Journal of Regional Economics 2024 3(1) 67-75

ANSER PRESS

Journal of Regional Economics

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The U.S. Broadband Tribal Gap: An Empirical Evaluation

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ABSTRACT

Broadband availability is generally lower in the Tribal areas of the United States than in other areas and several policies implemented over the years aim to close that gap. Using data on broadband deployment over the years 2014-2020, progress in closing the Tribal Gap is evaluated. Unmatched and matched sample are used, and a sample of census tracts within 30 miles of a Tribal area are also analyzed with and without matching. The gap between Tribal and non-Tribal census tracks has been getting smaller over time and by 2020 the Tribal Gap was near zero in all cases, especially when the deployment differences are conditioned on a few covariates.

KEYWORDS

Broadband; Tribal; non-Tribal; Census Tracts; United States; Covariates

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ISSN 2972-3434
doi: 10.58567/jre03010005

Received 24 January 2024; Accepted 6 November 2024; Available online 7 March 2025; Version of Record 15 March 2024

1. Background

Deploying broadband to all Americans has long been a goal of the U.S. Government.[1] In particular, broadband deployment to Tribal areas is a longstanding problem, and thus has received considerable attention by the federal agencies through various subsidy programs (GAO 2022). Has this focus been productive? In this article, I study broadband deployment over the years 2014-2020 in Tribal and non-Tribal census tracts using the FCC's Form 477 data to quantify progress.

As has been discussed in some detail, the Form 477's assumption that a census block is "served" if a single customer has access (or could have access in a short time) could lead to a substantial overstatement of availability in the relatively large areas covered by blocks in Tribal areas (Ford 2022; GAO 2018). Two approaches aim to address the relatively large square mileage of Tribal tracts. First, Coarsened Exact Matching ("CEM") is used to select a sample of non-Tribal tracts that are, in many respects, identical to Tribal areas, including square mileage. Second, the sample is limited to blocks (aggregated to tracts) within 30 miles of a Tribal area; these census blocks presumably are more like Tribal blocks in several dimensions, especially related to the costs of deployment.

In 2014, Tribal areas lagged behind non-Tribal areas by 34.6 percentage points in broadband availability, but this gap narrowed considerably to roughly 10 percentage points by 2020, demonstrating substantial progress in expanding broadband infrastructure to Tribal lands, though the availability gap remains and is sizable. Why does this gap remain, and can it be explained? When the analysis controls for key demographic and geographic factors (population, land area, median household income, education, and racial mix) and incorporates multiple matching methods to ensure comparable geographic conditions, including Coarsened Exact Matching (CEM) and examining areas within 30 miles of Tribal lands, the Tribal Gap essentially disappears. This suggests that the remaining differences in broadband availability are primarily explained by economic and demographic characteristics rather than Tribal status itself. Thus, it is plausible to consider Tribal areas as undifferentiated from non-Tribal areas, except for the challenging economic conditions of Tribal areas. These findings are encouraging as they suggest that federal efforts to close the Tribal broadband gap are showing measurable success, though the remaining relative disadvantage of Tribal areas are largely explained by underlying socioeconomic factors largely out of the control of federal regulators.

2. Literature Review

Several recent studies look at Internet availability and use on Tribal lands. For instance, Howard and Morris (2019) conduct a small primary survey which suggests that residents on Tribal lands predominantly use mobile wireless service to connect to the Internet, with many others using public Wi-Fi or shared connections. In an econometric analysis using multiple large datasets, Gregg, Bauer, and Feir (2022) use data on adoption, speed tests, and prices to look for Tribal disparities in these dimensions. The study does not look at availability, which is the focus here, but reports Tribal Gaps in several dimensions, though often a good portion of these gaps can be explained by a few factors.

