Long Term Outcomes of Treaty Quality for Native Americans

by

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ABSTRACT:

I examine the long run effects of treaty quality on outcomes for on-reserve Native Americans, using an index for treaty language created through natural language processing (NLP). I use an instrumental variable identification strategy based on the idea that the presence of minerals on a tribe's ancestral homelands is exogenously distributed. Where valuable minerals were present (as measured by mining activity at the time of treaty signing), the government had an incentive to demand greater property rights from the Native American signees. OLS results including state fixed effects suggest that moving from the lowest to the highest quality treaty corresponds to a 10% increase in modern-day per capita income. However, this result is not statistically significant and may be sensitive to control specifications. IV estimates, while also statistically insignificant, estimate an effect of 43% in the full specification, and as high as 67% when forced coexistence is assumed to be a function of treaty quality.

1. Introduction

America’s Indian reservations are some of the most visible examples of poverty within the country. The rate of poverty on reservations is 28.4%, nearly double the national average of 15.3% (U.S. Census Bureau, 2011). This rate increases to 36% when looking at families with children living on reservations. High school dropout rates are higher among Native Americans living on reservation than almost any other demographic group (15% compared to the national average of 10%). In 2000, the unemployment rate across all reservations was 14%, with some as high as 75%, compared to the national average of 4%. Kocherlakota (2015) uses Chety et al.’s economic mobility analysis (2014) to show that areas with significant Native American populations rank among the lowest in the country for absolute upward mobility.

Each of these separate but highly interrelated issues represent negative feedback loops which have sustained a cycle of poverty over many decades. In the past, scholars from a range of disciplines have studied the causes of these structural inequalities. Many have placed significant focus on inefficiencies in property rights on reservations, attributed to the fact that reservation land is managed by the Federal government (Anderson & Lueck, 1992). Others have highlighted the ways in which the destruction of a tribe’s traditional culture may have disrupted their ability to remain self-sufficient (Anders, 1981). In this paper, I investigate the extent to which the quality of treaties signed by Native American tribes has contributed to the low levels of income observed on reservations. It is evident upon reading these treaties that there exists a wide range of quality in the terms and language used. Treaties often outline the size and location of reservations, along with specific rights and benefits exchanged for the cession of their land. These terms have had lasting legal implications and may be significant factors in a tribe’s welfare.

There are a few obvious obstacles when trying to do any sort of analysis on a large amount of text. First, to answer empirical questions about the effects of treaty quality, one must define and quantify quality. Second, with nearly 600 historical treaties written between 1794 and 1911, the time needed to exhaustively read, analyze, and quantify the texts manually is substantial. The application of natural language processing (NLP) can overcome both hurdles. NLP allows a computer to "understand" written language by using an algorithm to quantify the linkages between the components of the text. After processing a body of texts, one can use the linkages to assign a numerical metric to each text based on the frequency of particular words or phrases. This technique is common in the field of computer science. Spirling (2011) was among the first to show the potential power of NLP in economic applications with his analysis of the treaties between Native American tribes and the U.S. government. In his paper, Spirling argues that his processing of treaty texts reveals a metric which allows him to assess the agreeableness or harshness of a treaty. He then uses this metric to interrogate several econometric questions about breakpoints in the history of treaty making. In this paper I use Spirling's natural language processing of treaties to examine the long-term effects of treaty quality on income.

The ultimate goal of this paper is to determine whether better treaties lead to better outcomes for a tribe. I use the NLP index created by Spirling (2011) as a measure of treaty quality. By examining the correlations between the index and key indicators of a "good" or "bad" treaty, I confirm that it is a reasonable proxy for treaty quality. I then estimate the relationship between this index and present day per capita income on reservations using Ordinary Least Squares (OLS). I expand on the OLS estimation by exploring models which control for fixed effects. However, these estimates still likely suffer from the problem of endogeneity, as many remaining unobservable variables could influence both treaty quality and present-day income. This could lead to biased and inconsistent estimates. To address this, I investigate an instrumental variable (IV) strategy adopted from Dippel (2014). The results of these estimated models suggest a considerable positive relationship between the treaty quality and per capita income on reservations. The fully specified OLS model including state fixed effects suggests that moving from the lowest quality treaty to the highest quality treaty tends to increase per capita incomes by 10%. Finally, while IV estimates are not statistically significant, the estimated coefficients suggest a sizable positive effect ranging from 29% to 43% across plausible control specifications.

