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The Economic Effects of Infrastructure Development in American Indian Tribal Areas with Low Income and High Unemployment

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Abstract: Some of the worst incidences of poverty in the United States exist in American Indian tribal areas, also known as "Indian Country." It is the responsibility of the Office of the Assistant Secretary for Indian Affairs, at the U.S. Department of the Interior, to promote policies to facilitate the economic development and growth of Indian Country. One of the key ingredients for such growth is improved infrastructure, especially in the most impoverished areas. This paper will provide guidance to economists and policy analysts, both within and outside of Indian Affairs, on how to develop infrastructure-based strategies for promoting economic growth in Indian Country. The paper presents a macroeconomic model that interrelates infrastructure development with household income and consumption and examines the multiplier effects that result from expanded infrastructure in tribal areas. The model demonstrates that states may easily benefit from supporting tribal infrastructure development, by various spillover effects.

Keywords: American Indians, Native Americans, Infrastructure, Economic Development, State

Introduction

In this paper, the term "tribal area" will refer to the land area occupied and belonging to a federally recognized, tribal nation in the United States. These land areas are sometimes referred to as land "held in trust," "restricted fee land," and "fee simple land." In colloquial language such land has historically been called "Indian reservations," but in actually, the term "reservation" has specific historical and legal meaning that is much more restrictive than the "tribal land" that can be affiliated with federally recognized American Indian and Alaska Native tribes.

Tribal land lies geographically within a state of the United States (though some tribes have areas that traverse more than one state). With regard to economic growth, it remains ambiguous as to whether economic growth *inside* a tribal area and economic growth outside that tribal area (but in the same state), are complements or substitutes. Such would depend in large part on non-economic factors, including the internal political policies of the state and perhaps even the idiosyncratic characteristics of the existing state leadership. Nevertheless, economic modeling can shed substantial light on the topic and help inform state policy on the topic of tribal economic growth.

To understand the ambiguities involved, let us consider that tribal members, who are living in those tribal areas, are also voting citizens in their states and thus they are expected to help elect those state leaders who they believe will offer the policies that are in the best interests of their tribe. Similarly, the demographic and economic statistics of any state naturally include, within their domain, the tribal areas in that state. As a result, state leaders will have more to be proud of (or brag about), in terms of these reported statistics, all else being equal, when the tribes in the state experience improvements in economic growth, life expectancies and other health-based indicators, educational attainment, reductions in crime, etc. From these considerations alone, one might first be inclined to assume that states will implement policies in tribal areas that would be equivalent to those implemented in non-tribal areas.

In reality, however, the situation is much more complicated than this. For example, when one travels in certain states from a typical non-tribal town, to inside a low-income tribal area, it can be analogous to international travel from an industrialized nation to a developing one. This inconsistency suggests that there is a fundamental, economic divide between tribal and non-tribal areas. To understand this divide, as a possible consequence of state economic policy, we can begin by asking: “What should be regarded as the state’s policy goal?” Consider the following three possibilities:

1. Overall Benefit to All State Residents
2. Overall Benefit to Non-Tribal State Residents
3. Maximization of the State’s Revenue Collection

This question needs to be asked because, whether certain economic actions by the state would achieve the state’s goals, could depend greatly on what those specific goals are. For example, if a particular action by the state substantially improves the economic well-being of, say, 100 tribal members, but simultaneously, slightly decreases the economic well-being of 100 non-tribal members, then the first goal listed above would be met, while the second would not be met. Similarly, if infrastructure development were expanded as a result of new tax-reduction incentives, which leads, in turn, to overall economic growth within the state, then perhaps goals #1 and #2 would be met, while goal #3 would not be met (depending on the circumstances).

Many would hope, or even expect, that it is the first goal listed that matters most to the state’s leadership. In fact, given the fact that tribal residents are also voting residents of the state, one might expect that goal #1 would be much more likely to apply than goal #2. On the other hand, some non-tribal residents in the state may view themselves as economic competitors with tribal residents, given the tribe’s sovereign status and its economic and governmental autonomy from the state at many levels (or, given cultural differences between the two demographic groups).