Most akin to this article, Mack, et al. (2022) use the FCC's Form 477 data to quantify the pattern in the Tribal Gap over time, though the authors measure the Tribal Gap as a difference in provider counts between Tribal and non-Tribal areas rather than availability of broadband service. With average number of providers exceeding four providers on Tribal lands (and in some cases above six providers), the results are unbelievable. Many Tribal areas have no broadband provider and I suspect few have as many as four providers. By my count, less than 20% of Tribal

[1] *See, e.g.,* Section 706 of the Telecommunications Act of 1996, 47 U.S.C. § 1302 ("The Commission and each State commission with regulatory jurisdiction over telecommunications services shall encourage the deployment on a reasonable and timely basis of advanced telecommunications capability to all Americans….").

areas have more than two providers and only 1.2% have as many four providers. The variable measuring the tract-level count of providers in Mack, et al., (2022) seems improperly constructed, an error discussed in Flamm and Vargas (2017) a few years earlier. Most importantly, the number of providers does not measure broadband availability; it could be that two providers cover only 20% of homes, or one provider covers 100% of homes. While availability and provider count (properly constructed) are somewhat correlated (ρ = 0.50), the two outcomes are not measuring the same thing.

An important question is why availability may differ between Tribal and non-Tribal areas. As the FCC (2019) has observed, Tribal areas present several challenges for broadband deployment including: (1) rugged terrain; (2) complex permitting processes governing access to Tribal lands; (3) jurisdictional issues involving states and sovereign Tribal governments; (4) a predominance of residential, rather than business, customers; (5) high poverty rates and low-income levels on Tribal lands, and (6) cultural and language barriers. I attempt to control for some of these differences, but there may be other barriers to deployment, including securing an arrangement with Tribal governments. In any case, while the Tribal Gap is mostly explained by a few demographic features, I make no specific claims about why a Tribal Gap may exist; my interest is limited to the Tribal Gap's magnitude.

3. Empirical Framework

My task is to estimate the "Tribal Gap," which I define as the means difference in the average availability of broadband between Tribal and non-Tribal census tracts. If, for example, non-Tribal areas have an average availability rate of 90% and Tribal areas 70%, then the Tribal Gap is 20 basis points. Ideally, the data would permit the average availability for a person or a household, but the Form 477 data are reported at the census block level. As the best approximation of availability, I use the lowest level of aggregation (the census block) to construct the availability variable and then aggregate to the census tract using a population-weighted mean. These outcomes are interpreted as the expected experience of a person living in the census tract. For instance, an availability rate of 0.90 indicates the typical household has a 90% probability of having access to a broadband network.

To estimate the Tribal Gap, the means differences over time t are estimated using,

$$y_{it} = \sum_{t=1}^{7} \Delta_t A_i \cdot D_t + \beta X_i + \mu_t + \varepsilon_{it} \tag{1}$$

where y_{it} is the broadband availability (per capita) in census tract i in year t, A_i is an indicator of Tribal tracts (= 1 for Tribal, zero otherwise), D_t is a dichotomous indicator for each year t, X_i is a set of covariates, μ_t is a year fixed effect, and ε_i is the econometric disturbance term. Since availability is bound on the unit interval and is often close to 1.0, the model is estimated using a Generalized Linear Model ("GLM") of the binomial family with a logit link so the predictions remain on the unit interval. Standard errors are clustered at the county level and the regression is weighted by population (for year 2019) so that the estimates represent the typical experience of a person. The GLM coefficients are not directly interpretable, so the gap is measured by the difference in the mean predicted y_t between Tribal and non-Tribal tracts. Hypothesis tests are conducted on these predictions.[2]

Excluding the X covariates produces a simple, unconditional means difference. That is, the means differences are a simple comparison of averages. This is akin to the statistic reported in the FCC's *Broadband Reports*, though the spread may differ slightly due to differences in population values and Tribal area indicators used to construct the means. Such differences may be informative as they measure the observed difference in availability.

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2 Stata 17 is used for all estimations. Predictions are generated using the -margins- command and hypothesis tests are based on the delta method.

