those who lived in predominately tribal areas are less likely to have high-speed broadband subscriptions (through cable, fiber optic or DSL) and more likely to access the internet only through cellular data plans or satellite internet subscriptions. These differences are large: e.g., 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. Unlike the tribal gap in internet access, observed factors such as household income and population density explain most of the variation in internet subscription types.

We also find large differences in average internet connection speeds in the last mile of internet service. On average, download (upload) speeds on fixed networks in tribal areas are 69 (78) percent slower compared to connection speeds in neighboring, non-tribal areas. Similar results exist for connection speeds from mobile broadband networks. In addition, we find slower average connection speeds in the middle mile in areas predominately occupied by reservation land compared to neighboring, non-reservation land. Controlling for differences in geographic, broadband cost and demand factors, the mean download (upload) speeds from fixed broadband networks located in tribal areas is still roughly 25 (30) percent slower on fixed broadband networks than neighboring non-tribal areas. We do not find tribal-specific factors are important drivers of the differences in middle-mile connectivity; however, clear policy implications cannot be determined from

estimates. A simple OLS regression implies that 53% of the variation in reserve prices are explained by our cost variables and state indicators. One of the motivations of adopting the Oster (2019)'s approach is to inflate the explanatory power of our cost factors.

these results since both last-mile and middle-mile connection data were collected at different levels of geographic precision. H

Last, consistent with past research (Park, 2020), we find that the lowest-priced Internet service provider (ISP) plan for basic broadband service is roughly 11 percent more expensive in predominately tribal areas compared with nearby non-tribal areas. Taken together, these results reveal a bleak picture of the state of the tribal digital divide: i.e, households located in predominately tribal areas face lower overall access to home internet and, when available, higher prices and slower average connection speeds even when compared to neighboring non-tribal areas.

We see our findings as particularly timely since the pandemic has shed increased light on broadband inequities across the country and, as a result, triggered federal policymakers to act quickly to subsidize broadband in high-cost deployment areas (Federal Communications Commission, 2021) and to create a tribal carve-out to expand broadband on tribal lands.[6] When considering policies to bridge the tribal broadband gap, it is important to know whether factors unique to Indian County has generated the gap. Our results strongly suggest that they do. Our results also contributes to our understanding of not only tribal broadband, but provides further evidence of the systematic price differences faced by Native people on reservations (Wellhausen et al., 2017; Cattaneo and Feir, 2020; O'Connell et al., 2011; Romero-Briones and Foxworth, 2016; Rivera and Foxworth, 2018) and by lower-income families in the U.S. as a whole (Myers et al., 2011; Broda et al., 2009; Chung and Myers Jr, 1999).

Our paper is organized as follows: In Section 2, we begin by presenting the data we have compiled on access, connection speeds, internet prices, cost and demand factors, and explaining 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

[6]For a description of the Department of Commerce's National Telecommunications and Information Administration (NTIA) Tribal Connectivity Program, see `https://broadbandusa.ntia.doc.gov/resources/grant-programs/tribal-broadband-connectivity-program`.

gap. We break down our results in Section 4, explaining the different measures of the digital divide we use (internet access, subscriptions, connection speeds and prices), In the last section, we discuss the policy relevance of our findings and suggest future important directions for research.

2 Data and Measurement

To compute the tribal gaps in internet-related outcomes, one would ideally have granular geographic information. Unfortunately, public-use data on internet usage and access do not contain precise coordinates so we need to make a decision rule to define whether a household is located in or just outside a federally recognized reservation. As a result, our unit of observation in the main sample is the census block group, which is the smallest geographic unit that contain broadband-related outcomes in the ACS. Some internet outcomes such as the minimum price for basic broadband and middle-mile connection speeds can only be measured at less precise geographical units such as zip code translation areas (ZCTAs). In both cases, we need to characterize a census block group or ZCTA as "tribal" and "non-tribal." We assign geographic units to tribal areas by overlapping TIGER/Line shapefiles of federal recognized reservations on both types of census geographies. Once those overlapping percentages are computed (see Figure 1), we identify "tribal" areas when 50% of more of the geographic unit's area overlaps with federal reservation land. To limit our "non-tribal" sample to nearby areas, "non-tribal" areas satisfy two conditions: (1.) 50% or less of the geographic unit's area contains federal reservation land and (2.) the center of the geographic unit is within 25 kilometers of the nearest "tribal" area's centroid.

To get a better sense of the sample, see Figure 2. Using the state of Minnesota for illustrative purposes, Panel A contains the location of Indian reservations within the state while Panel B contains the "tribal" block groups (in yellow) and "non-tribal" block groups (in blue) using our assignment rule. Fortunately, our tribal assignment rule appears to mirror the location of large, contiguous reservations. The non-tribal areas appear to be relatively uncovered by reservation land.[7]

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

The ACS data was collected over a five year period from 2015 to 2019 and released to the public in December 2020 (Steven Manson and Ruggles, 2020). This dataset is a nationally representative sample and contains questions regarding household internet access and internet subscription types. As mentioned above, the unit of observation is the census block group. Unfortunately, the ACS does not provide internet-related outcomes by race at granular levels so we use all households within a census block group to determine the household share of internet access.

We chose not to use the Federal Communications Commission's (FCC) Form 477 data, since this data is well-known for overstating broadband availability (Wavering Corcoran and Storey, 2019; United States Government Accountability Office, 2018).[8] Figure 3 illustrates the stark difference between the coverage of internet access between the FCC and the ACC on a sample reservation.

In this Figure, the available coverage of basic broadband, which is defined by the FCC as 25 Megabits per second (Mbps) download and 3 Mbps upload speed, on the Puyallup Reservation is shown in Panel A, while the fraction of households with basic internet according to the ACS is shown in Panel B. FCC data suggest that the entire

[7]Since we are interested in understanding the important of barriers related to the regulatory environment on historically recognized reservations, we drop Oklahoma Tribal Statistical Areas (OTSAs) from the sample.

[8]For example, the FCC defines a census block as completely "served" by an ISP if a provider serves at least one household in a census block, or if a provider *could* serve at least one household. Thus, in rural areas, an entire census block, which may cover hundreds of square miles, could be considered "served" even if an ISP does not presently provide internet to this community.

reservation should have access to the minimum standard for broadband, while the ACS reveals that there are block groups in this reservation where 20-30% of households do not have internet access. As a whole, ACS data reveal that 10% of households on this reservation do not have home internet.

More comprehensive reports suggest that the overall size of the FCC's overestimation for broadband coverage is staggering. For example, while the FCC claims that 21 million individuals do not have broadband available in their home, Busby and Tanberk (2021) provides evidence that the number is closer to 42 million. Additionally, novel research that uses queries to ISPs also shows that the FCC broadband availability maps are nosiest and, subsequently, most biased in rural and minority communities (Major et al., 2020). For these reasons, we choose to use ACS internet-related outcomes.

To measure the tribal connectivity gap, we adopt two types of self-administered internet speed tests. First, we use data collected by Ookla's Speedtest.net, a free web service that provides performance metrics across devices. In particular, we measure internet quality by averaging the upload and download speeds from fixed and mobile broadband networks from the first quarter of 2020 to the first quarter of 2021. While the exact precision 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 internet's "last mile," which calculates the speed that information travels from the nearest local server to the client's device. In order 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, a open source project that uses a single stream diagnostic tool to measure a device's internet performance. M-lab's speed test are taken from "off net" servers, which means the test computes the connection from

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

home to off-network servers (and back). Unlike the Ookla tests, these connection speeds informs the consumer of the connection to the internet's "middle mile" and, as a result, are typically slower. For our purposes, M-Lab data offers two advantages over Ookla data: (1.) M-Lab speed data represents the complete user experience and (2.) those connection speeds can be computed across a longer time period (i.e, we adopt data from 2015 to 2019) which should reduce the role of outliers. The key limitation with M-Lab data, however, is the geographic identification of their speed tests are located at the local server's site which may be many miles away from the home in rural areas. As a result we choose to aggregate these speed tests to the ZCTA level.