There is also a body of economic literature in the “Public Choice” school of thought that asserts that goal #3 is what matters most to the state (Piano, 2018). That is, people in this school of thought often believe that state governments (and the federal government as well) have leaders who see their goal as one of “expanding government.” This reflects a highly debated, multidisciplinary topic of discussion, but one that will not be discussed in this paper. Nevertheless, it might be useful for some people to know whether infrastructure development, even when financed by tax expenditures, may create enough economic growth to render tax revenues that are higher than they were prior to the application of those tax expenditures. This all leads us to now ask, would state support that increases tribal infrastructure “create a rising tide that will lift all boats”-making things better for tribal and non-tribal residents?

Some states appear to have answered this question already, in the affirmative. As a case in point, the State of New Mexico, in 2005, passed its own Tribal Infrastructure Act, which it has described as follows:

> This act recognizes that many of New Mexico’s tribal communities lack basic infrastructure, including, but not limited to water and wastewater systems, roads and electrical power lines. Through this competitive funding, all federally recognized tribes, nations and pueblos within New Mexico have an opportunity to submit a robust project proposal for their community. At each funding cycle, the project proposal is evaluated and based on scoring, is awarded funds (NMIAD, 2019).

Materials and Methods

Two-Country Model

The economic model that I will present is a “two-country” model, where one of the countries is a particular tribe and the other “country” is whatever else that tribe interacts with economically, typically a state of the United States, if the tribe is geographically located inside only one state, or it can be more than one state. Similarly, the tribe may trade with entities in another country outside the United States. So we may broadly think of the two hypothetical “countries” as being (1) the tribe in question and (2) the “rest of the world.”

However, because the rest of the world in most cases will be primarily the economy of one state, for ease of discussion and presentation I will simply use the word “state” (and the symbol “S”) as the placeholder for the “rest of the world” in this model.

We start with:

$$Y^T = C^T + I^T + G_I^T + G_S^T + X^T - M_I^T - M_C^T \tag{1}$$

$$Y^S = C^S + I^S + G_I^S + G_S^S + X^S - M_I^S - M_C^S \tag{2}$$

where, the “*T*” superscript refers to the “tribe” and the “*S*” to the state and:

Y	=	Annual output (state Y^S/tribe Y^T)-everything that is produced in a year
C	=	Consumption
I	=	Investment (physical capital produced inside the tribal area or the state)
G_I	=	Government expenditure on infrastructure
Gs	=	Government expenditure on government services
X	=	Exports (X^T is exports produced in tribal area and sold to entities outside the tribal area; X^S is exports produced in the state and sold to entities inside the tribal area.)
M_I	=	Imports that are capital goods (M_I^T is a measure of the physical capital, including improvement to infrastructure, that is imported

by tribe from the state; M_I^S a measure of the state importing physical capital from the tribe.)

M_C = Imports that are consumption goods and services (M_C^T is a measure of what is imported by tribe from the state; M_C^S a measure of the state importing from the tribe.)

Thus, Y^T represents all goods and services produced in the tribal area within a year, which is the tribe's "gross domestic product" or we can call it the "gross tribal product" as some tribes (like the Navajo Nation) already do. Some of what is produced in the tribe is consumed by the tribal population, denoted by C^T. Some is not consumed but invested by tribal enterprises, I^T. For example, if a tribal enterprise hires a tribal construction company to build a new building for it, then this would constitute such an investment as part of the gross tribal product. If that building were built for a tribal government entity, like a tribally managed school, then it would be government expenditure on infrastructure instead, G_I. If the tribal government spent money on services, such as the operating expenses of the school (paying the teachers' salaries, etc.), then this would be captured by the variable *Gs*. An understanding of the two remaining "import components" of the equation would benefit from a longer discussion, which is provided below.