When including the *X*, the means difference is conditioned on those variables. That is, how much of the unconditional Tribal Gap may be explained by relevant factors such as cost and demand? The means difference plausibly may be conditioned on many factors. Here, I take a somewhat limited approach and include factors indicated by the FCC as relevant to the deployment differences: (1) population; (2) square mileage (the two components of population density); (3) the median household income; and (4) the unemployment rate. The first three are measured in natural log form. Of course, many other covariates might be considered (e.g., education, and so forth), though several of the potentially relevant variables are correlated with income.

3.1. Data

Broadband deployment of consumer services is measured using the December releases of the FCC's 477 data over the years 2014 through 2020, a period over which the Commission had control of broadband data collection.[3] My analysis occurs at the census tract level, so tract-level values are population-weighted means of data measured at aggregation levels smaller than the tract..[4] The data are restricted to a balanced panel, but only a few tracts are excluded due to missing values. A Tribal tract is marked by joining census blocks to Tribal areas using a Tribal tract shape file. Demographic data are from Safegraph (2019 version), which are based on the American Community Survey ("ACS") for years 2015-2019 (thus time invariant in this sample).[5] These data are native to the census blocks group; the values are aggregated to the tract using a population-weighted mean or sum in case of population, area, and so forth.

3.2. Alternate Samples

Many factors affect broadband deployment, and the comparison of broadband deployment across Tribal and non-Tribal areas may be best quantified by comparing similar census tracts across the two groups. The number of Tribal census tracts is small but total census tracts counts are very large; Tribal tracts are about 1% of total tracts and such a small share can sometimes lead to imprecise estimates. Also, rural Tribal census blocks often cover relatively large areas, and the overstatement of the one-all assumption of the Form 477 data is presumably larger in geographically-larger census areas (Ford 2022).[6] To ensure reasonable comparisons and reliable estimates, I obtain a matched sample using Coarsened Exact Matching (CEM) (Iacus, King and Porro, 2011). The matching variables are population, square mileage (two variables that also define population density), median household income, the share of persons with a tertiary education, and the share of population that is minority (Black or Hispanic). The matching algorithm aims at a 2:1 match, though the unique character of Tribal areas prevents a 2:1 match in some cases. In a few instances, it was not possible to find a pair of good matches. The final match is 1.9:1 non-Tribal to Tribal tracts.

In addition to the CEM sample, I also analyze a sample of tracts within 30 miles of a Tribal area. Given the proximity to Tribal areas these tracts are expected to be similar in several dimensions to Tribal tracts, some perhaps unmeasurable. CEM is also applied to this sample to ensure apples-to-apples comparisons, especially in relation to the size of the tract.

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[3] Data available at: https://www.fcc.gov/general/broadband-deployment-data-fcc-form-477. Prior to December-2014, states collected broadband availability data so that data is generally incompatible.
[4] Analysis was also conducted at the block group level, but differences were small.
[5] Data available at: https://docs.safegraph.com/docs/open-census-data.
[6] If it is assumed the overstatement is equal in same-sized census blocks between non-Tribal and Tribal areas, then the errors cancel in the means difference. That is, say broadband is measured as $b_i + e_i(s_i)$ where e_i is an error related to the size of the area s_i. When s_i is the same and the e have a zero mean, then $b_i + e_i(s_i) - (b_k + e_j(s_j)) = b_i - b_j$ if $s_i = s_j$.

3.3. Sample Descriptive Statistics

Some descriptive statistics for the three samples are provided in Table 1. Means and standardized differences are provided. The standardized difference is a measure of the difference in the distributions across the Tribal and non-Tribal groups. A standardized differences more than 0.25 is viewed as "large," though some researchers prefer a difference of 0.10.

Table 1. Descriptive Statistics.

