# Tribes, Water, and Economic Characteristics of the Western United States

by

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## **Abstract**

Native American tribes in the Western United States experience persistent socio-economic challenges that impede economic development and improved standards of living within their communities. In this study, U.S. Census Bureau data on tribes is linked with additional data sources to perform econometric analyses to better understand how “tribal presence” explains economic well-being. This study finds, as expected, that “Tribal Presence” (created from percent of tribal land and percent of Native American population ) has a significant negative relationship with Per Capita Income at census tract and county spatial scales. Consistent with the findings on income, the Tribal Presence variable has a significant negative relationship with Percent Families Above Poverty. Variables for education, internet access, urban population, and climate were also significant determinants for income and family poverty. The climate variable results were interesting as they infer that the more unusually dry or wet it is, the more income and more poverty there is. Further analysis of counties with “tribal presence” was conducted to better understand how counties with tribes who have quantified water rights compare to counties with tribes who have yet to quantify water rights.

# Chapter 1
# Introduction

*I. Background*

Native Americans tribes were often coerced into treaty agreements limiting their landholdings, providing them with less desirable land areas, and in some instances placing them on land where they did not reside historically. As settlers spread across the western United States (U.S.), this coercion continued even as some tribes fought to avoid displacement. Tribal reservations are land areas where tribes have some governance sovereignty, but where tribes also are constrained by a complex relationship with the federal government. It has been difficult for most tribes to prosper economically, and their unusual landholding and governance status further complicates their ability for economic growth. Over the past 50 years, some tribes have pursued development opportunities through the acquisition of water rights via court decree or through negotiated settlements. Many tribes have used these rights to irrigate farms, build casinos, and build golf resorts on their lands, which can promote the growth of the reservation economy. The focus of this study is to examine the role of tribes in local and regional economies through empirical analysis, and to evaluate what factors assist in positive economic development of tribal communities.

In North America, tribes participated in a wide range of economic activities across the continent prior to settlement by Europeans. During this time, some were nomadic hunter-gatherers, traversing a region as the seasons changed. Other tribal peoples farmed and lived in permanent settlements. Tribes also engaged in trade during this time, often over long distances and particularly among areas containing high population densities (Carlos, 2012). Economic activities governed by Native American tribes are now mostly limited to their reservation lands. This long-term transition, forced upon tribal communities, has been a struggle for many tribes, and has resulted in difficult socio-economic circumstances.

At present, tribes are behind the rest of the United States in many important social categories. Native Americans across the U.S. have one of the lowest life expectancies, suffer twice as much from violent crime, have double the infant mortality rate, and have one of the lowest levels of education for any group in the country (Regan, 2014). These social challenges also impact economic development, as tribes grapple with high rates of poverty and deal with limited opportunities for economic growth. These problems are confounded by their conflicting relationship as “domestic dependents” of the U.S. federal government while also being sovereign governments (Regan, 2014).

*II. Tribes and Tribal Water Rights*

Water rights in the western U.S. emerged as a result of scarcity and differ from the other areas of the U.S. where water is often more abundant. In the west, there is a system of “prior appropriation” in which those who are first to beneficially use the water, are first in line to access the water, up to the amount they are allotted (Colorado Division of Water Resources, 1992). In part due to the rules of “prior appropriation,” the focus of this study is on ten target states and the federally recognized tribes within these states. Each state allocates water with a combination of “prior appropriation”, adjudicated court decrees, and water rights that are tied to property rights.

The history of tribes quantifying water rights begins in the U.S. Supreme Court. In 1905, the Fort Belknap Reservation began experiencing water shortages and the federal government filed a lawsuit on behalf of tribal communities challenging non-Indian farmers who had diverted their water source upstream. This legal challenge rose to the U.S. Supreme Court, in the case *Winters vs. United States* and set precedent that allowed for tribes to formally establish water rights for use on reservations with a priority date of the year their reservations were established (U.S. Supreme Court, 1908). In many parts of the West, tribal rights are the most senior rights (first in line) for the water source.  In 1963, an additional U.S. Supreme Court case *Arizona vs. California,* decided that water rights would be quantified through measuring the "practicably irrigable acreage" of the reservation land area, giving the tribes clarity in pursuit of quantified water rights (U.S. Supreme Court, 1963). Recently, the courts and parties negotiating over tribal water rights have also used an alternative to this quantification standard. Reservations were not created only so that tribes could form agrarian societies, but many treaties that established reservations include language describing these areas as "homelands" for tribes (Lowrey, 2012). In establishing this "homeland" standard, tribes have greater flexibility in using water and quantification is not limited to solely agricultural purposes.

In the past half-century, Native Americans activism and the passage of the Indian Civil Rights Act of 1968 have provided further development of tribal sovereignty and participation in regional water management. In 2004, Senator Brownback of Kansas introduced a resolution to Congress as "a first step toward healing the wounds that have divided us for so long - a potential foundation for a new era of positive relations between Tribal Governments and the Federal Government," This was signed into law by President Barack Obama in 2009 and partially serves as an official apology by the federal government to tribes (U.S. Congress, 2009). Tribes, having suffered through centuries of "ill-conceived policies" (U.S. Congress, 2009), now experience renewed political support, so that positive social outcomes can become the norm for tribal communities.

### *III. Purpose of Study*

Tribal members on reservations have increased rates of poverty and have lower incomes in comparison to the rest of the country. By quantifying their water rights, it is possible that tribes can have an additional opportunity to develop their communities' economies. There are challenges in gathering accurate information across many tribal communities. Within the past 50 years, some tribes have received financial considerations as part of their settlements involving tribal water rights. There appears to be little published research on how water rights quantification affects outcomes for tribes and their economies.

The overall aim of this study is to provide a starting-point for analysis of the economic effect of quantified tribal water rights. The information generated can be beneficial to tribes in future negotiations over water rights, as key details can be used to craft more specific policy measures that have greater and measurable impacts for tribe members. This study uses econometric analysis that includes Native American population and tribal land in ten western U.S. states to examine effects on income measures and poverty levels. This is completed using an econometric model specified with economic variables of interest.

*IV. Scope of Study*

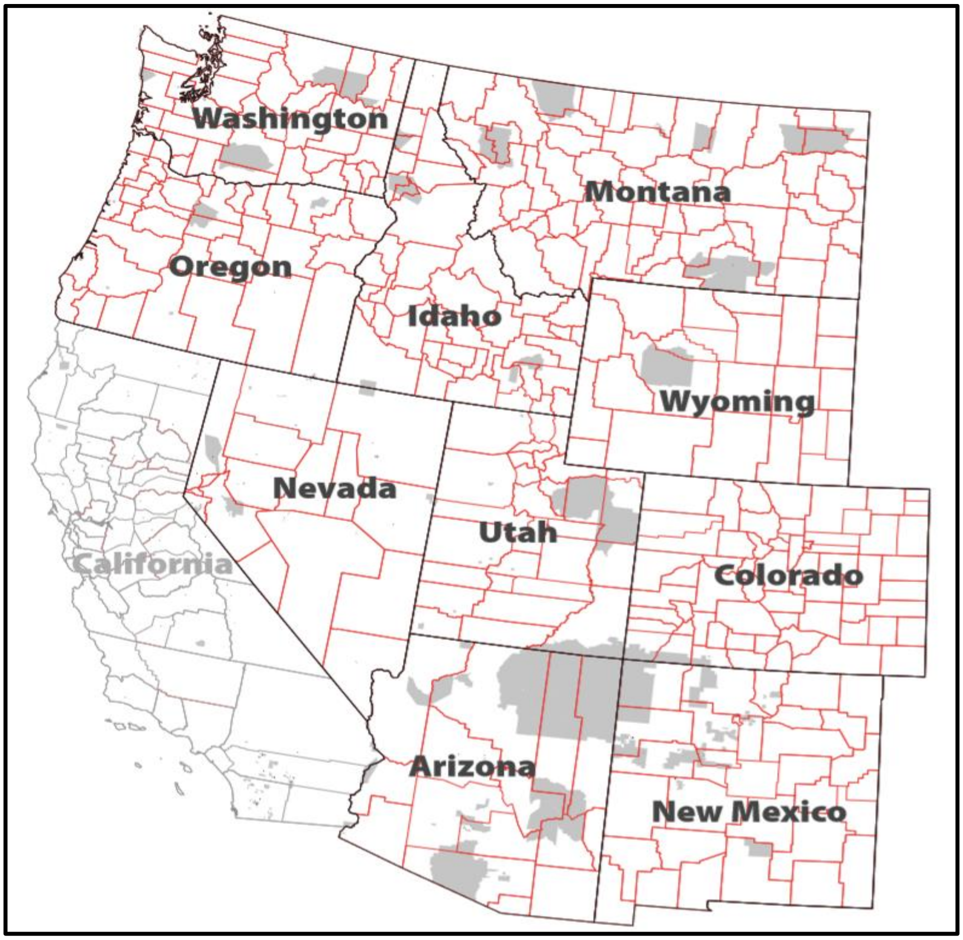
For this study, the western U.S. is defined as the states Arizona, Colorado, Idaho, Montana, New Mexico, Nevada, Oregon, Utah, Washington, and Wyoming. Within these ten states, there are 117 federally recognized tribes (National Conference of State Legislatures, 2018), with seven of these tribes having overlapping boundaries into adjacent states. In Table 1.1, a state comparison of tribal land, population living on reservation, and population who identify as Native American (alone or in combination with other) is depicted for each state in the study:

*Table 1.1 – Tribal Land and Population Statistics by State*

| State | Acres | Tribal Acres | Percent Tribal Acres | Population | Population on Reservations | Percent Population on Reservation | Population who Identify as Native American | Percent Identify as Native American |
|---|---|---|---|---|---|---|---|---|
| Arizona | 70,411,612 | 20,258,978 | 28.77% | 6,392,017 | 169,426 | 2.651% | 353,386 | 5.529% |
| Colorado | 66,553,110 | 1,138,934 | 1.71% | 5,029,196 | 12,153 | 0.242% | 107,832 | 2.144% |
| Idaho | 53,484,041 | 1,809,174 | 3.38% | 1,567,582 | 31,402 | 2.003% | 36,385 | 2.321% |
| Montana | 94,105,264 | 8,516,610 | 9.05% | 989,415 | 64,931 | 6.563% | 78,601 | 7.944% |
| New Mexico | 67,924,924 | 1,171,417 | 1.72% | 2,700,551 | 10,013 | 0.371% | 55,945 | 2.072% |
| Nevada | 77,817,175 | 7,748,193 | 9.96% | 2,059,179 | 130,835 | 6.354% | 219,512 | 10.660% |
| Oregon | 62,210,075 | 865,584 | 1.39% | 3,831,074 | 7,586 | 0.198% | 109,223 | 2.851% |
| Utah | 54,051,587 | 5,764,990 | 10.67% | 2,763,885 | 31,080 | 1.125% | 50,064 | 1.811% |
| Washington | 44,153,915 | 3,548,571 | 8.04% | 6,724,540 | 157,334 | 2.340% | 198,998 | 2.959% |
| Wyoming | 62,599,346 | 2,260,870 | 3.61% | 563,626 | 26,490 | 4.700% | 18,596 | 3.299% |
| **Total in Study Area** | **653,311,049** | **53,083,320** | **8.13%** | **32,621,065** | **641,250** | **1.966%** | **1,228,542** | **3.766%** |

California is not included in this study, although a part of the western United States. California has 109 federally recognized tribes as a result of the different patterns of tribal lands and complexities in spatial boundaries and policy, California tribes are not included in this study. However, there are a few tribes that have reservation boundaries that overlap into California, and these are included in the study. In Figure 1.1, a map of the states and tribes that are included in this study are shown. Notice that tribal (filled gray areas) reservations almost always overlap into multiple counties (red lines) and sometimes also into neighboring states:

*Figure 1.1 Map of Study Area*




*Map Credit: Nancy Bannister, University of Arizona,* 2019 (Bannister)

Currently, 53 of the 110 federally recognized tribes (48.2%) in the study area have quantified water rights either through court decree or settlement negotiations. Of these 53 tribes, 48 of them were able to quantify their water rights prior to 2010. Initially, tribal water rights were outcomes of court decrees. In more recent history, tribes have participated in negotiations with state and federal agencies and with water users and other stakeholders to produce more favorable outcomes for all parties. This process can take many decades to achieve a settlement. Gaining legal water rights does not mean that water begins flowing for the tribes, and often infrastructure to transport the water is needed. Some tribes have negotiated flexibility into their water rights agreements for purposes outside of agriculture on their reservation, including restoring stream flows to increase fish populations, and the ability to lease their water to other users for a negotiated price. Table 1.1 shows the number of tribes by state, the number of those tribes with quantified water rights, and the number of tribes which can lease their water to non-tribal users for off-reservation purposes. In principle, gaining rights to water should allow for greater economic independence of tribal communities, allowing for them to engage in agriculture, casinos, and golf resorts, or to receive compensation in lieu of using this water by leasing it to off-reservation users. All options have the potential to improve tribal economies by bringing additional revenue sources to tribal members. The purpose of this study is to explore this premise.

*Table 1.2 - State Summary of Counties, Tribes, and Quantified Water Rights*

| State | Number of Census Tracts | Number of Counties | Number of Federally Recognized Tribes | Number of Tribes with Formalized Quantified Water Rights | Number of Tribal Settlements that Authorize Water Leasing |
|---|---|---|---|---|---|
| Arizona | 1,524 | 15 | 22 | 13 | 9 |
| Colorado | 1,248 | 64 | 2 | 1 | 1 |
| Idaho | 298 | 44 | 4 | 3 | 1 |
| Montana | 271 | 56 | 7 | 7 | 6 |
| Nevada | 498 | 17 | 21 | 12 | 6 |
| New Mexico | 682 | 33 | 23 | 8 | 8 |
| Oregon | 828 | 36 | 10 | 1 | 1 |
| Utah | 587 | 29 | 7 | 3 | 1 |
| Washington | 1,447 | 39 | 12 | 4 | 0 |
| Wyoming | 132 | 23 | 2 | 1 | 0 |
| **Total** | **7,515** | **356** | **110** | **53** | **33** |

Economic information on tribes is not systematically available and therefore difficult to evaluate. Most tribes do not collect their own data across multiple matching measures and time periods. For tribes that do collect data, they often do not share it publicly. This study resolves this data challenge by merging U.S. Census Bureau, U.S. Department of Agriculture, Federal Communications Commission, and Bureau of Economic Analysis data across consistent spatial scales and comparable temporal scales for empirical analysis.

## *V. Results*

This research indicates that "Tribal Presence" has a negative and significant relationship with Per Capita Income within combined census tract and county spatial scales. With the second dependent variable, Percent of Families Above Poverty, "Tribal Presence" also has a negative and significant relationship. This means that those areas with tribal presence (defined as census tracts with reservation [tribal land] acreage greater than one acre and at least 2.5% Native American population), the less income people have, and the more family poverty there is. The variable representing educational attainment, "Percent 25 years and older with a bachelor's degree or higher" is a positively significant determinant of income and of families above poverty. The variable chosen to represent population density, "Percent Urban" is only a negatively significant determinant of families above poverty, indicating that the more urban the area, the more family poverty. Conversely, it also has a positive and significant relationship with income. The variable chosen to represent local climate, "2006-2010 Mean SPEI Squared", is significant and positive for both dependent variables. "Residential Internet Access per 1,000 Households", is a significantly positive determinant for income and families above poverty. These results are maintained when clustered robust errors are used.

To further understand the data, census tract data was aggregated to the county level, weighted by population of each tract. Counties were then grouped using the defined threshold for “tribal presence” and a comparison of means completed between these groups. This initial grouping resulted in moderate differences between the variables, with five variables having significant differences. However, the interpretation of the overall impact of this comparison is limited. The variables that exhibited differences between the groups are Percent 25 years and Older with a Bachelor’s degree or higher, Percent Working in Extraction/Resource Industries, Mean Commute, and Total Gross Farm Income/County Gross Domestic Product (GDP) have significantly different mean values between each category. Additionally, one of the dependent variables, Percent Families Above Poverty, showed a significantly different mean between the groupings. These results for counties with tribal presence are interpreted as having higher poverty, less educational attainment, work less in a specific occupational field, and less farm income as a proportion of County GDP.

Counties with tribal presence were divided further into groups by whether they contain tribes who have water rights (prior to 2011) and counties where tribes do not have water rights (or received them after 2010). This year cutoff was made as most of the data gathered is focused on 2010, with only one piece coming from 2012. Results of this analysis show that there is a difference between the two groupings along the variables used in this study. A significant difference of means between the two groups are found with Mean Commute, Percent Native American Population, Percent Tribal Land (in acres), and a dependent variable, Per Capita Income. These results for counties with quantified tribal water rights are interpreted as having shorter commutes, higher percent Native American population and percent tribal land, and lower

Per Capita Income. The goal of this analysis is to identify any non-trivial differences between the mean values of variables.

A second econometric analysis was performed using the county level data. First, a regression was performed using methodology used at the census tract level, with the primary variable of interest being Tribal Presence. Tribal Presence only maintained a significant relationship with Families Above Poverty. Another variable of interest was added to these county level models, “Quantified Tribal Water Rights”, a binary value that represents counties that have gained water rights prior to 2011. This variable was negative and significant only with family poverty, matching the results for tribal presence.

# Chapter 2
# Literature Review

"Long before the first Europeans reached what is now the western United States, Indian peoples shaped this land." – Richard White, *It's Your Misfortune and None of My Own: A New History of the American West.*

## *I. Background*

The purpose of this study is to explore the relationship between local and regional economies and tribal presence, as measured by tribal land and Native American population. Tribes lost parts or whole areas of their traditional lands through treaties with the U.S. government which established reservation boundaries. In addition to losing their lands, tribal cultures were often marginalized by government policies. This study examines the economic role of tribal presence through econometric analysis of available data, using census tract and county spatial scale. This study also focuses on quantified water rights for tribes and its use as a tool for developing tribal economies.

## *II. Native American Reservations*

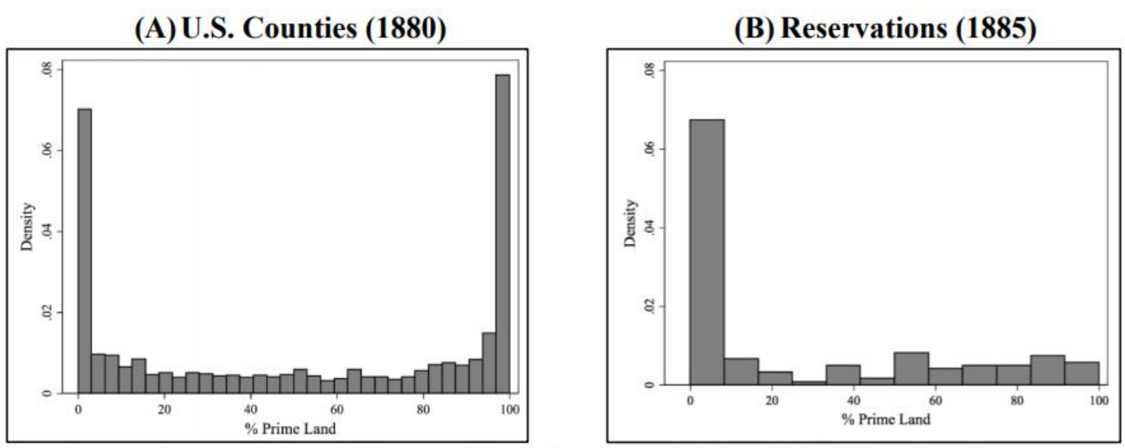
Upon the arrival of European settlers to North America, the indigenous population of the United States had access to their native lands altered and reduced. Many tribal communities were relocated, creating severe cultural challenges. This process would later become legally confirmed with the Indian Removal Act of 1830. Most eastern U.S. tribes had their land and populations relocated west of the Mississippi River. This impacted tribes already living in this portion of the country. They lost large portions of their traditional land (Sandifer, 1989). The land that tribes were involuntarily placed on and restricted to "were generally regarded as the least desirable by whites and were almost always located far from major population centers, trails, and transportation … For most of the nineteenth century the policy of the U.S. government was to isolate and concentrate Indians in places with few natural resources, far from contact with the developing U.S. economy and society" (Sandifer, 1989, page 37). This land that now belongs to tribes is their reservation land, but it is also held in trust by the federal government.

A paper on tribal economies by Leichenko examines whether persistent poverty on reservations is due to the tribes being "isolated, nonmetropolitan areas… (with low income) due largely to locational factors, such as the lack of access to markets, the absence of agglomeration economies, and an inadequate infrastructure" (Leichenko, 2003, page 365). This refers to the previous idea that tribes were given less than desirable areas of land discussed previously and is a much-theorized reason as to why tribal communities have persistent struggles economically and socially.

An important distinction as to how to properly group tribal areas and non-tribal areas was made within this paper. Leichenko, using the county spatial scale, first grouped counties by whether they contained any tribal land, and made a smaller further grouping of counties where Native Americans made up at least 5% of the population. The product of this grouping leaves 156 counties across the U.S. which meet this definition of any tribal land and above 5% Native American population. Results of this study showed that location is important as it relates to Per Capita Income. However, human capital, demographics, and especially college-educated and retirement age population shares have a positive impact as well. Initially, unemployment and Native American population have a negative impact on Per capita income. However ,this impact was lessened by the addition of more variables.

In a 2018 study by Leonard, it was found that the quality of agricultural land on reservations does not indicate a positive linear relation with American Indian per capita income (Leonard, 2018). This research found that instead of the linear relationship, there was a "U-shape", indicating a non-linear relationship, between income and agricultural land. Within this analysis, a measure of "prime agricultural" land was created from historic spring and summer rainfall patterns and soil data at an 800x800meter cell grid. Using data that corresponds to 1880s, they also found that few reservations contained 100% prime agricultural land. Counties across the U.S. have a much higher density of the prime agricultural land. This distribution is depicted in Figure 2.2:

*Figure 2.1 – Distribution Comparison of % Prime Agricultural Land* (Leonard, 2018)




**Notes:** Prime land received at least 15 inches of Spring/Summer rain during 1890-1930 and has above average soil productivity. See Appendix Figure A1 for a map of rainfall and soil data.

Here is further evidence that tribes were granted less desirable land, but also less productive land. Their income is constrained by the quality of land they were given, which limits their ability to grow further economically

With the strenuous and sometimes violent history between the federal government and North American tribes, tribes often still harbor suspicion towards working with federal agencies, especially when it comes to sharing sensitive information. Tribal governments retain a level of sovereignty in these decisions and are "likely to be evaluated within the historical context of federal policies designed to assimilate American Indian and Alaska Native (AI/AN) people into the culture of the colonizing United States" (James, 2014). This causes challenges in accurately assessing the issues that affect tribal people, and in evaluating which policies can be impactful in mitigating economic challenges of people on reservations.

### *III. Native American Population*

After being forced onto reservation lands through U.S. government action, two major events spurred migration off reservations and into the more urbanized areas of the country. The first event, World War II, saw over 25,000 Native Americans join as active military members, and another 50,000 Native American people contributed to the war effort by working in war-related industries (Snipp, 1996). Following the war, many of the Native Americans who migrated away from reservations as part of their involvement in the war, chose to stay in these urban areas. This was the first-time tribe members migrated off reservations en masse.

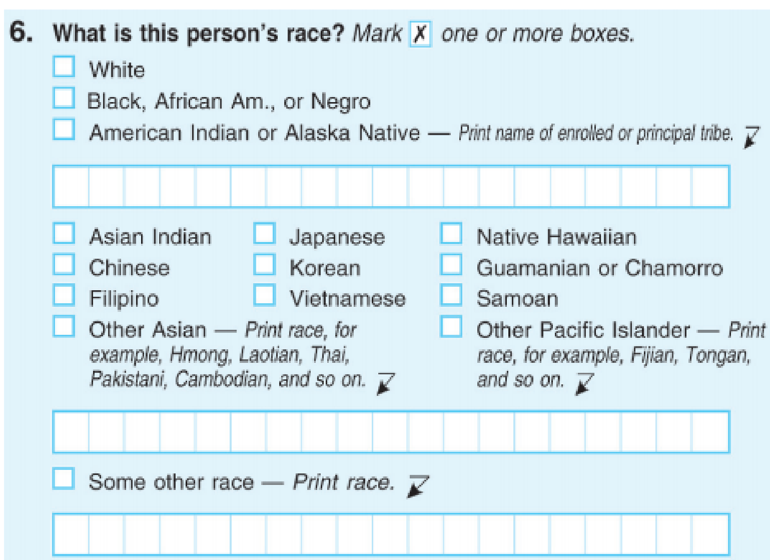
The second event to prompt Native Americans to move to more urbanized areas was the result of actions by the federal government following World War II. The goal of these policies was to "settle outstanding claims made by American Indian tribes against the federal government, dissolve the reservation system, and move American Indians to preselected urban locations" (Snipp, 1996, page 22). This movement would "cause the greatest resettlement of

American Indians since the Indian Removal Act" (Snipp, 1996, page 22). Native American population estimates from this era also reflect this movement. Prior to World War II, in 1926 there were "less than 10,000 American Indians in cities." (Snipp, 1996). Following the War, in 1960, this number increased to "160,000, and by 1970, had risen to 340,000". During this same time period, the overall percentage of all Native Americans in the U.S. living in urban areas rose from 30% to 45%. However, the U.S. government did not continue to prioritize relocation policies. In 1980, a small majority of Native Americans remained outside of urban areas. In the 1990s, that flipped to the majority living in urban areas (Snipp, 1996). This out migration movement also limited economic growth of the reservations. With the migration pattern continuing, opportunities to develop are limited by lack of population.