2. Literature Review

Economists have only relatively recently begun studying indigenous issues, but their findings are already unveiling important insights for understanding both these specific issues, as well as questions in wider economic contexts. For example, while the practice of homesteading has traditionally been thought of as an inefficient method of land disposal, Allen (1991) examines how the US government may have rationally minimized the cost of enforcing property rights by creating homesteading opportunities in areas where conflict with indigenous groups was an issue. This new body of literature often combines econometric techniques with social and historical analyses typically used by sociologists.

Dippel (2014) considers forced coexistence – a situation where multiple bands who did not traditionally share government were amalgamated onto one reserve. In many cases, bands within the same tribal nation traditionally made decisions independently. Dippel shows that the imposition of shared government had significant and long-lasting negative impacts, estimating a

30% decrease in modern-day per capita incomes. Dippel uses mining activity as an instrumental variable for this imposition of shared government. Native North Americans (unlike some groups in South America) did not engage in mining. Dippel (2014) argues that because of this, the presence or absence of minerals on a tribe's ancestral homelands is assigned quasi-randomly. Furthermore, he believes that due to the higher value of the land, tribes located on known mineral deposits were more likely to be put into situations of forced coexistence for two reasons. First, the creation of more concentrated reserves allowed the government to free up more of the valuable land. Second, keeping the tribes in concentrated areas made monitoring them to prevent them from returning to their homelands less costly. If the presence of minerals is thought to have no other effect (after controlling for relevant variables) on per capita incomes other than its indirect effect through forced coexistence, then it is a valid instrument. In this paper, I suggest that an increase in land value due to mineral presence may have also affected present-day incomes on reservations through its effect on treaty negotiation. In fact, forced coexistence can be thought of as a function of treaty quality.

In another recent advance in the study of indigenous economic issues, Spirling (2011) analyses the determinants of treaty quality. In particular, he is interested in changes to the American Constitution in 1871 which significantly altered the legal process for treaty making. In order to test the importance of this structural break in the history of treaty making, Spirling uses a technique called Natural Language Processing (NLP) to create a measure of treaty quality. This process began being developed in the 1950s in response to Alan Turing's Turing Test (Turing, 1950), but has exploded in scope and capability over the past twenty years due to increases in computing power and advances in machine learning (Hirschberg & Manning, 2015). Spirling uses Kernel Principal Component Analysis (KPCA), followed by an unsupervised random forest machine learning algorithm to assign each treaty with an objective metric representing how harsh or friendly the wording is. I explain this methodology in greater detail in the Data section.

Treaties – including those between the state and a native nation – can be thought of as contracts (Miller, 2007). This interpretation allows for the use of standard contract theory in assessing the determinants of a treaty's content. Spirling argues that the favorability of a treaty (from the perspective of the tribe) is determined in significant part by the tribe's military strength relative to the military strength of the government signing the treaty. While early treaties were being signed, many tribes had a military strength at least relatively competitive with the newly founded US Army; by the signing of the final treaties in the early 1900s, the balance of power had shifted overwhelmingly toward the State. Spirling finds a corresponding downward trend in the quality of the treaties over time. I use the concept of treaties as negotiated contracts to motivate the logic behind my instrumental variable approach.

Feir, Gillezeau, and Jones (2017) show that the shock created by the near-extinction of bison in North America had a large and persistent effect on tribes who traditionally depended heavily on bison for subsistence. They find that these tribes have incomes which are 20-40% lower than tribes that were not bison dependent. As the near-extinction occurred while many treaties were being signed, it is highly likely that bison-dependent tribes were at a disadvantage in treaty negotiations and received worse treaties as a result. Treaty quality may be a highly significant avenue which allowed the initial effects of food scarcity to persist over 130 years.

3. Data

The data I use comes from two main sources. Information on treaties and treaty quality comes from Spirling (2011). This dataset includes transcriptions of each treaty, the date and location of signing, the names of the involved tribes, and Spirling's NLP index. Treaties are sorted into four categories: "Valid and Operable," "Ratified," "Rejected," and "Unratified." The first category contains treaties which were signed prior to the 1871 constitutional changes to the treatymaking process, and which were therefore made directly by the President; roughly 60% of treaties fall into this category. Treaties labelled as "Ratified" were written after the 1871 constitutional changes and ratified through Congress in statute form; these share the same legal recognition as treaties labelled "Valid and Operable." "Rejected" treaties are those which were rejected by Congress, whether before or after 1871. In principle, these treaties do not have any current legal standing. However, several rejected treaties, written in California shortly after the acquisition of the state from Mexico, have been presented as evidence in court cases over the past 150 years (Flushman & Barbieri, 1986; Adoptive Couple v. Baby Girl, 2013). Despite the recognition of land rights implicit in negotiating a treaty, after the treaty was rejected the Federal government divvied up Native signees to these rejected treaties into existing reservations. In some cases, bands were left with no land at all. Given that the terms set out in these treaties presently remain unenforceable, I choose to omit these treaties from my analysis. Finally, "Unratified" treaties are those which were written prior to 1871 but were never submitted to Congress for ratification. Often these were negotiated by individuals without consent of the government. In many cases, an official treaty was constructed and ratified shortly after. I omit this category of treaties from my analysis for the same reasons as the "Rejected" category.