Why Imports Are Subtracted from Production

One of the most common sources of confusion in national economic accounting is the subtraction of imports from the other components of output (consumption, investment and government services). In particular, one might rightfully ask, "If output is a measure of what is *produced* within a nation, then why should imports be subtracted from *what is produced?* The fact that imports were purchased does not change *how much was produced* within the nation, so why should imports be counted as, essentially, *negative* output?" The reason is that, in national accounting, what are called imports are generally assumed to be purchased by a business to resell at a retail level domestically and so the final sale of the product is a domestic sale, whose full sales price would be counted in GDP if the value of the import were not subtracted from it.

For example, suppose a bottle of wine is imported from France and sold in a store in the United States for \$25, while the seller in France received \$15 for the wine when it was imported into the United States, which also covered its transportation costs. From the sale of the wine in the United States, we would first be inclined to attribute a contribution to GDP of \$25, as a consumption expenditure (C). However, France had produced \$15 in the value of the wine (and its transport) and the U.S. produced \$10 worth of value in terms of providing the retail service of running a store in which the customer could find and purchase the wine. Hence, consumption would be \$25 in this case, in the sense that the buyer consumed something worth \$25 (in both the wine and retail convenience). However, in measuring how much was *produced* in the United States and how much income was earned in the United States, we must recognize that only \$10 was produced because that was the "value added" in the United States to the sale and likewise, the only income earned was \$10 within the United States. Hence, the import of \$15 must be subtracted (from the \$25) to measure the true output for the nation where the item was sold to retail customers.

The same may apply to investment goods. Suppose that a small office building is built as an investment by a company, in a tribal area, where the building has a sales value of \$1 million. Though it was built in the tribal area suppose it contains materials and equipment (like heating and air conditioning units) that were acquired from outside the tribal area and these materials and equipment cost \$0.3 million. In this case, the investment would still be valued at \$1 million since that is what the investment is worth, but imports of \$0.3 million would be subtracted, since the tribal economy only *produced* \$0.7 million in terms of the value added of output.

Now suppose a tribal member drives outside the tribal area to purchase an item. Given how often this could happen, this is an important economic effect that needs to be included in this analysis. In this case the tribal member is acting, essentially, in a non-exclusive capacity: first as an "importer" and then as a "domestic purchaser from that importer." Nothing in this activity involved the production of anything in the tribal economy, but consumption (C) did rise, since the product that was brought in was consumed. The proper approach then is to treat this event as both an increase in consumption expenditures and simultaneously, as an increase in imports, by the same amount.

For example, if *P* is the price of the item that was purchased and brought into the area, then consumption expenditures would rise by *P* and so would imports. Since imports are subtracted from everything else, the net effect on production "on the tribal economy side" is zero, commensurate with the fact that there was a rise in consumption, but there was no change in tribal output. On the "state economy side," however, the item was an export and it indeed was an output of that state's economy and so the state's economy would have grown by *P*.

The Equivalence of Output and Income and Its Implied Multiplier Effects

If someone lives in a tribal area but works outside the tribal area (in the "state economy") then their income, as wages, is part of the GSP, but if they work for a company in the tribal area their wages is a part of the

GTP regardless of where they live. An important, reasonable assumption, however, is that the GTP generally reflects the aggregate income of the residents of the tribal area. Thus, the economic outputs, to the tribe and state, are also the *incomes*, respectively, of tribal residents (who work for, or manage, organizations in the tribal area) and of state residents who are not also tribal residents. For ease of presentation, let us denote state residents who are not also tribal residents as "NT state residents" (with "NT" meaning not-tribal). Similarly, we can denote the consumption of "NT state residents" as simply "state NT consumption."