	Full Sample			CEM Sample		
	Tribal	Non-Tribal	St. Diff.	Tribal	Non-Tribal	St. Diff.
Population	4,104	4,502	0.173	4,084	4,091	0.004
Sq. Miles	219.76	25.63	0.686	161.3	154.4	0.213
Median Income	53,758	68936	0.550	55,662	56,558	0.049
College	0.129	0.189	0.633	0.135	0.136	0.002
Minority	0.144	0.299	0.645	0.128	0.124	0.019
Obs.	723	71,261		568	1,077	
	Within 30 Miles Sample			CEM Sample		
Population	4,104	4,597	0.221	4,045	4,087	0.023
Sq. Miles	219.76	26.56	0.705	149.50	126.66	0.117
Median Income	53,758	69,306	0.597	57,328	58,602	0.072
College	0.129	0.193	0.770	0.140	0.143	0.050
Minority	0.144	0.285	0.611	0.108	0.100	0.057
Obs.	723	16,843		446	775	

For the full sample, the standardized differences are quite large for all but population. CEM performs its task by making the differences much smaller and below the 0.25 threshold. Likewise, for tracts within 30 miles of a Tribal area the standardized differences are large, but CEM again makes for comparable groups. Note, however, that some tracts are lost in the matching, indicating that the difficulty in finding non-Tribal tracts that match the unique characteristics of Tribal areas. Still, the samples remain large.

4. Results

To start, I begin by analyzing the entire dataset. In Figure 1, the trends in the Tribal Gap are illustrated for the unmatched sample with and without covariates along with indicators for statistical significance (* 10%, ** 5%, and *** 1%). The unconditioned means of the outcome are listed at the bottom of the figure (A = 1 for Tribal areas). The conditioned means differences are indicated by the dashed line. Conditioning on the covariates shrinks the Tribal Gap since part of the difference is explained by the covariates.

Plainly, the deployment differences between non-Tribal and Tribal areas are shrinking over time. For the unconditioned means difference, the availability rate difference between Tribal and non-Tribal areas was -0.346 in 2014, but the difference had fallen to -0.101 by 2020.[7] A 10-percentage point difference is not small and warrants attention. All the unconditioned differences in the unmatched sample are statistically significant at the 1% level. When conditioned on the covariates (population, square miles, and median income), the gap is essentially eliminated, suggesting Tribal areas are not treated differently than non-Tribal areas with similar characteristics. In 2020, the Tribal Gap is -0.002, a difference that is not statistically different from zero. Even in 2014, the Tribal Gap is small (-0.013) though statistically different from zero at the 10% level. A test of whether the Tribal Gap is equal in 2014 and 2020 is rejected at the 1% level for the unconditioned sample and 10% for the conditioned sample.

[7] The Tribal Gaps reported here match closely those in FCC (2020): 2014 (-0.323); 2015 (-0.321); 2016 (-0.288); 2017 (-0.254); and 2017 (-0.221).