Spirling creates his NLP treaty index in the following manner: First, each document is tokenized into overlapping 5 letter strings. Counting the number of these strings that two treaties have in common (normalized by their combined length) creates a measure for the relative similarity in language between those two documents. Repeating this for every pairing of documents produces a *kernel matrix.* From this kernel matrix, a kernel principle component analysis (KPCA) process discovers non-linear combinations of the word stems which create the strongest differential in language across the documents – in some sense this is analogous to the way Ordinary Least Squares estimation finds a linear trend that minimizes squared residuals. The KPCA process identifies up to ten possible dimensions which contribute to this differential, with the explanatory power dropping sharply after the first dimension. Spirling chooses to consider only the most important dimension as a differential of interest. This is an unsupervised process, that is, Spirling does not tell the algorithm what kind of differential to look for. Therefore, he must uncover the meaning of this dimension. To do this, Spirling treats the dimension of interest as an index whose value can be predicted by regressing it on the frequency of each word in a document. Doing this with a random forest machine learning algorithm produces estimates for the relative importance of each word in determining whether a treaty receives a high or low language index score.

Examining these words, it is clear that higher treaty values are associated words that roughly correspond with mutualism: words that correlate with positive index values include “friendship,” “peace,” and “mutually.” In contrast, words such as “reserve,” “land,” and “sold” are correlated with low index values; these words tend to be focused on the terms of a transaction. Spirling focuses his analysis on breakpoints in the way these treaties were formed, and does not require a particularly strict definition of “quality” beyond this differential of mutual to transactional. As a further confirmation that a high score on Spirling's index is an indicator of a good treaty, I examine the correlation of the index with other variables that can be thought of as signals of a good or bad treaty. I find that transactional treaties tend to be correlated with smaller reservations which are situated further from the center of their ancestral homelands, and that they are also correlated with situations of forced coexistence as defined by Dippel (2014). These results are provided in *Table 1.* Based on these findings, I assert that this index represents a reasonable proxy for treaty quality.

The other primary data source comes from Dippel (2014). This set contains measures for the prevalence of mining by white settlers in each tribe's ancestral homeland. To construct the mining data, Dippel digitizes maps of Native American ancestral homelands and overlays a map of gold and silver mining clusters taken from the 1880 Census. He then assigns each mining cluster a value equal to the aggregated state-level mineral extraction from the 1870, 1880, and 1990 Censuses divided by the number of clusters in the state. Finally, he calculates the mining exposure of each tribe by summing the mining values of clusters which fall inside the ancestral homeland of each tribe, then dividing by the total area of the ancestral homeland. The final data is separated into two variables corresponding to gold and silver mining, respectively.

This dataset also contains reservation-level economic indicators compiled from US Censuses from 1970 to 2000. These include information on per capita income, unemployment, and population for each reservation, as well as indicators for the surrounding counties. I use per capita income as the dependent variable of interest throughout this paper, while other economic indicators are used as controls. Finally, Dippel's dataset includes a number of relevant variables taken from Murdock's Ethnographic Atlas (1967), a compendium of over one-thousand distinct societies from across the globe and a number of their observable features. These include controls for tribal characteristics such as whether a tribe is nomadic or sedentary. I supplement this tribal characteristic data with additional data on bison dependencies from Feir, Gillezeau, and Jones (2017). I provide a full list of the controls used in Appendix.

I match treaties to reservations using Dippel's *state_name* variable. This is an identifier which is somewhat more specific than a tribal level identification, as it separates many larger tribes into sub-tribes. Combining the data for analysis is not a trivial task. First, treatymakers tended to be inconsistent in specifying the exact tribe or band involved in the treaty. Further, there are cases where state treatymakers incorrectly presumed that villages or even extended families represented a larger nation. In a number of cases, treaties refer to tribes by the name of one or more of their leaders, rather than the tribe name. Together, this leads to significant confusion over exactly which group of Native Americans are involved in each treaty. Even when the nation is correctly identified, there are often multiple spellings and names for the same tribe, and at times the same name is used to refer to multiple, distinct groups. To ensure that the correct group is matched, I investigate each individual name and treaty using several sources (Clark, 2009; Hodge, 1907-10; Deloria & DeMaille, 1999). The lack of information available for many tribes poses a significant problem to the matching process. Often, a lack of secondary sources makes it unclear whether a particular tribe went extinct or whether the writer of the treaty used a misnomer.