As a hypothetical example, which is not realistic, but it will help us visualize the model, suppose that there is a boycott of the tribe's products, whereby NT residents in the state can no longer purchase any goods or services that were produced by the tribe. This would then cause the tribe's exports to fall to zero, i.e., $X^T = 0$. This change will cause Y^T (tribal output and income) to fall, at first, by X^T. However, if income falls by this amount, then we would not expect tribal residents to consume the same amount of goods and services as they consumed before. So, the fall in X^T will have the "ripple effect" (or "multiplier effect") of causing a fall in C^T and since C^T is also part of both output and income, then income will fall even further. However, the fall in X^T has to happen *first*, since there would otherwise be no reason for C^T to fall. Likewise, M_C^T (the tribe's imports of consumer goods and services from the state) would likely fall after the tribe's exports are eliminated. M_C^T would fall for two reasons: First, tribal consumers will have lower income (from the loss of X^T) and so they would be less willing and able to purchase those imports. Second, for various possible reasons, tribal consumers may be less inclined to purchase products from the state, in response to the boycott. In other words, there could be a *trade war* between the tribe and the state.

In the above discussion I deliberately used the words, "M_C^T would *likely* fall" rather than "M_C^T *would* fall" because there may be exceptions when strange circumstances prevail. For example, suppose that the state produced some very inexpensive food items, while none of the food items produced by the tribe were as inexpensive. A fall in income among tribal residents might then cause them to demand cheaper food produced by the state, in which case M_C^T would rise.

Now let us consider a more favorable scenario where, rather than the tribe's exports being boycotted, they *double* from what they were the previous year (for whatever reason). In this case, tribal income would initially rise by X^T, but then consumption, C^T would also rise (due to the increase in income from exports), so ultimately tribal output and income (Y^T) would rise by more than X^T. Hence, the tribe would experience a *positive* multiplier effect this time.

On the other hand, we may ask what happens to the state economy under this scenario that was rosy for the tribe (of X^T doubling)? Initially, the state would lose income (Y^S) because the increase in X^T, by definition, would mean a rise in the state's imports, (i.e., some rise in the combination of M_I^S and M_C^S), supposedly replacing the state's domestic production by the same amount. However, the increase in the tribe's income would cause the tribe to be more inclined to purchase imports from the state and this would have a countervailing *positive* effect on the state's income.

Five Growth-Related Factors and Their Policy Implications

This model will introduce five major factors and their policy implications:

1. **State Support for Tribal Government Expenditure on Infrastructure.** The state may provide, at its own discretion, financial support for the tribe's government-managed infrastructure projects
2. **State Social Assistance to the Tribe.** The state is assumed to provide social assistance to the tribe, according to set policies (and in some cases laws), which increase tribal consumption, but at the expense of state NT consumption
3. **Tribal Investment Amplified by Tribal Expenditure on Infrastructure.** Tribal enterprise expenditures on investment (in physical capital, i.e., facilities and equipment) is assumed to increase as a consequence of government infrastructure investment
4. **State Exports to the Tribe Growing with the Tribe's Income.** Economic growth of the tribe will lead to the tribe purchasing more products from the state
5. **State Social Assistance to the Tribe Diminishing with Tribal Economic Growth.** The more the tribe experiences economic growth (especially per capita), the less social assistance the state would provide to the tribe, thereby increasing state consumption (from the state now having more money for its own consumption)

Here is now the main question to be addressed by this model:

> **If the state increases its financial support to the tribe's government-managed infrastructure projects, will the state's own NT consumption ultimately rise or fall?**

That is, while we may easily assume that the state's support for tribal infrastructure will benefit the tribe, will it also be beneficial overall to state's, nontribal residents? If it is not beneficial to NT state residents, then the state is unlikely to support tribal infrastructure development, simply as a policy matter, because such support would conflict with the economic interests of the state's nontribal population (Under an alternative perspective, one might expect the nontribal population to be altruistic toward the tribe, but this perspective remains an open question.)