There are many examples of strained relationships between tribes, the federal government and third parties. The Hopi and Navajo tribes in Arizona had an agreement with a mining company to excavate resources on their lands. As wards of the tribes, the federal government was tasked with protecting tribes, but did not assist in doing so with the mining company. As a result, the tribe wound up with an "undervalued" payment amount from profits from the mine. As a consequence of building a slurry to move the coal from one station to another, the tribes lost a substantial amount of potable water that could have been used on the reservation (Grogan, 2011). In this arid area of the United States, water shortages pose a big problem, as "in 2018, 40% of homes on the Navajo reservation lack sanitation and running water… The Navajo Reservation is an area size of West Virginia that spreads across 13 counties in New Mexico, Arizona and Utah" (PBS, 2018).

Migration off reservations and many other factors cause families to form between Native American's and other ethnic groups, incorporating tribes further into the urbanized landscape of the United States. Results from the 2010 Census showed that "out of the total U.S. population, 2.9 million people or 0.9 percent, were American Indian and Alaska Native… In addition, 2.3 million people, or another 0.7 percent, reported American Indian and Alaska Native in combination with one or more other races" (U.S. Census Bureau, 2017). The U.S. Census Bureau has made efforts to better record data on Native American people, with emphasis beginning in 2000. Figure 2.2 shows how the Census poses the question on race and Native American ethnicity:

*Figure 2.2 – 2010 Decennial Census Question on Race*



**6. What is this person's race?** *Mark* ✗ *one or more boxes.*

☐ White
☐ Black, African Am., or Negro
☐ American Indian or Alaska Native — *Print name of enrolled or principal tribe.*

☐ Asian Indian
☐ Chinese
☐ Filipino
☐ Other Asian — *Print race, for example, Hmong, Laotian, Thai, Pakistani, Cambodian, and so on.*
☐ Japanese
☐ Korean
☐ Vietnamese
☐ Native Hawaiian
☐ Guamanian or Chamorro
☐ Samoan
☐ Other Pacific Islander — *Print race, for example, Fijian, Tongan, and so on.*

☐ Some other race — *Print race.*

Source: (U.S. Census Bureau, 2010)

From 2000 U.S. Decennial Census data, Native Americans on reservations had per capita income of $7,942, compared with $21,587 for the average U.S. residents, and 39 percent of tribespeople live in poverty (Grogan, 2011). Even with the migration of Native American populations and a turn towards U.S. policies less hostile to Native Americans, there have been limited improvements in the socio-economic outlook for tribes. Struggles on reservations remain persistent.

*IV. Native American Reservation Economies*

Currently, Native American communities located on reservations have limited opportunities for development. An economy should allow for individuals to work and create wealth for themselves in a way that coordinates their efforts with opportunities. Tribal reservations are largely rural and disconnected from major hubs of business, have limited populations (some of which chose to migrate elsewhere for opportunity), and are restricted in their ability to independently manage reservations resources without interference from the U.S. government. Even though they may be "resource-rich" and receive payments from federal assistance programs, nearly all reservations remain on the lower end of the income spectrum in the United States (Anderson, 2006). Tribes face many economic challenges and assessing what works and what does not is important to tribal success.

Although tribes were intentionally given land that was deemed undesirable, over the course of many decades some reservations have been found to contain coal, oil, and gas deposits, which have increased the value of the land. Specifically, significant quantities of these resources can be found primarily in Arizona, Colorado, Montana, New Mexico, Oklahoma, Utah, and Wyoming (Grogan, 2011). Of these seven states, six of them are included in this study. The Department of the Interior estimates that undeveloped reserves of coal, natural gas, and oil on tribal lands could generate nearly $1 trillion in revenues for tribes and surrounding communities. These resources present untapped potential economic opportunities for tribes. However, their difficult relationship as sovereign nations under the protection of the federal government, along with many other considerations, affect tribe's ability to develop these energy resources.

A primary source of income for tribes is agriculture. According to the 2012 USDA Agricultural Census, the number of American Indian farmers in the United States was 58,475 across the country. This was a 5 percent increase since the last Agricultural Census in 2007 (U.S. Department of Agriculture, 2014). Eighty percent of these farmers lived in seven states in 2012: Arizona, Oklahoma, New Mexico, Texas, Montana, California, and South Dakota. Three of these states are included in this study. Apache County, Arizona had more American Indian farmers than any other county in the United States. Apache County also has portions of three different reservations within the county boundaries and the most land designated as reservation land of any county within the United States (Arizona Commerce Authority, 2018). In 2012, two-thirds of American Indian farmers specialize in livestock production. A total of 37,851 farms having a principal operator who is Native American, sold $1.8 billion in agricultural products and operated 51 million acres of farmland. (U.S. Department of Agriculture, 2014)

In addition to agriculture and energy resources, gaming, fishing, and forestry present possibilities for which many tribes look to generate income and opportunity. In the United States, 199 reservations of the total reservation lands contain 7.7 million acres of forestlands, and 185 reservations contain 10.2 million acres of woodlands (Hendee, 2012). The difference between these two definitions is that forest lands have a closed-canopy (trees that have branches come together which close off a clear view of the sky) and allow for very little light. Woodlands have a limited amount of cover (30% to 100%) from tree canopies (Missouri Department of Conservation, 2018).

Tribes have recently gained further leverage to promote growth of their economies. Since the passage of the "Indian Gaming Regulatory Act" in 1988, tribal gaming has grown from a "$121 million segment of the U.S. gaming industry, to a $30 billion plus segment in 28 states" (Meister, 2017). Gaming as a component of tribal economies has raised questions of the value received for tribal communities. In a paper by Taylor which compared the U.S. Decennial Census of 1990 and 2000, income levels rose by "33 percent and the poverty rate dropped by 7 percent" across tribes. Those with gaming operations have limited differences in these measurements compared to those without casinos (Taylor, 2005). This highlights concerns that gaming may not be benefitting tribe members. This concern promotes the need to find evidence of what is working to improve socio-economic characteristics of tribes.

In 1996, research using U.S. Census data concluded that education is the most prominent factor in promoting sustainable tribal economic development. The paper, completed by Vinje, used fifteen models comprised of three sets of U.S. Decennial Census data, and a bivariate linear regression with five different types of employment to come to their conclusion (Vinje, 1996). Results showed that education was the most robust variable within this analysis. The paper also asserts that promoting government or private employment, or the usage of natural resource or development of manufacturing, all result in outcomes which do not increase economic development activity. This is a concern, as one of the primary suggestions for tribal economic growth is for tribes to access and manage their natural resources, and this research seems to contradict that advice.

Although the previous paper by Vinje indicates the importance of education, tribes face challenges in this demographic as well. College graduation rates increased for tribal communities between 1990 and 2000, but were still less than half of the 31% of the general U.S. population who have achieved at least a bachelor's degree (Taylor, 2005). From this same time period, however, tribal communities are on par with high school completion when compared to the rest of the U.S., a figure that also appears to be rising for 2000 compared to 1990.

A study in 2000 by Cornell and Kalt revealed that resource and human capital endowments are not the keys to the success in launching Native American economies. Using percent workforce employed and percent of adults with income over the Bureau of Indian Affairs minimum (similar to a poverty level), they found that tribal institutions, which can be defined as the structure in which a society chooses to operate (can be legal institution of laws agreed upon by the community, socially in how disputes are resolved within the community) are a main determinant of economic success across tribes (Cornell S. K., 2000). Communities which have these institutions present in a way that allows for the community to understand the important processes, allows for the community to learn how to grow and develop within the structure. It is difficult to create these institutions, especially to tribal outsiders like a non-governmental organization or the U.S. federal government. Additionally, development is strengthened when the structures match indigenous norms and customs, and therefore have the capacity to reinforce tribal traditions.

Pickering has conducted research using U.S. Census Bureau data to test whether cultural characteristics of tribes impact their level of economic development. Using Per Capita Income as the dependent variable, economic variables such as education, percent employed in manufacturing, percent employed in managerial or professionals, population, and reservation size were used as independent variables. This data was joined with social and cultural characteristics such as social structure, presence of intergroup reciprocity, and political organization that existed pre-European contact (Pickering, 2000). Results of this study conclude that the cultural characteristics have no impact on the dependent variable, but that these characteristics are significant in a second regression performed on various measures of income inequality. The paper completed by Pickering is used to inform this study, as Per Capita Income is also be used as a dependent variable in econometric models, and in further analysis of difference of means between groupings of tribal communities.

Past research has investigated factors affecting economic development of tribal reservations. In examining the success stories, tribes that are able to "move aggressively to take control of their futures and rebuild their nations, rewrite constitutions, reshape economies, and reinvigorate indigenous community and culture… they are creating sustainable, self-determined economies and building societies that work" (Cornell, S.K, 2006, page 2). Tribes which can fully access tribal sovereignty can effect positive change within their community and cultures. In addressing the reality that tribal communities do need to be rebuilt and treated similar to countries with economic development needs, granting a tribal government the ability to make their own decisions means that they will be more likely to find ways to meet their needs. Within the current study, the focus is to further assist tribal governments with the exploration of data so that the crucial issues can be investigated and provide insight into what sources of "nation-building" are effective.

*V. Native American Economies and Water Rights*

Tribes in the Western U.S. are quantifying their water rights using the court system, which results in decrees, and through negotiating with other stakeholders over tribal water rights. This is an integral opportunity for a tribe's ability to develop their resources, which could assist in sustainable economic growth and to further empower tribal sovereignty. Water supplies are important for tribal salmon hatcheries and fish reintroduction efforts, riparian restoration, forestry, agriculture, small-scale hydropower, and municipal uses (CRITFC, 2019). An increase in these opportunities through quantification of water rights could assist in retaining Native American population on the reservation, providing potable water to reservation residents, and opportunities for economic growth.

Increasingly, tribal water quantification agreements also include the opportunity to lease their water resources to other users who may be willing to pay more than the value of water for on-reservation uses. As an example, tribal farming enterprises could forgo their use in order to lease the water to non-tribal users (Colby, 2006). The question that arises is if water quantification (or leases in lieu of water use) provide measurable increase in the economic status of tribal families or individuals. In acquiring quantified water rights, tribes are not immediately awarded with water flows onto their reservations. As some tribes do not have direct access to the water source for which they gained rights, some tribal water settlements include water infrastructure development. Some settlements have gone underfunded and not completed, further delaying the acquisition of water. If tribes can lease their quantified water, at minimum they can pursue options to be compensated in the interim and use water as a source of income. For the tribal water right quantifications that have occurred between 1978 and 2016, the average estimated federal cost of each settlement or court decree is $209.9 million of nominal dollars (Stern, 2017). This figure represents the litigation costs as well as any implementation and infrastructure costs that may have been negotiated. It is important for tribes and stakeholders to maintain an awareness of the financial cost of quantifying water rights.

With climate change, increased temperatures lead to scarcity of water and increased demand for secure sources of water. In Arizona, the Hualapai Tribe depends on tourism, big-game hunting, cattle grazing, and forestry for revenue, and its economy was greatly impacted by a multiyear drought in the early 2000s. The drought forced the tribe to sell approximately 500 of its cattle because of supplemental water and feed costs (Knutson, Svoboda, & Hayes, 2006). Tribal governments need to be reliable in order to sustain economic growth, and secured sources of water can alleviate some concerns and provide for greater sources of tribal resilience in the face of increasing weather pattern fluctuations.

A study completed by Deol and Colby analyzes characteristics of tribes who have quantified their water rights compared to those who do not (Deol, 2017). Using two models, one completed using a "Probit model", which estimated the probability that tribes have quantified their water rights using the compiled characteristics, and a series of second models which use income and employment to test whether these economic variables have a relationship with quantified tribal water rights and tribal casinos. The results of this study found that "tribes who operate casinos and have higher revenues from agricultural goods are more likely to have quantified water rights. And if a tribe has quantified water rights, they are more likely to operate a casino" (Deol, 2017). Deol's report did not seek to establish a causal relationship between having quantified water rights and having a casino. The data is inconclusive regarding whether tribes first quantify water rights, and this allows for leverage to build a casino, or whether tribes building a casino allows for them to pursue water rights quantification.

There are some success stories for tribal economies. Water can play a role in this, but without further understanding of the impact of the water rights, it may be difficult to fully justify using the already limited resources tribal governments to pursue the quantification process. Native American tribes need relevant and culturally appropriate monitoring, assessment, and research on their waters and lands and to develop, or be included in the development of, contingency, management, and mitigation plans (Cozzetto, 2013). Tribes also need actual and concrete implementation of projects that can have measurable results. Climate change can and should be incorporated so that tribal projects can also withstand the upcoming challenges that impact the entire world.

*VI. Economic Studies at the Census Tract level*

Few studies have used census tracts as the primary observation unit and spatial scale to complete their analysis. It can be difficult to convey how and why the U.S. Census Bureau creates this geographic marker for their surveys. Tracts are created with an optimal population of 4,000 people, but also ideally have a minimum of 1,200 and maximum of 8,000 people (U.S. Census Bureau, 2015). Geographically, tracts are designated using obvious permanent markers. Within this study, a critical point to remember about census tracts is that they are nested, or contained fully, within a county. They do not overlap across counties and into multiple counties and can be scaled up to reflect the entirety of a county.

One paper that uses census tracts as a unit of measure was completed by Prieger and examines whether there are economic benefits to mobile broadband internet access in rural areas (Prieger, 2013). This paper performed various regressions with different types of broadband access being the explained (dependent variable) at the census tract level. The study conclusions are explained across rural and urban development perspectives, and the outcomes of this research state that “for faster forms of fixed broadband, availability and the number of providers in rural areas is lower than in urban areas broadband, but rural availability appears to be greater than urban availability for lower-speed fixed broadband” (Prieger, 2013). This means that while high-speed broadband access is not necessarily spread evenly across rural and urban areas, if the speed does not particularly matter, the access is quite similar. The result of this paper show that economic analysis can be performed using census tracts data.

An additional example of research completed using census tract as the spatial scale was published by Conley. Using variables gathered from census data that cover racial/ethnic makeup, employability and education, housing, and others, the paper investigated if there were any spatial patterns in unemployment in Chicago (Conley, 2002). Results from this paper show a meaningful relationship between unemployment and spatial clusters. However, once they were able to remove the spatial connection by using a non-parametric function, the next most significant factor in unemployment are the racial and ethnic variables included in the study, and explain their observed patterns (Conley, 2002). This paper assists in identifying common problems with performing analysis using census tracts. It also is important as it confirms that meaningful analysis of race/ethnicity patterns can be performed at the census tract level and incorporating economic characteristics into this analysis can produce meaningful insights.

### *VII. Contributions of this Study*

This study uses census tract data to assess relationships between economic variables related to tribes in ten western U.S. states. Including tribal demographics as an independent variable is a new contribution of this research. Additionally, this study looks to explore whether there are significant differences between groupings of counties by specific tribal characteristics. Previous work has been done to confirm the economic hardships of tribal communities through various methods of analysis. By completing this evaluation at the census tract level, a higher resolution of data is achieved. This paper may be the most up-to-date analysis done with at the census tract spatial scale.

# Chapter 3
# Theoretical Model

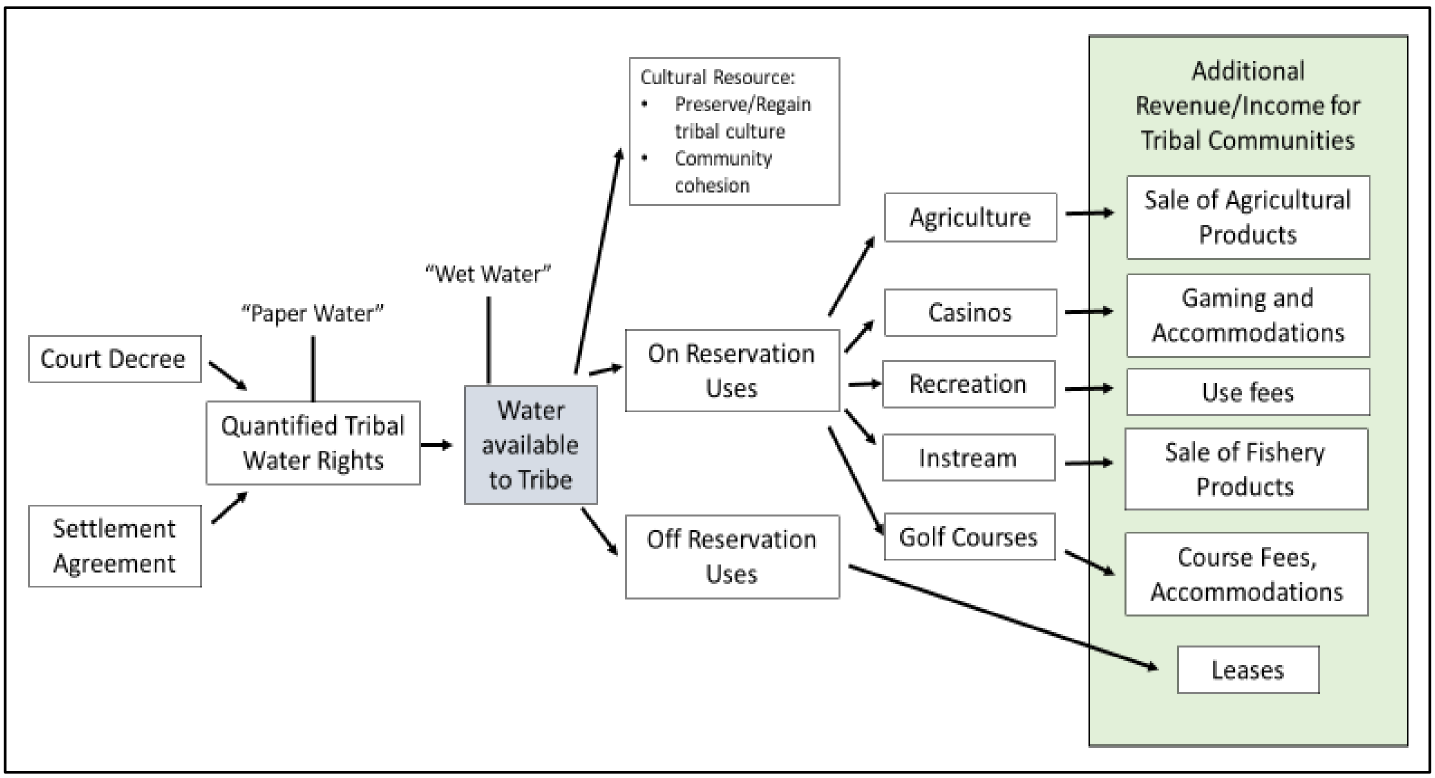
Tribal reservations and tribal communities are often likened to developing countries, in that they struggle with access to necessities like housing, food, and water and meeting the needs of their populations. Decisions must be made how to best allocate their resources. Often, the stakes are much higher relative to other communities in the U.S. as basic needs can go unmet if the decisions do not result in their desired outcomes. To understand this development process, Acemoglu states:

> *"It is not just about growth of aggregate output, but also about the fundamental transformation of an economy, ranging from its sectoral structure, to its demographic and geographic makeup, and perhaps more importantly, to its entire social and institutional fabric. These processes naturally require a much more holistic approach to economic growth and development than in many other areas of economics. Thus, the political, social and demographic elements in the process of growth are paramount."*
>
> (Acemoglu, 2012)

The main message of this statement is that economic growth and development outcomes that we wish to measure are the result of many converging and interacting factors. A well-rounded approach is required to understand them.

By gaining quantified tribal water rights, tribes are potentially unlocking a new opportunity for economic development. With the "homeland" standard being applied to these quantifications, the uses for tribal water have expanded and could provide tribes with multiple avenues to generate addition revenue sources but also to preserve/regain aspects of their cultural heritage. There is a difference between winning a court decree or agreeing to a settlement and receiving “paper water,” which is a right to the water, but no actual water delivered for tribal uses. This is different than receiving the water or gaining “wet water” for use on tribal lands. Figure 3.1 provides a flow-chart depicting how water rights can potentially impact tribal communities:

*Figure 3.1 – Potential Impact of Quantification of Tribal Water Rights*




Tribes can pursue different methods to best use their acquired water, each of which entail their own benefits and costs for tribes. The additional revenue generated from each of these projects could amount to increased income opportunities for members of the specific tribes. These factors were considered when creating the model that follows in this chapter.

*I. Model Definition*

To explore and understand tribal economies, previous research has been reviewed in order to create a model that better encompasses factors that may explain the economic well-being of tribal areas and communities. The history of tribes and the relationship between their reservation lands and the U.S. government was explored, the migration of Native American populations was reviewed, along with recent research on the composition of tribal economies and the connection with the persistent socio-economic struggles of tribes, as well as how quantified tribal water rights have been found to impact economic growth of tribes. The synthesis of these results is helpful in creating a model that will look to explore and measure whether tribal presence explains in a significant manner a relationship with two dependent variables that will serve as proxies for economic well-being.

Past literature has used a general model that accounts for locational, structural, individual, and demographic characteristics of a locality or region (Leichenko, 2003). Locational examples include access to other communities, a structural example would be natural resource availability, individual can be unique industries within an area, and demographic could be education levels. To begin, two dependent variables are chosen as indicators of economic prosperity within communities. The first, Per Capita Income, is a measure of total income adjusted by total population within a defined area. The higher the value in this measure, the greater the economic health of that area. This is an individual measure, as it accounts for the size of the population. The second variable, Percent Families Above Poverty, is a measure of family income adjusted by family size. For families who are below the poverty threshold. It implies that families do not make enough money to meet the needs of the members of the family. A high value would signify that in the corresponding area, there is opportunity for families to provide for their members. The second variable differs from the first as it accounts for family units, as opposed to individuals, and it focuses on family poverty rather than average income.

The explanatory variables included in this model cover the characteristics previously mentioned. For locational measures, Percent Urban, Mean Commute in Minutes, and Residential Fixed Internet Access per 1000 Households are used to account for regional factors. For structural measures, Five Year Mean Standard Evapo-transpiration Index (SPEI) and Irrigation-Crop Surface Water Withdrawals are used to account for natural resource availability. For individual characteristics, Farm Gross Income/County GDP is used to describe the composition of agriculture within counties. Percent of Individuals over 25 years old with a Bachelor's Degree, Percent Working in Extraction/Resource Industries, and a combination of Tribal Land and Native American population is utilized at the tract level to create a binary variable of Tribal Presence, and these three are categorized as demographic variables.

The dependent variables for this theoretical model are similar to the one proposed by Leichenko in 2003. However, the explanatory variables chosen in this study differ from previous modeling done by Leichenko. Instead of binary variables to explain tribal land and Native American populations as a threshold, this paper creates a binary variable that accounts for Percent tribal land of total land (greater than or equal to 1 acre) and percent Native American population of total population (greater than or equal to 2.5% Native American population).

The theoretical model in this paper is therefore proposed as:

$$Per\ Capita\ Income = f(locational\ factors, structural\ factors, individual\ factors, demographic\ and\ tribal\ factors)$$

And

$$\%\ Families\ Above\ Poverty = f(locational\ factors, structural\ factors, individual\ factors,\ demographic\ and\ tribal\ factors)$$

These models will be used to examine local and regional economies and to identify the impact of tribal presence, a variable combined from percent tribal land and percent Native American population, at census tract spatial scales. Furthermore, relationships with the other variables within the model that are primarily serving as controls across spatial scales could exhibit interesting relationships.

In modeling local and regional economies, Acemoglu noted that factors which can generate production outcomes can be difficult to separate and insert into a model as they often lack independence from each other. By combining variables that represent broad categories together to characterize developing economies, a general model is chosen as it can provide insight and understanding as to the relation between tribes and the surrounding economies.

*II. Expected Relationships within Models*

This general model is created based on background information about tribal economies and includes environmental aspects that could provide additional insight into how the availability and use of these resources interacts with tribal variables. With these variables selected, expected coefficient signs and expected significances are listed in Table 3.1**:**

*Table 3.1 Expected Sign and Significance of Independent Variables*

| Variable | Category | Per Capita Income | % Families Above Poverty |
|---|---|---|---|
| “Tribal Presence” | Demographic | - | - |
| Percent Urban | Locational | + | + |
| Mean Commute in Minutes | Locational | -/+ | -/+ |
| Percent 25yrs and older with bachelor’s or more | Demographic | + | + |
| Percent Working in Extraction/Resource Industries | Demographic | - | - |
| Total Gross Farm Income / County GDP | Individual | - | - |
| Residential Internet per 1,000 Households | Locational | + | + |
| Irrigation-Crop Surface Water Withdrawals | Structural | - | - |
| Mean SPEI Squared, 2006-2010 | Structural | - | - |

**Key:**

| | |
|---|---|
| - | expected to have a negative relationship |
| + | expected to have a positive relationship |
| (green) | = Expected to have highly significant |
| (yellow) | = Expected to be somewhat significant |
| (blue) | = Expected to important, but of unknown significance |

The sign on the coefficient for each of these variables is qualitative, in that a variable that is expected to be negative, means it is likely to produce lower values of the dependent variables.

The expected significance of an independent variable means that it will correlate to a change in the dependent variable.  An example of this would be if “Mean Commute” shows a positive and significant relationship with income (the further the commute, the more income), that it would logically have a negative and significant relationship with poverty (the further the commute, the less poverty) in order for results to be consistent across the two dependent variables. Research has shown that education has a substantial impact on increasing income and reducing poverty, and it is expected that this will show up in the model regression results. Internet access has previously been linked to higher income levels and is expected to be lower in areas with higher levels of poverty, as shown in Table 3.1.

The effect of Percent Urban on income and family poverty is complicated. It can be expected that the more urban an area, the more economic opportunity there is, and this will have a positive relationship with income. However, poverty can be concentrated in some urban areas, however there are still opportunities to be found outside of urban areas. The expectation about the sign and significance of this variable is unknown. Mean Commute is similarly complex, as the expectation is that a longer commute indicates higher income, as it necessitates the ability to afford car and gas. Conversely, longer commutes could indicate a need to seek cheaper housing options further away, and this could offset the cost of a vehicle and gas. This variable should be significant, but it is not a priori clear in what direction it will affect income and poverty.