Because treaties are associated with multiple tribes and bands, and reservations can contain more than one band, matching is at times both many-to-one and one-to-many. This presents a possible issue; I must match some treaties that were signed only by a sub-group of a large nation to the nation as a whole. For instance, Dippel's *state_name* identifier "Iroquois" is a very broad categorization which covers dozens of bands on various reservations. I match 7 different treaties made by sub-tribes of the Iroquois nation to the *state_name* identifier "Iroquois". As these treaties do not necessarily implicate other members of the Iroquois nation, this makes certain matches somewhat weak. In cases where a group (as identified by *state_name*) signed multiple treaties, I use the median treaty index value. This approach allows for a broader view of the quality of treaties signed by a tribe. However, it might also be argued that the most recent treaty is of greatest importance. I do not implement a "last signed" match in this paper, but this should be considered an avenue of further research.

4. Methodology

OLS Estimation:

I first use the ordinary least squares (OLS) method to estimate the following general model:

(1) $lpcinc_{i,j} = \alpha + \beta_1 treatyindex_{i,j} + \beta_2 treatydummy_{i,j} + \gamma_1 FC_{i,j} + \gamma_2 resctls_{i,j} + \gamma_3 tribectls_j + u_{i,j}$

The dependent variable $lpcinc_{i,j}$ is the modern-day logged per capita income of the i^{th} reservation for the j^{th} tribe. While tribes that did not receive a treaty are assigned an index value of zero, the inclusion of $treatydummy_{i,j}$ allows the "quality" of having no treaty to vary. I also include a binary variable for forced coexistence on the reservation ($FC_{i,j}$), a situation which is known to affect present day income (Dippel, 2014). I group all other controls into two categories: reservation specific controls, $resctls_{i,j}$, and tribe specific controls, $tribectls_{i,j}$. I fully outline these regressors in Appendix. Of particular note in the set of tribe controls is a measure for bison dependency, shown by Feir, Gillezeau, and Jones (2017) to have a large impact on modern-day per capita incomes. I also test this model for robustness to control specification, regressing the model for each possible combination of controls.

Despite the range of controls utilized, unobservable characteristics could introduce bias to Model (1). For instance, a tribe's ability to adapt to changing circumstances is difficult to quantify directly but would likely have a significant impact on their economic outcomes. When these variables are fixed for particular observable groups of observations, a fixed effects model can estimate their effects on per capita income. To test this, I estimate both a tribe fixed effects model, and a state fixed effects model.

Fixed Effects Model:

There are potentially many unobservable characteristics which may account for some variation in modern-day income. Some of these effects may be fixed among certain groupings of observations; for instance, the different laws and tax schemes in each state may have positive or negative impacts on the incomes of all people living in the state. At a tribe level, the observable characteristics given in Murdoch's Ethnographic Atlas (1968) may not cover all tribal characteristics relevant to modern-day income. To account for these effects, I estimate both a tribe fixed effects model, and a state fixed effects model. Each of these models takes the following form:

(2) $lpcinc_{i,j} = FE_{i,j} + \beta_1 treatyindex_{i,j} + \beta_2 treatydummy_{i,j} + \gamma_1 FC_{i,j} + \gamma_2 resctls_{i,j} + \gamma_3 tribectls_j + u_{i,j}$

where $FE_{i,j}$ represents a vector of fixed effects. For the tribe fixed effects model, $FE_{i,j}$ is a vector of dummies for each tribe. Tribes are defined according to the conventions given by

Murdock's Ethnographic Atlas (1968). This model produces a causal estimate for treaty quality if the only omitted variables are fixed at the tribe level. Likewise, for the state fixed effects model, $FE_{i,j}$ contains a dummy for each state, and estimates a causal relationship if the only omitted variables are fixed at a state level. Each of these models identifies a relationship using only within-tribe or within-state variation across reservations, respectively. This decrease in usable variation increases the standard deviations of coefficient estimates, but may reduce bias due to omitted variables. Despite these attempts to eliminate endogeneity, however, it is reasonable to assume that there may be further unobservable variables affecting both treaty quality and modern-day per capita income. To estimate causal effects in the face of this endogeneity problem, I explore an instrumental variable identification strategy using historical mining as an instrument for treaty quality.