Ookla and M-Lab data share one major limitation: both datasets are based on individuals voluntarily running speed tests. Therefore, the observed speed tests may not be representative of the overall connection speed distribution. For example, speed test data likely suffer from positive selection (i.e, higher-income households are more likely to conduct speed tests) which may affect the precision of speed measurements in tribal areas (McMahon et al., 2011). In addition, speed tests are often run during times of extreme bottlenecks. However, there is no a priori information that households in tribal areas are more likely to conduct a speed test during periods of unusually poor connectivity; thus, the direction of the 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 service using BBN data. BBN collected pricing plans from over 2,000 ISPs by zip code during the third quarter of 2020.[10] Those prices reflect the lowest regular monthly plan for residential fixed broadband, whose minimum requirement is a 25 Mbps download and 3 Mbps upload speed (Zimmer, 2018). Their price data are collected at the zip code level which is converted to the zip code tabulation area (ZCTA) level using the HUD crosswalk.[11]

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

[11]Zip codes, for the most part, perfectly align with ZCTAs. However, for completeness, HUD's UDS Mapper crosswalk link all zip codes to ZCTAs. For more information, see `https://udsmapper.org/`

In order to account for differences in broadband deployment cost between tribal and non-tribal areas, we incorporate additional data from various sources. First, since high-speed fiber-optic infrastructure often follows primary roads, we measure both the distance to the nearest highway and distance to the nearest urban area using Census TIGER/Line shapefiles. Second, we measure topographic differences by computing the mean slope of the terrain from a 1/3 arc-second resolution map of elevation changes from the National Elevation Dataset (NED), and the tree canopy cover percentage from the National Land Cover Database (NLCD). Population density is taken from the ACS. We also control for income and demographic differences by adopting ACS data on median household income, poverty rate and median age.

Table 1 presents an overview of the tribal gap in the control variables using the census block group as our unit of observation. Column 1 provides the mean for each control variable on tribal areas and column 2 contains the mean in the non-tribal sample. Since census block groups are spatially correlated, we report the robust standard errors and errors clustered at the county level in column 3.

Except for the proportion of tree cover, there is a statistically significant gap between tribal and non-tribal areas for each co-variate. In particular, median household income and population density are substantially lower on tribal land compared with neighboring non-tribal areas. Tribal areas also contain a younger population compared with non-tribal areas. The distance between the centroid of tribal areas to the center of the nearest city is much greater for tribal areas than non-tribal even though both areas border each other. This result, however, is in part purely mechanical: the size of census block groups are defined by population and given the tribal gap in population density, the size of census block groups assigned as "tribal" are much larger than neighboring non-tribal, block groups. Other control variables (the major highway indicator, poverty rate, and mean slope of terrain) all suggest that there are large differences between tribal areas

zip-code-to-zcta-crosswalk/.

and non-tribal areas, even when non-tribal areas are in close proximity. These differences motivate our use of robustness checks (i.e, Oster (2019)) since observables likely differ as well and may impair the role of tribal-specific factors on the broadband gap.

3 Empirical Framework

To measure the tribal digital divide in its various forms, we use the following empirical framework:

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

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 let $x = 50$ for the bulk of specifications; however, to illustrate that tribal gaps are insensitive to our assignment rule, we allow x to vary across all possibilities (i.e. x is $\in$[1,100]) and report the $\hat{\beta}$ for each x when we measure the raw tribal gaps.

The control variables are grouped into two categories. Since many Indian reservations are located in remote, high broadband cost areas, $\mathbf{Cost}_i$ contains geographic variables such as distance to a major city, an indicator set to one if a geographic unit contains a major highway and a full set of state indicators. Since the FCC's CACM takes in account terrain and population to estimate the cost of providing voice and broadband-capable networks in small geographic areas, we also include the mean slope of the terrain, the proportion of tree canopy, and population density. These controls allow us identify the mean difference in Y, while accounting for the cost of deploying broadband due to traditional cost differences. We also adopt Oster (2019)'s bias-adjusted approach to determine how unobserved cost factors, which are proportional to the observed factors, affect the tribal coefficient in Eq. (1). If we find that the adjusted gap is still large in absolute size after using the Oster correction, then we interpret this to mean that traditional cost differences cannot explain the tribal digital divide.

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 impacts the profitability in service areas and is substantially lower in tribal areas (see Table 1), income could be considered a confounder. However, using income as a control may mediate the OLS coefficient on *tribal* since tribal-specific factors may also influence incomes themselves. In this vein, income may be considered a "bad control" (Cinelli et al., 2020). If income mediates the effect of tribal-specific factors on broadband outcomes, then our estimated adjusted tribal gap will only partially reveal the effects of factors unique to Indian County on broadband outcomes. As a result, overcontrolling will bias the results against the hypothesis that tribal-specific factors help drive the tribal gap.

We also adopt a common strategy used in the spatial regression discontinuity literature 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 weight given to a specific unit decays with distance from the border of a federal Indian reservation.[12] This weighting scheme places more weight on geographic areas just inside and outside of federal reservation borders. To account for spatial autocorrelation, the block-group sample's standard errors are clustered at the county level while the ZCTA-sample's standard errors are clustered at the state level.

[12]When we run regressions with Ookla and M-Lab data, we drop this method and weight by the number of internet speed tests per geographic unit. This method will place more weight on the more precisely measured connection speeds (i.e, more weight is given to observations with a greater number of speed tests.

4 Results

4.1 Home Internet Access and Subscriptions

We first use ACS data to investigate the size of the tribal gap in home internet access and, when internet is available, the tribal gap in internet subscription types. The ACS classifies a household as having internet access if a household member either has an internet subscription of any type or has internet access without a subscription via a municipal wireless network (Ryan and Lewis, 2017). Therefore, using the ACS definition of internet access, a residence may not have internet access if an ISP does not provide internet to their service area (i.e. a supply-side reason), or if internet is available, a residential household is unwilling to buy an internet subscription at the market price (i.e. a demand-side reason).

Figure 4 shows four unconditional tribal gaps in internet access and subscriptions in the ACS. Panel A depicts the 95% confidence interval for β in Eq. (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 of internet-subscribing households with broadband subscriptions, *conditional* on having internet. Panels C and D show the 95% confidence intervals using the share of internet-subscribing households with cellular data plans and satellite internet, respectively.

Figure 4, Panel A shows that the raw tribal gap is highly statistically significant for all values of x and ranges in size from 16.2 (when $x > 1$) to 22.2 percentage points (when $x > 99$). This finding is consistent with Tanberk and Cooper (2021), who finds a tribal gap in internet access of 18% when comparing zip codes that overlap with reservations with non-reservation zip codes. The point estimates of the raw tribal gap in households with a broadband subscription in Panel B are stable across all overlapping percents and range between 16-19 percentage points. Panel C shows that the share of internet-subscribing households with cellular data plans only is between 8-10 percentage points greater on tribal land. Last, panel D shows that the share of internet-subscribing households with satellite internet only is between 3-4 percentage points greater on tribal land.

To better understand how specific factors drive the tribal gap in internet access and, conditional on having internet, the tribal gaps in subscription types, we estimate the adjusted tribal gap and report the OLS results in Table 2. For simplicity, for these regressions, we define a block group as a tribal areas if 50% of its area overlaps with reservation land, and zero otherwise; however, Figure 4 shows that the estimated gaps are insensitive to the assignment rule. For each outcome, we report the results in three ways. First, we simply report the unconditional tribal gap in each outcome. This is identical to the raw tribal gaps measured at $x = 50$ in Figure 4. Second, we report the adjusted tribal gap by controlling for cost factors and provide a lower-bound estimate of the adjusted tribal gap using Oster (2019). Third, we add demographic and income controls to test the stability of the tribal coefficient.