The set of variables that relate to agriculture, Farm Income/County GDP, Percent Working in Extraction/Resource Industries, and Irrigation-Crop Surface Water Withdrawals, all have the same expectations within this model. The economic assumption being made is that agriculture is often a low value occupation. This judgement is being made in comparison to other occupations. Therefore, it is expected that these variables will have a small and negative impact on income, and a similar significance but positive impact on poverty.

It is difficult to create an expectation on sign for the Mean SPEI squared variable. This variable has a “standard normal” distribution centered on zero, and squaring it means that unusual dryness or wetness for an area results in a positive value. This could create an interesting relationship with poverty and income. A significant and positive result for this variable on the regressions using income would mean that when an area is more dry or wet than usual, it would increase income. This is difficult to believe, as it is more likely that unusual conditions cause instability in markets and should lower income values. Due to this, the sign of Mean SPEI Squared’s coefficient expected to negative, as any unusual dryness or wetness will cause lower income and fewer families above poverty, but the significance is unknown.

Tribal Presence is expected to have a negative impact on the dependent variables. To be clear, this means that the greater the tribal presence, the less income. Consequently, this would mean the same for families above poverty, as with greater tribal presence, comes higher levels of poverty, and therefore lower values of families above poverty. Previous studies have suggested through comparison of group averages that this relationship exists. However, these studies have not developed a model that holds other factors constant to confirm this outcome.

# Chapter 4
# Data Collection

*I. Overview*

The data gathered in this study from six sources, is combined across two compatible spatial scales. U.S. Census Bureau data was collected across the two spatial scales and is for the year 2010. All other data is at the county spatial scale and for 2010, except for U.S. Department of Agriculture (USDA) information which is at the county-level but for year 2012. This USDA data is used to create a farm importance variable, “Total Farm Gross Income/ County Gross Domestic Product (GDP)” and is derived from the USDA Agriculture Census from 2012 in combination with Bureau of Economic Analysis (BEA) data from 2012. For the climactic variable, “Standardized Precipitation-Evapotranspiration Index (SPEI)”, a three-year average is used, with the final year of this information being 2010. The temporal scale of all variables is close (between 2010 and 2012) and the best publicly available data.

*II. U.S. Census Bureau Data*

The U.S. Census Bureau uses census tracts to divide up counties into distinct survey areas. Tracts are divided so that each belong to a specific county. This is done to provide a “stable set of geographic units for the presentation of statistical data” (U.S. Census Bureau, 2012). Census tracts do vary widely in geographic size, because they are created so that their populations optimally lie between 1,200 and 8,000 people, with a target census tract population being 4,000 people (U.S. Census Bureau, 2015). Therefore, land area which has a higher population density will have a higher number of tracts which consist of an overall smaller spatial area. In rural areas of land with lower population density, census tracts cover a larger area of land.

The U.S. Census Bureau does collect and provide information specific to federally recognized tribes. However, this data is limited and is best used as a link back to census tracts. A summary of the data gathered by the Census Bureau for each tribe is included in Appendix A**,** as is a figure which shows how tribal areas and census tracts overlap with each other. One piece of data gathered at the tribal level that has an additional measurement in the Decennial Census is Native American population. There are two potential measures for this, one included in tribal survey data, and one included in the general census survey data. These measures contain different values and are compared in Table 4.1, which was created by identifying the counties with the highest percent urban population across the ten states in this study. Native American population and land acreage is included to better understand the variables in question. These results show that the first measure, "Population Living on Reservation" is collected only where there is tribal land present. The second measure, "Population who identify as Native American" is collected across the general survey area, and contains population figures for those who self-identify as "American Indian alone or in combination… those respondents who reported American Indian and/or Alaska Native, whether or not they reported any other races" (U.S. Census Bureau, 2018).

*Table 4.1 – Native American population figures for predominantly Urban Counties*

| State | County | Urban Population | Total Population | Percent Urban | Population Living on Reservation | Percent Living on Reservation | Population who identify as Native American | Percent Identify as Native American | Tribal Land (acres) | Tribes |
|---|---|---|---|---|---|---|---|---|---|---|
| AZ | Maricopa County | 3,726,888 | 3,817,117 | 97.64% | 10,793 | 0.28% | 107,271 | 2.81% | 271,770 | Fort McDowell Yavapai, Salt River Pima |
| CO | Denver County | 600,158 | 600,158 | 100.00% | 0 | 0.00% | 14,995 | 2.50% | 0 | |
| ID | Ada County | 370,894 | 392,365 | 94.53% | 0 | 0.00% | 5,884 | 1.50% | 0 | |
| MT | Silver Bow County | 30,287 | 34,200 | 88.56% | 0 | 0.00% | 1,131 | 3.31% | 0 | |
| NM | Bernalillo County | 634,766 | 662,564 | 95.80% | 2,811 | 0.42% | 40,444 | 6.10% | 229,517 | Navajo, Isleta Pueblo |
| NV | Clark County | 1,925,784 | 1,951,269 | 98.69% | 637 | 0.03% | 30,205 | 1.55% | 78,892 | Fort Mojave, Moapa River |
| OR | Multnomah County | 725,464 | 735,334 | 98.66% | 0 | 0.00% | 18,041 | 2.45% | 0 | |
| UT | Salt Lake County | 1,020,354 | 1,029,655 | 99.10% | 0 | 0.00% | 15,377 | 1.49% | 0 | |
| WA | Pierce County | 742,814 | 795,225 | 93.41% | 46,774 | 5.88% | 25,408 | 3.20% | 22,428 | Nisqually, Puyallup |
| WY | Sweetwater County | 39,024 | 43,806 | 89.08% | 0 | 0.00% | 754 | 1.72% | 0 | |

Two U.S. Census Bureau data resources are used in this study; the 2010 Decennial Census, collected every ten years by the Census Bureau, and the 2010 American Community Survey (ACS), which is published every year. Responses to both are compelled by law but cover different topics (U.S. Census Bureau, 2019). The American Community Survey collects data on social and economic characteristics of communities, which are reported also at the census tract spatial scale. ACS results are based on monthly samples, which are then used to produce annual estimates for each of the variables of measure within the nation (U.S. Census Bureau, 2014). Previously, ACS data was gathered within the Decennial Census. The annual sample size for the ACS is 3.54 million U.S. households.

The U.S Decennial Census was most recently released in 2010, and the information provided by that report allows for connecting data between other sources in this study. The primary goal of the Decennial Census is to "provide population counts to Congress… to reapportion seats in the House of Representatives, to realign congressional districts, and… distribute hundreds of billions of dollars in federal funds each year." (U.S. Census Bureau, 2019). For this study, this amounts to population demographics at the census tract level within the ten target states in the western U.S. The Decennial Census also provides for interconnecting data at the County level, with its "FIPS" designations, and census tract level, with its "GEOID2" labels. All data resources are aligned using one of these two spatial identifiers. These two spatial scales are also connected, as the census tracts are all within specified counties. The ACS and Decennial Census are created so that the demographics can be compared. When joining these two data sources, the population figures were compared to verify this accuracy.

The two variables selected as dependent variables for this study, “Per Capita Income” and “Percent Families Above Poverty” have different definitions. “Per Capita Income” is defined by the U.S. Census Bureau as “the mean income computed for every man, woman, and child in a particular group including those living in group quarters. It is derived by dividing the aggregate income of a particular group by the total population in that group” (U.S. Census Bureau, 2010). As for “Percent Families Above Poverty”, it is the alternate percentage from Percent Families Below Poverty, defined by the U.S. Census Bureau as a

> “set of money income thresholds that vary by family size and composition to determine who is in poverty. If a family's total income is less than the family's threshold, then that family and every individual in it is considered in poverty. The official poverty thresholds do not vary geographically, but they are updated for inflation using the Consumer Price Index (CPI-U). The official poverty definition uses money income before taxes and does not include capital gains or noncash benefits” (U.S. Census Bureau, 2018).

These two measures differ initially by type of population they define. Per Capita Income is an individual measure, whereas Percent Families Below Poverty is a family measure. Second, Per Capita Income is not created using any thresholds, but is the average income for people of that area. Poverty is measured using thresholds updated for inflation but is a standard income value depending on family size and is a “low bar” for what families need in order to purchase goods and services essential to health and security, an example of this calculation, consider a family of five, two children, a mother and father, and a great-aunt. The poverty threshold for a family of this size is $29,986 (in 2017). The family income would have to be below this value (threshold) in order to be in poverty (U.S Census Bureau, 2017).

*III. U.S. Department of Agriculture Data*

The USDA gathers information for the “Census of Agriculture”, which is published every five years, and is collected for any farm or land area that “raises or sells more than $1,000 of agricultural products” (U.S. Department of Agriculture, 2018). The Census of Agriculture gathers data on “land use and ownership, operator characteristics, production practices, income and expenditures” and from the 2012 Census of Agriculture, “Total Gross Farm Income” by county is used in this study to partially define agricultural importance. In addition, data from the BEA (Bureau of Economic Analysis, 2012) is used to create a county-level measure of agricultural importance, by dividing “Total Gross Farm Income” by “County Gross Domestic Product”, to define and understand the county-level impact of farming, for counties within the scope of the study.

*IV. Additional Data Sources*

This study also uses 2010 survey data gathered by the Federal Communications Commission (FCC, 2010). The FCC collects information on Internet Service providers at the County and Census Tract spatial scale, dating back to 2009. Prior to that year, they collected similar information back to 2000. Although offered at Census Tract level, this data was examined and has many missing values. So, the county measure of “Residential Fixed (Internet) Connections per 1,000 Households” was included in this study.

The final data resource is the Center for Disease Control and Prevention (CDC). With data going back to 1985, they have provided access to climate information by counties using monthly “Standardized Precipitation-Evapotranspiration Index” (SPEI), which was supplied by the Cooperative Institute for Climates and Satellites – North Carolina (Centers for Disease Control and Prevention, 2017). SPEI classifies the precipitation and water balance anomalies with respect to the long-term records and is calculated using "using the cumulative water balance instead of precipitation sums… the SPEI hence represents the standard-normal distributed water balance" (MeteoSwiss, 2011). Table 4.2 depicts how the values for this measure are entered. Provided by the CDC, these values are collected monthly at the county level, and then were created into a three-year "Mean SPEI", which covers the years 2007 to 2010 for the counties within the study. Using this resource allows for the data to be joined by spatial scale and temporal scale.

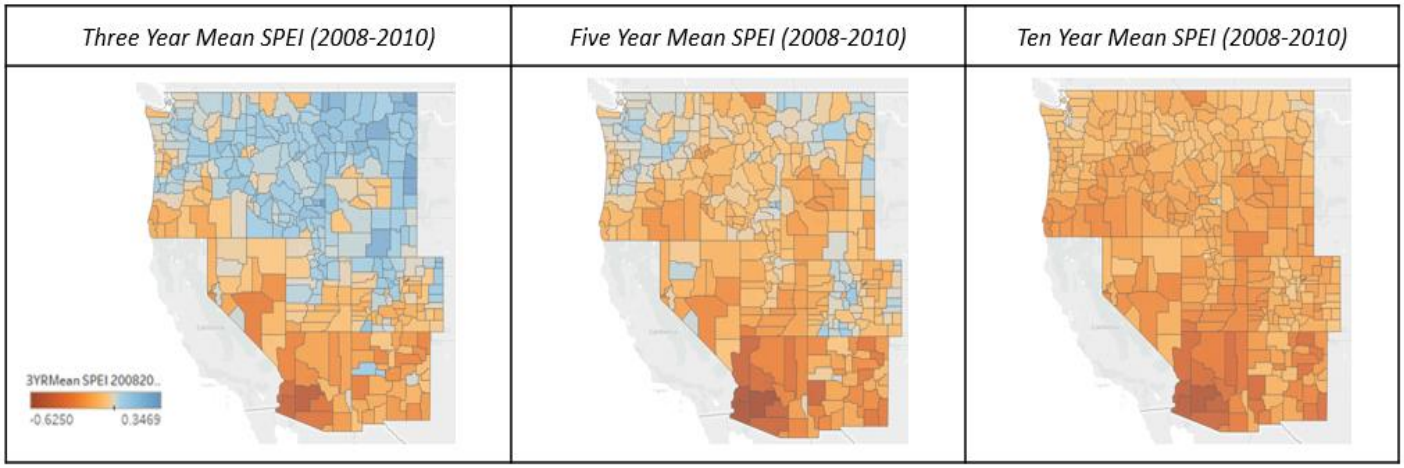
*Table 4.2 – Mean SPEI values interpretation*

| index value | color | description | frequency of event in respective month |
|---|---|---|---|
| > 2 | | exceptionally wet | 1 x in 50 years or less |
| 1.6 bis 1.99 | | extremely wet | 1-2 x in 40 years |
| 1.3 bis 1.59 | | severely wet | 1-2 x in 20 years |
| 0.8 bis 1.29 | | moderately wet | 1-2 x in 10 years |
| 0.5 bis 0.79 | | slightly wet | 1-2 x in 5 years |
| 0.49 bis -0.49 | | normal | |
| -0.5 bis -0.79 | | slightly dry | 1-2 x in 5 years |
| -0.8 bis -1.29 | | moderate drought | 1-2 x in 10 years |
| -1.3 bis -1.59 | | severe drought | 1-2 x in 20 years |
| -1.6 bis -1.99 | | extreme drought | 1-2 x in 40 years |
| < - 2 | | Exceptional drought | 1 x in 50 years or less |

*Source: MeteoSwiss* (MeteoSwiss, 2011).

A proper time-span for this variable was also chosen. Initially, a three-year (36 month) mean was assumed to be an adequate measure. However, after comparing the data across the spatial scale of this study, this has a high level of variability, and it was deemed better to use a longer temporal scale of five years. In Figure 4.1, the different temporal lengths are compared:

*Figure 4.1 – Comparison of Temporal Scales for Mean SPEI*




*V. Data Challenges*

Data on tribes is sparse and difficult to compile outside of publicly accessible resources. It would be ideal for analysis purposes if more specific information could be collected and compared across tribes at the reservation spatial scale. However, gathering this information would require collaborative efforts across over 109 tribes in the area researched by this study (National Conference of State Legislatures, 2018). This study therefore uses census tracts as its primary spatial unit of measure. However, some data is only available at the county level. Table 4.2 shares which variables are at the different scales. With multiple data sources, it was not possible to maintain the exact temporal scale across all variables, but they are close for phenomena that changes slowly (Years 2010 or 2012).

*Table 4.3 Spatial Scale of Variables Used*

| Variable | Census Tract Level | County Level |
|---|---|---|
| Per Capita Income | X | |
| Percent Families Above Poverty | X | |
| Percent Tribal Land | X | |
| Percent Native American Population | X | |
| Percent Urban | X | |
| Mean Commute in Minutes | X | |
| Percent 25yrs and older with bachelor’s or more | X | |
| Percent Working in Extraction/Resource Industries | X | |
| Total Gross Farm Income / County GDP | | X |
| Residential Internet per 1,000 Households | | X |
| Irrigation-Crop Surface Water Withdrawals | | X |
| Mean SPEI, 2006-2010 | | X |

Additionally, it is important to recognize that one dependent variable, “Percent Families Above Poverty” is a threshold measure. This threshold of poverty could be considered arbitrary but is a commonly accepted measure and is helpful as the family grouping does differ from the individual scale that is represented with “Per Capita Income”.

A further concern within this study is that values within the data likely are spatially clustered, with neighboring census tracts containing similar values. As census tracts are a small spatial scale, errors (residuals) could potentially be correlated across spatial units. By using two dependent variables in this study, it may be possible to identify a consistent pattern between the two that exists independently outside of this issue. This challenge of spatial autocorrelation is addressed in the next chapter.

*VI. Final Dataset*

The advantages of using multiple data sources in this study are to provide broad insight into how tribal land and population combined to create tribal presence factor into local economies. By maintaining variables at the census tract spatial scale, their variability across geographic units is maintained, and important factors that would otherwise be excluded can be included through merging multiple sources.

There are 7,515 census tracts in the ten states included in this study. For the data included in this study, there were 25 tracts with incomplete data (0.33%). Tracts with zero population were first to be removed. The rest of the incomplete observations are attributed to the education variable, "Percent of individuals 25 years and older with bachelor's or higher". The observations with the missing values were removed from this analysis, resulting in 7,490 total observations.

Two dependent variables are chosen for analysis. The two variables represent different units of population, and are "Per Capita Income", a measure for individuals, and "Percent Families Above Poverty", a measure that represents the family unit. Both are differently sized groups of people, and the independent variables may have somewhat different relationships with each. Table 4.3 provides dependent variable definitions and descriptive statistics.

*Table 4.4 Dependent Variable definitions and descriptive statistics*

| Variable | Definition | Min | Max | Median | Mean | St.Dev |
|---|---|---|---|---|---|---|
| Per Capita Income (n=7,490) | "Per capita income is the mean income computed for every man, woman, and child in a particular group. It is derived by dividing the total income of a particular group by the total population." | $0.00 | $ 165,454.00 | $ 24,889.50 | $ 27,221.43 | $ 12,110.35 |
| Percent Families Above Poverty (n=7,490) | "a set of money income thresholds that vary by family size and composition to determine who is in poverty. If the total income for a family, then the family (and every individual in it) or unrelated individual is considered in poverty." This value was used and the opposite, those above, was calculated. | 2.90% | 100% | 92.60% | 89.84% | 9.61% |

*Source:* (U.S. Census Bureau, 2018)

As a variable of interest, Tribal Presence was created from two tribal variables "Percent Tribal Land" and "Percent Native American population". Percent Tribal Land was calculated using Tribal Land acres, provided by the U.S. Census relationship file, for each tract, divided by the total land area of the census tract. Native American population is collected as a count variable. Figure 4.2 shows the density distribution for the two tribal variables, prior to the percent calculations:

*Figure 4.2 – Densities of Tribal Variables used to create Tribal Presence*

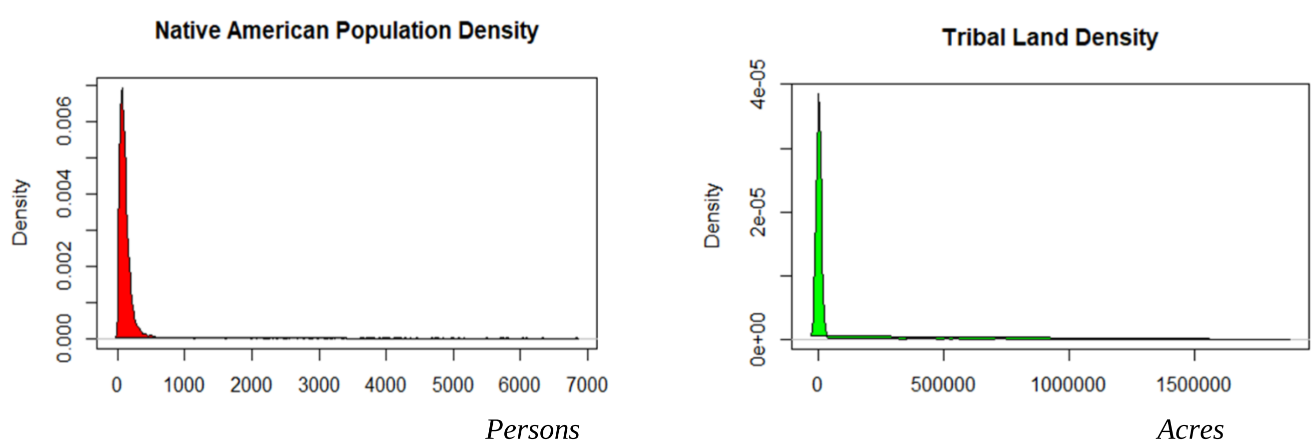


Table 4.5 contains definitions and descriptive statistics of the independent variables. These variables include both census tract and county level spatial scales, with Total Gross Farm Income/County GDP (farm importance), Irrigated Crop – Surface Water (water usage), Residential Fixed Connections per 1,000 Households (internet access), and Standardized Precipitation-Evapotranspiration (SPEI, climate) variables all measured at the county scale. The other variables in this study are at the census tract spatial scale and include Mean Commute to Work in minutes (work opportunities within tract), Percent Individuals above 25 years that are High School graduates, or have bachelor's degree or higher (education), and Percent in Occupation types (work in tracts). Of the occupation types, only percent in "Agriculture, Fishing, Mining, and Hunting" occupations are kept, as this study is focused on how water and therefore agriculture contributes to a local economy.

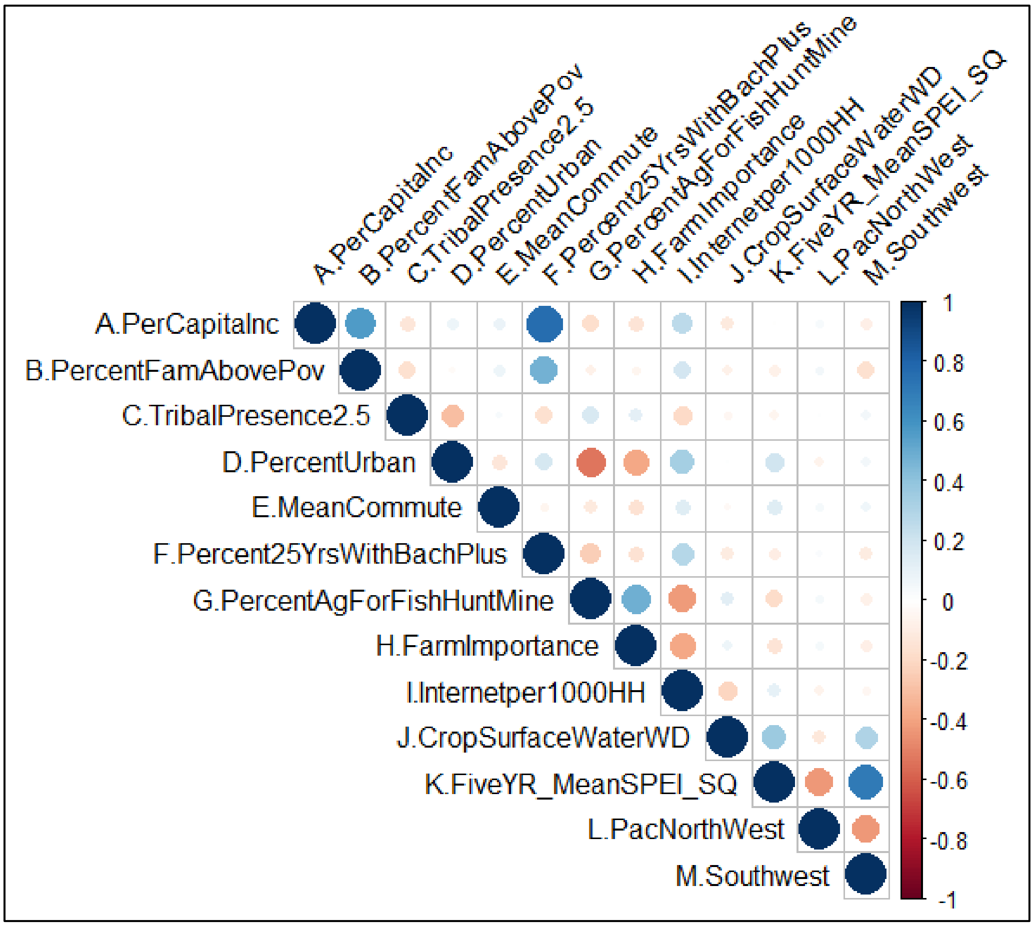
*Table 4.5 – Independent Variable Definitions and Descriptive Statistics*

| Variable (Abbreviation) | Definition | Min | Max | Median | Mean | St.Dev |
|---|---|---|---|---|---|---|
| "Tribal Presence" (TribalPresence2.5) n=7,490 | Tracts that contain at least 1 acre of tribal land and at least 2.5% Native American Population | 0.00 | 1.00 | 0.000 | 0.048 | 0.213 |
| Percent Urban (Per_Urban) n=7,490 | Population defined as "Urban areas of densely developed territory, specifically all territory, population and housing units in urbanized areas and urban clusters" by U.S. Census Bureau, divided by Total Population, in Census Tract | 0.00 | 1.00 | 100.00% | 81.72% | 33.98% |
| Mean Commute in Minutes (Mean_Traveltime_toWork_inMin) n=7,490 | Mean Commute for Workers, in Minutes | 0.00 | 64.60 | 22.900 | 23.211 | 6.334 |
| Percent 25yrs and older with Bachelors or more (Per_Over25yrs_withBach_orHigher) n=7,490 | Population over the age of 25 who have a Bachelor's degree or higher, divided by Total Population, in Census Tract | 0.00 | 100% | 24.4% | 28.36% | 17.05% |
| Percent Working in Extraction/Resource Industries (CPer_Extraction/Resource) n=7,490 | Population whose occupation "primarily engaged in growing crops, raising animals, harvesting timber, and harvesting fish and other animals from a farm, ranch, or their natural habitats", divided by Total Population in Census Tract | 0.00 | 83.5% | 0.90% | 3.27% | 6.45% |
| Total Gross Farm Income / County GDP (CPer_TotalGrossFarmIncome_ofCountyGDP) n=7,490 | "Gross income from farm-related sources received in 2012 before taxes and expenses from the sales of farm byproducts and other sales and services closely related to the principal functions of the farm business" divided by " gross domestic product which are estimates of the value of the goods and services produced in a county." | 0.00 | 0.41 | 0.00098 | 0.00478 | 0.013 |
| Residential Internet per 1,000 Households (CResidential_Internet_per1000HH) n=7,490 | Residential Fixed High-Speed Connections over 200 kbps in at least one direction per 1,000 Households | 1.00 | 5.00 | 4.00 | 3.83 | 0.52 |
| Irrigation-Crop Surface Water Withdrawals (CIrrgCrop_SurfWater) n=7,490 | "Surface water that is applied by an irrigation system to assist crop and pasture growth. Irrigation includes water that is applied for pre-irrigation, frost protection, chemical application, weed control, field preparation, harvesting, dust suppression, leaching of salts from the root zone. Irrigation water use estimates also include conveyance losses." | 0.00 | 1134.73 | 24.70 | 112.44 | 180.14 |
| Mean SPEI Squared, 2006-2010 (5YR_MeanSPEI_SQ) n=7,490 | "calculated using the cumulative water balance instead of precipitation sums. The SPEI hence represents the standard-normal distributed water balance" as a montly measure, which was then transformed into a 5-year mean. This variable was then squared to remove negative values and to indicate any generally unusual climate pattern. | 5.48E-35 | 0.390625 | 0.010 | 0.086 | 0.135 |
| Southwest (SouthWest) n=7,490 | Variable created to account for regionality within the model. Includes the states Washingon, Oregon, Idaho. | 0.00 | 1.00 | 0.00 | 0.343 | 0.475 |
| Pacific North-West (PacNorthWest) n=7,491 | Variable created to account for regionality within the model. Includes the states Arizona and New Mexico | 0.00 | 1.00 | 0.00 | 0.269 | 0.443 |

*Sources:* (U.S. Census Bureau, 2018; U.S. Department of Agriculture, 2012; Bureau of Economic Analysis, 2012; FCC, 2010; USGS, 2010; CDC, 2010)

After variable selection but prior to estimating the model parameters, the variables were checked for correlation. This was done to see that none of the variables included in the model exhibit “perfect collinearity”. This is when one variable does not have a constant or exact linear relationship with one of the other variables (Woolridge, 2006). This includes a relationship with the dependent variables but also other intendent variables. Results from this correlation check are shown in Figure 4.3:

*Figure 4.3 – Correlation Plot for All Variables within Study*




It is expected that the education variable Percent 25 Years and Older with a bachelor’s degree or higher (E) would have a positive correlation and the plot above provides insight to this relationship, but primarily with Per Capita Income (A). The relationship between these two variables is not perfectly collinear. The other variable relationship of note is Percent Urban (D), which has a negative relationship with the Percent Working in Extraction/Resource Industries (F). This is logical as there are less farms in urbanized areas, as compared to more rural areas.