Instrument Variable Model:

Ultimately, the greatest concern in estimating the effects of treaty quality on income is an endogeneity problem caused by unobservable variables which are not fixed at a controllable level. It is very likely that there exist unobservable variables that have impacted both treaty quality and present-day income. For instance, while I am able to control for a small number of large wars between Native American tribes and the U.S., there were many more instances of poorly documented small-scale violence at a band level or smaller. These altercations may have fostered a more negative relationship between the band and the Federal Government, leading to not only a poor treaty, but also mistreatment of the band through other channels. In this case, the estimated treaty index coefficient will not give a true causal effect of treaty quality. In order to make satisfactory claims about long term causal relationships, it is necessary to introduce exogenous variation to our model. Dippel's mining instrument for forced coexistence (2014) may also be a helpful instrument for treaty quality.

In his paper on forced coexistence, Dippel argues that as no American tribes had any significant form of mining, tribal ancestral homelands are effectively quasi-randomly distributed over mineral deposits. The justification for mining as an instrument for treaty quality is similar. For tribes whose ancestral homelands sat upon known mineral deposits, the U.S. government had a strong incentive to sign treaties which would restrict Native Americans to reserves on less valuable land, leaving mineral rich land ready for extraction. These treaties are transactional in nature and therefore tend to fall on the low side of the treaty language index. If the correlation between government knowledge of mineral deposits and treaty language holds, and mineral deposits do not affect current incomes (after controlling for the present day economic benefits of being near mining activity), mineral deposits may be a valid instrument for treaty quality.

I estimate the following Two-Stage Least Squares model:

$$(3) \qquad treatyindex_{i,j} = \alpha + \varphi_1 mining_{i,j} + \varphi_2 FC_{i,j} + \varphi_3 resctls_{i,j} + \varphi_4 tribectls_j + \nu_{i,j}$$

$$(4) \qquad lpcinc_{i,j} = \alpha + \beta_1 \widehat{treatyindex}_{i,j} + \gamma_1 FC_{i,j} + \gamma_2 resctls_{i,j} + \gamma_3 tribectls_j + u_{i,j}$$

Where $\widehat{treatyindex}_{i,j}$ is the vector of fitted values for the treaty index, obtained from the first stage of the model. For simplicity, I restrict the sample to tribes which have signed at least one treaty in the IV model.

If valid, using this instrument will help to address the endogeneity problem with our treaty index; however, it is not without flaw. While I control for the economic effects of present day mining activity on a reservation, historic mining may still impact income on reserves though channels other than its effect on treaty quality. Historic mining clusters may have stimulated the growth of local economies, creating lasting benefits to those living nearby even if the mine no longer operates. If this is the case, historic mining will be correlated with $u_{i,j}$ and will not be a valid instrument. To minimize these difficult-to-observe effects, Dippel constructs the instrument using only mining clusters which were on a tribe's ancestral homeland, but *not* within a one-county radius of their reservation. State treatymakers had to negotiate the land these mining clusters are on, but the clusters are too far from the current reservation to have a significant direct or indirect economic impact.

Another concern is that despite having no knowledge of the minerals underneath their homelands, tribes may have non-randomly settled on mineral-rich lands based on desirable or undesirable above-ground features which correlate with below-ground minerals. As a hypothetical example, tribes who relied heavily on fresh water fishing may have disproportionately lived in areas with rocky, mountainous streams – the types of areas where gold was first found in California. These tribes may have been better or worse equipped to deal with changing lifestyles than tribes with other means of subsistence, leading to long term welfare effects. To control for this possibility to some extent, I use an index for terrain ruggedness which captures the type of terrain on a tribe's ancestral homelands.

Finally, there may be a concern over the timing of the mining data. While the majority of treaties were signed between

5. Results

As a confirmation exercise for the validity of the treaty index, I first examine the correlations between the index and some key indicators of treaty quality. These indicators are Dippel's measure for forced coexistence, the distance a tribe was removed from their homelands, and the size of their reservation as a fraction of ancestral homeland size. One might expect that good treaties are less likely to feature situations of forced governance, as these typically represent larger departures from traditional ways of life. Likewise, a good treaty likely corresponds to a larger reservation which remains within or very close to their ancestral homelands. I regress the treaty index on each of these indicators with the following results:

Table 1. Confirmation Exercise

	sizeasfraction	*FC*	*removal*
Intercept	0.2235	0.2824	0.5561
Coefficient	39.677	-0.063	-0.027
F-statistic	10.43	12.25	9.606
p-value	0.0013	0.0005	0.002
R^2	0.0155	0.0182	0.0143

See Appendix for a detailed description of all variables.

As hoped, the index is positively related to the size of a tribe's reservation in relation to their former territory, and negatively related to the distance they were forced to move from their homelands as well as the presence of forced coexistence. Each of these regressions are significant at a 5% significance level. This provides some further confirmation that the treaty language index is a good proxy for treaty quality.