Simplistically and in the absence of any economic analysis (or economic model), myopic state policy makers may obtusely assume that it is against the self-interest of NT state residents to support tribal infrastructure, based only on the imperceptive notion, "How could anyone who gives money to anyone else be better off in the process?"

Actually, the state *can* be better off by supporting the tribe's infrastructure, depending on the circumstances, which are, in fact, outlined in the five factors listed above. Specifically, let us call the amount of support that the state gives to the tribal government for infrastructure *Z*. As soon as this support is provided, the state NT residents may see themselves as being worse off by *Z*. However, tribal income will automatically rise by Z, as a component of G_I^T. By factor #3 above, tribal investment (I^T) will then also rise, thereby increasing tribal income further. With these rises in tribal income, tribal residents will import more of the state's products (Factor #4 above) and they will require less assistance from the tribe (Factor #5). Thus, while the state loses the funds it provided to the tribe for infrastructure, it gains in the additional exports it sells to the tribe in the aftermath of the infrastructure change and it gains in having to make lower social assistance payments to the tribe. In this sense the state's investment in the tribe's infrastructure may well be an investment in its own state economy.

Social Assistance from the State to the Tribe and Tribal Infrastructure

With regard to the state's social assistance to the tribe, let us look now, specifically, at the tribe's consumption, C^T, which depends on other factors, like income, Y^T. In particular, assuming a linear relationship for simplicity, we may write:

$$C^T = A^T + c^T Y^T + S \tag{3}$$

Where:

- A^T = Autonomous consumption of tribally produced products
- c^T = Marginal propensity to consume tribally produced products ($0 < c^T < 1$)
- S = Social assistance payments to the tribe from the state

In this model, consumption by tribal members depends on the variables listed above. Autonomous consumption, A^T, is what tribal members would consume even if their income were zero, by draining their savings, falling into debt, or selling items they already own and by receiving forms of assistance that are independent of the tribe or the state, such as social assistance from the federal government directly. Examples might include the Supplemental Nutritional Assistance Program (SNAP, commonly known as "food stamps) and assistance from nonprofit, charitable organizations (such as church-run homeless shelters).

The social assistance that the tribal members receive from the state could involve a variety of state programs, such as:

- Child care (including adoption and foster care)
- State contributions to Medicaid assistance
- State contributions to Temporary Assistance for Needy Families, which are known as Maintenance-of-Effort funds and
- Energy and weatherization assistance (to help cover heating bills)

The marginal propensity to consume, c^T, is the fraction of tribal income that will be spent on tribal goods. Whatever income is *not* spent, $\left[\left(1-c^T\right)Y^T\right]$, is spent by households on taxes (to the tribe and state) and otherwise entered into savings (or paying off debt, etc.).

We can specify the state's "infrastructure assistance" to the tribal government as:

$$G_I^T = \alpha Y^T + Z \tag{4}$$

with:

- α = The proportion of the tribe's income that is spent on infrastructure (with or without any support from the state), which could occur through tax collection by the tribe
- Z = Infrastructure support provided to the tribe from the state (as already introduced)

The consumption of the NT state residents can be expressed as simply:

$$C^S = A^S + c^S\left(Y^S - S - Z\right) \tag{5}$$

where the state's income available for consumption is reduced by *S and* Z. Now, the state's income available for consumption is also reduced by taxes and savings, though these reductions are captured by C^S being less than 1 and the more savings and taxes there are, the lower c^S would be. However, it is important for us to have X and Z handled explicitly as they are in Equation 5, for reasons that will shortly become evident.