This collection of data has been merged according to either county or census to be useful in examining the relationship between local economies and Native American tribes within the target states. This study uses this merged data to explore how tribal land and Native American population impact the selected dependent variables, and how a comparative analysis of the counties with tribal presence differ along selected known characteristics.

# Chapter 5
# Econometric Models and Results

*I. Model Specification*

Based on the conceptual model discussed in Chapter 3, an econometric model was created to explore the role of tribal presence using two economic variables as dependent variables. Previous research indicates that tribes suffer from higher rates of poverty and lower incomes when compared to the overall United States (Regan, 2014).

Potential independent variables were examined using a linear multi-variate regression model. The econometric models explored reflect many of the opportunities and limitations consistent with tribal reservations. The results from other variables are listed in Appendix B, along with a brief explanation of why they are not included in this study. Limitations of the cross-sectional data prevent establishing causal relationships. Instead, the model focus is on providing empirical analysis that explores the potential effects of tribal land and Native American population, when other factors are controlled for.

There are two dependent variables in this study, Per Capita Income and Percent Families Above Poverty. As established in Chapter 3, these are used to explain economic well-being at the county and census tract spatial scales. With these two dependent values, the expected signs of the coefficients for independent variables would need to match in order to have a stable relationship with income and poverty.

For each dependent variable, two models each were created as follows:

**Model 1**: $$Per\ Capita\ Income = \beta_0 + \beta_1 Tribal\ Presence\ + Locational\ Variables + Structural\ Variables + Individual\ Factors + Demograhpic\ Variables +\ \varepsilon$$

**Model 2**: $$\%\ Families\ Below\ Poverty = \beta_0 + \beta_1 Tribal\ Presence + Locational\ Variables + Structural\ Variables + Individual\ Factors + Demograhpic\ Variables +\ \varepsilon$$

The independent variables were presented in Chapter 3. “Tribal Presence”, a binary variable, indicates if a tract has greater than 1 acre of tribal land and greater than 2.5% Native American population. This model also includes independent variables where the only reliable data is found at the county-level. In order to include these variables, they were imputed as the same value for each census tract within the county. This is possible as each census tract is nested within a defined county. Census tract data is kept at this spatial scale and is not averaged at county level and retains the original variability.

In order to estimate parameters for the linear regression model, “Ordinary Least Squares (OLS)” is used, which minimizes the sum of the squared residuals (Woolridge, 2006). This procedure gives a parameter estimate for each independent variable that minimizes the distance (error or residual) between the value predicted by the model and the actual value given by the data. OLS estimators are based on a set of assumptions made so that the parameters can considered good estimates for the population in the study. These assumptions and their validity are discussed further in the next section.

*II. Model Diagnostics*

For a linear regression on cross-sectional data, various econometric concerns must be considered. Assumptions (also referred to as Gauss-Markov assumptions) must be made in order to use OLS as a “Best Linear Unbiased Estimator (BLUE)”. One of these assumptions is that the for this model are constant variance and “spherical” errors, also defined as homoskedastic. Tests for heteroskedasticity can be applied: if it is present, the residuals will have non-constant values, and a pattern will emerge that corresponds with changes to the dependent variable (Woolridge, 2006).

To test this assumption of homoskedasticity, White’s Test and Breusch-Pagan Tests are most commonly used. For Breusch-Pagan, the model is estimated, and the residuals obtained. These residual estimates are then regressed on the same set of independent variables, and the “R-squared” from this second regression is retained. This measures how well the independent variables explains the deviations from the first regression. This is then used to compute a “p-value”, which indicates whether to keep or reject the hypothesis that the model is homoskedastic (Woolridge, 2006).

White’s Test regresses the squared residuals from the initial OLS model against the independent variables ($x_i$), squares of independent variables ($x_i^2$), and cross products ($x_i*x_j$). This also results in a test statistic that can be used to compute a p-value and allows for the null hypothesis (that the model is homoskedastic) to be accepted or rejected.

Both tests were performed on the two models presented in this chapter, with the null hypothesis of homogeneity. The results of the tests are in Table 5.1:

*Table 5.1 – Heteroskedasticity Test Results*

| Model | Dependent Variable | Variable of Interest | Test | P-value | Reject Null? |
|---|---|---|---|---|---|
| 1 | Per Capita Income | "Tribal Presence" | White | <0.0001 | Yes |
| | | | Breusch-Pagan | <0.0001 | Yes |
| 2 | % Families Above Poverty | "Tribal Presence" | White | <0.0001 | Yes |
| | | | Breusch-Pagan | <0.0001 | Yes |

These results show that for the two models within this section, the null hypothesis was rejected. This result signifies that the models exhibit heteroskedasticity. To correct for this, model standard errors can be re-estimated using White's Robust Standard Errors to ensure their values are not biased by heteroskedasticity.

In econometric models, independent variables are chosen so that they explain change in dependent variables, and their independence means they change without influence of the dependent variable. If this independence is questionable, it could mean that reverse causality is possible between the variables, and the dependent variable also explains changes in the independent variable. To estimate a linear model, the explanatory variables must exhibit independence from other variables (but not independent of the residuals). To provide an example of endogeneity within this model, it would be to claim that a census tract has high per capita income because it has a high value of internet connections, rather than internet connections mean that people are able to have higher incomes. If variables do not exhibit independence, they are then endogenous within the structure of the model.

Endogeneity in the model will result in biased estimates, and the Durbin-Hausman-Wu test can assist in testing for it in OLS regression models. This test is performed by selecting an instrumental variable (IV). For this model, the IV selected was "Percent of Population in the workforce who use Public Transit (Per_PublicTransit)", as it was thought this would have a relationship with "Mean Commute in Minutes" but not directly with the dependent variables of income and poverty. This instrumental variable was also ideal as it is a measure that can be applied at the census tract level.

Both models were tested using the Durbin-Hausman-Wu test for endogeneity with the null hypothesis being that the variables are exogenous. The results of the tests are in Table 5.2:

*Table 5.2 – Durbin-Hausman-Wu Tests for Endogeneity Results.*

| Model | Dependent Variable | Variable of Interest | Instrumental Variable | P-value | Reject Null? |
|---|---|---|---|---|---|
| 1 | Per Capita Income | "Tribal Presence" | Per_PublicTransit | <0.0001 | Yes |
| 2 | % Families Above Poverty | "Tribal Presence" | Per_PublicTransit | <0.0001 | Yes |

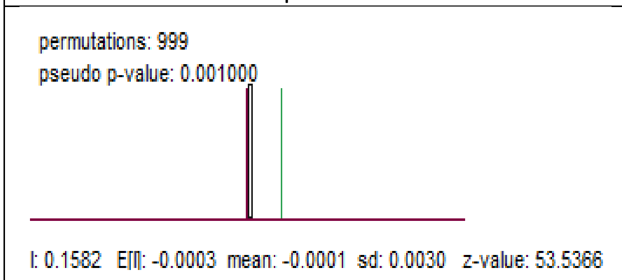
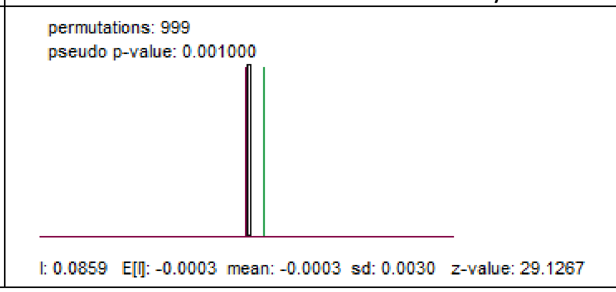
These results indicate the presence of endogeneity in the model. This is of concern, as it means that there is not full exogeneity of the independent variables. One of the difficulties of using the Durbin-Hausman-Wu test is that it depends on the validity of the instruments (IV) selected (Zijian Guo, 2016). The chosen instrument for this test was "Percent using Public Transit", as could have a relationship with either Percent Urban or Mean Commute in Minutes, and possibly both. The validity of the IV can distort the results of the test. This means that it is possible for the results to be less biased but remain under suspicion that endogeneity exists or could also suggest that variables were omitted from the model or that there is simultaneity of the variables. The final point regarding endogeneity is that this study does not aim establish causality, in that the independent variables cause change in the dependent variable. Instead, this study is inquiring whether a relationship does indeed exist between the variables.

A final concern in the collected data for this study is that it is being analyzed primarily at the Census Tract level. Given that census tracts are relatively small units of spatial scale, they may exhibit variable values similar to their neighbors. Typically, the concern of this relation applies to time-series data, in that events that occur in one year, impact events that occur in the following years. "Spatial Auto-correlation" can be described as "everything is related to everything else. But near things are more related than distant things." (Tobler, 1969). This means that the census tracts that are near one another are more likely to have similar values within the independent variables than those which are farther away. It is fair to assume that census tracts do not individually represent a stand-alone economy, it is possible that a county can possibly exist more independently from other counties.

A common test for the level of spatial auto-correlation within a model is Moran's I. This test considers the variable of interest and the locations of the variable and measures spatial autocorrelation. The resulting statistic can either reject or confirm the null hypothesis that the variable is dispersed randomly. If it is rejected, the variable is then said to be clustered (ArcGIS,

2018) and the values are correlated across the spatial scale. For this study, the dependent variables, Per Capita Income, and Percent Families Below Poverty were analyzed using Moran's I and test the hypothesis that their values are dispersed randomly. Table 5.4 below illustrates the results of the test:

*Table 5.3 - Moran's I p-value results*

| Per Capita Income | Percent Families Below Poverty |
|---|---|
|  |  |

These results indicate that both variables reject the null hypothesis and the dependent variables do indeed have evidence of spatial autocorrelation. This is consistent with the logic stated previously, the size and scale of census tracts makes it nearly implausible that the dependent values are not influenced by other tracts that are close by.

To correct for spatial-autocorrelation, the errors were clustered by county. The assumption behind doing this is that errors within a county are more likely to be correlated, and those outside of each county are uncorrelated. This clustering of errors was chosen over heteroskedastic robust errors, as the two cannot both be used. Results with robust results are included in Appendix B. By using Clustering-Robust Standard Errors, the errors are larger and therefore not misrepresenting the statistical inference for each variable (Cameron, 2013). With these larger standard errors correlated within counties, the effect is primarily reduced significance of the county level variables.

*III. Results*

After testing the models using different diagnostic tests, the results of the linear models with Per Capita Income using errors clustered by county are shared in Table 5.4:

**Table 5.4: OLS estimates for Per Capita Income with Clustered Errors**

| ***Depedent Variable: Per Capita Income*** **Variables** | **Model 1 (Std. Error)** |
|---|---|
| Intercept | 8,404.51*** (1869.53) |
| Tribal Presence 2.5% | -1,757.04*** (505.80) |
| Per_Urban | 3,330.45*** (695.12) |
| Mean_Traveltime_toWork_inMin | 112.53** (35.12) |
| Per_Over25yrs_withBach_orHigher | 849.97*** (35.12) |
| CPer_AgForFishMine | 36.06 (38.68) |
| CFarm Income/County GDP | -36,951.01*** (9,900.38) |
| CResidential_Internet_per1000HH | 776.56* (390.26) |
| CIrrgCrop_SurfWater | -4.83* (1.91) |
| CFiveYR_MeanSPEI_Squared | 14,140.51** (4,852.98) |
| Pacific-Northwest | -1,244.18 (794.62) |
| Southwest | -1,400.98 (1,288.17) |
| Observations | 7490 |
| R-squared | 0.52433 |
| Adjusted R-Squared | 0.52363 |
| F-statistic | 749.359 on 11 and 7478 DF |
| P-value | < 2.22e-16 |
| | *Significance '***' 0.001, '**' 0.01, '*' 0.05, '.' 0.1* |

While most variables included in the econometric model are significant, the first important result to note is the significance of the tribal presence variable on Per Capita Income. As this variable is combined from information on tribal land and percent Native American population, when this threshold is met, there is a significantly negative impact on Per Capita Income. This reflects the previous literature that explored differences of means for tribal communities as it related to income.

Some interesting relationships are indicated in these results. “Percent Urban” has positive explanatory power for the model, suggesting that the more urban a census tract, the more income the people have. While this could be attributed to increased population densities in urban areas, and therefore more opportunity, the U.S. Census Bureau does partition census tracts to the best of their abilities so that they fall within a population range. Alternatively, this would mean that more rural areas have lower incomes.

An additional intriguing finding was that the variable “Mean Travel Time to Work” has positive explanatory significance on Per Capita Income. This would imply that the greater the commute, the higher the income received. It is hard to believe that the further you are from work, the more income you have. There could exist a non-linear relationship in that the two extreme values represent less income, but for the middle values there is a commute that does relate to higher levels of income.

There is a curious result for “5 Year Mean SPEI squared.” This variable is peculiar in that a value of zero would describe a county in their normal precipitation and evapotranspiration levels, while any positive value means it is wetter than usual or that it is was dryer than usual over the five years. These results suggest that unusual dryness or wetness positively and significantly impacts income, where usual levels would have lower income levels. The logic of this is hard to determine. The regional variables Pacific Northwest and Southwest were added to help control for regional variation that could be exhibited expressly through this variable, but the relationship was maintained, and the regional variables were not significant. Further regional and state variables were explored to better understand this relationship, and are listed in Appendix C.

In Table 5.5 below, the results for the second dependent variable, Percent Families Below Poverty, are shared:

| **Table 5.5: OLS estimates for % Families Above Poverty with Clustered Errors** | |
|---|---|
| ***Depedent Variable: % Families Above Poverty*** **Variables** | **Model 2 (Std. Error)** |
| Intercept | 79.53*** (1.77) |
| Tribal Presence 2.5% | -5.01*** (0.97) |
| Per_Urban | -4.65*** (0.63) |
| Mean_Traveltime_toWork_inMin | 0.08* (0.04) |
| Per_Over25yrs_withBach_orHigher | 0.43*** (0.04) |
| CPer_AgForFishMine | 0.01 (0.04) |
| CFarm Income/County GDP | -3.74 (9.06) |
| CResidential_Internet_per1000HH | 1.28** (0.42) |
| CIrrgCrop_SurfWater | -0.0003 (0.001) |
| CFiveYR_MeanSPEI_Squared | 6.28* (2.97) |
| Pacific-Northwest | 0.20 (0.65) |
| Southwest | -2.93*** (0.82) |
| Observations | 7490 |
| R-squared | 0.27107 |
| Adjusted R-Squared | 0.26999 |
| F-statistic | 252.801 on 11 and 7478 DF |
| P-value | < 2.22e-16 |
| | *Significance '***' 0.001, '**' 0.01, '*' 0.05, '.' 0.1* |

First, overall there are less significant variables in this model than in the previous model, with “Irrigation – Crop Surface Water Withdrawals” and “Farm Income/County GDP” are both no longer significant. However, Tribal Presence, remains stable in this model and with the expected values. Recall that Percent Families Above Poverty indicates those families that are not below the poverty threshold, and since the Tribal Presence variable has a significant negative relationship, a census tract that meets this criterion would signify that it has higher percent of families below poverty.

In these results, “Percent Urban” is now negative and significant, in that the more urban the population, the higher amount of poverty there is. This could reflect the opposite of what is found with Per Capita Income, with higher population densities meaning there is more competition for opportunity and therefore less overall opportunity. The two dependent variables measure a different group of population. Per Capita Income aggregates incomes values for all people in a tract, and divides by total population. This means high earners and low earners are both represented. Families Above Poverty only captures the low earners, as they are in poverty. Education also remains stable, as in the previous model, “Percent of population over 25 years old with a bachelor’s degree or Higher” indicates higher incomes and less poverty. Also stable is the variable for internet access, as in this model it denotes lower poverty, and in the previous model, it suggested that there is a connection to higher income.

Again, the abnormality persists with the “Mean SPEI squared” variable. For Percent of Families Below Poverty, these results indicate that when census tracts within a county are experiencing more than usual dryness, less poverty is likely to be present. The Southwest regional variable is now significant and negative. This indicates that tracts in the Southwest (Arizona and New Mexico) experience more poverty compared to tracts in other states.

*IV. Further Analysis of Counties by Tribal Presence*

The focus of this section is to explore the differences in the values of variables for counties with "tribal presence" and those without. A second comparison is made within those counties with "tribal presence", creating two groups of counties, those with quantified tribal water rights and those without. There are counties with multiple tribes having at least one tribe with water rights, and these are therefore included in the "with quantified tribal water rights" county category. The purpose of this exploration is to test in a simple way for measurable difference between these different sets of two counties across the variables of interest for this study. These groupings were then created into binary variables and were used to perform an econometric analysis at the county-level.

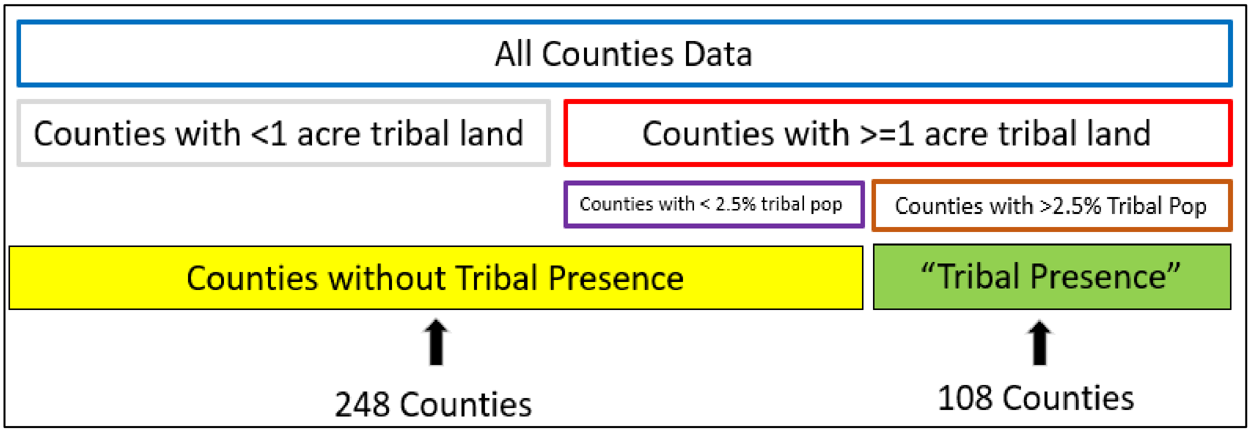
*i. Methods*

Using the benchmark of "counties with tribal presence," all counties were sorted according to this metric. In this paper, the threshold for "tribal presence" for each spatial scale is defined as:

County: any county which has percent Native American population is above 2.5%, measured and sorted within the group of counties that contain any tribal land.

The initial split of the dataset is whether a county contains any tribal land. Within the ten states of this study, there are 356 counties. In grouping counties by "contains tribal land", we have 134 counties (37.6% of total counties). The second threshold that creates the benchmark "tribal presence" are counties which contain percent Native American population above 2.5%. Within the 134 counties containing tribal land, 108 of them meet the Native American population threshold. Figure 5.2 depicts this process:

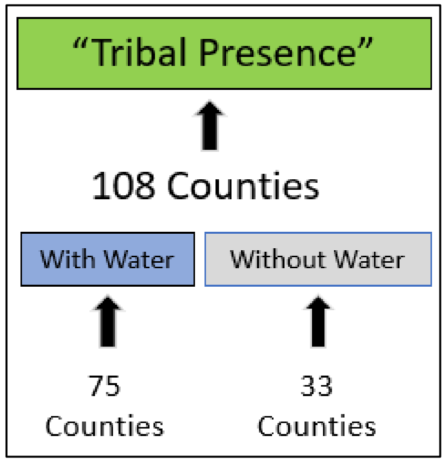
*Figure 5.2: Counties with Tribal Presence*




The grouping process is similar to the one used by Leichenko, where counties are first grouped by whether they contain tribal land (Leichenko, 2003). Leichenko used a cutoff of at least 5% Native American population, where this study uses a cutoff of 2.5% Native American population for counties who contain tribal land. A lower threshold was used as this study has a smaller overall set of counties to draw from, compared to that of Leichenko. The average Percent Native American population for the original set of 356 counties is 5.2%.

The next step was is to evaluate the 108 counties with tribal presence for tribal water right quantification. These counties are checked to verify the specific tribes have reservation (land acreage) within each county. Appendix D contains a list of tribes, the year they quantified their water rights, and the name of the agreement. This was done in order to identify which counties contain tribes with quantified water rights and tribes which do not have water rights. For counties that meet the tribal presence threshold, and do have tribes with quantified water rights, 75 counties within the study area meet these criteria. The counter is that 33 counties have tribes, but these tribes have not quantified their water rights. Results from a census tract comparison of quantified tribal water rights status can be found in Appendix E**.** Figure 5.2 shows how these two categories were formed from within the existing "tribal presence" group data:

*Figure 5.3 – Counties with and without Water Rights*




For each grouping of counties, values for each of the variables in this study ranked to perform a Mann-Whitney test. This test is calculated by organizing the data in ascending order and assigning a rank to each ordered value. These ranks are then used to test a hypothesis regarding the equality of the medians (Wilson, 2009). This tests if the sample populations are identical, and the result of the test provides a p-value which can be used to describe how significant the differences between the groups are.

Variables that were collected at the census tract level were aggregated to the county level using a population weighting procedure. The census tract population was divided by the total county population, and then multiplied by the census tract value for that variable. This was then summed up across the county to create a "population weighted" value for each of the five census tract variables in this study. These weighted values were used to produce the results of this section.

*ii. Results*

To better understand the relationships of the variables at the county-level, a bivariate exploration of the data was carried out. Table 5.6 below shows the median and mean values measured for the first grouping, Counties with and without Tribal Presence, and the resulting p-value that coincides with the Mann-Whitney comparison for each variable:

*Table 5.6 – Mann-Whitney test results between Counties with Tribal Presence*

| Variable | *Counties with Tribal Presence (n=108)* | | | *Counties without Tribal Presence (n=248)* | | | Mann-Whitney p-value | |
|---|---|---|---|---|---|---|---|---|
| | Median | Mean | St.Dev | Median | Mean | St.Dev. | | |
| % Families Below Poverty | 88.52% | 87.93% | 4.74% | 90.66% | 90.20% | 4.42% | 0.0000 | *** |
| Per Capita Income | $21,880.39 | $22,451.06 | $4,375.01 | $22,933.83 | $24,002.23 | $6,302.90 | 0.1146 | . |
| Percent Urban | 55.82% | 50.03% | 28.61% | 52.41% | 43.83% | 38.08% | 0.1026 | |
| Mean Commute | 20.47 | 21.07 | 5.12 | 19.08 | 20.03 | 5.30 | 0.0343 | * |
| Percent 25yrs with Bach+ | 17.80% | 19.84% | 6.99% | 19.87% | 23.37% | 10.42% | 0.0042 | ** |
| Percent Ag, Fish, Forest, Hunt, Mine | 6.20% | 9.44% | 8.64% | 10.15% | 12.02% | 10.59% | 0.0379 | * |
| 5 -YR Mean SPEI | -0.09 | -0.13 | 0.14 | -0.07 | -0.08 | 0.09 | 0.0512 | . |
| 5-YR Mean SPEI Squared | 0.01 | 0.04 | 0.07 | 0.01 | 0.02 | 0.03 | 0.0512 | . |
| Irrig-Crop Surface Water | 7.87 | 72.66 | 138.63 | 17.34 | 98.25 | 180.29 | 0.7231 | |
| Internet per 1,000 HH | 3.00 | 3.25 | 0.83 | 3.00 | 3.38 | 0.79 | 0.2535 | |
| FarmIncome/County GDP | 0.01 | 0.02 | 0.03 | 0.01 | 0.03 | 0.05 | 0.0783 | . |
| Percent Tribal Land | 5.61% | 12.36% | 0.16 | 1.93% | 2.06% | 0.95% | 0.0000 | *** |
| Percent NA Population | 8.00% | 17.58% | 0.22 | 0.00% | 0.83% | 7.33% | 0.0000 | * |

| *p-value* | |
|---|---|
| *** | *>0.001* |
| ** | *>0.01* |
| * | *>0.05* |
| . | *>0.1* |

These results indicate that one of the dependent variables, % Families Above Poverty, has a significant difference between (p-value less than 0.1 are shaded in yellow/gray) the two groups, with Counties with Tribal Presence containing more poverty than those without Tribes. This is consistent with econometric analysis presented previously in this chapter. As expected, counties with tribal presence have significant differences between tribal land and population variables, since these were the measures used to split up the two groups.