Next, I regress the simple OLS model, using a number of different control specifications to test robustness. I list these regressors in greater detail in Appendix. Results are detailed in *Table 2.*

Table 2. OLS Results

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
treaty_dummy	-0.0068	0.0087	-0.0409	-0.0877	**0.1429****	**0.1428****	0.0664	0.0255
	(0.1122)	(0.1115)	(0.1223)	(0.1218)	(0.0439)	(0.0434)	(0.0478)	(0.0472)
index	-0.2507	-0.3428	-0.0820	-0.0575	**-0.2916****	**-0.328*****	-0.1576	-0.1309
	(0.2416)	(0.2414)	(0.2582)	(0.2558)	(0.0924)	(0.0917)	(0.0988)	(0.0962)
FC		**-0.2269****		**-0.2792*****		**-0.1162*****		**-0.184*****
		(0.0695)		(0.0753)		(0.0276)		(0.0295)
R^2	0.0046	0.0205	0.0452	0.0649	0.8586	0.8623	0.8635	0.8716
F-statistic	1.549	4.602	3.442	4.534	359.9	339.8	255.9	230.1
Controls included:								
FC		X		X		X		X
Tribe controls			X	X			X	X
Reservation controls					X	X	X	X

Each regression contains 664 observations. Bold results are statistically significant at a 10% level.
$* p < 5\%$, $** p < 1\%$, $*** p < 0.1\%$.

While most of the OLS estimates for *treaty_dummy* and *index* are not statistically significant, the estimated effects of the treaty index are in most cases sizable. The most significant estimate comes from the model featuring only reservation-level controls. This estimate suggests that having made at least one treaty corresponds to a 15% increase in on-reserve per capita income, and that moving from the most negative to the most positive treaty index level results in a 33% decrease in per capita income. This runs counter to the expected effect of the treaty index. While I do not report the results in this paper, running these regressions on only reservations with treaties results in highly similar estimates. However, these effects do not seem to be very robust to control specification. Furthermore, the explanatory power of treaty quality without any controls is very low; R^2 in the first specification is less than 0.5%. In general, the reservation-level controls seem to bring a large amount of explanatory power to the model, while tribe-level controls do not contribute much. As tribes can be highly geographically dispersed and often only loosely associated with one another, it is reasonable to think that the much more localized reservation-level controls should have a larger effect on economic outcomes like income.

Next, I investigate the tribe and state fixed effects model to control for unobservable characteristics at each of these levels. The results are outlined in *Table 3* and *Table 4.* The structure of the robustness checks used here are identical to those in the OLS regression.

As expected, the estimated parameters in the tribe fixed effects model have much higher standard errors, as only within-tribe variation is used for estimation. This is particularly problematic for the tribe fixed effects model; while some tribes have as many as 12 reservations, many only have 1 or two. This is likely causing much of the wide variation in estimates between model specifications.

Table 3. Tribe Fixed Effects OLS Results

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
treaty_dummy	0.1468	0.1365	0.1332	0.05	0.0449	0.042	0.1225	0.0828
	(0.2633)	(0.2623)	(0.2949)	(0.2969)	(0.1147)	(0.1138)	(0.1224)	(0.1228)
index	-0.1221	-0.1964	-0.2197	-0.1087	-0.1371	-0.1739	-0.2967	-0.2425
	(0.5863)	(0.5849)	(0.6324)	(0.633)	(0.2663)	(0.2645)	(0.2765)	(0.276)
FC		**-0.3065***		**-0.2941***		**-0.15*****		**-0.1327***
		(0.1297)		(0.1428)		(0.047)		(0.052)
R^2	0.139	0.147	0.1427	0.1489	0.8957	0.8975	0.8968	0.898
F-statistic	1.325	1.393	1.286	1.332	61.72	62.06	59.1	59.04
Controls included:								
FC		X		X		X		X
Tribe controls			X	X			X	X
Reservation controls					X	X	X	X

Each regression contains 664 observations. Bold results are statistically significant at a 10% level.
$* p < 5\%$, $** p < 1\%$, $*** p < 0.1\%$.

There does not seem to be any strong pattern in the difference between these estimates and the original OLS estimates for *treaty_dummy* or *index*. Furthermore, very few of the tribe fixed effects have any degree of statistical significance. Given all this, and the overall decrease in F-statistics associated with a large decrease in degrees of freedom, I contend that the tribe fixed effects are not sufficiently relevant to warrant their inclusion in the model.