According to the first set of columns in Table 2, the raw gap in internet access decreases from 21 to 15 percentage points after cost factors are added. Oster (2019)'s bias-adjustment in Column 2 shows that the adjusted tribal gap would fall to 8 percentage points when we amplify the predictive power of the cost controls. Thus, using standard regression techniques, standard cost factors account for approximately 28% of the gap (or as an upper-bound, 61% of the gap). Column 3 shows that income and demographic differences do explain a sizable amount of the raw tribal gap (approximately 27% of the gap). This result imply that recent policies such as the Emergency Broadband Benefit program, which provide cash transfers to households on tribal areas (as well as smaller cash transfers to households in non-tribal, rural areas) will be partially successful in decreasing the tribal gap in internet access. However, the adjusted tribal gap is still 9.3 percentage points and highly significant after controlling for cost and income differences which implies that roughly one half of the raw tribal gap is left unexplained.

Table 2, Column 4 reveals that conditional on having internet, the share of households with broadband subscriptions is 19 percentage points smaller on tribal land; however, unlike Column 2, the adjusted tribal gap is highly influenced by cost controls (i.e, approximately 55% of the gap is explained by cost factors). As a result, Oster (2019)'s bias-adjusted β in Column 5 shows that the cost-adjusted tribal gap is close to 1 percentage points. Controlling for household income, poverty rates and median age further lowers the tribal gap and accounts for approximately 30% of the raw gap. As a result, 85% of the tribal gap in broadband subscriptions is explained by income and cost factors.

Since previous work has identified consumers greater reliance on both cellphones in Indian County (Howard and Morris, 2019) and satellite subscriptions in rural areas in general (Rawls et al., 2020), we estimate some stylized facts regarding the extent to which households on tribal land are exclusively using cellular plans (columns 7-9) or satellite internet plans to access residential internet (columns 10-12). Column 7 shows that households on tribal land are twice as likely to access the internet exclusively from cellular data plans. Observed cost factors account for less than one-third of the tribal gap and, as a result, Oster (2019) approach suggests that omitted factors associated with broadband costs cannot explain away this gap. As a result, income and demographics factors explain a much larger share (approximately half) of the raw gap.

The difference in the household share with satellite internet subscriptions in tribal and non-tribal areas, conditional on having internet, is also very stark (see Col. 10): households with home internet on tribal areas are five times as likely to only have satellite internet subscriptions compared to non-tribal households with home internet. Unlike the cellular data plan gap, cost factors account for over 70% of the gap (Column

11) as demand factors account for only 5% of the gap (Column 12). The Oster (2019) estimate in Column 11 suggests that cost factors explain the entire gap.

These results mask the heterogeneity in tribal gaps. To illustrate some of the inter-tribal variation in broadband internet, Figure 5 shows the state-by-state variation of the conditional tribal gap in internet access. These state-level gaps are estimates of β from Eq. (1) using a full set of controls. We also only report state tribal gaps if there at least 100 observations within a state. Figure 5 revels that the largest deficiency of internet access in tribal areas (relative to neighboring, non-tribal areas) is located in Arizona and New Mexico. Those states contain the majority of the Navajo Nation, whose lack of digital inclusion has been well-documented in press articles and in recent Congressional hearings (Nez, 2020; Park, 2020). In addition, though less widely discussed, the differences in internet access in Phoenix suburbs and neighboring reservations (in particular, Gila River and Salt River reservations) may also drive this large gap. The states with the smallest tribal gap in internet access are scattered across the upper Midwest and the southeast, while in Florida, after controlling for all observed factors, tribal areas contain more households with internet access than households in non-tribal areas.

4.2 Connection Speeds

We now establish some stylized facts regarding the tribal gap in home internet connections. We simplify the measurement of internet connections by concentrating the average difference in upload and download speeds across a relatively long period of time.

We first show the raw tribal gap in Ookla's last-mile download and upload speeds from fixed broadband networks across all overlapping percentages in Figure 6. Both Panels A and B show that as the area overlap between block groups and reservation areas increases, the difference in average download and upload speeds between tribal and non-tribal areas increases significantly. Figure 7 shows the same estimates, but for speed tests from mobile broadband networks. While the download (Panel A) and upload speeds (Panel B) in tribal areas are still substantively lower in non-tribal areas, the tribal gap in upload speeds from mobile broadband networks is smaller than the tribal gap in upload speeds from fixed broadband networks - the raw gap in mobile broadband networks for upload speeds is approximately 55 log points while roughly 78 log points for fixed broadband networks. Figure 8 reveals a similar relationship using M-Lab's middle-mile connection speeds.

We determine the role of observed factors on the tribal connectivity gap in Tables 3 and 4. In each table, the tribal indicator in Eq. (1) equals one if 50% or more of a block group (or ZCTA) overlaps with federal Indian reservation land, zero otherwise. Column 2 in Tables 3 and 4 show that costs factors account for 62-64% of the mean gap in download speeds from both fixed and mobile networks. The Oster (2019)'s bias-adjusted β suggest that omitted cost factors would substantially lower the gap; however, the gap would still be negative and in the range of 2-3 percentage points. Income and demographic factors (cols. 3 in Tables 3 and 4) do not substantially change the tribal coefficient.

The raw tribal gaps in upload speeds taken from fixed and mobile broadband networks are partially driven by cost factors (e.g., see Col. 5 in Table 4) while income differences do not account for much of the gap in upload speeds. As a result, approximately 30-40% of the tribal gap in mean upload speeds from fixed and mobile networks is left unexplained.

Using alternative internet speed measurements, Figure 8 shows that the raw tribal gaps in middle-mile connection speeds are substantial. Similar to internet speeds taken from Ookla tests, mean download (upload) speeds are approximately 65% (53%) slower on tribal areas compared to neighboring, non-tribal areas. Table 5 shows that much of the difference in middle-mile speeds can be attributed to observed cost differences between tribal and non-tribal areas. As a result, the tribal gaps in average download and upload speeds that incorporate the middle mile of internet service are not statistically significant at the 1% level once the full set of controls are added. In addition, Oster (2019) estimates in columns 2 and 5 show that omitted cost factors would overturn the results which implies that the cost factors fully explain the tribal gap. We cannot claim that barriers unique to Indian Country only affect the "last mile" of connectivity since data on middle-mile connectivity is measured as a less precise geographic identification which may attenuate estimates of β.

4.3 Internet Prices

Last, we measure differences in the price for basic internet service plans by comparing the lowest-cost monthly residential internet plans on and off tribal lands. Figure 9 reports 95% confidence intervals of this difference using the natural log of the lowest-price broadband plan available within each ZCTA as the outcome. Similar to the previous outcomes, we start by estimating Eq. (1) without any controls for all possible overlapping thresholds (i.e. for all $x \in [1,100]$), while restricting the sample to "tribal" ZCTAs and ZCTAs within 25 kilometers from the center of non-tribal ZCTAs to the center of the nearest "tribal" ZCTAs.

The estimates in Figure 9 show that there is a positive, statistically significant gap in prices for basic residential broadband services between tribal and non-tribal areas across all overlapping percentages. The estimated range suggests that the lowest-priced ISP plans are between 11-14% higher on tribal land compared with nearby non-tribal areas.

Next, we estimate the determinants of this gap by adding cost factors related to broadband deployment. Similar to the previous specifications, we designate a ZCTA as a tribal area if at least 50% of its area overlaps with reservation land. Table 6 reports these results. The models follow the same schema as 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. With respect to the lowest Internet service plan for basic broadband, the estimated tribal gap in Column 1 is roughly 11%. Adjusting for geographic and cost factors lowers the estimated gap to 0.6% and the gap become statistically insignificant. Income and demographic factors further reduce the price gap. Thus, unlike the tribal gaps in internet access and last-mile connection speeds, the direct effects of factors unique to Indian Country are not significant drivers of higher prices paid for households in tribal areas for basic broadband service. Rather, the higher prices appear to be completely driven by the higher costs of broadband deployment in tribal areas.