Of the additional independent variables tested through this method, three stood out as having significant differences between the two groups. The percent of the population with a bachelor’s degree or higher is greater in counties without tribal presence. Counties without tribal presence have a higher percentage of population working in extraction/resource industries. Counties with tribal presence are drier, as the Mean SPEI variable indicates, compared to counties without tribal presence. The different in SPEI likely reflects the history of land being set aside for reservations was generally less attractive to settlers of European descent. This was a U.S. policy stance when reservation boundaries were established. There is also a small difference in the Farm Income as part of County GDP variable, with counties without Tribal Presence having higher values in this metric.

A key theme of this study is quantified water rights for tribes. A second Mann-Whitney test was performed within the counties with tribal presence, to measure those with quantified tribal water rights and those without quantified water rights. Results from this test are in Table 5.7:

*Table 5.7 - Mann-Whitney Test results between Counties with Quantified Water Rights*

| Variable | *Counties with Quantified Tribal Water Rights (n=75)* | | | *Counties without Quantified Tribal Water Rights (n=33)* | | | Mann-Whitney p-value | |
|---|---|---|---|---|---|---|---|---|
| | Median | Mean | St.Dev | Median | Mean | St.Dev. | | |
| % Families Below Poverty | 87.88% | 87.39% | 5.35% | 88.69% | 89.16% | 2.58% | 0.1423 | |
| Per Capita Income | $21,600.50 | $22,027.64 | $4,658.47 | $22,674.41 | $23,413.40 | $3,527.35 | 0.0707 | . |
| Percent Urban | 46.82% | 47.38% | 29.59% | 62.12% | 56.04% | 25.65% | 0.1419 | |
| Mean Commute | 19.95 | 20.30 | 4.67 | 23.95 | 22.83 | 5.69 | 0.0339 | * |
| Percent 25yrs with Bach+ | 17.74% | 19.99% | 7.18% | 17.85% | 19.52% | 6.63% | 0.8310 | |
| Percent Ag, Fish, Forest, Hunt, Mine | 6.25% | 9.41% | 8.10% | 5.58% | 9.50% | 9.88% | 0.7388 | |
| 5 -YR Mean SPEI | -0.10 | -0.14 | 0.16 | -0.08 | -0.09 | 0.10 | 0.2123 | |
| 5-YR Mean SPEI Squared | 0.01 | 0.05 | 0.08 | 0.01 | 0.02 | 0.03 | 0.2123 | |
| Irrig-Crop Surface Water | 9.17 | 84.02 | 155.12 | 5.04 | 46.84 | 87.34 | 0.7402 | |
| Internet per 1,000 HH | 3.00 | 3.21 | 0.76 | 4.00 | 3.33 | 0.99 | 0.3301 | |
| FarmIncome/County GDP | 0.01 | 0.02 | 0.03 | 0.01 | 0.01 | 0.02 | 0.3075 | |
| Percent Tribal Land | 15.90% | 23.10% | 0.24 | 0.71% | 5.04% | 10.90% | 0.000001 | *** |
| Percent NA Population | 6.33% | 15.14% | 0.19 | 4.97% | 6.04% | 4.99% | 0.0312 | * |

| *p-value* | |
|---|---|
| *** | *>0.001* |
| ** | *>0.01* |
| * | *>0.05* |
| . | *>0.1* |

These results show some statistically statistical difference in the variables used in this study between counties. Within the data of this study, there are lower incomes among the counties with tribes who have water rights, as compared to those without quantified water rights. Additionally, there is a difference between the amount of tribal land and percent Native American population, as those counties with quantified water rights have higher averages for both variables. This could be that tribes with larger quantities of land or with larger populations have greater use and need for water. They could also have more acreage to use the water gained through quantification. There is also the possibility that those with quantified water rights have yet to receive the water or have not yet reaped the rewards of water on their land, as there is often a lag between quantifying water rights and receiving wet water. Of interest is that there is a small but statistically significant difference between the commute to work time for both groups of counties. Those with quantified water rights seem to have a shorter commute.

Comparisons at the tribal presence level (Table 5.6) show that there are some significant differences in variables related to socio-economic challenges for tribes. These results do not signify that there is a causal linkage between water rights and the values or significance of these variables.

The first exploration at the county-level was a performed across four linear regression models. Using the same dependent variables, two estimations were completed for each. One model used “Tribal Presence” as an independent variable. The second model removed tribal presence and instead “Quantified Tribal Water Rights” was used. These models were tested for homoskedasticity using both Breusch-Pagan and White’s test, and the results of this rejected the null hypothesis of homoskedasticity. Results for this test can be found in Appendix C. This means that the models at the county level again exhibit heteroskedasticity, and to resolve this, White’s Robust Standard Errors were used. The estimated coefficients for these four models can be found in Table 5.8:

| *Table 5.8 - County Level Regression with White's Robust Errors* | | | | |
|---|---|---|---|---|
| | ***Dependent variable:*** | | | |
| | ***Per Capita Income (Std.Errors)*** | | ***% Families Above Poverty (Std.Errors)*** | |
| Intercept | 6,431.64*** (1,537.29) | 6,858.07*** (1,549.31) | 77.79*** (1.58) | 77.87*** (1.56) |
| Tribal Presence 2.5% | 60.20 (369.47) | | -1.05** (0.44) | |
| County has Quantified Tribal Water Rights | | -625.67 (403.69) | | -0.87* (0.48) |
| Percent Urban | -263.40 (727.89) | -276.82 (722.89) | -1.06* (0.63) | -1.14* (0.63) |
| Mean Commute Time | 140.16*** (45.68) | 135.75*** (45.85) | 0.16*** (0.04) | 0.15*** (0.04) |
| Percent Over 25yrs with Bachelor Degree or Higher | 395.77*** (46.79) | 391.26*** (46.62) | 0.12*** (0.03) | 0.13*** (0.03) |
| Percent Working in Extraction/Resource Industries | 113.10*** (29.90) | 108.57*** (29.84) | 0.12*** (0.03) | 0.11*** (0.03) |
| Farm Income/County GDP | -17,904.87*** (6,576.40) | -18,135.14*** (6,515.19) | -12.63* (5.63) | -12.60** (5.66) |
| Residential Internet per 1,000 Households | 1,571.87*** (293.72) | 1,564.95*** (290.91) | 1.89*** (0.30) | 1.89*** (0.30) |
| Irrigation: Crop - Surface Water | -3.29*** (0.87) | -3.44*** (0.87) | -0.002 (0.001) | -0.001 (0.001) |
| Five Year Mean SPEI Squared | 15,777.10*** (4,319.59) | 17,492.84*** (4,501.23) | 9.04** (4.21) | 9.43** (4.12) |
| Northwest Region | -640.00 (452.99) | -635.87 (438.54) | -0.75* (0.43) | -0.91** (0.41) |
| Southwest Region | -2,711.19*** (618.40) | -2,679.91*** (614.81) | -4.49*** (0.74) | -4.61*** (0.74) |
| Observations | 356 | 356 | 356 | 356 |
| R-squared | 0.63447 | 0.63638 | 0.418 | 0.41453 |
| Adjusted R-Squared | 0.62278 | 0.62475 | 0.39939 | 0.39581 |
| F-statistic | 54.2809 | 54.7316 | 22.4606 | 22.1423 |
| P-value | < 0.000 | < 0.000 | < 0.000 | < 0.000 |
| | | *Significance* | *'***' 0.001, '**' 0.01, '*' 0.05, '.' 0.1* | |

The results contain some interesting changes compared to the census tract models. First, Tribal Presence is no longer significant across each dependent variable, but it remains significant and negative with Percent Families Above Poverty. Counties with Quantified Tribal Water Rights is also a negatively significant variable, but only with Percent Families Above Poverty. Mean

Commute, Percent Over 25yrs with a bachelor's degree or higher, Percent Working in Extraction/Resource Industries, Farm Income/County GDP, Internet Access, Five Year Mean SPEI squared, and Southwest Region were all significant across all four models. Percent Urban and Northwest Region are only significant and negative with the Percent Families Above Poverty dependent variable. Irrigation-Crop Surface Water Withdrawals is only significant and negative with Per Capita Income.

Further differences between the census tract model discussed earlier this chapter and these county models do exist. "Percent Working in Extraction/Resource Industries" is insignificant in the census tract models, but in all four models presented in this section it is significant and positive. Additional peculiarities exist with Mean SPEI squared, as it is again stable across all four models and positive. This indicates that unusual dryness or wetness at the county level increases income and the percent of people above poverty. Percent Urban is stable in these models, which is counter to census tract results of significant but unstable, in that the signs change between income and poverty.

Tribes need information to better evaluate the benefits of acquiring quantified water rights and to compare economic outcomes is an excellent starting point. If tribes can further develop this evaluation capacity, it is possible that they would be able to break through some of the persistent problems they face as indigenous communities.

# Chapter 6
# Conclusions and Future Work

The tribal nations of the United States face long histories of disenfranchisement and violence by the Europeans who established the United States more than two hundred years ago. Social and economic challenges for tribal communities persist to present day. This study analyzes data to evaluate the relationship between tribal presence and selected economic variables. An additional assessment was completed to test whether census tracts and counties with tribal presence have significant differences between tribal areas with quantified water rights and those without these rights.

This study makes use of data available at the census tract spatial scale. This spatial scale is the smallest unit for which data on tribes is collected by the U.S. Census Bureau every ten years as a component of the Decennial Census. In order to maintain the highest possible spatial resolution, census tracts were retained for primary analysis in this study. However, the study also explores results at the county level for comparative purposes.

*I. Conclusions*

Two econometric models with variables of interest related to tribal presence are estimated. This study shows that tribal presence, as defined, has a negative relationship with income and poverty with at two spatial scales, census tract and county.

The analyses also were performed with all variables scaled to the county level. This county-level analysis was performed as people are more aware of how counties are designated and used to demarcate geographic boundaries. They are less familiar with the process in which census tracts are established.

To further analyze the relationship between economic variables and quantified water rights, counties included in this study were separated by tribal presence. Then, those counties with tribal presence are contrasted between counties with quantified water rights and those without. A comparative analysis was performed using clear threshold for tribal presence for each spatial scale. The values for each group were ranked and compared using a Mann-Whitney test to identify statistically significant differences.

For the county comparison, an initial analysis contrasted counties with tribal presence to those without. These results showed a significant difference between the dependent variables (poverty and income), as well as  differences for tribal land and percent Native American population. The latter was expected as these were the variables used to create the groupings. Five independent variables showed statistically significant differences. The counties with tribal presence showed statistically significant difference in attainment of bachelor's degrees, drier climate, and a lower percentage of people working in extraction/resource industries, and mean commute times, and farm income as a proportion of county GDP. For each of these variables, counties with tribal presence have lower median values compared to counties without tribal presence.

This study also compared differences of counties with tribal presence that have quantified their water rights and compared them to counties who have not acquired them. These results showed that tribes with water rights have a higher percentage of families in poverty, but also have significantly higher amounts of tribal land and population. Even though no causal relationship can be established, it is possible that tribes with lower incomes are more likely to quantify their water rights. Also, since this study only reviewed data from one time period, it is possible that previously the income levels for these counties with quantified water rights was even lower prior to gaining their rights.

Finally, an econometric analysis was performed with the data all scaled to county levels. Two variables of interest were chosen, tribal presence and counties containing tribes with quantified water rights, in addition to previous control variables explored in the census tract model. Each of these variables was estimated with the two dependent variables. At the county level, only Percent Families Above Poverty had a negative and significant relationship with the two tribal variables. Per Capita Income did not have a significant relationship with these variables at the county level.

*II. Future Work*

The goal of this study was to explore potential effects of "tribal presence" measurements at two compatible spatial scales. Additionally, a second goal of this study was to examine any economic effects of tribal water quantification. The quantification of water rights is an opportunity for tribes to mobilize water resources for greater independence and sovereignty. Poverty differences were not found between counties with quantified tribal water rights and those without, but there was a difference in income. More research is needed to examine whether quantifying water rights provides tribes with measurable economic leverage.

Questions remain as a result of this study. One question is regarding the results for the variable Mean SPEI. Attempts to further explain this variable led to confounding results and did not provide any further insight into differences of dryness or wetness. Hopefully future studies can focus on this issue and find answers to them that prove to be helpful for tribal communities.

It is suggested that including another minority group as a comparison group to future analysis could prove useful in quantifying tribal economic well-being. It might also be interesting to pursue the difference between tribes who were relocated, perhaps by including the distance of their relocation in an econometric analysis. It might also be appealing to create an econometric model which aims to predict the quantity of acre-feet a tribe should receive in their water rights, taking into account "practicably irrigable acreage" formula and additional factors, and apply it to tribes who currently have not quantified their water rights.

This study provides a starting point for further analysis of the economic impact of the quantification of tribal water rights. Tribes have limited resources, and if it were possible to put a value on quantifying tribal water rights, this would allow for tribes to make more informed decisions as to how to allocate their resources that best satisfies their needs and values. With climate change and population growth, water allocation decisions will continue to gain prominence and importance throughout the world. These challenges will impact impoverished communities the most. Developing further methods to prepare for this future and mitigate impending challenges, is imperative for tribal nations looking to use all possible sources of leverage they have in order to assist their communities.

# Appendices

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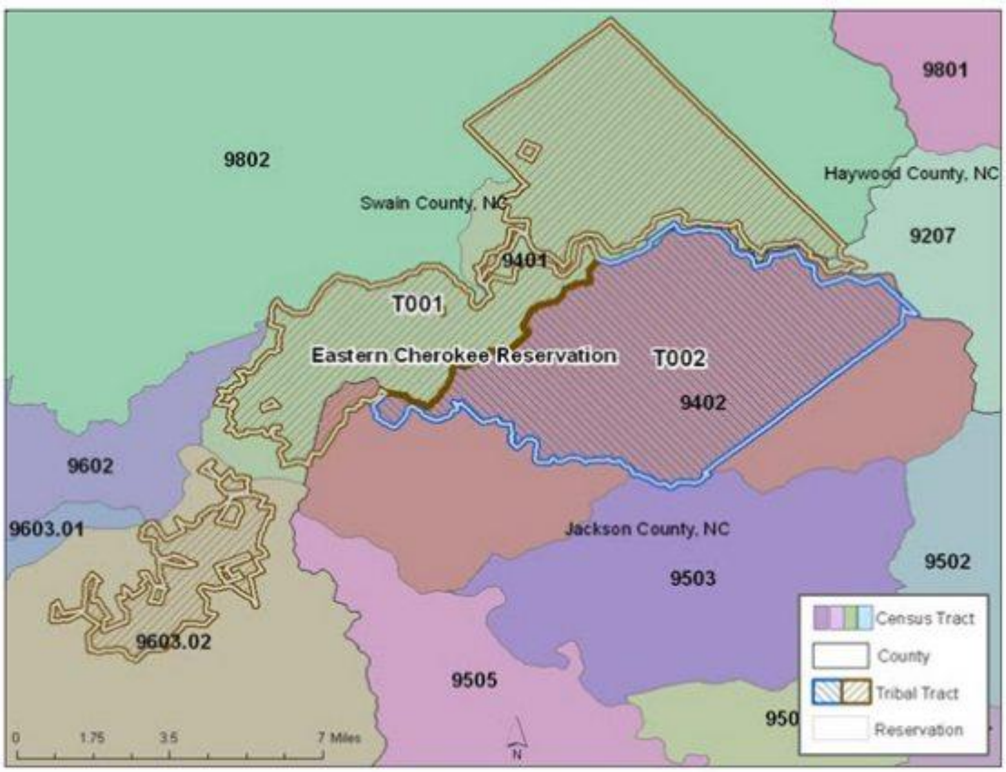
## A. Tribal Census Tract Variable Descriptions

Information collected for 2010 U.S. Decennial Census, https://www.census.gov/geo/maps-data/data/centract_aia_rel_layout.html

| Column Name | Maximum Length | Column Description |
|---|---|---|
| STATEFP | 2 | State FIPS Code |
| COUNTYFP | 3 | County Code code |
| TRACTCE | 6 | Census Tract Code |
| AIANNHCE | 4 | American Indian Area Code |
| NAME | 74 | American Indian Area Name |
| TRACTAREA | 12 | Total Area of the Census Tract (square meters) |
| AREAINT | 11 | Total Area of the Intersection Between the Census Tract and the American Indian Area (square meters) |
| PERCENT_AREA | 22 | Percentage of Total Area of the Census Tract Covered by the American Indian Area |
| TRACTPOP | 5 | 2010 Population Count of the Census Tract |
| POPINT | 5 | 2010 Population Count of the Intersection Between the Census Tract and the American Indian Area |
| PERCENT_POP | 17 | Percentage of the 2010 Population Count of the Census Tract Covered by the American Indian Area |
| TRACATHU | 4 | 2010 Housing Unit Count of the Census Tract |
| HUNT | 4 | 2010 Housing Unit Count of the Intersecting Polygon |
| PERCENT_HU | 20 | Percentage of the 2010 Housing Unit Count of the Census Tract Covered by the American Indian Area |

Tribal Tract, Census Tract, County overlaps. https://www.census.gov/newsroom/blogs/random-samplings/2012/07/decoding-state-county-census-tracts-versus-tribal-census-tracts.html



## B. List of Variables

| Source | Variable | Description | Rationale for Not Including | Regression and Page Number |
|---|---|---|---|---|
| US Census | Total Population | Population within the Census Tract | Census tracts are expected to fit between a range of 1,200 people and 8,000 people. | Regression 2.A, Page 78 |
| US Census | Total Land Acres | Land Acres within the Census Tract | Used partially as an interaction variable to create "Percent Tribal Land". | Regression 2.A, Page 78 |
| US Census | Median HH Income | Median Household Income within the Census Tract | Did not want to confound results with similar dependent variable. | Regression 2.E, Page 9 |
| US Census | Percent Unemployed | Percent of people in the Labor Force but without a job within Census Tract | Concerns over collinearity with dependent variables. | Regression 2.A, Page 78 |
| US Census | Percent of HS Graduates | Percent of people who have graduated high school or equivalent within Census Tract | Removed in favor of a single education variables (Percent Bachelors or higher). | Regression 2.A, Page 78 |
| US Census | Percent of HS Graduates or Some College | Percent of people who have completed HS or completed some college, but not a bachelor's degree | Removed in favor of a single education variables (Percent Bachelors or higher). | Regression 2.E, Page 9 |
| US Census | Percent of Households Receiving Food stamps | Percent of households receiving food stamps within Census Tract | Concerns over collinearity with dependent variables. | Regression 2.B, Page 6 |
| US Census | Tribal Population Living on Reservation | Tribal Tract Designation for population in Census Tract, via Tribal Relationship Files | Removed in favor of "Population who Identify as Native American" | Regression 2.D, Page 8 |
| US Census | Percent Manual Labor | Combination of three census variables on occupations - Manufacturing, Construction, Transportation/Warehouse | Removed in favor of a single occupation variable or category | Regression 2.D, Page 8 |
| US Census | Percent Office Professionals | Combination of four census variables on occupations - Information, Professionals, Finance/Insurance, Public Admin | Removed in favor of a single occupation variable or category | Regression 2.D, Page 8 |
| US Census | Percent Retail Wholesale | Combination of two census variables on occupations - Retail and Wholesale Trade | Removed in favor of a single occupation variable or category | Regression 2.D, Page 8 |
| US Census | Percent Education Health Arts | Combination of two census variables on occupations - Education/Social/Healthcare, Arts/Food/Recreation | Removed in favor of a single occupation variable or category | Regression 2.D, Page 8 |
| US Census | Percent Other Occupations | Census designated variable for occupations that do not fall into other categories | Removed in favor of a single occupation variable or category | Regression 2.D, Page 8 |

| | | | | |
|---|---|---|---|---|
| USDA | Metro County | Binary designation for if a county is metro (1, if yes) or non-metro (0) | Removed in favor of "Percent Urban" census tract measure. | Regression 2.A, Page 78 |
| USDA | Number of Farms | Number of Farms within the County | Removed in favor of "Farm Income/County GDP" as it provides for better accounting of farm importance. | Regression 2.A, Page 78 |
| USDA | Percent of Irrigated Farm Acres | Percent of Farm Acres Irrigated within the County (of total possible acreage) | Removed in favor of "Farm Income/County GDP" as it provides for better accounting of farm importance. | Regression 2.A, Page 78 |
| USDA | Average Farm Size (Acres) | Average Farm Size (Total Farm Acres/Number of Farms) within County | Removed in favor of "Farm Income/County GDP" as it provides for better accounting of farm importance. | Regression 2.A, Page 78 |
| USDA | Percent of Farms with American Indian Operator | Percent of Farms with reported Native American principal operators. | Removed due to possible collinearity issues with "Percent Tribal Land" and "Native American population". | Regression 2.A, Page 78 |
| USDA | Percent of Farms with Principal Female Operator | Percent of Farms with reported Female principal operators. | Removed due to unclear relationship with focus of study. | Regression 2.A, Page 78 |
| USDA | Number of Farms with Internet Access | Number of Farms within the County who report internet access | Removed in favor of "Residential Internet Connections per 1,000 HH", not limited to farms. | Regression 2.C, Page 7 |
| USDA | Farming Dependent | USDA Binary designation for if a county primarily depends on farming occupations (1, if yes) or not (0) | Removed in favor of percent occupation categories, collected by census tracts | Regression 2.A, Page 78 |
| USDA | Mining Dependent | USDA Binary designation for if a county primarily depends on mining occupations (1, if yes) or not (0) | Removed in favor of percent occupation categories, collected by census tracts | Regression 2.A, Page 78 |
| USDA | Recreation Dependent | USDA Binary designation for if a county primarily depends on recreation occupations (1, if yes) or not (0) | Removed in favor of percent occupation categories, collected by census tracts | Regression 2.A, Page 78 |
| USDA | Government Dependent | USDA Binary designation for if a county primarily depends on government occupations (1, if yes) or not (0) | Removed in favor of percent occupation categories, collected by census tracts | Regression 2.A, Page 78 |

| | | | | |
|---|---|---|---|---|
| USDA | Manufacturing Dependent Designation | USDA Binary designation for if a county primarily depends on manufacturing occupations (1, if yes) or not (0) | Removed in favor of percent occupation categories, collected by census tracts | Regression 2.A, Page 78 |
| USDA | Low Education, County Designation | USDA Binary designation for if a county has low education (1, if yes) or not (0) | Binary variable did not have the explanatory capability of two education achievement variables. | Regression 2.A, Page 78 |
| USDA | Low Employment, County Designation | USDA Binary designation for if a county has low employment (1, if yes) or not (0) | Binary variable with limited explanatory capability and concerns over collinearity with dependent variables. | Regression 2.A, Page 78 |
| USDA | Population Loss, County Designation | USDA Binary designation for if a county has significant population loss (1, if yes) or not (0) | Binary variable with limited explanatory capability and unclear relationship with desired area of study. | Regression 2.A, Page 78 |
| USDA | Retirement Destination County | USDA Binary designation for if a county is a retirement destination (1, if yes) or not (0) | Binary variable with limited explanatory capability and unclear relationship with desired area of study. | Regression 2.A, Page 78 |
| USDA | Persistent Poverty, County Designation | USDA Binary designation for if a county has persistent poverty (1, if yes) or not (0) | Binary variable with limited explanatory capability and concerns over collinearity with dependent variables. | Regression 2.A, Page 79 |
| USDA | Persistent Child Poverty, County Designation | USDA Binary designation for if a county has persistent child poverty (1, if yes) or not (0) | Binary variable with limited explanatory capability and concerns over collinearity with dependent variables. | Regression 2.A, Page 79 |
| FCC | Residential Fixed Connections with Speed Designation | Residential Fixed Connections at Least 768 kbps Downstream and 200 kbps Upstream per 1,000 Household | Eliminated in favor of one internet access variable, "Residential Internet Connections per 1,000 HH" | Regression 2.A, Page 79 |
| FCC | Total Internet Providers | Providers of Fixed Connections over 200 kbps in at Least One Direction | Eliminated in favor of one internet access variable, "Residential Internet Connections per 1,000 HH" | Regression 2.C, Page 7 |
| FCC | Number of Resident Providers | Providers of Residential Fixed Connections over 200 kbps in at Least One Direction | Eliminated in favor of one internet access variable, "Residential Internet Connections per 1,000 HH" | Regression 2.C, Page 7 |
| FCC | Number of Resident Providers with Speed Designations | Providers of Residential Fixed Connections at Least 3 mbps Downstream and 768 kbps Upstream | Eliminated in favor of one internet access variable, "Residential Internet Connections per 1,000 HH" | Regression 2.C, Page 7 |
| FCC | Number of Mobile Connections | Providers of Mobile Connections over 200 kbps in at Least One Direction | Eliminated in favor of one internet access variable, "Residential Internet Connections per 1,000 HH" | Regression 2.A, Page 79 |

| | | | | |
|---|---|---|---|---|
| CDC | Average Heat Index, 2010 | Average Heat Index for 2010, by county | Removed in favor of Standardized Precipitation-Evapotranspiration Index (SPEI), Mean for 2008-2010 | Regression 2.E, Page 9 |
| CDC | Average Daily Precipitation in mm, 2010 | Average Daily Precipitation in mm for 2010, by county | Removed in favor of Standardized Precipitation-Evapotranspiration Index (SPEI), Mean for 2008-2010 | Regression 2.E, Page 9 |
| CDC | Median SPEI 2008-2010 | Median three-year Standardized Precipitation Evapotranspiration Index value, by County | Removed in favor of SPEI Mean for 2008-2010, as wider variation was thought to be valuable. | Regression 2.F, Page 10 |
| USGS | Public Supply of Freshwater, Surface | Public Supply of Freshwater Surface Withdrawals, by county | Eliminated in favor of one water use variable, "Irrigated Crop Surface Water Withdrawals" | Regression 2.E, Page 9 |
| USGS | Public Supply of Freshwater, Total | Public Supply of Freshwater Total Withdrawals, by county | Eliminated in favor of one water use variable, "Irrigated Crop Surface Water Withdrawals" | Regression 2.E, Page 9 |
| USGS | Percent Surface Water from Total Water Withdrawal | Percent Surface Water from Total Water Withdrawals, by county | Eliminated in favor of one water use variable, "Irrigated Crop Surface Water Withdrawals" | Regression 2.E, Page 9 |
| USGS | Total Water Withdrawals | Total Water Withdrawals by county | Eliminated in favor of one water use variable, "Irrigated Crop Surface Water Withdrawals" | Regression 2.E, Page 9 |
| Self-Created | State-Level Regional Dummies | State Level Regional Dummies, North-West, South-West, Mountain-West | Regional environmental factors better captured with SPEI by county, and possible arbitrary nature of regions. | Regression 2.E, Page 9 |