Table 4. State Fixed Effects OLS Results

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
treaty_dummy	-0.1116	-0.1158	-0.1187	-0.1441	-0.0407	-0.0402	-0.0176	-0.0352
	(0.1914)	(0.1910)	(0.2044)	(0.2050)	(0.0721)	(0.0713)	(0.0758)	(0.0752)
index	0.2541	0.2325	0.3966	0.3899	0.1271	0.1074	0.1126	0.0982
	(0.3812)	(0.3807)	(0.3980)	(0.3976)	(0.1468)	(0.1452)	(0.1508)	(0.1493)
FC		**-0.1768**		-0.1512		**-0.1431*****		**-0.1428*****
		(0.0953)		(0.1032)		(0.0363)		(0.0392)
R^2	0.1259	0.1307	0.1379	0.1409	0.8849	0.8878	0.888	0.8904
F-statistic	2.129	2.167	2.005	2.011	92.29	92.97	82.69	83.17
Controls included:								
FC		X		X		X		X
Tribe controls			X	X			X	X
Reservation controls					X	X	X	X

Each regression contains 664 observations. Bold results are statistically significant at a 10% level.
$* p < 5\%$, $** p < 1\%$, $*** p < 0.1\%$.

In the state fixed effects model, I find a reversal of the sign on both the treaty dummy and the treaty index. For instance, the model with all controls implies that signing at least one treaty *decreases* per capita income by 3.5%, while moving from the lowest treaty on the index to the highest corresponds to an *increase* in per capita income of 9.8% This large change in estimates may imply that state fixed effects are important determinants of per capita income; correspondingly, most of the state fixed effects are statistically significant. This is perhaps unsurprising, as legal and economic conditions can change quite dramatically between states. I take these state fixed effects to be relevant to the model and include them in the IV estimation. As in the OLS estimation, I re-estimate these models using only reservations that have signed treaties and find no significant differences in estimates.

Table 5 outlines results from my estimation of the instrumental variable model. Note that this regression considers only observations without a matched treaty. In addition to the control specifications described in the table, I also include a control for the ruggedness of terrain on a tribe's ancestral homeland in the first stage of each regression. This accounts for the possibility that tribes may have non-randomly chosen their homelands based above-ground terrain differences which correlate to mineral presence.

Table 5. IV Results

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
index	0.0718	0.1252	0.6489	0.4066	0.6545	0.2868	0.6711	0.4258
	(0.8042)	(0.7875)	(1.415)	(1.4040)	(0.5294)	(0.5359)	(0.5003)	(0.4887)
FC		-0.1346		-0.1139		**-0.1148***		**-0.0935**
		(0.0925)		(0.1355)		(0.0456)		(0.0491)
R^2	0.0019	0.0028	0.1192	0.1218	0.8861	0.8892	0.8909	0.8934
F-statistic (instruments)	14.45	15.401	17.816	18.085	18.270	17.361	21.407	22.049
Wald statistic	0.0080	1.414	1.391	1.373	73.27	73.48	66.36	66.42
Sargan p-value	0.942	0.941	0.691	0.648	0.055	0.045	0.016	0.018
Controls included:								
State fixed effects			X	X	X	X	X	X
FC		X		X		X		X
Tribe controls			X	X			X	X
Reservation controls					X	X	X	X

Each regression contains 438 observations. Bold results statistically significant at a 10% level.
$* p < 5\%$, $** p < 1\%$, $*** p < 0.1\%$.

While the instrument based on exposure to gold mining is significantly correlated with the treaty index value, silver mining is not a statistically significant predictor of index values. However, F-statistics for the first stage seem to be sufficiently strong to satisfy the relevance requirement for instrumental variables. Each specification passes the rule-of-thumb guide for weak instruments given by Staiger and Stock (1997). Although statistically insignificant, the estimated causal effects of treaty quality on income are substantial in magnitude: In the full control specification, moving from the lowest treaty index value to the highest has the effect of increasing per capita income by 43%. Even the lowest estimate, in the specification with no controls, estimates an economically significant 7% effect. I view the final specification as the most plausible model, and thus the central result to this paper. However, as Sargan tests are statistically significant in the last four specifications, we may be concerned about instrument validity for these estimates.

These results should be interpreted with care, especially where forced coexistence is not used as a control. While the treaty index is created using a natural language processing algorithm, the causal effects uncovered are likely not acting primarily through language in and of itself. Rather, it is likely that the language is a strong indicator of important treaty terms which, through their legal implications, are influential on wealth. One could think of forced coexistence as an essential part of treaty quality which may be picked up by the treaty language index. Removing it as a control from the otherwise fully controlled specification increases the estimated effect of the treaty index to 67%. Thus, it appears that the treaty index does pick up much of the effect of forced coexistence. This in turn implies that the causal components of treaty quality, where observable, could be decomposed and analyzed individually. I leave this exercise for further research.