5 Discussion and Conclusions

We use standard regression techniques and robustness checks via the Oster (2019)'s beta-adjusted approach to determine the extent to which standard cost factors as well as demand factors explain the various dimensions of the tribal digital divide. We find that standard cost factors, similar to those used by the FCC's Connect American Cost model, are important determinants of all internet-related tribal gaps measured in this paper. Income differences, however, play a more nuanced role in the tribal digital divide. Median household income is an significant predictor of the access gap and in the decision to access the internet using cable, fiber optic or DSL or cellular data plans. This implies that subsidies to income should increase internet access in tribal areas and decrease the reliance on exclusively using cellular data plans to access. However, we find that income differences are not strong predictors of connection speeds, especially last-mile connection speeds. Thus, income subsidies are not expected to ameliorate the tribal gap in last-mile connectivity. The same result holds for households who access the internet through satellite internet subscriptions: those households likely located in highly rural areas and face fewer alternatives to access the internet at home.

Our results also show that omitted factors play an uneven role in understanding the determinants of the tribal digital divide. For example, the tribal gap in prices and middle-mile connectivity are not robust to omitted variable bias. Thus, the combination of standard cost factors and omitted variables fully explain those gaps. Yet, the unexplained portion of the tribal gap in access and last-mile connectivity is substantial: thus, either omitted variables or tribal-specific factors directly correlated with tribal land account for as much as 40% of these gaps. The Oster method suggests that the unexplained portion of the gap are driven by factors uniquely related to Indian County.

These results beg the question: what tribal-specific factors might drive this unexplained gap? The precise barriers to broadband access and, when available, internet performance are still unclear.[13] The Federal Communications Commission (2019)'s Report on Broadband Deployment In Indian Country suggests that "complex permitting processes governing access to Tribal lands, jurisdictional issues involving states and sovereign Tribal governments, lack of the necessary infrastructure [among others]" are leading obstacles to deploying broadband. The lack of build out requirements to tribal areas in past FCC funding programs has also been highlighted as a contributing factor (Native Nations Communications Task Force, 2019).

Here, we focus on two observed factors specific to Indian County that may influence the tribal gap in broadband access: (1.) the degree of reservation land held in trust and restricted fee and (2.) whether a tribe is exempt from Public Law 280 (PL 280). The former variable has been suggested in government reports to drive up the cost of broadband deployment for two reasons: first, both trust land and restricted fee land complicates the process of ISP securing rights-of-ways; second, trust land is hard to use as collateral to gain access to credit markets (United States Government Accountability

[13] For example, the Bureau of Indian Affairs recommends conducting an assessment of the key barriers to access in their National Tribal Broadband Strategy (Henning and Rodman, 2021).

Office, 2018). The potential effects of PL 280 status on broadband access is largely driven by the economics literature which claims that state jurisdiction over civil matters on tribal land stabilizes contract enforcement which may have affected contracting between tribes and ISPs (Anderson and Parker, 2008).

Table 7 provides the correlates between the tribal gap in access and these two factors. For this exercise, the unit of observation is the reservation and we compute the access gap as the household share with home internet in reservation i divided by the share of households with internet in reservation i's neighboring, non-tribal areas. The outcome (mean = 0.77) can be interpreted as the number of households with home internet in tribal areas for every household with home internet in non-tribal areas. Thus, we find for every 100 households with internet access in non-tribal areas, only 77 households in tribal areas have home internet. In column 1, we report the OLS results from regressing a reservation's internet access gap on the share of land held in trust and restricted fee, and a PL 280 indicator which equals one if a reservation is located in a PL 280 state, zero otherwise while controlling for cost factors.[14] Column 2 includes income and demographic factors.

Table 7, column 1 suggests the correlation between the share of land held in trust and restricted fee and the access gap is negative and highly significant. Therefore, reservations with a large share of trust land are associated with fewer households with home internet as a fraction of neighboring households with home internet in non-tribal areas. The PL 280 indicator is positive but insignificant. Column 2 shows that the PL 280 variable is still insignificant but the coefficient on trust land share remains negative and highly significant. Thus, after controlling for cost and income differences, if a reservation moved from the 25th to the 75th percentile of the trust share distribution,

[14]Data on fee, restricted fee and trust land by reservation is publicly available at `https://data.nativeland.info/organization/native-lands-advocacy-project`. We code the reservation that are not exempt from PL 280 following the definitions in Anderson and Parker (2008) and Wellhausen et al. (2017).

the tribal gap in access decrease by 34 households per 1,000 non-tribal households (or 4% of the raw access gap).[15] Thus, while trust land share is a statistically significant factor, the role of trust land in the broadband gap is relatively small.

These results suggest that factors unique to Indian Country play an important role in understanding broadband deficiencies such as internet access. Limited tax bases, challenges to access credit markets and a lack of past tribal carve-outs in federal broadband programs all seemingly contribute to the lack of tribal digital equity. Recent federal programs such as NTIA Tribal Connectivity Program, the Rural Digital Opportunity and the Emergency Broadband Benefit Program do create new sources of federal funds or subsidies that directly address digital inequities between tribal and non-tribal areas. In addition, large amounts of discretionary COVID-19 relief funding from the Coronavirus Aid, Relief, and Economic Security (CARES) Act and American Rescue Plan Act (ARPA) provide an additional source of funds; however, these formula-based funds allocate a larger share of funds to tribes with a greater number of tribal employees. 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.[16] Over time, future research should be able to identify the role of these federal programs on closing the tribal broadband gap.

[15] This result does not suggest transferring land out of trust status is preferable to privatization since other outcomes, especially tribal sovereignty, are tied to trust land status. Rather, the negative correlation implies that government failure to maintain its federal trust relationship appear to have increased the access gap between tribal and non-tribal areas.

[16] Data on the combined CARES Act and ARPA allocations are located at `https://hpaied.org/`.

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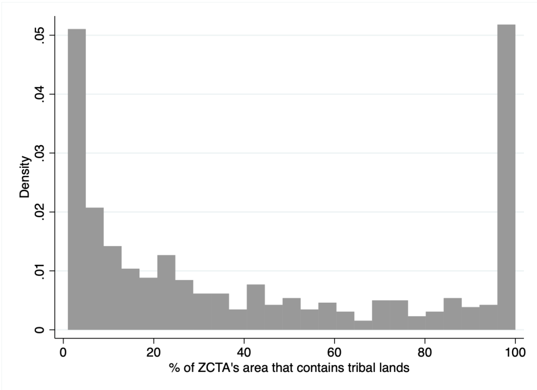
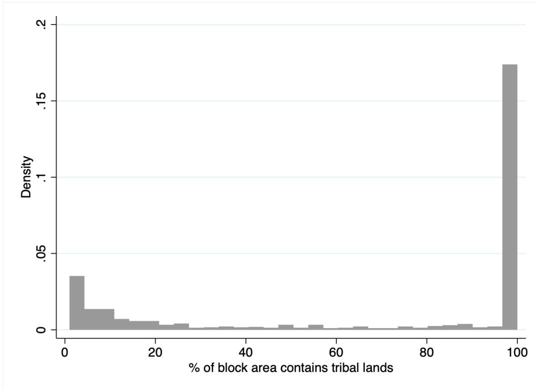