## Regressions of Listed Variables

*Regression 2.A*

| | *Dependent variable:* | |
|---|---|---|
| | Avg per Capita Income | Ind/Fam Below Poverty |
| Total_Population | 0.001 | 0.0000 |
| | (0.001) | (0.0000) |
| Percent_TribalPop | 724.57 | 2.48 |
| | (2,750.37) | (2.36) |
| CountyLandAcres | -0.0001 | -0.0000 |
| | (0.0002) | (0.0000) |
| Percent_TribalLand | -1,978.07 | -0.28 |
| | (2,736.47) | (2.35) |
| AverageCommute_MinMean | -35.40 | -0.03 |
| | (55.35) | (0.05) |
| Percent_HSGrads | -4,485.55$^{**}$ | 1.94 |
| | (2,237.16) | (1.92) |
| NumbFarms_2012 | -0.91$^{*}$ | 0.001$^{*}$ |
| | (0.47) | (0.0004) |
| AverageSizeofFarmsinAcres2012 | -0.28 | 0.0004$^{**}$ |
| | (0.19) | (0.0002) |
| AcresofIrrigLandasPercent2012 | -19.91 | 0.01 |
| | (18.85) | (0.02) |
| Percent_FarmsFemalePrincipalOp_2012 | 20,192.20$^{***}$ | 0.15 |
| | (3,274.35) | (2.81) |
| Percent_FarmswithAmIndianAlaskanOperator2012 | -7,479.11$^{***}$ | 9.50$^{***}$ |
| | (2,613.11) | (2.24) |
| USDA_Metro | 437.93 | -1.00$^{*}$ |
| | (703.21) | (0.60) |
| Farming | -1,347.31$^{*}$ | -0.41 |
| | (726.23) | (0.62) |
| Mining | 1,350.61$^{*}$ | -1.27$^{*}$ |
| | (764.26) | (0.65) |
| Manufacturing | -336.21 | -1.51 |
| | (1,429.00) | (1.22) |
| Government | -2,343.04$^{***}$ | 2.11$^{***}$ |
| | (606.67) | (0.52) |
| Recreation | 1,304.49$^{**}$ | 0.01 |
| | (576.62) | (0.49) |
| Low_Education | -1,219.34 | 3.02$^{***}$ |
| | (952.55) | (0.82) |
| Pop_Loss | -95.86 | 0.37 |
| | (933.39) | (0.80) |
| Retirement_Dest | -1,421.49$^{**}$ | 0.59 |
| | (591.92) | (0.51) |
| rfc_per_1000_hhs | 2,584.77$^{***}$ | -1.80$^{***}$ |
| | (353.35) | (0.30) |
| tmw_prov | 68.72 | 0.36$^{**}$ |
| | (173.49) | (0.15) |
| Constant | 16,076.24$^{***}$ | 13.75$^{***}$ |
| | (2,122.50) | (1.82) |
| Observations | 355 | 355 |
| $R^2$ | 0.51 | 0.42 |
| Adjusted $R^2$ | 0.48 | 0.38 |
| *Note:* | $^{*}$p<0.1$^{**}$p<0.05$^{***}$p<0.01 | |

## *Regression 2.B*

| | *Dependent variable:* | |
|---|---|---|
| | Average per Capita Income | Percent Families Below Poverty |
| | -1 | -2.00 |
| Tribal_Population | 0.059 | 0.00 |
| | -0.07 | 0.00 |
| Total_Population | 0.002$^{**}$ | 0.00 |
| | -0.001 | 0.00 |
| Percent_TribalPop | 389.613 | 0.00 |
| | -3,095.48 | -0.02 |
| TribalLandAcres | 0.00004 | 0.00 |
| | -0.001 | 0.00 |
| CountyLandAcres | -0.0002 | 0.00 |
| | -0.0002 | 0.00 |
| Percent_TribalLand | -83.27 | 0.008 |
| | -3,398.49 | -0.022 |
| Per_Unemploy | 46,170.520$^{**}$ | -0.167 |
| | -22,873.07 | -0.145 |
| AverageCommute_MinMean | -34.296 | -0.0001 |
| | -58.971 | -0.0004 |
| `Average of Percent_Pop_HsGrad_est` | -9,417.055$^{***}$ | 0.049$^{***}$ |
| | -2,310.23 | -0.015 |
| `Average of Percent_HH_receivestamps` | -50,965.720$^{***}$ | 0.438$^{***}$ |
| | -7,256.40 | -0.046 |
| | -894.088 | -0.006 |
| Constant | 32,172.810$^{***}$ | 0.046$^{***}$ |
| | -2,624.07 | -0.017 |
| Observations | 356 | 356 |
| $R^2$ | 0.47 | 0.656 |
| Adjusted $R^2$ | 0.43 | 0.63 |
| Residual Std. Error (df = 330) | 4,513.04 | 0.029 |
| F Statistic (df = 25; 330) | 11.714$^{***}$ | 25.156$^{***}$ |
| *Note:* | $^{*}$p $^{**}$p $^{***}$p<0.01 | |

| | *Dependent variable:* | |
|---|---|---|
| | Average per Capita Income | Percent Families Below Poverty |
| | -1 | -2.00 |
| Percent_FarmswithInternetAccess2012 | 2,230.20 | -0.014 |
| | -2,505.30 | -0.016 |
| num_farms | -0.599 | 0.00001$^{*}$ |
| | -0.517 | 0 |
| USDA_Metro | 1,594.953$^{**}$ | -0.008$^{*}$ |
| | -715.976 | -0.005 |
| Farming | -3,674.530$^{***}$ | 0.003 |
| | -925.877 | -0.006 |
| Mining | -1,435.86 | -0.002 |
| | -954.953 | -0.006 |
| Manufacturing | -2,080.88 | -0.007 |
| | -1,614.45 | -0.01 |
| Government | -2,996.002$^{***}$ | 0.014$^{***}$ |
| | -818.981 | -0.005 |
| Recreation | 458.619 | 0.002 |
| | -808.196 | -0.005 |
| Nonspecialized | -1,880.335$^{*}$ | 0.003 |
| | -986.424 | -0.006 |
| Low_Education | -1,971.627$^{**}$ | 0.022$^{***}$ |
| | -981.453 | -0.006 |
| Low_Employment | -768.259 | 0.010$^{**}$ |
| | -683.683 | -0.004 |
| Pop_Loss | -1,267.69 | 0.015$^{**}$ |
| | -968.734 | -0.006 |
| Retirement_Dest | -1,013.64 | 0.002 |
| | -635.395 | -0.004 |
| Persistent_Poverty | -1,936.45 | 0.042$^{***}$ |
| | -1,360.98 | -0.009 |
| PersistentChild_Poverty | -809.603 | 0.023$^{***}$ |
| | -894.088 | -0.006 |
| Constant | 32,172.810$^{***}$ | 0.046$^{***}$ |
| | -2,624.07 | -0.017 |
| Observations | 356 | 356 |
| $R^2$ | 0.47 | 0.656 |
| Adjusted $R^2$ | 0.43 | 0.63 |
| Residual Std. Error (df = 330) | 4,513.04 | 0.029 |
| F Statistic (df = 25; 330) | 11.714$^{***}$ | 25.156$^{***}$ |
| *Note:* | $^{*}$p $^{**}$p $^{***}$p<0.01 | |

*Regression 2.C*

```
Call:
lm(formula = avgpercap ~ ., data = avgpercapinc)

Residuals:
   Min     1Q Median     3Q    Max 
 -9582  -2454   -200   1812  31802 

Coefficients:
                                       Estimate Std. Error t value Pr(>|t|)    
(Intercept)                           1.842e+04  3.002e+03   6.134 2.49e-09 ***
Tribal_Population                     3.684e-02  6.881e-02   0.535  0.59270    
Total_Population                     -3.222e-04  1.257e-03  -0.256  0.79786    
Percent_TribalPop                     2.270e+03  3.016e+03   0.753  0.45205    
TribalLandAcres                      -1.385e-04  9.451e-04  -0.147  0.88355    
CountyLandAcres                      -1.941e-04  1.795e-04  -1.081  0.28046    
Percent_TribalLand                   -1.736e+03  3.294e+03  -0.527  0.59846    
Per_Unemploy                         -3.254e+04  2.047e+04  -1.589  0.11295    
AverageCommute_MinMean                8.439e+01  5.706e+01   1.479  0.14012    
`Average of Percent_Pop_HsGrad_est` -6.455e+03  2.290e+03  -2.818  0.00513 ** 
Percent_FarmswithInternetAccess2012  1.200e+01  2.463e+01   0.487  0.62650    
`#_Farms_2012`                       -1.280e+00  5.542e-01  -2.309  0.02157 *  
USDA_Metro                           -3.647e+02  7.548e+02  -0.483  0.62930    
Farming                              -2.253e+03  9.638e+02  -2.338  0.02000 *  
Mining                               -8.356e+02  9.384e+02  -0.890  0.37386    
Manufacturing                        -2.551e+03  1.563e+03  -1.632  0.10361    
Government                           -2.609e+03  8.021e+02  -3.253  0.00126 ** 
Recreation                            7.598e+02  8.010e+02   0.949  0.34354    
Nonspecialized                       -1.708e+03  9.650e+02  -1.770  0.07772 .  
Low_Education                        -1.650e+03  9.810e+02  -1.682  0.09350 .  
Low_Employment                       -6.957e+02  6.592e+02  -1.055  0.29209    
Pop_Loss                             -3.245e+02  9.506e+02  -0.341  0.73303    
Retirement_Dest                      -1.361e+03  6.246e+02  -2.179  0.03003 *  
Persistent_Poverty                   -9.543e+02  1.341e+03  -0.712  0.47708    
PersistentChild_Poverty              -2.314e+03  8.482e+02  -2.728  0.00672 ** 
rfc_per_1000_hhs                      1.819e+03  5.595e+02   3.251  0.00127 ** 
rfc_per_1000_hhs_btop                 7.118e+02  5.392e+02   1.320  0.18773    
total_prov                            4.621e+02  1.130e+02   4.089 5.46e-05 ***
total_residential_prov               -4.531e+02  1.889e+02  -2.398  0.01703 *  
total_residential_prov_nbp           -3.241e+02  1.859e+02  -1.744  0.08212 .  
tmw_prov                              1.799e+02  1.851e+02   0.972  0.33175    
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 4370 on 325 degrees of freedom
Multiple R-squared:  0.5107,	Adjusted R-squared:  0.4655 
F-statistic: 11.31 on 30 and 325 DF,  p-value: < 2.2e-16
```

*Regression 2.D*

```
Call:
lm(formula = Per_Capita_Inc_All ~ ., data = newdata)

Residuals:
   Min     1Q Median     3Q    Max 
-48861  -5467   -859   4292 102353 

Coefficients:
                                                 Estimate Std. Error t value Pr(>|t|)    
(Intercept)                                    -7.124e+03  1.987e+03  -3.586 0.000338 ***
`Tribal Land Area`                             -6.658e-03  1.940e-03  -3.432 0.000603 ***
`Tribal Population`                            -4.992e-01  2.205e-01  -2.264 0.023598 *  
Mean_Traveltime_toWork_inMin                    1.391e+02  1.965e+01   7.079 1.59e-12 ***
Per_25Over_withHSorSomeCollege                  2.644e+01  1.396e+01   1.893 0.058345 .  
Per_Over25yrs_withBach_orHigher                 3.799e+00  1.142e+01   0.333 0.739346    
Per_18to24s_withBach                            3.881e+01  1.267e+01   3.063 0.002198 ** 
Per_18to24_withHSorSomeCollege                 -9.728e+00  8.129e+00  -1.197 0.231464    
Per_AgForestFishHuntMining                      1.896e+02  2.466e+01   7.692 1.64e-14 ***
Per_Construction                               -2.334e+02  2.684e+01  -8.696  < 2e-16 ***
Per_Manufacturing                               9.288e+01  2.553e+01   3.638 0.000277 ***
Per_Wholesale_trade                             4.309e+02  5.204e+01   8.280  < 2e-16 ***
Per_Retail_trade                               -1.294e+02  2.544e+01  -5.088 3.71e-07 ***
Per_Transportation_Warehouse                    4.081e+01  3.619e+01   1.128 0.259559    
Per_Information                                 6.042e+02  5.352e+01  11.289  < 2e-16 ***
Per_Finance_Insurance_RealEstate                1.110e+03  3.091e+01  35.911  < 2e-16 ***
Per_Professional_Scientific_Management_Admin_Waste 7.402e+02  2.459e+01  30.102  < 2e-16 ***
Per_Education_Healthcare_Social                 2.534e+02  1.931e+01  13.122  < 2e-16 ***
Per_Arts_Food_Recreation_Accomodation           4.776e+01  1.966e+01   2.429 0.015152 *  
Per_PublicAdmin                                 1.277e+02  2.818e+01   4.532 5.94e-06 ***
C_Residential_Internet_per1000HH                2.753e+03  2.489e+02  11.062  < 2e-16 ***
C_Total_Internet_Providers                     -1.854e+01  1.250e+01  -1.484 0.137931    
C_USDA_Metro                                   -2.753e+03  3.818e+02  -7.211 6.12e-13 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 9203 on 7420 degrees of freedom
  (72 observations deleted due to missingness)
Multiple R-squared:  0.4349,	Adjusted R-squared:  0.4332 
F-statistic: 259.6 on 22 and 7420 DF,  p-value: < 2.2e-16
```

```
Call:
lm(formula = Median_HH_Income ~ ., data = HHincRegdata)

Residuals:
    Min      1Q  Median      3Q     Max 
-107524   -9328    -557    8449  130674 

Coefficients:
                                                            Estimate Std. Error t value Pr(>|t|)    
(Intercept)                                               -3.493e+04  3.621e+03  -9.646  < 2e-16 ***
`Tribal Land Area`                                         4.308e-03  3.345e-03   1.288  0.19792    
`Tribal Population`                                        7.773e-01  3.785e-01   2.054  0.04003 *  
Pop_Urban                                                  5.058e-01  9.173e-02   5.514 3.62e-08 ***
Mean_Traveltime_toWork_inMin                               7.039e+02  3.329e+01  21.145  < 2e-16 ***
Per_25Over_withHSorSomeCollege                             5.335e+02  2.346e+01  22.744  < 2e-16 ***
Per_Over25yrs_withBach_orHigher                            1.187e+03  1.962e+01  60.498  < 2e-16 ***
C_Residential_Internet_per1000HH                           1.127e+03  4.242e+02   2.657  0.00790 ** 
C_Total_Internet_Providers                                 1.954e+02  2.724e+01   7.172 8.10e-13 ***
`Irrigation-Crop, surface-water withdrawals, fresh, in Mgal/d`  4.443e+00  2.025e+00   2.194  0.02825 *  
`Irrigation-Crop, total withdrawals, fresh, in Mgal/d`    -2.965e+00  1.208e+00  -2.454  0.01414 *  
manuallabor                                                3.000e+02  3.384e+01   8.866  < 2e-16 ***
officeprofessional                                         1.925e+02  3.927e+01   4.901 9.73e-07 ***
retailwholesale                                           -1.201e+02  4.315e+01  -2.784  0.00539 ** 
educationhealtharts                                       -3.581e+02  3.388e+01 -10.569  < 2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 15860 on 7475 degrees of freedom
  (25 observations deleted due to missingness)
Multiple R-squared:  0.5537,	Adjusted R-squared:  0.5528 
F-statistic: 662.3 on 14 and 7475 DF,  p-value: < 2.2e-16
```

*Regression 2.E*

```
Call:
lm(formula = Median_HH_Income ~ ., data = hhidata)

Residuals:
    Min      1Q  Median      3Q     Max 
-105371   -8882    -316    8470  126400 

Coefficients:
                                                       Estimate Std. Error t value Pr(>|t|)    
(Intercept)                                          -1.605e+05  9.355e+03 -17.152  < 2e-16 ***
SW                                                   -7.541e+03  6.798e+02 -11.093  < 2e-16 ***
NW                                                   -3.428e+03  7.032e+02  -4.875 1.11e-06 ***
`TRACTAREA (acres)`                                  -1.715e-03  6.234e-04  -2.750 0.005968 ** 
`Tribal Land Area`                                    2.140e-03  3.338e-03   0.641 0.521463    
`Tribal Population`                                   1.372e+00  3.787e-01   3.622 0.000294 ***
Per_Urban                                             6.135e+02  7.645e+02   0.803 0.422247    
Mean_Traveltime_toWork_inMin                          6.968e+02  3.534e+01  19.715  < 2e-16 ***
C_NetIncome_Operators_AvgPerFarm_2012                -3.002e-03  3.910e-03  -0.768 0.442620    
Per_25Over_withHSorSomeCollege                        5.111e+02  2.362e+01  21.643  < 2e-16 ***
Per_Over25yrs_withBach_orHigher                       1.225e+03  2.019e+01  60.676  < 2e-16 ***
Per_AgForestFishHuntMining                            5.624e+02  5.228e+01  10.758  < 2e-16 ***
Per_ManualLabor                                       6.471e+02  4.455e+01  14.526  < 2e-16 ***
Per_OfficePros                                        5.085e+02  4.240e+01  11.993  < 2e-16 ***
Per_RetailWholesale                                   2.027e+02  4.883e+01   4.150 3.35e-05 ***
Per_SocialOccups                                     -1.296e+02  4.016e+01  -3.227 0.001254 ** 
C_Residential_Internet_per1000HH                      1.960e+03  4.299e+02   4.559 5.23e-06 ***
C_Total_Internet_Providers                           -9.471e+01  3.921e+01  -2.415 0.015751 *  
Per_IrrigCrop_SurfaceWater_fromTotal                  7.561e+02  6.591e+02   1.147 0.251369    
Per_PublicSupply_SurfaceWater_fromTotal               1.619e+03  6.554e+02   2.470 0.013522 *  
`Total withdrawals, total (fresh+saline), in Mgal/d` -4.769e-01  6.495e-01  -0.734 0.462780    
C_Avg_Daily_Precipitation_mm_2010                    -5.875e+02  1.771e+02  -3.318 0.000911 ***
C_AvgDailyMax_HeatIndex_F_2010                        1.234e+03  1.010e+02  12.219  < 2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 15400 on 7451 degrees of freedom
  (41 observations deleted due to missingness)
Multiple R-squared:  0.5797,	Adjusted R-squared:  0.5784 
F-statistic:   467 on 22 and 7451 DF,  p-value: < 2.2e-16
```

*Regression 2.F*

```
Call:
lm(formula = Per_Capita_Inc_All ~ ., data = pci)

Residuals:
   Min     1Q Median     3Q    Max 
-56843  -3527   -389   2922 115994 

Coefficients:
                                      Estimate Std. Error t value Pr(>|t|)    
(Intercept)                         -1.452e+04  1.966e+03  -7.387 1.67e-13 ***
Per_TribalLand                      -2.242e+03  1.225e+03  -1.831   0.0672 .  
`Tribal Population`                  3.784e-01  3.025e-01   1.251   0.2110    
Per_Urban                           -2.410e+03  3.380e+02  -7.131 1.09e-12 ***
Mean_Traveltime_toWork_inMin         6.608e+01  1.602e+01   4.124 3.76e-05 ***
C_Per_TotalGrossFarmIncome_ofCountyGDP -9.050e+05  1.765e+06  -0.513   0.6081    
Per_25Over_withHSorSomeCollege       1.702e+02  1.063e+01  16.012  < 2e-16 ***
Per_Over25yrs_withBach_orHigher      6.339e+02  9.229e+00  68.679  < 2e-16 ***
Per_AgForestFishHuntMining           2.302e+02  2.339e+01   9.841  < 2e-16 ***
Per_Labor                            1.773e+02  2.027e+01   8.743  < 2e-16 ***
Per_OfficePros                       2.488e+02  1.939e+01  12.832  < 2e-16 ***
Per_RetailWholesale                  1.011e+02  2.235e+01   4.522 6.22e-06 ***
Per_SocialOccups                    -3.226e+01  1.828e+01  -1.765   0.0776 .  
C_Residential_Internet_per1000HH     2.524e+02  1.916e+02   1.317   0.1878    
C_Total_Internet_Providers           1.180e+02  1.387e+01   8.510  < 2e-16 ***
C_Per_IrrigCrop_SurfaceWater_fromTotal -1.749e+03  2.671e+02  -6.548 6.21e-11 ***
C_TotalWD                           -2.085e+00  2.275e-01  -9.165  < 2e-16 ***
`20082010_Median_SPEI`              -6.722e+03  5.186e+02 -12.961  < 2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 7058 on 7470 degrees of freedom
Multiple R-squared:  0.6609,	Adjusted R-squared:  0.6602 
F-statistic: 856.6 on 17 and 7470 DF,  p-value: < 2.2e-16
```

```
Call:
lm(formula = Median_HH_Income ~ ., data = hhi)

Residuals:
    Min      1Q  Median      3Q     Max 
-112072   -9236    -359    8367  129461 

Coefficients:
                                      Estimate Std. Error t value Pr(>|t|)    
(Intercept)                         -6.936e+04  4.348e+03 -15.950  < 2e-16 ***
Per_TribalLand                      -2.054e+03  2.709e+03  -0.758 0.448439    
`Tribal Population`                  1.272e+00  6.691e-01   1.902 0.057264 .  
Per_Urban                            2.078e+03  7.477e+02   2.779 0.005469 ** 
Mean_Traveltime_toWork_inMin         6.640e+02  3.544e+01  18.737  < 2e-16 ***
C_Per_TotalGrossFarmIncome_ofCountyGDP -1.027e+07  3.904e+06  -2.630 0.008566 ** 
Per_25Over_withHSorSomeCollege       5.506e+02  2.351e+01  23.418  < 2e-16 ***
Per_Over25yrs_withBach_orHigher      1.228e+03  2.041e+01  60.153  < 2e-16 ***
Per_AgForestFishHuntMining           6.644e+02  5.175e+01  12.839  < 2e-16 ***
Per_Labor                            6.649e+02  4.485e+01  14.827  < 2e-16 ***
Per_OfficePros                       5.192e+02  4.289e+01  12.106  < 2e-16 ***
Per_RetailWholesale                  1.901e+02  4.944e+01   3.844 0.000122 ***
Per_SocialOccups                    -9.437e+01  4.043e+01  -2.334 0.019612 *  
C_Residential_Internet_per1000HH     1.745e+03  4.238e+02   4.118 3.86e-05 ***
C_Total_Internet_Providers           1.166e+02  3.067e+01   3.802 0.000145 ***
C_Per_IrrigCrop_SurfaceWater_fromTotal  1.638e+03  5.908e+02   2.772 0.005583 ** 
C_TotalWD                           -8.781e-01  5.033e-01  -1.745 0.081071 .  
`20082010_Median_SPEI`              -1.302e+04  1.147e+03 -11.346  < 2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 15610 on 7470 degrees of freedom
Multiple R-squared:  0.5674,	Adjusted R-squared:  0.5664 
F-statistic: 576.3 on 17 and 7470 DF,  p-value: < 2.2e-16
```