The causal effects of treaty quality may be in fact be smaller than they “should” be. There is a historical precedence for very limited legal recognition of the rights given to Native American tribes in these treaties. In many cases, treaty terms were neglected by the U.S.

government without significant repercussion (Oliffe, 2011). It is quite possible that tribes were unable to take full advantage of the positive benefits of having signed a good treaty, attenuating the effects as they would have been if all terms had been upheld. The Standing Rock Sioux reservation has been a high-profile example of this. In April 2016, members of the Standing Rock reservation formed a camp attempting to blockade the construction of the Dakota Access Pipeline which was being built through unceded territory near the reservation. The land in question was originally designated as part of their reservation in the 1851 Treaty of Fort Laramie. A subsequent treaty in 1868 reduced the size of their reservation but left the original land to the north as "unceded Indian territory," and specifically gave the signees the right to refuse any white settlement in this area. Despite this, the protest camp was forcibly removed by police in October 2016. At the time of writing, the Dakota Access Pipeline is in full operation.

6. Conclusion

My results, while not statistically significant, suggest a substantial positive relationship between treaty quality and modern-day per capita income on reservations. After controlling for a number of variables at the reservation, tribe, and state levels, OLS estimates suggest that moving from the lowest treaty index value to the highest value coincides with a 10% increase in per capita income. Using an instrumental variable strategy based on historical mining activity, I find that the true causal effect may be even greater. While the estimate varies considerably across control specifications, moving from the lowest to the highest index value is estimated to increase income by 43% for the fully specified model. This effect is even greater if we assume that forced coexistence is a function of treaty quality; the estimated effect of treaty quality is 67% when I remove forced coexistence as a control from the full model. However, Sargan tests for validity of the instruments fail for some specifications. As a further concern, the explanatory power of the treaty index net of any controls is quite low, with an R^2 of around 0.5% in the initial OLS estimates. This suggests that while the effect may be considerable, there are many other things causing the high degree of variation in incomes across reservations in America.

7. Appendix

Variables used:

lpcinc – Log of per capita income for on reservation Native Americans, 1970-2000

treaty_dummy – Dummy variable. Equal to 1 if the reservation is associated with at least one treaty, otherwise equal to 0.

index – Index for treaty quality created using Natural Language Processing. Scaled from zero to one.

FC – Dummy variable for forced coexistence. Equal to 1 if the reservation contains two or more bands that did not traditionally share a government, otherwise equal to 0.

state – U.S. State in which the reservation is located.

state_name – Identification variable. Identifies both tribes and sub-tribes.

Tribe Controls:

ea_v5 – Calories obtained from agriculture in a traditional way of life. Assumed exogenous.

ea_v30 – Dummy variable for sedentary lifestyle. Equal to 1 if the traditional way of life was sedentary, otherwise equal to 0. Assumed exogenous

ea_v32 – Complexity of local community. Assumed exogenous.

ea_v66 – Wealth distinctions. Equal to 0 if none, equal to 1 if some, and equal to 2 if there are defined classes (ie. nobility). Assumed exogenous.

HC – Dummy variable for historic centralization. Equal to 1 if separate bands traditionally shared government, otherwise equal to 0.

everwar – Dummy variable for previous wars with the United States. Equal to 1 if the tribe has ever been at war with the U.S.

bisondep – Dummy variable for bison dependency. Equal to 1 if a tribe was traditionally dependent on bison, otherwise equal to 0.

Reservation Controls:

logdist – Distance from the nearest city with a population greater than 50,000 (km).

pcinc_co – Per capita income across counties bordering the reservation.

unempl_co – Unemployment rate across counties bordering the reservation.

logpop – Log of reservation population.

d1970, d1980, d1990 – Dummy variables for the year of observation for modern day variables. For the year 2000, each is equal to 0.

Summary Statistics:

Table 6. Summary Statistics

Variable	Min	Max	Median	Mean	Standard Deviation
Per capita income, 1970	575	2341	1004	1086	375.16
Per capita income, 2000	4043	38647	8879	10031	4851.15
Reservation area (km^2)	0.01	62404	261.71	2154.77	5684.62
Ancestral homelands area (millions of km^2)	1131	201800	18370	42970	46207
index	0	0.7052[a]	0.2479	0.2411	0.2203

[a]While the treaty index is scaled from 0 to 1 after the NLP algorithm is complete, the matching process takes the median treaty for tribes with more than one. After the match, the highest index value is 0.7052.

8. References

9.

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