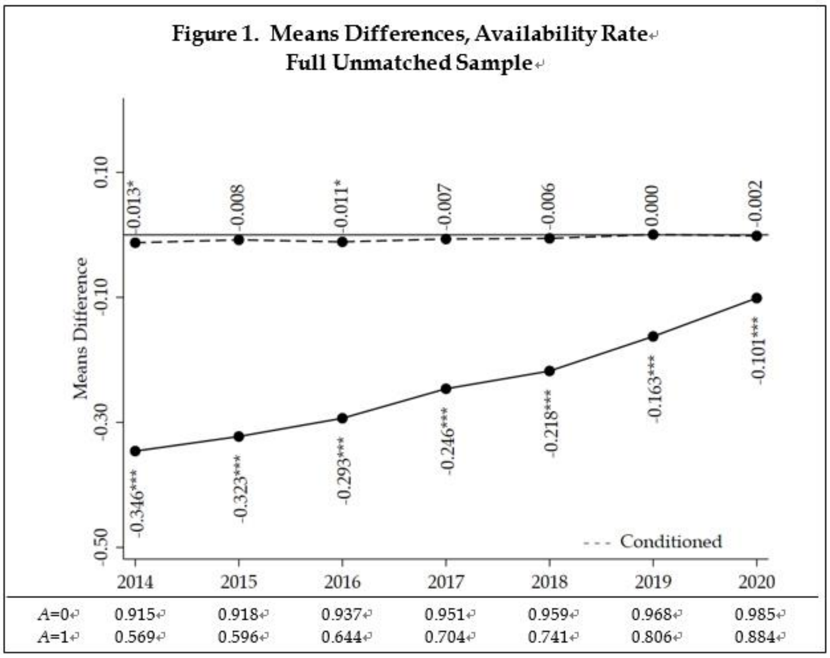


Figure 1. Means Differences, Availability Rate, Full Unmatched Sample.

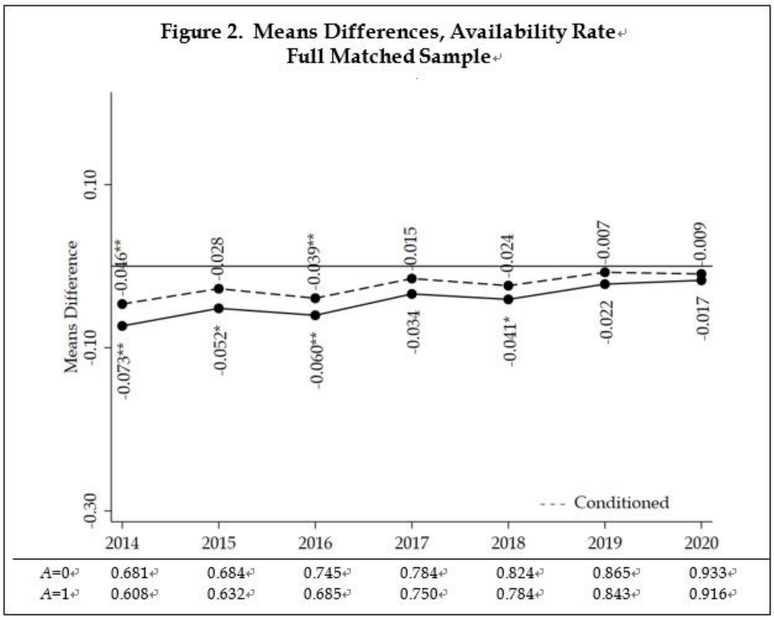


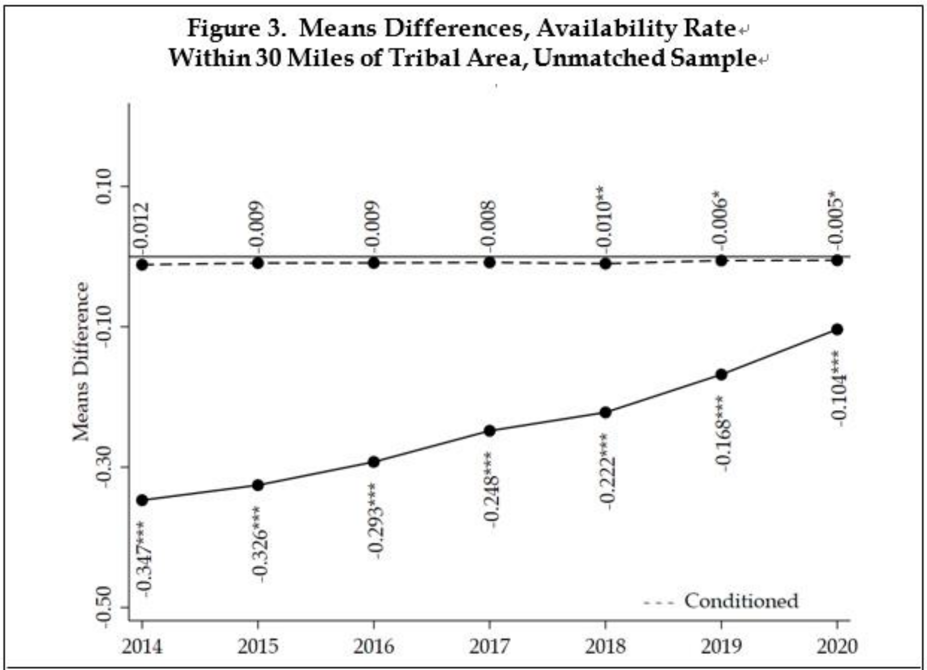
Figure 2. Means Differences, Availability Rate, Full Matched Sample.