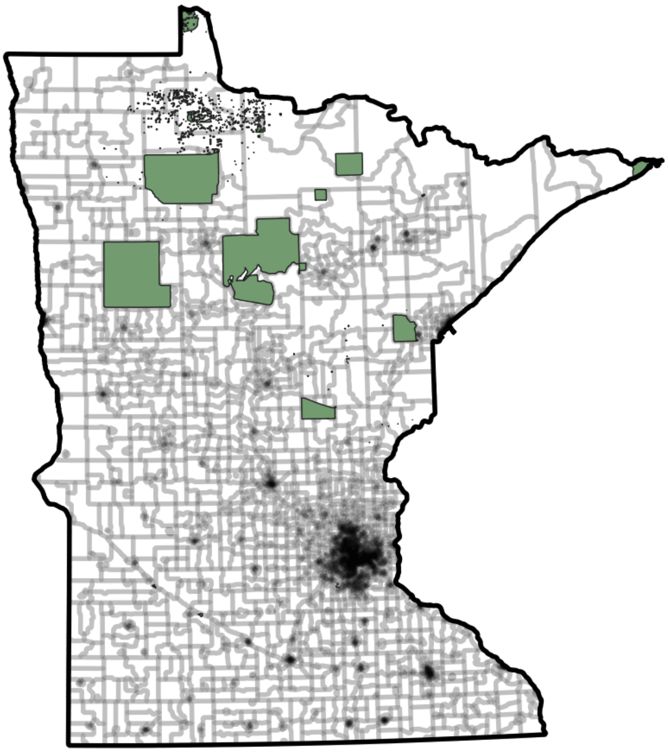
(a) Overlapping ZCTAs with Reservations



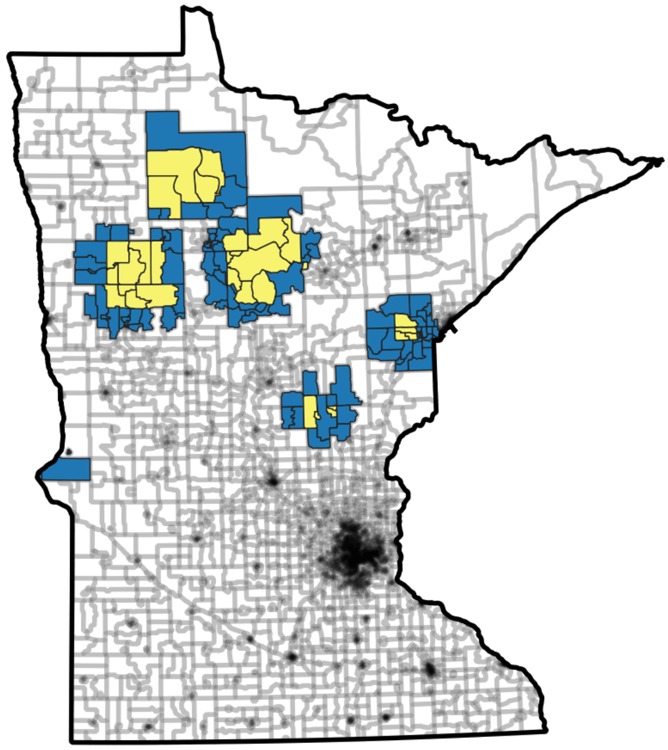
(b) Overlapping Census Block Groups with Reservation

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

Notes: We drop all geographical units with less than an overlap percent less than 1% as those overlaps are likely due to slight map 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 that satisfy the following two conditions: (1.) 50% or less of its area contains federally recognized Indian reservation land, and (2.) its centroid is within 25 kilometers of the centroid of the nearest "tribal area."

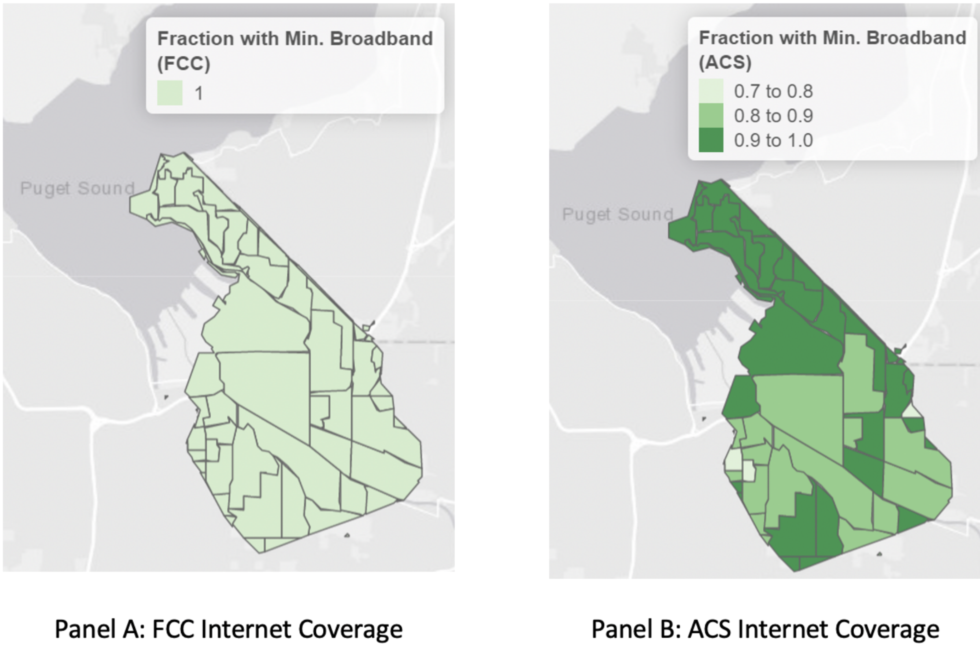
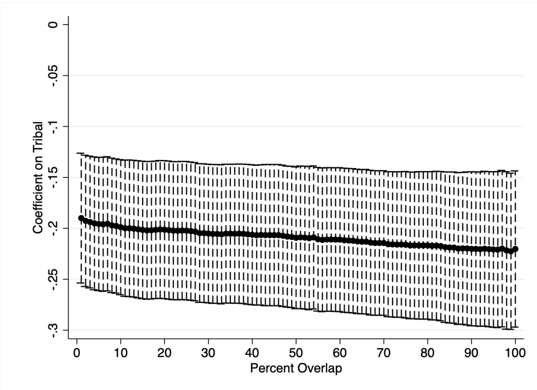
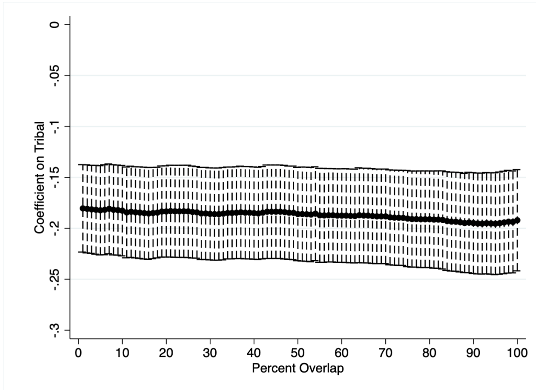


Figure 3: An Illustrative Example of Broadband Coverage Across Two Datasets

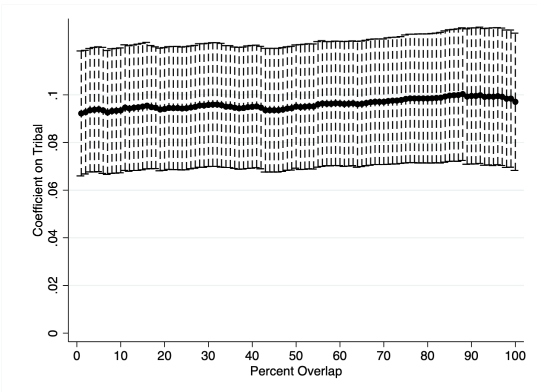
Notes: Panel A shows the census block groups within the Puyallup Reservation with advertised speeds that meet the FCC's minimum broadband requirement. The indicator is equal to 1 if a block group contains at least 25 Mpbs download/3 Mpbs upload speed availability in the Puyallup Reservation. The entire reservation is colored in since the Form 477 shows ISPs cover the entire reservation. Panel B shows the share of households in the ACS who report having internet access at home.