*Regression 2.G – Results from Clustered County Level Regressions*

```
> coeftest(pciA, vcov = vcovHC(pciA, type="sss", cluster="group"))

t test of coefficients:

                                       Estimate  Std. Error t value          Pr(>|t|)
(Intercept)                          6431.63625  2045.92173  3.1436         0.0018138 **
Ctribal_Presence2.5                    60.19568   633.88030  0.0950         0.9243989
Cper_Urban_PopWeighted               -263.39896  1013.32713 -0.2599         0.7950696
CMeanCommute_PopWeighted              140.16155    39.46445  3.5516         0.0004363 ***
Cper_25Over_withBach_PopWeighted      395.77035    56.55068  6.9985 0.000000000136 ***
Cper_AgForFishMineHunt_PopWeighted    113.09603    44.21569  2.5578         0.0109610 *
Crev_FarmIncome_of_CountyGDP       -17904.86916  9677.65670 -1.8501         0.0651530 .
CResidential_Internet_per1000HH      1571.86810   388.90376  4.0418 0.0000654873430 ***
CIrrgCrop_SurfWater                    -3.29185     0.93023 -3.5387         0.0004573 ***
fiveYR_MeanSPEI_SQ                  15777.09612  5563.59307  2.8358         0.0048420 **
Northwest                            -640.00358   998.86890 -0.6407         0.5221258
Southwest_AZNM                      -2711.18719  1285.65670 -2.1088         0.0356847 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
> coeftest(pciB, vcov = vcovHC(pciB, type="sss", cluster="group"))

t test of coefficients:

                                     Estimate Std. Error t value         Pr(>|t|)
(Intercept)                         6858.0724  1939.7318  3.5356        0.0004626 ***
Chas_water                          -625.6715   530.7426 -1.1789        0.2392684
Cper_Urban_PopWeighted              -276.8150  1037.0179 -0.2669        0.7896802
CMeanCommute_PopWeighted             135.7510    41.3328  3.2843        0.0011273 **
Cper_25Over_withBach_PopWeighted     391.2566    56.3326  6.9455 0.0000000001893 ***
Cper_AgForFishMineHunt_PopWeighted   108.5679    42.7717  2.5383        0.0115793 *
Crev_FarmIncome_of_CountyGDP      -18135.1417  9189.1536 -1.9735        0.0492343 *
CResidential_Internet_per1000HH     1564.9470   394.8777  3.9631 0.00008998148341 ***
CIrrgCrop_SurfWater                   -3.4379     0.9907 -3.4702        0.0005863 ***
fiveYR_MeanSPEI_SQ                 17492.8432  6254.5464  2.7968        0.0054510 **
Northwest                           -635.8718   946.0687 -0.6721        0.5019584
Southwest_AZNM                     -2679.9138  1252.7057 -2.1393        0.0331148 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
> coeftest(fabA, vcov = vcovHC(fabA, type="sss", cluster="group"))

t test of coefficients:

                                      Estimate Std. Error t value               Pr(>|t|)
(Intercept)                         77.7930419  2.1767406 35.7383 < 0.0000000000000002 ***
Ctribal_Presence2.5                 -1.0512516  0.7181897 -1.4638              0.1441749
Cper_Urban_PopWeighted              -1.0608854  0.5293709 -2.0040              0.0458484 *
CMeanCommute_PopWeighted             0.1612812  0.0658107  2.4507              0.0147559 *
Cper_25Over_withBach_PopWeighted     0.1244355  0.0264902  4.6974            0.000003814 ***
Cper_AgForFishMineHunt_PopWeighted   0.1151419  0.0310050  3.7137              0.0002383 ***
Crev_FarmIncome_of_CountyGDP       -12.6320353  6.9074481 -1.8288              0.0683019 .
CResidential_Internet_per1000HH      1.8863058  0.4271645  4.4159            0.000013490 ***
CIrrgCrop_SurfWater                 -0.0015292  0.0011998 -1.2745              0.2033399
fiveYR_MeanSPEI_SQ                   9.0363824  4.2774857  2.1125              0.0353599 *
Northwest                           -0.7532723  0.6675119 -1.1285              0.2599046
Southwest_AZNM                      -4.4932741  1.0869107 -4.1340            0.000044838 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
t test of coefficients:

                                      Estimate Std. Error t value               Pr(>|t|)
(Intercept)                         77.8715279  1.9495450 39.9434 < 0.0000000000000002 ***
Chas_water                          -0.8718131  0.7040534 -1.2383              0.2164577
Cper_Urban_PopWeighted              -1.1350771  0.5116030 -2.2187              0.0271616 *
CMeanCommute_PopWeighted             0.1519043  0.0581651  2.6116              0.0094066 **
Cper_25Over_withBach_PopWeighted     0.1284941  0.0253916  5.0605           0.0000006823 ***
Cper_AgForFishMineHunt_PopWeighted   0.1149431  0.0322429  3.5649              0.0004154 ***
Crev_FarmIncome_of_CountyGDP       -12.5987597  7.0197799 -1.7948              0.0735711 .
CResidential_Internet_per1000HH      1.8853170  0.4146040  4.5473           0.0000075403 ***
CIrrgCrop_SurfWater                 -0.0012194  0.0011828 -1.0309              0.3033002
fiveYR_MeanSPEI_SQ                   9.4261928  4.6515105  2.0265              0.0434868 *
Northwest                           -0.9142565  0.6806465 -1.3432              0.1800870
Southwest_AZNM                      -4.6118275  1.0828580 -4.2589           0.0000265380 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

## C. Regression Results with Mean SPEI and Regional Dummies

### Per Capita Income

```
                                       Estimate Std. Error t value Pr(>|t|)    
(Intercept)                            1.70e+03   7.93e+02    2.15   0.0317 *  
Per_TribalLand                        -3.40e+03   4.57e+02   -7.44  1.1e-13 ***
Per_Urban                             -2.26e+03   3.50e+02   -6.45  1.2e-10 ***
Mean_Traveltime_toWork_inMin           2.07e+02   1.84e+01   11.23  < 2e-16 ***
Per_Over25yrs_withBach_orHigher        5.61e+02   1.01e+01   55.59  < 2e-16 ***
CPer_AgForFishMine                     7.71e+01   2.66e+01    2.90   0.0037 ** 
CPer_TotalGrossFarmIncome_ofCountyGDP -2.85e+05   1.86e+06   -0.15   0.8785    
CResidential_Internet_per1000HH        1.25e+03   1.59e+02    7.85  4.6e-15 ***
CIrrgCrop_SurfWater                   -2.45e+00   4.60e-01   -5.32  1.1e-07 ***
C20082010_Mean_SPEI                   -1.12e+04   2.24e+03   -5.01  5.5e-07 ***
SW                                     2.90e+03   4.13e+02    7.02  2.4e-12 ***
NW                                     1.80e+03   2.30e+02    7.83  5.6e-15 ***
C20082010_Mean_SPEI:SW                 9.88e+03   2.42e+03    4.08  4.5e-05 ***
C20082010_Mean_SPEI:NW                 1.10e+04   2.68e+03    4.11  4.1e-05 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
                                       Estimate Std. Error t value Pr(>|t|)    
(Intercept)                            3.44e+03   7.98e+02    4.30  1.7e-05 ***
Per_PopIdentifyasNA                   -9.35e+03   5.29e+02  -17.68  < 2e-16 ***
Per_Urban                             -2.69e+03   3.50e+02   -7.67  2.0e-14 ***
Mean_Traveltime_toWork_inMin           2.04e+02   1.82e+01   11.23  < 2e-16 ***
Per_Over25yrs_withBach_orHigher        5.55e+02   1.01e+01   54.78  < 2e-16 ***
CPer_AgForFishMine                     6.05e+01   2.65e+01    2.29    0.022 *  
CPer_TotalGrossFarmIncome_ofCountyGDP -8.64e+05   1.94e+06   -0.44    0.656    
CResidential_Internet_per1000HH        1.03e+03   1.57e+02    6.54  6.5e-11 ***
CIrrgCrop_SurfWater                   -2.57e+00   4.56e-01   -5.65  1.7e-08 ***
C20082010_Mean_SPEI                   -1.16e+04   2.24e+03   -5.20  2.0e-07 ***
SW                                     3.44e+03   4.17e+02    8.24  < 2e-16 ***
NW                                     1.79e+03   2.29e+02    7.84  5.2e-15 ***
C20082010_Mean_SPEI:SW                 1.12e+04   2.42e+03    4.64  3.5e-06 ***
C20082010_Mean_SPEI:NW                 1.19e+04   2.68e+03    4.45  8.6e-06 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

### Percent Families Below Poverty

```
                                       Estimate Std. Error t value Pr(>|t|)    
(Intercept)                            2.16e+01   9.93e-01   21.74  < 2e-16 ***
Per_TribalLand                         1.13e+01   8.90e-01   12.65  < 2e-16 ***
Per_Urban                              4.11e+00   3.16e-01   12.98  < 2e-16 ***
Mean_Traveltime_toWork_inMin          -1.26e-01   1.85e-02   -6.82  1.0e-11 ***
Per_Over25yrs_withBach_orHigher       -2.58e-01   6.40e-03  -40.31  < 2e-16 ***
CPer_AgForFishMine                    -4.27e-03   1.98e-02   -0.22     0.83    
CPer_TotalGrossFarmIncome_ofCountyGDP -1.53e+03   1.35e+03   -1.13     0.26    
CResidential_Internet_per1000HH       -1.37e+00   2.04e-01   -6.71  2.1e-11 ***
CIrrgCrop_SurfWater                   -1.04e-06   5.69e-04    0.00     1.00    
C20082010_Mean_SPEI                   -1.46e+01   2.34e+00   -6.22  5.4e-10 ***
SW                                     1.24e-02   4.52e-01    0.03     0.98    
NW                                    -1.05e-01   2.39e-01   -0.44     0.66    
C20082010_Mean_SPEI:SW                 1.22e+01   2.61e+00    4.67  3.0e-06 ***
C20082010_Mean_SPEI:NW                 1.94e+01   2.92e+00    6.63  3.5e-11 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
                                       Estimate Std. Error t value Pr(>|t|)    
(Intercept)                            1.82e+01   9.53e-01   19.13  < 2e-16 ***
Per_PopIdentifyasNA                    2.25e+01   9.99e-01   22.56  < 2e-16 ***
Per_Urban                              4.81e+00   3.06e-01   15.72  < 2e-16 ***
Mean_Traveltime_toWork_inMin          -1.21e-01   1.80e-02   -6.72  2.0e-11 ***
Per_Over25yrs_withBach_orHigher       -2.45e-01   6.36e-03  -38.51  < 2e-16 ***
CPer_AgForFishMine                     2.76e-02   1.95e-02    1.42  0.15631    
CPer_TotalGrossFarmIncome_ofCountyGDP -4.38e+02   1.18e+03   -0.37  0.71106    
CResidential_Internet_per1000HH       -9.31e-01   1.92e-01   -4.86  1.2e-06 ***
CIrrgCrop_SurfWater                    2.32e-04   5.53e-04    0.42  0.67478    
C20082010_Mean_SPEI                   -1.34e+01   2.31e+00   -5.82  6.3e-09 ***
SW                                    -1.10e+00   4.48e-01   -2.46  0.01381 *  
NW                                    -9.20e-02   2.33e-01   -0.39  0.69297    
C20082010_Mean_SPEI:SW                 9.15e+00   2.58e+00    3.55  0.00039 ***
C20082010_Mean_SPEI:NW                 1.75e+01   2.88e+00    6.06  1.4e-09 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

## % Families Above Poverty

| | Estimate | Std. Error | t value | Pr(>\|t\|) | |
|---|---|---|---|---|---|
| (Intercept) | 75.29258559 | 1.95950312 | 38.4243 | < 2.2e-16 | *** |
| Tribal_Presence2.5 | -5.25105602 | 0.95276342 | -5.5114 | 3.679e-08 | *** |
| Per_Urban | -4.39941909 | 0.58230014 | -7.5552 | 4.677e-14 | *** |
| Mean_Traveltime_toWork_inMin | 0.13719512 | 0.03782993 | 3.6266 | 0.0002891 | *** |
| Per_Over25yrs_withBach_orHigher | 0.27311091 | 0.02723508 | 10.0279 | < 2.2e-16 | *** |
| Per_AgForestFishHuntMining | 0.00040035 | 0.04173538 | 0.0096 | 0.9923466 | |
| Crevised_FarmInc_Of_CountyGDP | 19.04150039 | 9.82794121 | 1.9375 | 0.0527236 | . |
| CResidential_Internet_per1000HH | 1.52410276 | 0.37787394 | 4.0334 | 5.553e-05 | *** |
| CIrrgCrop_SurfWater | 0.00219677 | 0.00137935 | 1.5926 | 0.1112896 | |
| fiveYR_MeanSPEI_SQ | -0.63403999 | 3.29803240 | -0.1922 | 0.8475532 | |
| CO | -0.25894664 | 1.50160386 | -0.1724 | 0.8630910 | |
| ID | 1.73139938 | 1.36858714 | 1.2651 | 0.2058750 | |
| MT | 1.32832744 | 1.24613212 | 1.0660 | 0.2864760 | |
| NM | 4.82284725 | 0.62474570 | 7.7197 | 1.318e-14 | *** |
| NV | -1.12107782 | 1.36364118 | -0.8221 | 0.4110344 | |
| OR | 1.40145124 | 1.30595389 | 1.0731 | 0.2832499 | |
| UT | 3.17246628 | 1.20111847 | 2.6413 | 0.0082770 | ** |
| WA | 2.00152736 | 1.28954290 | 1.5521 | 0.1206755 | |
| WY | 6.71522977 | 1.38576178 | 4.8459 | 1.286e-06 | *** |

---
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

## Per Capita Income

| | Estimate | Std. Error | t value | Pr(>\|t\|) | |
|---|---|---|---|---|---|
| (Intercept) | 3875.39116 | 1423.50369 | 2.7224 | 0.0064954 | ** |
| Tribal_Presence2.5 | -1523.25788 | 464.80744 | -3.2772 | 0.0010533 | ** |
| Per_Urban | -3176.62210 | 515.11507 | -6.1668 | 7.330e-10 | *** |
| Mean_Traveltime_toWork_inMin | 159.10303 | 27.52094 | 5.7812 | 7.717e-09 | *** |
| Per_Over25yrs_withBach_orHigher | 565.84605 | 33.30625 | 16.9892 | < 2.2e-16 | *** |
| Per_AgForestFishHuntMining | 64.13223 | 32.59459 | 1.9676 | 0.0491541 | * |
| Crevised_FarmInc_Of_CountyGDP | -8854.72307 | 7041.45140 | -1.2575 | 0.2086069 | |
| CResidential_Internet_per1000HH | 919.92341 | 333.57554 | 2.7578 | 0.0058339 | ** |
| CIrrgCrop_SurfWater | -0.88521 | 1.35556 | -0.6530 | 0.5137639 | |
| fiveYR_MeanSPEI_SQ | 10268.94271 | 2813.28726 | 3.6502 | 0.0002639 | *** |
| CO | 1598.14709 | 1169.49011 | 1.3665 | 0.1718128 | |
| ID | 943.76929 | 1236.00174 | 0.7636 | 0.4451498 | |
| MT | -431.26042 | 1361.34656 | -0.3168 | 0.7514121 | |
| NM | 6233.71984 | 716.21281 | 8.7037 | < 2.2e-16 | *** |
| NV | 916.18781 | 1121.13748 | 0.8172 | 0.4138431 | |
| OR | 1528.90985 | 1191.66517 | 1.2830 | 0.1995309 | |
| UT | -1536.37920 | 1663.77470 | -0.9234 | 0.3558131 | |
| WA | 3844.06071 | 1144.98871 | 3.3573 | 0.0007910 | *** |
| WY | 5414.64054 | 1631.39938 | 3.3190 | 0.0009077 | *** |

---
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

**D. Tribes with Quantified Water Rights**

| Tribe | State | Agreement Year | Water Rights Quantification Formalized Thru: | Agreement Name |
|---|---|---|---|---|
| Ak Chin Indian Community | AZ | 1984 | Settlement | Ak-Chin Settlement Act of 1984 |
| Cocopah Tribe of Arizona | AZ | 1963 | Court Decree | Arizona v. California |
| Colorado River Indian Tribes | AZ | 1963 | Court Decree | Arizona v. California |
| Fort McDowell Yavapai Nation | AZ | 1990 | Settlement | Fort McDowell Indian Community Water Rights Settlement Act of 1990 |
| Fort Mojave Indian Tribe | AZ | 1963 | Court Decree | Arizona v. California |
| Gila River Indian Community | AZ | 2004 | Settlement | Settlement Act as Title II of the Arizona Water Settlements Act |
| Pascua Yaqui Tribe of Arizona | AZ | 1980 | Settlement | CAP Allocations of January 1982 |
| Quechan Tribe | AZ | 1963 | Court Decree | Arizona v. California |
| Salt River Pima-Maricopa Indian Community | AZ | 1988 | Settlement | Salt River Pima-Maricopa Indian Community Water Rights Settlement Act |
| San Carlos Apache Tribe | AZ | 1999 | Settlement | San Carlos Apache Tribe Water Rights Settlement Act |

| | | | | |
|---|---|---|---|---|
| Tohono O'odham Nation of Arizona | AZ | 2004 | Settlement | Southern Arizona Indian Water Rights Settlement |
| White Mountain Apache Tribe | AZ | 2010 | Settlement | Claims Resolution Act of 2010 |
| Yavapai-Prescott Indian Tribe | AZ | 1995 | Settlement | Yavapai-Prescott Indian Tribe Water Rights Settlement Act of 1994 |
| Zuni Tribe | AZ | 2003 | Settlement | Zuni Indian Tribe Water Rights Settlement Act of 2003 |
| Chemehuevi Tribe | CA | 1963 | Court Decree | Arizona v. California |
| Southern Ute Indian Tribe | CO | 1986 | Settlement | Colorado Ute Indian Water Rights Settlement |
| Nez Perce Tribe | ID | 2004 | Settlement | Snake River Water Agreement |
| Shoshone-Bannock Tribes | ID | 1990 | Settlement | 1990 Fort Hall Indian Water Rights Agreement |
| Assiniboine and Sioux Tribes | MT | 1985 | Settlement | Fort Peck - Montana Compact |
| Blackfeet Tribe | MT | 2015 | Settlement | H.R.5633 - Blackfeet Water Rights Settlement Act |
| Chippewa-Cree Indians | MT | 1999 | Settlement | Water Rights Compact with the State of Montana, Chippewa Cree Tribe of the Rocky Boy’s Reservation, |

| | | | | |
|---|---|---|---|---|
| | | | | and United States |
| Confederated Salish and Kootenai Tribes | MT | 2016 | Settlement | Salish and Kootenai Water Rights Settlement Act of 2016 |
| Crow Tribe of Montana | MT | 2010 | Settlement | Crow Tribe Water Rights Settlement Act of |
| Fort Belknap Indian Community | MT | 2001 | Settlement | Water Rights Compact entered into by the State of Montana, the Fort Belknap Indian Community of the Fort Belknap Indian Reservation, and the United States of America |
| Northern Cheyenne Tribe | MT | 1991 | Settlement | Northern Cheyenne Water Rights Compact |
| Jicarilla Apache Nation | NM | 1992 | Settlement | Jicarilla Apache Tribe Water Settlement Act |
| Mescalero Apache Tribe | NM | 1993 | Court Decree | New Mexico v. Mescalero Apache Trip |
| Navajo Nation | NM | 2010 | Settlement | San Juan River Basin in New Mexico Navajo Nation Water Rights Settlement Agreement |

| | | | | |
|---|---|---|---|---|
| Pueblo of Nambe | NM | 2010 | Settlement | Aamodt Litigation Settlement Act |
| Pueblo of Pojoaque | NM | 2010 | Settlement | Aamodt Litigation Settlement Act |
| Pueblo of San Idelfonso | NM | 2010 | Settlement | Aamodt Litigation Settlement Act |
| Pueblo of Taos | NM | 2010 | Settlement | Taos Pueblo Water Rights Settlement Agreement |
| Pueblo of Teseque | NM | 2010 | Settlement | Aamodt Litigation Settlement Act |
| Las Vegas Tribe of Paiute Indians | NV | 1999 | Settlement | Not Available |
| Moapa Band of Paiute Indians | NV | 2016 | MOU | Unavailable |
| Paiute-Shoshone Tribe | NV | 1990 | Settlement | Fallon Paiute Shoshone Indian Tribes Water Rights Settlement Act |
| Pyramid Lake Paiute Tribe | NV | 1990 | Settlement | Pyramid Lake Paiute Tribe - Fish Springs Ranch Settlement Act |
| Shoshone-Paiute Tribe | NV | 2009 | Settlement | Shoshone-Paiute Tribes of the Duck Valley Reservation Water Rights Settlement Act |
| Confederated Tribes of the Warm Springs Reservation of Oregon | OR | 1997 | Settlement | Confederated Tribes of the Warm Springs Reservation |

| | | | | |
|---|---|---|---|---|
| | | | | Water Rights Settlement Agreement |
| Pauite Indian Tribe of Utah | UT | 2000 | Settlement | Shivwits Band of the Paiute Indian Tribe of Utah Water Rights Settlement Act |
| Ute Indian Tribe | UT | 1992 | Settlement | Ute Indian Water Compact |
| Ute Mountain Tribe | UT | 1986 | Settlement | Colorado Ute Indian Water Rights Settlement |
| Confederated Tribes and Bands of the Yakama Nation | WA | 2006 | Court Decree | Ecology vs. Yakima Reservation Irrigation District |
| Confederated Tribes of the Colville Reservation | WA | 1978 | Court Decree | Colville Confederated Tribes v. Walton |
| Lummi Tribe | WA | 2007 | Settlement | United States and Lummi Nation v. Ecology |
| Spokane Tribe | WA | 1984 | Court Decree | United States vs. Anderson |
| Arapahoe and Shoshone Tribes | WY | 1992 | Court Decree | Big Horn River General Adjudication |

## E. Tract Level Mann-Whitney Results

| | statistic | p.value | method | data.name |
|---|---|---|---|---|
| mwFAPov | 761980.5 | 0.00000000 | Wilcoxon rank sum test with | othernewdata$Percent_Fam |
| mwPerCap | 738003 | 0.00000000 | Wilcoxon rank sum test with | othernewdata$Per_Capita_I |
| mwperUrb | 454456 | 0.00000000 | Wilcoxon rank sum test with | othernewdata$Per_Urban ar |
| mwComm | 1313583.5 | 0.36917260 | Wilcoxon rank sum test with | othernewdata$Mean_Travel |
| mwperBach | 1678579.5 | 0.00000000 | Wilcoxon rank sum test with | othernewdata$Per_Over25y |
| mwperAgF | 1878461 | 0.00000000 | Wilcoxon rank sum test with | othernewdata$Per_AgFores |
| mw5SPEI | 1331739.5 | 0.17572881 | Wilcoxon rank sum test with | othernewdata$`20062010_M |
| mw5SPEISQ | 1212835.5 | 0.10408381 | Wilcoxon rank sum test with | othernewdata$`5Yr_MeanSP |
| mwIrrCrop | 1022207 | 0.00000000 | Wilcoxon rank sum test with | othernewdata$CIrrgCrop_Su |
| mwInternet | 853583 | 0.00000000 | Wilcoxon rank sum test with | othernewdata$CResidential |
| mwFarmI | 1849370.5 | 0.00000000 | Wilcoxon rank sum test with | othernewdata$Crevised_Far |
| mwperNA | 2419451 | 0.00000000 | Wilcoxon rank sum test with | othernewdata$Per_PopIden |
| mwperTL | 2547829 | 0.00000000 | Wilcoxon rank sum test with | othernewdata$Per_TribalLa |

## F. County Level Regression Results

*Dependent Variable: Per Capita Income*

| | Estimate | Std. Error | t value | Pr(>\|t\|) | |
|---|---|---|---|---|---|
| (Intercept) | -4.48e+03 | 3.27e+03 | -1.37 | 0.1722 | |
| Cper_TribalLand | -1.51e+03 | 1.02e+03 | -1.48 | 0.1388 | |
| Cper_Urban_PopWeighted | 1.42e+02 | 4.32e+01 | 3.29 | 0.0011 | ** |
| Cper_25Over_withBach_PopWeighted | 4.94e+02 | 4.58e+01 | 10.77 | < 2e-16 | *** |
| Cper_25yrs_HSorSomeColl_PopWeighted | 1.26e+02 | 4.47e+01 | 2.83 | 0.0050 | ** |
| Cper_AgForFishMineHunt_PopWeighted | 1.02e+02 | 3.09e+01 | 3.31 | 0.0010 | ** |
| C20082010_Mean_SPEI | -4.39e+03 | 1.66e+03 | -2.65 | 0.0085 | ** |
| CIrrgCrop_SurfWater | -1.79e+00 | 8.42e-01 | -2.12 | 0.0346 | * |
| CResidential_Internet_per1000HH | 1.51e+03 | 3.10e+02 | 4.88 | 1.6e-06 | *** |
| CPer_TotalGrossFarmIncome_ofCountyGDP | -1.97e+05 | 1.55e+06 | -0.13 | 0.8991 | |

| | Estimate | Std. Error | t value | Pr(>\|t\|) | |
|---|---|---|---|---|---|
| (Intercept) | -4.52e+03 | 3.24e+03 | -1.40 | 0.1639 | |
| Cper_TribalPop | -1.53e+03 | 1.03e+03 | -1.49 | 0.1373 | |
| Cper_Urban_PopWeighted | 1.42e+02 | 4.32e+01 | 3.29 | 0.0011 | ** |
| Cper_25Over_withBach_PopWeighted | 4.95e+02 | 4.60e+01 | 10.76 | < 2e-16 | *** |
| Cper_25yrs_HSorSomeColl_PopWeighted | 1.27e+02 | 4.45e+01 | 2.86 | 0.0045 | ** |
| Cper_AgForFishMineHunt_PopWeighted | 1.02e+02 | 3.09e+01 | 3.31 | 0.0010 | ** |
| C20082010_Mean_SPEI | -4.27e+03 | 1.67e+03 | -2.56 | 0.0110 | * |
| CIrrgCrop_SurfWater | -1.82e+00 | 8.51e-01 | -2.14 | 0.0329 | * |
| CResidential_Internet_per1000HH | 1.49e+03 | 3.12e+02 | 4.79 | 2.5e-06 | *** |
| CPer_TotalGrossFarmIncome_ofCountyGDP | -1.47e+05 | 1.56e+06 | -0.09 | 0.9253 | |

| | Estimate | Std. Error | t value | Pr(>\|t\|) | |
|---|---|---|---|---|---|
| (Intercept) | 5.31e+01 | 3.89e+00 | 13.63 | < 2e-16 | *** |
| Cper_TribalLand | 4.60e+00 | 1.29e+00 | 3.58 | 0.00039 | *** |
| Cper_Urban_PopWeighted | -1.43e-01 | 3.62e-02 | -3.96 | 8.9e-05 | *** |
| Cper_25Over_withBach_PopWeighted | -4.13e-01 | 4.32e-02 | -9.57 | < 2e-16 | *** |
| Cper_25yrs_HSorSomeColl_PopWeighted | -3.93e-01 | 4.85e-02 | -8.10 | 9.4e-15 | *** |
| Cper_AgForFishMineHunt_PopWeighted | -1.18e-01 | 2.49e-02 | -4.76 | 2.9e-06 | *** |
| C20082010_Mean_SPEI | -4.91e-01 | 1.62e+00 | -0.30 | 0.76239 | |
| CIrrgCrop_SurfWater | -1.84e-03 | 1.04e-03 | -1.76 | 0.07879 | . |
| CResidential_Internet_per1000HH | -1.24e+00 | 2.83e-01 | -4.40 | 1.4e-05 | *** |
| CPer_TotalGrossFarmIncome_ofCountyGDP | 1.50e+03 | 1.27e+03 | 1.19 | 0.23647 | |

---
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

| | Estimate | Std. Error | t value | Pr(>\|t\|) | |
|---|---|---|---|---|---|
| (Intercept) | 5.30e+01 | 3.84e+00 | 13.80 | < 2e-16 | * |
| Cper_TribalPop | 5.27e+00 | 1.60e+00 | 3.28 | 0.0011 | * |
| Cper_Urban_PopWeighted | -1.42e-01 | 3.59e-02 | -3.95 | 9.6e-05 | * |
| Cper_25Over_withBach_PopWeighted | -4.14e-01 | 4.27e-02 | -9.70 | < 2e-16 | * |
| Cper_25yrs_HSorSomeColl_PopWeighted | -3.94e-01 | 4.79e-02 | -8.23 | 4.0e-15 | * |
| Cper_AgForFishMineHunt_PopWeighted | -1.17e-01 | 2.49e-02 | -4.71 | 3.6e-06 | * |
| C20082010_Mean_SPEI | -9.15e-01 | 1.62e+00 | -0.56 | 0.5734 | |
| CIrrgCrop_SurfWater | -1.68e-03 | 1.05e-03 | -1.60 | 0.1107 | |
| CResidential_Internet_per1000HH | -1.17e+00 | 2.85e-01 | -4.12 | 4.7e-05 | * |
| CPer_TotalGrossFarmIncome_ofCountyGDP | 1.33e+03 | 1.34e+03 | 1.00 | 0.3201 | |

---
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

## G. Diagnostic Results

*Breusch-Pagan Test for Heteroskedasticity*