In the matched sample, illustrated in Figure 2, the unconditional differences are much smaller, but the pattern is the same. When conditioned on the covariates, the Tribal Gaps are slightly larger than those for the unmatched sample. Since the matching algorithm includes the regression covariates, the differences between unconditioned and conditioned Tribal Gaps are smaller. The unconditioned means difference falls from -0.073 to -0.017 over the interval, a statistically significant changes at the 5% level. The change between 2014 and 2020 is statistically different from zero at the 10% for the conditioned means. By 2020, the Tribal Gaps of -0.017 for the unconditioned mean and -0.009 for the conditioned mean, both of which are quite small. These results are encouraging, suggesting that broadband availability in Tribal areas is becoming closer or equal to non-Tribal areas over time, and that any broadband gap is largely the result of economic characteristics and not the disparate treatment of Tribal areas.

The influence of matching is observed by comparing Figures 1 and 2. In Figure 1, the conditioned means difference is near zero in all years, which is not the case for Figure 2. This discrepancy reflects the large means differences in the explanatory variables in the unmatched sample and the functional form of the model. When those differences are tamed with matching, the projection between groups has less severe consequences for the predictions.

4.1. Within 30 Miles Sample

Figure 3 illustrates the trend in the availability gap for the sample including only tracts within 30 miles of a Tribal area. The Tribal Gaps are comparable to those from the full sample. The Tribal Gap is closing. For the unconditioned means differences, the Tribal Gap closes from -0.347 in 2014 to -0.104 in 2020. When conditioned on the covariates, the Tribal Gap is essentially zero. A test of whether the Tribal Gap is equal in 2014 and 2020 is rejected at the 1% level for the unconditional means difference. The conditioned means differences are small across the board.



A=0	0.916	0.921	0.936	0.953	0.963	0.974	0.988
A=1	0.569	0.596	0.644	0.704	0.741	0.806	0.884

Figure 3. Means Differences, Availability Rate, Within 30 Miles of Tribal Area, Unmatched Sample.

The matched sample (shown in Figure 4) also shows the Tribal Gap is shrinking. The unconditioned means difference falls from -0.067 to -0.020 over time. The conditioned means differences are relatively small, though sometimes statistically different from zero at the 10% level. A test for the equality of the Tribal Gap in 2014 and 2020 is rejected at the 10% level for the unconditional means difference but not the conditioned means difference.