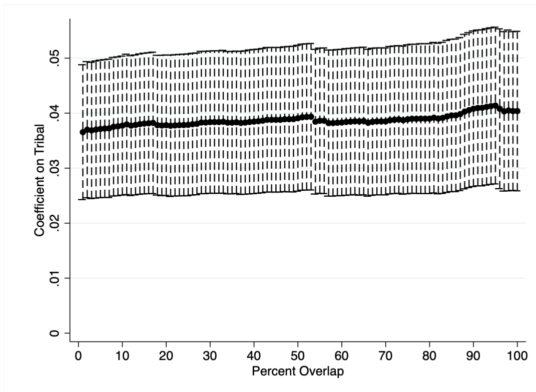
(a) Internet Access



(b) Broadband Subscription



(c) Only Cellular Data Plans



(d) Only Satellite Internet Subscriptions

Figure 4: The Tribal Gap in Internet Access and Subscriptions

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$\in$ [1,100]. 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.

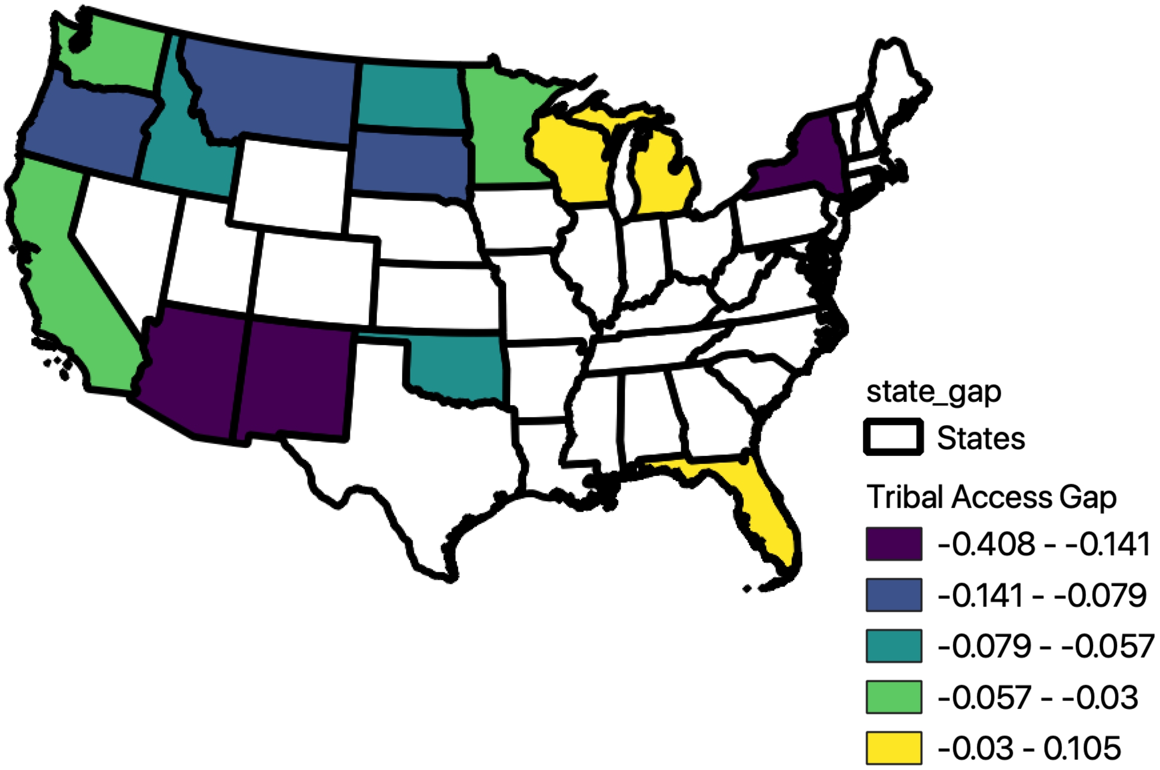
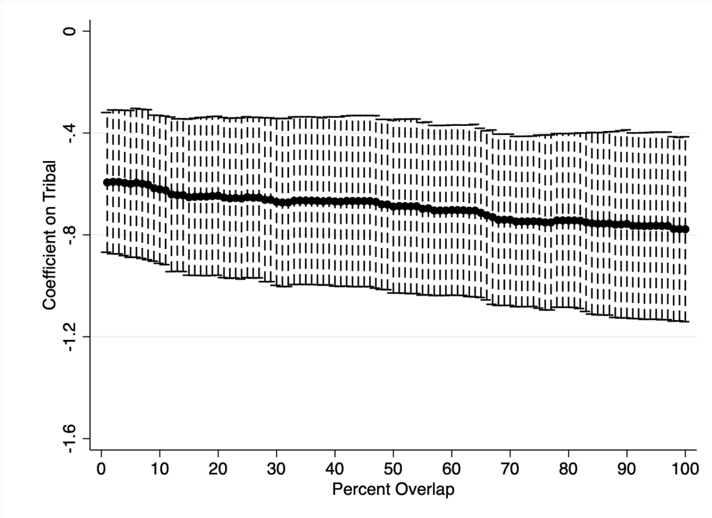
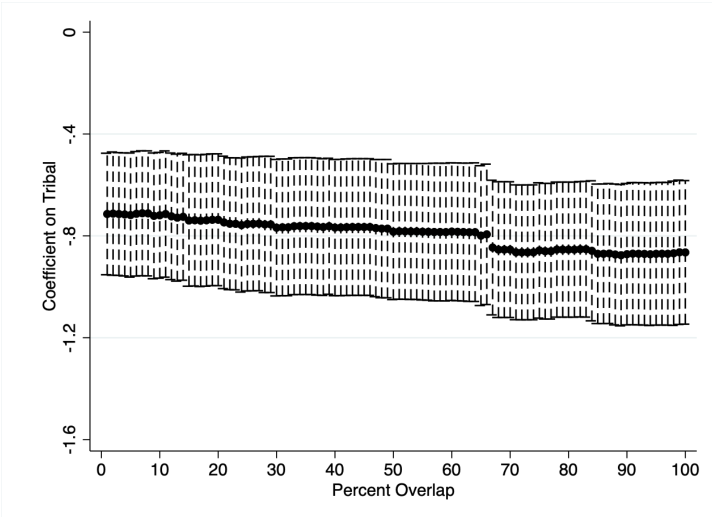


Figure 5: Conditional Tribal Gap in Home Internet across States

Notes: The states with the lowest share of households with internet access in tribal areas (relative to neighboring, non-tribal areas) are in yellow and states where the share of households with internet access in tribal areas is greater than the share of households with internet access in non-tribal areas are in purple. The tribal gap is determined by regressing home internet access share on the tribal indicator and a full set of cost controls for each state.