With regard to infrastructure development having a positive effect on investment, we can write:

$$I^T = \beta Y^T + \gamma G_I^T \tag{6}$$

Where:

β = The proportion of the tribe's income that is spent on investment (without or without any support from the state), where we know that 0 < α + β + c < 1 since each of these three parameters refers to separate proportional draws out of income

γ = The positive, independent effect that government expenditure on infrastructure has on investment (such as a new road attracting businesses to develop on it)

We would also expect the social assistance payments to the tribe, *S*, from the state, to be a function of the per capita income of the tribe, where the lower it is, the greater these payments would be. One approach would be to define *S* as follows, for some parameter δ, with 0 < δ < 1, where P^T and P^S represent the populations of the tribe and the NT state residents, respectively:

$$\frac{S}{P^T} = \delta\left(\frac{Y^S}{P^S} - \frac{Y^T}{P^T}\right) \tag{7}$$

The left-hand side of the equation represents the amount of the state's social assistance to the tribe per capita. This per-capita assistance level is seen as proportional (by the proportion δ) to the difference between the per-capita income of the state and the per-capita income of the tribe. The greater δ is, the more altruistic the state is in its social assistance. Of course, this assumes $Y^S/P^S > Y^T/P^T$ since the tribe is a "low income" tribe, in this particular model, as was stated at the outset.

The Determinants of Tribal Imports

As we know, what the tribe exports to the state is also what the state imports from the tribe and vice versa. We thus have:

$$X^T = M_I^S + M_C^S \tag{8}$$

$$X^S = M_I^T + M_C^T \tag{9}$$

We may then rewrite Equation 1, using more of the tribal variables as follows:

$$Y^S = C^S + I^S + G_I^S + G_S^S + M_I^T + M_C^T - X^T \tag{2'}$$

As already discussed, imports are subtracted from production because they are already included in consumption in the case of M_C^T and included in investment (I^T) in the case of M_I^T. We may then understand imports of consumption goods, by the tribe, as representing a certain proportion of all consumer goods and likewise understand imports of investment goods as representing a certain proportion of all investment goods purchased by the tribe. These proportions would likely change as the tribe grows economically, but a constant proportion could be used in the model as a first approximation prior to any substantive change in economic growth. Furthermore, it is not clear in what directions these proportions would change with tribal economic growth, as that would depend on whether the growth was "export driven" (in which case they would rise) or the growth was "import-substitution driven" (in which case they would fall).

We can then specify the following relationships:

$$M_I^T = \phi_I^T I^T \tag{10}$$

$$M_C^T = \phi_C^T C^T \tag{11}$$

where, ϕ_I^T is the proportion (in terms of value added) of all tribal investment (in physical capital, e.g., facilities and equipment) that is brought into the tribe, originally, as imports and similarly, ϕ_C^T is the proportion of all tribal consumption of consumer goods and services that is brought in, originally, as imports. These parameters could be called, respectively, the "marginal propensity to import physical capital" and the "marginal propensity to import consumer goods and services." Accordingly, both are between 0 and 1. The greater these parameters are, the more they reflect a "leakage" out of the tribal economy and into the state economy, whenever investment goods or consumer goods and services are purchased by tribal residents. The greater the leakage, the worse it is for the tribe in the sense that it will lower economic growth by causing there to be lower multiplier effects within the tribe's own economy. On the other hand, the greater the magnitude of this leakage into the state economy, the more the tribe's growth will benefit the NT state economy, and thus, the greater will be the incentive for the state to contribute to the tribe's infrastructure.

Results and Discussion

Obtaining the Reduced Form of the Model

Substituting these parameters into Equation 1 then renders:

$$Y^T = \left(1-\phi_C^T\right)C^T + \left(1-\phi_I^T\right)I^T + G_I^T + G_S^T + X^T \tag{1'}$$

By substitution, from Equation 7, Equations 3 and 5 can now be rewritten as:

$$C^T = A^T + \left(c^T - \delta\right)Y^T + \delta\left(\frac{P^T}{P^S}\right)Y^S \tag{3'}$$

$$C^S = A^S - c^S Z + c^S\left[1-\delta\left(\frac{P^T}{P^S}\right)\right]Y^S + c^S \delta Y^T \tag{5'}$$