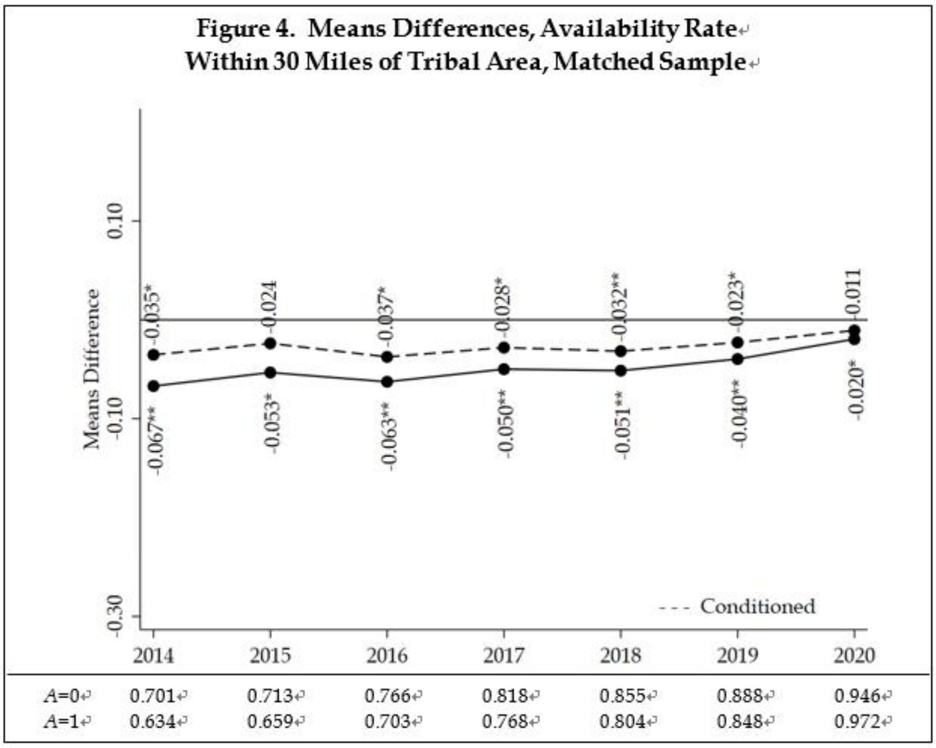


Figure 4. Means Differences, Availability Rate, Within 30 Miles of Tribal Area, Matched Sample.

When conditioned on the covariates, the Tribal Gap is -0.011 in 2020 and not statistically different from zero. Even with the unconditioned means difference, the Tribal Gap is relatively small at -0.020 in 2020, and even smaller when conditioned (-0.011). The relatively small Tribal Gaps in the matched sample suggest that similar tracts near Tribal areas are not much different in broadband availability than are Tribal census tracts. It appears that the observed gaps merely reflect the economic challenges of serving Tribal areas.

5. Conclusion

Is the Tribal Gap getting smaller? In this article, several samples and methods are used to quantify the Tribal Gap over time. In all cases the Tribal Gap is getting closer to zero over time and by 2020 is near zero when conditioned on covariates or in matched samples. The unconditioned differences, however, shows about a 10-percentage spread in availability in Tribal areas. These results are largely encouraging and suggests efforts to close the Tribal Gap are meeting with some success, though work remains to be done. These results do not imply that broadband is ubiquitous in either Tribal or non-Tribal areas; instead, these results simply demonstrate that the difference in availability between Tribal and non-Tribal areas is shrinking and that this difference is mostly explained by a few demographic characteristics.

Going forward, the interesting question is how public policy can do more to shrink the tribal gap? Since the gap is largely explained by a few factors, such as geographic conditions and income levels, shrinking the gap faces several hurdles. Addressing the socio-economic conditions point perhaps to economic development initiatives, such as improving median household income and employment in Tribal areas, though such efforts have a long history. Likewise, targeted subsidies to offset lower population density and higher deployment costs are already in place, though more attention to the details of existing programs, including empirical analysis of success and failures, may improve the efficacy of subsidies. Streamlining permitting processes for deploying broadband on Tribal lands may prove helpful, though that responsibility lies with Tribal area leaders. Better coordination between federal, state, and Tribal governments may reduce jurisdictional barriers, or at least provide clearer frameworks for service providers to work with Tribal governments.

There are some limitations to this analysis. Tribal census tracts are geographically large, and the available broadband deployment data tends to overstate availability in large census areas (Ford 2022). This overstatement may be sizable for Tribal tracts, though the matching methods should address, at least in part, such discrepancies. Also, the socio-demographic data may be viewed as somewhat course. The geographic character and cultural nuances may be substantially different though unobserved. Yet again, matching methods and the variables used in the analysis are still effective and explain the differences in availability. Of course, broadband availability changes over time, so the continued analysis of the data, using proper methods, is encouraged.

Funding Statement

This research received no external funding.

Acknowledgments

Acknowledgments to anonymous referees' comments and editor's effort.

Conflict of interest

All the authors claim that the manuscript is completely original. The authors also declare no conflict of interest.

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