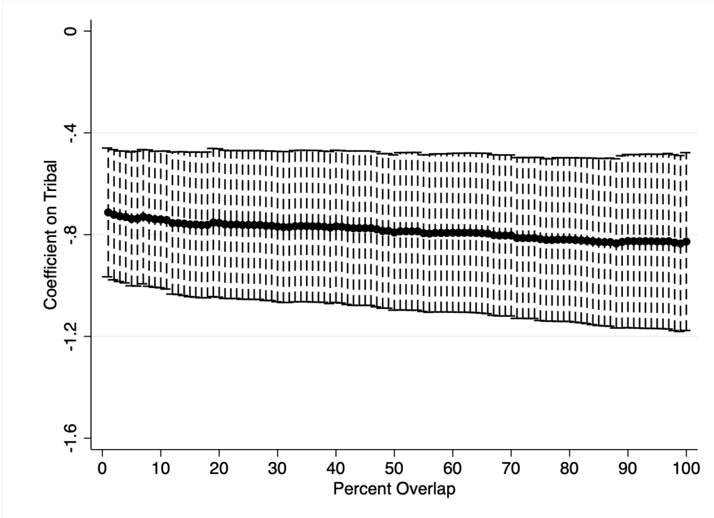
(a) Log(Average Download Speeds from fixed broadband networks)



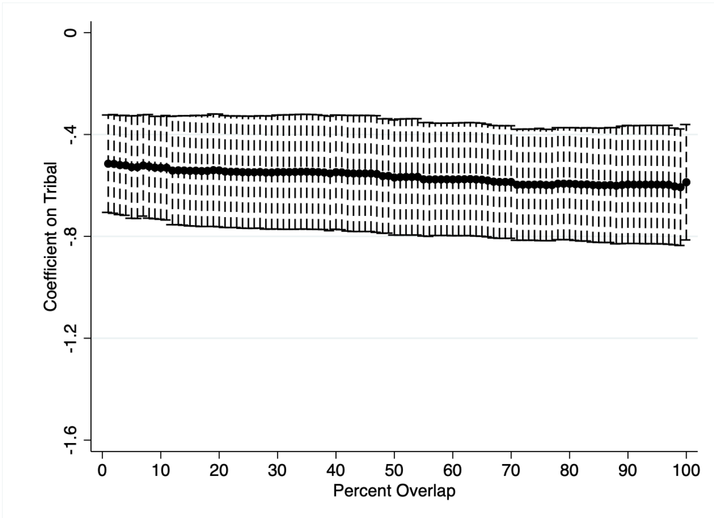
(b) Log(Average Upload Speed from fixed broadband networks)

Figure 6: Tribal Gaps from Ookla Speed Tests: Fixed broadband Networks

Notes: Each panel shows the coefficient and 95% confidence interval for separate regressions of the outcome of internet on the percent of census block group that overlaps with federal Indian reservation land. The outcome in Panel A is the log of mean download speeds from fixed broadband networks and the outcome in Panel B is the log of mean upload speeds from fixed broadband networks. The regressions are weighted by the number of tests from fixed sources. The standard errors are clustered at the county level.



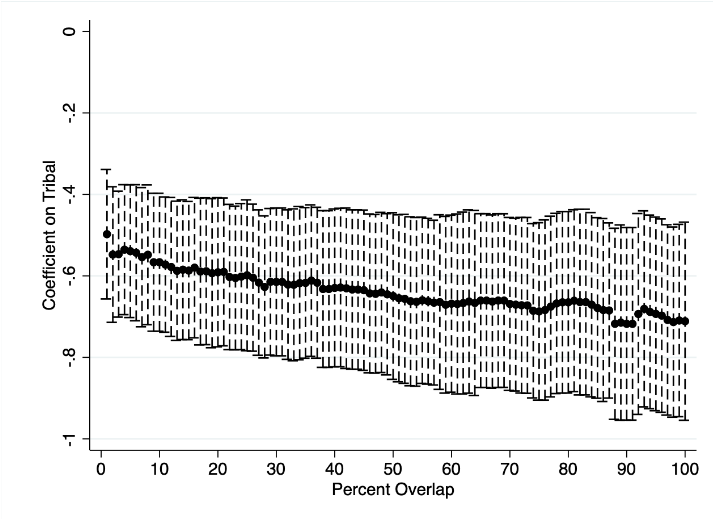
(a) Log(Average Download Speeds from mobile broadband networks)



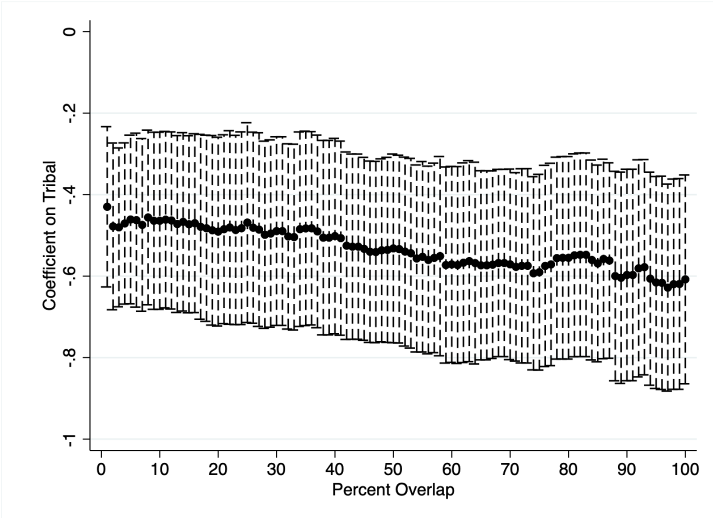
(b) Log(Average Upload Speed from mobile broadband networks)

Figure 7: Tribal Gaps from Ookla Speed Tests: Mobile broadband Networks

Notes: Each panel shows the coefficient and 95% confidence interval for separate regressions of the outcome of internet on the percent of census block group that overlaps with federal Indian reservation land. The outcome in Panel A is the log of mean download speeds from mobile device and the outcome in Panel B is the log of mean upload speeds from mobile broadband networks. Each regression is weighted by the number of tests from mobile broadband networks. The standard errors are clustered at the county level.



(a) Log(Average Download Speeds from M-Lab Tests)



(b) Log(Average Upload Speeds from M-Lab Tests)

Figure 8: Tribal Gap in Connection Speeds using M-Lab Data

Notes: Each panel shows the coefficient and 95% confidence interval for separate regressions of the outcome of internet on the percent of zip code that overlaps with federal Indian reservation land. The outcome in panel (a) is the log of the average download speed, and the outcome in panel (b) is the log of the average upload speed. The standard errors are clustered at the state level.

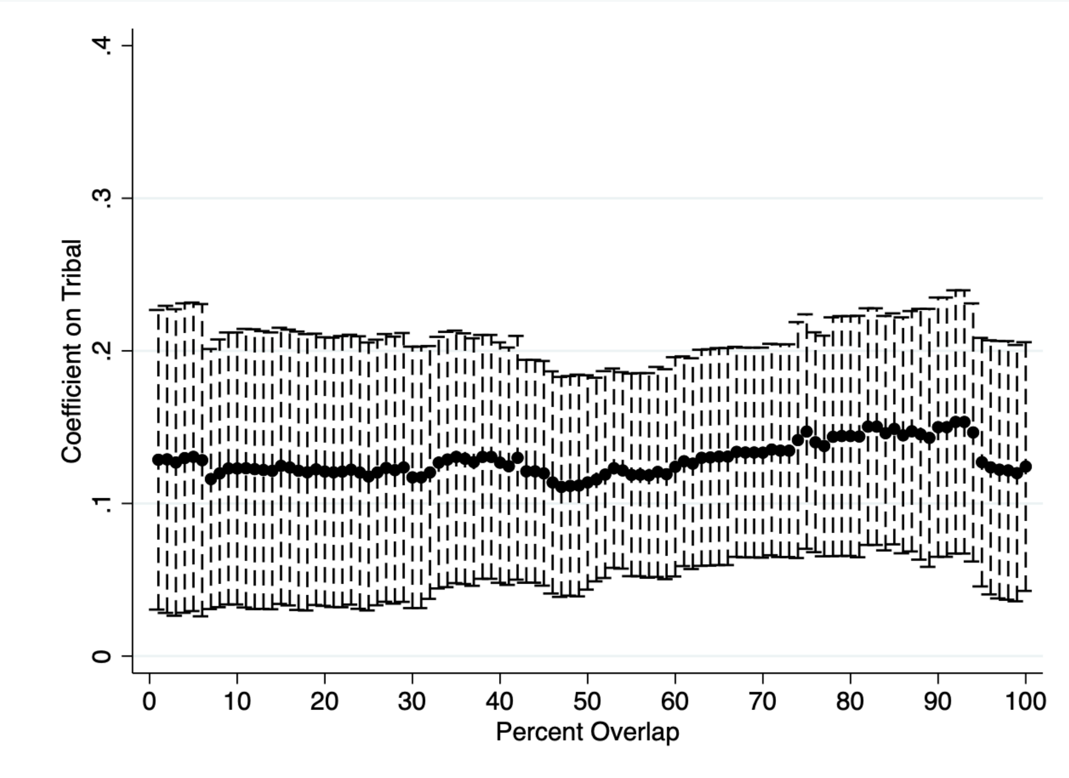


Figure 9: Tribal Gap in Lowest-Priced Internet Service Plan

Notes: Each panel shows the coefficient and 95% confidence interval for separate regressions of the log of the price of the lowest priced Internet Service Plan on the percent of zip code that overlaps with federal Indian reservation land. The standard errors are clustered at the state level.