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By substitution of Equation 4 into Equation 6, we have:

$$I^T = \gamma Z + (\beta + \alpha\gamma)Y^T \tag{6'}$$

Substitution of Equations 3', 4 and 6' into Equation 1' then yields:

$$Y^T = \left(\eta + \theta Z + \lambda Y^S\right) / \mu \tag{1''}$$

where we can use the following parameters for ease of notation:

$$\eta = \left(1 - \phi_C^T\right) A^T + G_S^T + X^T \tag{12}$$

$$\theta = 1 + \left(1 - \phi_I^T\right)\gamma \tag{13}$$

$$\lambda = \left(1 - \phi_C^T\right)\delta\left(\frac{P^T}{P^S}\right) \tag{14}$$

$$\mu = 1 - \left(1 - \phi_C^T\right)\left(c^T - \delta\right) - \left(1 - \phi_I^T\right)(\beta + \alpha\gamma) - \alpha \tag{15}$$

Substitution of Equations 5', 10 and 11 and then 3' and 6', into Equation 2' renders:

$$Y^S = \left(\sigma + \pi Z + \rho Y^T\right) / \psi \tag{2''}$$

where, similar to before, we can use the following parameters for ease of notation:

$$\sigma = A^S + \phi_C^T A^T - X^T + I^S + G_I^S + G_S^S \tag{16}$$

$$\pi = \phi_I^T \gamma - c^S \tag{17}$$

$$\rho = c^S\delta + \phi_I^T(\beta + \alpha\gamma) + \phi_C^T\left(c^T - \delta\right) \tag{18}$$

$$\psi = 1 - c^S\left[1 - \delta\left(\frac{P^T}{P^S}\right)\right] - \delta\phi_C^T\left(\frac{P^T}{P^S}\right) \tag{19}$$

We then observe in our derivations the repetition of a particular function of these parameters, so for further simplification, let us define one final parameter as follows:

$$\omega = 1 / (\psi\mu - \lambda\rho) \tag{20}$$

With Equations 1'' and 2'' we have two equations and three unknowns (Y^T, Y^S *and* Z; which are, respectively, the Gross Tribal Product, the Gross State Product and the infrastructure support provided to the tribe from the state). From these equations we will be able to solve for GSP and GTP as a function of Z and we will also be able to solve for tribal consumption and state NT consumption as functions of Z. From here, we will be able to estimate how a change in Z will affect all of these dependent variables. He have:

$$Y^T = \omega\left[\psi\eta + \lambda\sigma + (\psi\theta + \lambda\pi)Z\right] \tag{21}$$

$$Y^S = \omega\left[\sigma\mu + \rho\eta + (\pi\mu + \rho\theta)Z\right] \tag{22}$$

From Equation 3' we then have tribal consumption as a function of Z:

$$\begin{aligned} C^T &= A^T + \omega\left(c^T - \delta\right)\left[\psi\eta + \lambda\sigma + (\psi\theta + \lambda\pi)Z\right] \\ &+ \delta\omega\left(\frac{P^T}{P^S}\right)\left[\sigma\mu + \rho\eta + (\pi\mu + \rho\theta)Z\right] \end{aligned} \tag{23}$$

Likewise, from Equation 5' we then have state NT consumption as a function of Z:

$$\begin{aligned} C^S &= A^S - c^S Z + \omega c^S\left[1 - \delta\left(\frac{P^T}{P^S}\right)\right]\left[\sigma\mu + \rho\eta + (\pi\mu + \rho\theta)Z\right] \\ &+ \omega c^S\delta\left[\psi\eta + \lambda\sigma + (\psi\theta + \lambda\pi)Z\right] \end{aligned} \tag{24}$$