```
        studentized Breusch-Pagan test

data:  pcireg
BP = 491.06, df = 9, p-value < 2.2e-16

> bptest(pcireg3)

        studentized Breusch-Pagan test

data:  pcireg3
BP = 491.78, df = 9, p-value < 2.2e-16

> bptest(fbpreg)

        studentized Breusch-Pagan test

data:  fbpreg
BP = 292.27, df = 9, p-value < 2.2e-16

> bptest(fbpreg3)

        studentized Breusch-Pagan test

data:  fbpreg3
BP = 288.86, df = 9, p-value < 2.2e-16
```

*White's Test for Heteroskedasticity*

```
> bptest(pcireg, ~ I(fitted(pcireg)) + I(fitted(pcireg)^2))

        studentized Breusch-Pagan test

data:  pcireg
BP = 67.464, df = 2, p-value = 2.241e-15

> bptest(pcireg3, ~ I(fitted(pcireg3)) + I(fitted(pcireg3)^2))

        studentized Breusch-Pagan test

data:  pcireg3
BP = 67.699, df = 2, p-value = 1.992e-15

> bptest(fbpreg, ~ I(fitted(fbpreg)) + I(fitted(fbpreg)^2))

        studentized Breusch-Pagan test

data:  fbpreg
BP = 81.109, df = 2, p-value < 2.2e-16

> bptest(fbpreg3, ~ I(fitted(fbpreg3)) + I(fitted(fbpreg3)^2))

        studentized Breusch-Pagan test

data:  fbpreg3
BP = 61.93, df = 2, p-value = 3.565e-14
```

*Hausman-Wu Test for Endogeneity*

```
ivreg(formula = Per_Capita_Inc_All ~ Per_TribalPop + Per_Urban +
    Mean_Traveltime_toWork_inMin + Per_25Over_withHSorSomeCollege +
    Per_Over25yrs_withBach_orHigher + CPer_TotalGrossFarmIncome_ofCountyGDP +
    Per_AgForestFishHuntMining + CResidential_Internet_per1000HH +
    CIrrgCrop_SurfWater + C20082010_Mean_SPEI | Per_TribalPop +
    Per_Urban + Per_PublicTransit_wEmployment + Per_25Over_withHSorSomeCollege +
    Per_Over25yrs_withBach_orHigher + CPer_TotalGrossFarmIncome_ofCountyGDP +
    Per_AgForestFishHuntMining + CResidential_Internet_per1000HH +
    CIrrgCrop_SurfWater + C20082010_Mean_SPEI, data = newdata)

Residuals:
   Min     1Q Median     3Q    Max
-75362  -4352   -189   3988 132959

Coefficients:
                                      Estimate Std. Error t value Pr(>|t|)
(Intercept)                           8.41e+03   3.13e+03    2.68   0.0073 **
Per_TribalPop                        -2.54e+03   5.59e+02   -4.55  5.5e-06 ***
Per_Urban                            -5.77e+03   8.48e+02   -6.80  1.2e-11 ***
Mean_Traveltime_toWork_inMin         -5.14e+02   1.21e+02   -4.26  2.1e-05 ***
Per_25Over_withHSorSomeCollege        1.54e+02   1.20e+01   12.80  < 2e-16 ***
Per_Over25yrs_withBach_orHigher       6.26e+02   9.98e+00   62.68  < 2e-16 ***
CPer_TotalGrossFarmIncome_ofCountyGDP -1.18e+07  3.63e+06   -3.25   0.0012 **
Per_AgForestFishHuntMining           -1.43e+01   3.59e+01   -0.40   0.6908
CResidential_Internet_per1000HH       2.16e+03   2.93e+02    7.37  1.9e-13 ***
CIrrgCrop_SurfWater                  -3.69e+00   5.63e-01   -6.55  6.3e-11 ***
C20082010_Mean_SPEI                  -8.39e+03   7.53e+02  -11.15  < 2e-16 ***

Diagnostic tests:
                  df1  df2 statistic p-value
Weak instruments    1 7479     196.8 < 2e-16 ***
Wu-Hausman          1 7478      42.4 7.8e-11 ***
Sargan              0   NA        NA      NA
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 8550 on 7479 degrees of freedom
Multiple R-Squared: 0.502,	Adjusted R-squared: 0.502
Wald test:  665 on 10 and 7479 DF,  p-value: <2e-16
```

```
Call:
lm(formula = Per_Capita_Inc_All ~ Per_TribalPop + Mean_Traveltime_toWork_inMin +
    Per_Over25yrs_HSgradorHigher + CPer_TotalGrossFarmIncome_ofCountyGDP +
    Per_AgForestFishHuntMining + CResidential_Internet_per1000HH +
    CIrrgCrop_SurfWater + C20082010_Mean_SPEI + d.hat, data = newdata)

Residuals:
   Min     1Q Median     3Q    Max
-33159  -5340  -1468   3401 125147

Coefficients:
                                       Estimate Std. Error t value Pr(>|t|)
(Intercept)                           -2.69e+04   1.67e+03  -16.16  < 2e-16 ***
Per_TribalPop                         -7.41e+02   7.70e+02   -0.96     0.34
Mean_Traveltime_toWork_inMin           2.33e+02   1.84e+01   12.63  < 2e-16 ***
Per_Over25yrs_HSgradorHigher           6.27e+02   1.06e+01   59.28  < 2e-16 ***
CPer_TotalGrossFarmIncome_ofCountyGDP -1.31e+07   2.38e+06   -5.51  3.7e-08 ***
Per_AgForestFishHuntMining             1.46e+01   2.01e+01    0.72     0.47
CResidential_Internet_per1000HH        3.51e+03   2.50e+02   14.03  < 2e-16 ***
CIrrgCrop_SurfWater                   -2.85e+00   6.64e-01   -4.29  1.8e-05 ***
C20082010_Mean_SPEI                   -7.45e+03   6.05e+02  -12.32  < 2e-16 ***
d.hat                                 -8.54e+02   5.83e+01  -14.64  < 2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 9380 on 7480 degrees of freedom
Multiple R-squared:  0.401,	Adjusted R-squared:  0.401
F-statistic:  557 on 9 and 7480 DF,  p-value: <2e-16
```

```
ivreg(formula = Percent_Families_BelowPoverty ~ Per_TribalPop +
    Per_Urban + Mean_Traveltime_toWork_inMin + Per_25Over_withHSorSomeCollege +
    Per_Over25yrs_withBach_orHigher + CPer_TotalGrossFarmIncome_ofCountyGDP +
    Per_AgForestFishHuntMining + CResidential_Internet_per1000HH +
    CIrrgCrop_SurfWater + C20082010_Mean_SPEI | Per_TribalPop +
    Per_Urban + Per_PublicTransit_wEmployment + Per_25Over_withHSorSomeCollege +
    Per_Over25yrs_withBach_orHigher + CPer_TotalGrossFarmIncome_ofCountyGDP +
    Per_AgForestFishHuntMining + CResidential_Internet_per1000HH +
    CIrrgCrop_SurfWater + C20082010_Mean_SPEI, data = newdata)

Residuals:
    Min      1Q  Median      3Q     Max
-31.765  -5.686  -0.736   4.749  93.892

Coefficients:
                                     Estimate Std. Error t value Pr(>|t|)
(Intercept)                          4.17e+01   3.73e+00   11.18  < 2e-16 ***
Per_TribalPop                        8.27e+00   1.03e+00    8.03  1.1e-15 ***
Per_Urban                            7.29e+00   9.37e-01    7.78  8.3e-15 ***
Mean_Traveltime_toWork_inMin         8.74e-01   1.40e-01    6.23  4.8e-10 ***
Per_25Over_withHSorSomeCollege      -5.34e-01   1.70e-02  -31.38  < 2e-16 ***
Per_Over25yrs_withBach_orHigher     -5.42e-01   1.40e-02  -38.81  < 2e-16 ***
CPer TotalGrossFarmIncome ofCountvGDP  1.67e+04   3.43e+03    4.86  1.2e-06 ***
```

```
Call:
lm(formula = Percent_Families_BelowPoverty ~ Per_TribalPop +
    Mean_Traveltime_toWork_inMin + Per_Over25yrs_HSgradorHigher +
    CPer_TotalGrossFarmIncome_ofCountyGDP + Per_AgForestFishHuntMining +
    CResidential_Internet_per1000HH + CIrrgCrop_SurfWater + C20082010_Mean_SPEI
    d.hat, data = newdata)

Residuals:
   Min     1Q Median     3Q    Max
-36.62  -3.86  -1.06   2.66  83.05

Coefficients:
                                       Estimate Std. Error t value Pr(>|t|)
(Intercept)                            6.56e+01   1.23e+00   53.20  < 2e-16 ***
Per_TribalPop                          7.01e+00   5.70e-01   12.30  < 2e-16 ***
Mean_Traveltime_toWork_inMin          -1.58e-01   1.36e-02  -11.59  < 2e-16 ***
Per_Over25yrs_HSgradorHigher          -5.81e-01   7.82e-03  -74.27  < 2e-16 ***
CPer_TotalGrossFarmIncome_ofCountyGDP  3.69e+03   1.76e+03    2.10  0.03614 *
Per_AgForestFishHuntMining            -1.45e-01   1.49e-02   -9.73  < 2e-16 ***
CResidential_Internet_per1000HH       -1.15e+00   1.85e-01   -6.23  5.0e-10 ***
CIrrgCrop_SurfWater                   -1.04e-03   4.91e-04   -2.12  0.03372 *
C20082010_Mean_SPEI                    1.72e+00   4.48e-01    3.83  0.00013 ***
d.hat                                  1.69e-01   4.32e-02    3.92  8.8e-05 ***
---
```

```
ivreg(formula = Per_Capita_Inc_All ~ Per_TribalLand + Per_Urban +
    Mean_Traveltime_toWork_inMin + Per_25Over_withHSorSomeCollege +
    Per_Over25yrs_withBach_orHigher + CPer_TotalGrossFarmIncome_ofCount
    Per_AgForestFishHuntMining + CResidential_Internet_per1000HH +
    CIrrgCrop_SurfWater + C20082010_Mean_SPEI | Per_TribalLand +
    Per_Urban + Per_PublicTransit_wEmployment + Per_25Over_withHSorSome
    Per_Over25yrs_withBach_orHigher + CPer_TotalGrossFarmIncome_ofCount
    Per_AgForestFishHuntMining + CResidential_Internet_per1000HH +
    CIrrgCrop_SurfWater + C20082010_Mean_SPEI, data = newdata)

Residuals:
   Min     1Q Median     3Q    Max
-75387  -4357   -191   3995 132974

Coefficients:
                                      Estimate Std. Error t value Pr(>
(Intercept)                           8.40e+03   3.14e+03    2.67   0.
Per_TribalLand                       -2.53e+03   5.59e+02   -4.53   6.1
Per_Urban                            -5.78e+03   8.52e+02   -6.78   1.3
Mean_Traveltime_toWork_inMin         -5.15e+02   1.21e+02   -4.26   2.0
Per_25Over_withHSorSomeCollege        1.54e+02   1.20e+01   12.79   < 2
Per_Over25yrs_withBach_orHigher       6.26e+02   1.00e+01   62.58   < 2
CPer_TotalGrossFarmIncome_ofCountyGDP -1.18e+07  3.64e+06   -3.25   0.
Per_AgForestFishHuntMining           -1.45e+01   3.59e+01   -0.40   0.
CResidential_Internet_per1000HH       2.17e+03   2.93e+02    7.42   1.3
CIrrgCrop_SurfWater                  -3.68e+00   5.63e-01   -6.54   6.8
C20082010_Mean_SPEI                  -8.40e+03   7.53e+02  -11.16   < 2

Diagnostic tests:
                  df1  df2 statistic p-value
Weak instruments    1 7479     197.4 < 2e-16 ***
Wu-Hausman          1 7478      42.5 7.4e-11 ***
Sargan              0   NA        NA      NA
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 8550 on 7479 degrees of freedom
Multiple R-Squared: 0.502,	Adjusted R-squared: 0.501
Wald test:  664 on 10 and 7479 DF,  p-value: <2e-16
```

```
Call:
lm(formula = Per_Capita_Inc_All ~ Per_TribalLand + Mean_Traveltime_toWork_inMin +
    Per_Over25yrs_HSgradorHigher + CPer_TotalGrossFarmIncome_ofCountyGDP +
    Per_AgForestFishHuntMining + CResidential_Internet_per1000HH +
    CIrrgCrop_SurfWater + C20082010_Mean_SPEI + d.hat, data = newdata)

Residuals:
   Min     1Q Median     3Q    Max
-33151  -5336  -1473   3402 125154

Coefficients:
                                       Estimate Std. Error t value Pr(>|t|)
(Intercept)                           -2.70e+04   1.67e+03  -16.19  < 2e-16 ***
Per_TribalLand                        -8.38e+02   7.65e+02   -1.09     0.27
Mean_Traveltime_toWork_inMin           2.33e+02   1.84e+01   12.62  < 2e-16 ***
Per_Over25yrs_HSgradorHigher           6.27e+02   1.06e+01   59.28  < 2e-16 ***
CPer_TotalGrossFarmIncome_ofCountyGDP -1.31e+07   2.38e+06   -5.50  3.9e-08 ***
Per_AgForestFishHuntMining             1.47e+01   2.01e+01    0.73     0.47
CResidential_Internet_per1000HH        3.50e+03   2.50e+02   14.03  < 2e-16 ***
CIrrgCrop_SurfWater                   -2.85e+00   6.64e-01   -4.29  1.8e-05 ***
C20082010_Mean_SPEI                   -7.44e+03   6.05e+02  -12.30  < 2e-16 ***
d.hat                                 -8.51e+02   5.83e+01  -14.61  < 2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 9380 on 7480 degrees of freedom
Multiple R-squared:  0.401,	Adjusted R-squared:  0.401
F-statistic:  557 on 9 and 7480 DF,  p-value: <2e-16
```

## H. R Code Documentation

```
#Full code File
#dataset -> tribedatarevised, at census tract level

#remove incomplete observations
newdata1 <- na.omit(finaldata)
#creates dataset with 7490 obs from original 7515

#create regions by state

newdata1$PacNorWest <- ifelse(newdata1$ST_CO=="53" | newdata1$ST_CO=="41"| newdata1$ST_CO=="16", 1, 0)
newdata1$SouthWest <- ifelse(newdata1$ST_CO=="4" | newdata1$ST_CO=="35", 1, 0)

#descriptive stats
descriptives2 <- pastecs::stat.desc(corplot4)
write.csv(descriptives2, "descriptives2.csv")

#correlation plot
library(corrplot)
M <- cor(newdata1)
corrplot(M, type="upper", tl.col="black", tl.srt=45)

#run pooled linear models which enables error clustering by county

library(plm)
fab <-
plm(formula=Percent_Fam_AbovePov~Tribal_Presence2.5+Per_Urban+Mean_Traveltime_toWork_inMin+Rev_Per_25Yr_Wba
ch+Per_AgForestFishHuntMining+Crevised_FarmInc_Of_CountyGDP+CResidential_Internet_per1000HH+CIrrgCrop_SurfWat
er+fiveYR_MeanSPEI_SQ+PacNorWest+SouthWest, data=newdata1, model="pooling", index=c("State_County"))
pci <-
plm(formula=Per_Capita_Inc_All~Tribal_Presence2.5+Per_Urban+Mean_Traveltime_toWork_inMin+Rev_Per_25Yr_Wbach+
Per_AgForestFishHuntMining+Crevised_FarmInc_Of_CountyGDP+CResidential_Internet_per1000HH+CIrrgCrop_SurfWater+
fiveYR_MeanSPEI_SQ+PacNorWest+SouthWest, data=newdata1, model="pooling", index=c("State_County"))

#diagnostic tests

library(lmtest)

#breusch-pagan
bptest(fab)
bptest(pci)

#whites test
bptest(fab, ~ fitted(fab) + I(fitted(fab)^2))
bptest(pci, ~ fitted(pci) + I(fitted(pci)^2))

#hausman wu with percent public transit
library(AER)
library(sandwich)
colnames(newdata)
ivpci <- ivreg(formula= Per_Capita_Inc_All ~ Tribal_Presence2.5 + Per_Urban + Mean_Traveltime_toWork_inMin +
Per_Over25yrs_withBach_orHigher +
        Crevised_FarmInc_Of_CountyGDP + CResidential_Internet_per1000HH + CIrrgCrop_SurfWater +
fiveYR_MeanSPEI_SQ +
        PacNorWest + SouthWest
       |Tribal_Presence2.5 + Per_Urban + Per_PublicTransit_wEmployment + Per_Over25yrs_withBach_orHigher +
        Crevised_FarmInc_Of_CountyGDP + CResidential_Internet_per1000HH + CIrrgCrop_SurfWater +
fiveYR_MeanSPEI_SQ +
        PacNorWest + SouthWest,
      data = newdata1)
```

```
ivfab <- ivreg(formula= Percent_Fam_AbovePov ~ Tribal_Presence2.5 + Per_Urban + Mean_Traveltime_toWork_inMin +
Per_Over25yrs_withBach_orHigher +
              Crevised_FarmInc_Of_CountyGDP + CResidential_Internet_per1000HH + CIrrgCrop_SurfWater +
fiveYR_MeanSPEI_SQ +
              PacNorWest + SouthWest
            |Tribal_Presence2.5 + Per_Urban + Per_PublicTransit_wEmployment + Per_Over25yrs_withBach_orHigher +
              Crevised_FarmInc_Of_CountyGDP + CResidential_Internet_per1000HH + CIrrgCrop_SurfWater +
fiveYR_MeanSPEI_SQ +
              PacNorWest + SouthWest,
            data = newdata1)

summary(ivpci,vcov =vcovHC(ivpci, type="HC1"), diagnostics = TRUE)

summary(ivfab,vcov =vcovHC(ivfab, type="HC1"), diagnostics = TRUE)

#spatial autocorrelation done in GeoDa

#returned high probability that dependent variables have spatial autocorrelation, to solve, errors clustered by county

#return clustered errors by county
G <- length(unique(newdata1$State_County))
N <- length(newdata1$State_County)
dfa1 <- (G/(G - 1)) * (N - 1)/pci$df.residual

# display with cluster VCE and df-adjustment
firm_c_vcov <- dfa1 * vcovHC(pci, type = "HC0", cluster = "group", adjust = T)
coeftest(pci, vcov = firm_c_vcov)


clustpci <- coeftest(pci, vcov=vcovHC(pci, type="sss", cluster="group"))
clustfab <- coeftest(fab, vcov=vcovHC(fab, type="sss", cluster="group"))


#Robust Errors
robustpci <- coeftest(pci, vcov = vcovHC(pci, "white1"))
robustfab <- coeftest(fab, vcov = vcovHC(fab, "white1"))

#comparative mannwhit tests
#upload county level data
CountyWeighted$fiveYR_MeanSPEI_SQ <- CountyWeighted$`5YRMean_SPEI_SQ`
newdata <- subset(CountyWeighted, CountyWeighted$CTribalLand>=1)
othernewdata <- subset(newdata, newdata$Cper_IdentifyasNA>=0.025)

mydata <- subset(CountyWeighted, CountyWeighted$CTribalLand<1)
mydata2 <- subset(newdata,newdata$Cper_IdentifyasNA<0.025)
mydata1 <- rbind(mydata, mydata2)
colnames(CountyWeighted)

CountyWeighted$CFam_AbovePOv <- 100-CountyWeighted$Cper_FamiliesBelowPov_PopWeighted

mwFAPov <- wilcox.test(othernewdata$CFam_AbovePOv, mydata1$CFam_AbovePOv)
mwPerCap <- wilcox.test(othernewdata$Cper_Capita_Inc_PopWeighted, mydata1$Cper_Capita_Inc_PopWeighted)

#regressions with clustered results and water
str(CountyWeighted)
colnames(CountyWeighted)
fabA <-
plm(formula=CFam_AbovePOv~Ctribal_Presence2.5+Cper_Urban_PopWeighted+CMeanCommute_PopWeighted+Cper_25Ov
er_withBach_PopWeighted+Cper_AgForFishMineHunt_PopWeighted+Crev_FarmIncome_of_CountyGDP+CResidential_Intern
et_per1000HH+CIrrgCrop_SurfWater+fiveYR_MeanSPEI_SQ+Northwest +Southwest_AZNM , data=CountyWeighted,
model="pooling", index=c("State"))
```

```
fabB <-
plm(formula=CFam_AbovePOv~Chas_water+Cper_Urban_PopWeighted+CMeanCommute_PopWeighted+Cper_25Over_with
Bach_PopWeighted+Cper_AgForFishMineHunt_PopWeighted+Crev_FarmIncome_of_CountyGDP+CResidential_Internet_per1
000HH+CIrrgCrop_SurfWater+fiveYR_MeanSPEI_SQ+Northwest +Southwest_AZNM , data=CountyWeighted,
model="pooling", index=c("State"))
pciA <-
plm(formula=Cper_Capita_Inc_PopWeighted~Ctribal_Presence2.5+Cper_Urban_PopWeighted+CMeanCommute_PopWeighted
+Cper_25Over_withBach_PopWeighted+Cper_AgForFishMineHunt_PopWeighted+Crev_FarmIncome_of_CountyGDP+CResi
dential_Internet_per1000HH+CIrrgCrop_SurfWater+fiveYR_MeanSPEI_SQ+Northwest +Southwest_AZNM ,
data=CountyWeighted, model="pooling", index=c("State"))
pciB <-
plm(formula=Cper_Capita_Inc_PopWeighted~Chas_water+Cper_Urban_PopWeighted+CMeanCommute_PopWeighted+Cper_
25Over_withBach_PopWeighted+Cper_AgForFishMineHunt_PopWeighted+Crev_FarmIncome_of_CountyGDP+CResidential_
Internet_per1000HH+CIrrgCrop_SurfWater+fiveYR_MeanSPEI_SQ+Northwest +Southwest_AZNM , data=CountyWeighted,
model="pooling", index=c("State"))


cpciA <- coeftest(pciA, vcov = vcovHC(pciA, "white1"))
cpciB <- coeftest(pciB, vcov = vcovHC(pciB, "white1"))
cfabA <- coeftest(fabA, vcov=vcovHC(fabA, "white1"))
cfabB <- coeftest(fabB, vcov=vcovHC(fabB, "white1"))


#create results output for use in thesis
options(scipen = 999)
library(stargazer)
stargazer(cpciA,cpciB,cfabA,cfabB, type = "html", out = "countyrobust.htm",
        title="Regression Results", single.row=TRUE,digits = 2,
        ci.level=0.9)

#breusch-pagan
bptest(fabA)
bptest(fabB)
bptest(pciA)
bptest(pciB)

#whites test
bptest(fabA, ~ fitted(fabA) + I(fitted(fabA)^2))
bptest(pciA, ~ fitted(pciA) + I(fitted(pciA)^2))
```

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