Table 1: Summary Statistics of Control Variables

	Tribal	Non-Tribal	s.e.
Household Income (log)	10.639	11.017	(0.016)*** [0.065]***
Pop Density (log)	3.911	7.766	(0.092)*** [0.315]***
Median Age (years)	37.749	40.384	(0.392)*** [1.087]***
Distance to Urban Area (km)	19.944	1.396	(0.821)*** [2.074]***
Tree Cover share	0.128	0.109	(0.007)*** [0.024]
Highway Indicator	0.112	0.180	(0.012)*** [0.023]***
Mean Slope ($\angle$)	4.142	1.886	(0.162)*** [0.335]***
Poverty Rate	0.254	0.142	(0.006)*** [0.017]***
Observations	739	10297	

Notes: A block group is considered a tribal area if 50% or more of its area contains federally recognized Indian reservation land. Non-tribal areas are block groups with less than 50% of its area contains reservation land but contain a segment that is within one of the three thresholds. Household income and population density are measured in logs. Median age is measured in years. Tree cover share is measured as proportion of area covered by tree canopy. Primary road is an indicator which is turned on if the block group contains a major highway. Distance to city is measured in kilometers from the centroid of a block group to the nearest centroid of a city. The mean slope is measured as an angle. 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 with 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	-0.209	-0.150	-0.093	-0.186	-0.081	-0.029	0.095	0.067	0.021	0.039	0.011	0.009
	(0.036)***	(0.029)***	(0.021)***	(0.023)***	(0.018)***	(0.013)**	(0.013)***	(0.012)***	(0.008)**	(0.007)***	(0.005)**	(0.005)**
Oster's β		-0.081			-0.010			0.045			-0.005	
R2	0.14	0.27	0.54	0.10	0.28	0.45	0.04	0.14	0.34	0.07	0.22	0.24
N	11,036	11,036	10,808	11,034	11,034	10,808	11,034	11,034	10,808	11,034	11,034	10,808

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 contains distance to the nearest city, mean terrain, proportion of tree canopy, pop density and a primary road indicator. The third model of each set of columns add demographic and income controls: median age, poverty rate and median household income. Oster's β follows the method described in Oster (2019) where the maximum R^2 is assumed to be 1.3 times the R^2 from the model with full set of cost controls. The sample is restricted to all block groups that overlap with reservation land and block groups within 25 kilometers of a reservation border. 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: OLS Regressions with Ookla Data, Fixed Broadband Networks

	The Dependent Variable is:					
	log(Average Download Speed)			log(Average Upload Speed)		
	(1)	(2)	(3)	(4)	(5)	(6)
Tribal	-0.689	-0.265	-0.248	-0.784	-0.365	-0.299
	(0.173)***	(0.099)***	(0.102)**	(0.136)***	(0.101)***	(0.098)***
Oster's β		-0.033			-0.154	
R2	0.08	0.45	0.48	0.02	0.27	0.33
N	11,067	11,047	10,796	11,067	11,047	10,796

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 Jan 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 contain the following controls: distance to the nearest city, mean elevation, percent of tree cover, a major highway indicator, population density and a full set of state indicators. The last column adds income/demographic controls median household income, poverty rate, and median age. Oster's β follows the method described in Oster (2019) where the maximum R^2 is assumed to be 1.3 times the R^2 from the model with full set of controls. We weight each observation by the number of fixed tests conducted over the five quarter window. Standard errors are clustered at the county level. ***, **, *: significant at the 1%, 5%, 10% levels.

Table 4: OLS Regressions with Ookla Data, Mobile Broadband Networks

	The Dependent Variable is:					
	log(Mean Download Speed)			log(Mean Upload Speed)		
	(1)	(2)	(3)	(4)	(5)	(6)
Tribal	-0.792	-0.282	-0.319	-0.569	-0.127	-0.160
	(0.156)***	(0.121)**	(0.125)**	(0.115)***	(0.065)*	(0.069)**
Oster's β		-0.023			-0.015	
R2	0.05	0.24	0.25	0.04	0.28	0.29
N	11,066	11,046	10,798	11,066	11,046	10,798

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 mobile broadband networks across five quarters starting in Jan 2020 and Columns 4 through 6 use the log of mean upload speed from mobile broadband networks across those same five quarters. For each outcome, the first model is the unconditional gap. The second model contain the following controls: distance to the nearest city, mean elevation, percent of tree cover, population density, a major highway indicator and a full set of state indicators. The last column adds income/demographic controls: median household income, poverty rate, and median age. Oster's β follows the method described in Oster (2019) where the maximum R^2 is assumed to be 1.3 times the R^2 from the model with full set of controls. We weight each observation by the number of tests conducted over the five quarter window. Standard errors are clustered at the county level. ***, **, *: significant at the 1%, 5%, 10% levels.

Table 5: OLS Regressions with M-Lab Data

	The Dependent Variable is:					
	log(Average Download Speed)			log(Average Upload Speed)		
	(1)	(2)	(3)	(4)	(5)	(6)
Tribal	-0.649 (0.104)***	-0.181 (0.053)***	-0.117 (0.057)**	-0.532 (0.118)***	-0.113 (0.072)	-0.018 (0.063)
Oster's β			0.289			0.146
R2	0.09	0.31	0.33	0.05	0.30	0.31
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 contains distance to the nearest city and mean terrain, proportion of tree canopy, and a primary road indicator. The third model of each set of columns adds the three potential endogenous controls to the model: median age, poverty rate, population density and median household income. The sample is restricted to ZCTAs whose centroid is located within 25 km of a reservation border. Each regression is weighted by the distance to the nearest reservation border. Robust standard errors are in state level. ***, **, *: significant at the 1%, 5%, 10% levels.

Table 6: OLS Regressions with BBN Data

	The Dependent Variable is the Share of Households with: log (Minimum Priced Internet Plan)		
	(1)	(2)	(3)
Tribal	0.114	0.006	0.001
	(0.036)***	(0.030)	(0.025)
R2	0.02	0.34	0.35
N	725	725	703

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 city, mean elevation, percent of tree cover, population density, a highway indicator and a set of state indicators. The last column adds demographic and income controls: median household income, poverty rate, and median age. Oster's β follows the method described in Oster (2019) where the maximum R^2 is assumed to be 1.3 times the R^2 from the model with full set of controls. The control group is restricted to "non-tribal" ZCTAs whose centroid is within 25 kilometers of the centroid of a "tribal" ZCTAs. 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 7: Tribal Determinants of Access Gap

	With Cost Controls	With Cost & Income Controls
	(1)	(2)
Trust Land Share	-0.172	-0.1157
	(0.051)***	(0.056)***
Public Law 280 Status	0.053	0.030
	(0.037)	(0.034)
R2	0.21	0.28
N	109	106

Notes: The dependent variable is reservation i's mean share of households with home internet divided by mean share of households with home internet in reservation i's non-tribal neighbors. Column 1 contains the following cost factors measured at the reservation: mean slope, tree canopy share percentage, and population density. Column 2 contains each cost factors and the median household income, median age and poverty rate on reservation i. Robust standard errors are in parentheses. ***, **, *: significant at the 1%, 5%, 10% levels.