Focusing on changes only, we can now ask how much a change (denoted by "Δ") in Z will cause a positive or negative change in the other variables. Specifically, on the basis of Equations 21-24, we have:

$$\Delta Y^T = \omega(\psi\theta + \lambda\pi)\Delta Z \tag{25}$$

$$\Delta Y^S = \omega(\pi\mu + \rho\theta)\Delta Z \tag{26}$$

$$\Delta C^T = \omega\left[\left(c^T - \delta\right)(\psi\theta + \lambda\pi) + \delta\left(\frac{P^T}{P^S}\right)(\pi\mu + \rho\theta)\right]\Delta Z \tag{27}$$

$$\Delta C^S = c^S\left\{\omega\left[1 - \delta\left(\frac{P^T}{P^S}\right)\right](\pi\mu + \rho\theta) + \omega\delta(\psi\theta + \lambda\pi) - 1\right\}\Delta Z \tag{28}$$

Note that, as it should be, the only "size dependent" variable on the right-hand side of Equations 25-28 is ΔZ. Everything else is parameters that offer no clue as to how large the state or the tribe is, which means, in effect, we have a clean model that will not be distorted by size effects.

The next step in the analysis will be for us to estimate ranges of values for the structural parameters in the first eleven equations of the model, based, preferably, on available data (wherever possible) and on defensible judgment calls (wherever data are not available). This will result in the substitution of all the parameters in Equations 25-28 by actual numerical estimates, which will then enable us to see how a change in state-supported tribal infrastructure, under these conditions and general assumptions, would benefit the tribe and the state.

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Estimating the Marginal Propensity to Consume

Let us start with the tribe's consumption of consumer goods and services, noted by the equation: $C^T = A^T + c^T Y^T + S$. One of the essential ingredients in this equation, is the Marginal Propensity to Consume out of income (MPC), c^T. Not all "marginal propensities to consume" mean the same thing in economic research—the greatest difference among them is whether they are implicitly referring to the marginal effect of a transitory income change or the marginal effect of a "permanent" one. An example of the former would be a household acquiring some inheritance money in a particular year that would not be expected ever again. An example of the latter would be a wage earner acquiring a new job with a higher salary that is expected to remain year-after-year. For reasons that should be obvious, the type of marginal propensity to consume that we need to have in this model is the one in reference to permanent income as opposed to transitory income. Unfortunately, for a variety of logical reasons, economic research has had a much easier time estimating (from the analysis of data) the MPC for transitory income and so there are many more estimates of it than of the other kind. In addition, as one would expect, the MPC for low-income groups is much higher than for other income groups. (One way of looking at this is simply that people living "from paycheck to paycheck" cannot easily save any small increases in their earnings.)

In the absence of reliable MPCs for permanent income, for low-income households (and especially for tribal households), we could still turn to guidance from a similar measure, which is much more easily obtainable—the "Average Propensity to Consume" (APC). The APC is simply C^T/Y^T, or the proportion of income that is spent on consumption. Economists have estimated that the APC can be about 0.8 for low income groups (Fisher *et al*., 2016), meaning they spend \$80 on consumption for every \$100 they earn as income. For this kind of estimate, however, what households receive in social assistance would also be counted as their monetary income in a broader sense, so we really have, in this statistic, the equation: $0.8 = (C^T)/(Y^T+S)$. This would then imply the following for the MPC (C^T):

$$c^T = 0.8 - \left(A^T + .2S\right) / Y^T \tag{29}$$

It is reasonable to assume that both autonomous consumption (i.e., consumption when you have no income, A^T) and 20 percent of social assistance (.2S) are very small fractions of income from production, Y^T. A conservative estimate can then be made that such a fraction is approximately 10 percent, implying that the MPC, $c^T = 0.7$. We can likewise estimate a range: $0.6 < c^T < 0.75$.

The APC for the richest 10 percent of households is approximately 0.6 (Fisher *et al*., 2016) suggesting that a ballpark estimate for the average APC for the state may be midway between the 0.6 and 0.8, which would put it at around 0.7. The variables A^S, S and Z, which enter into the determination of C^S may also be assumed to be very small fractions of Y^S, implying that the MPC for the state (with regard to permanent income) is, in all likelihood, slightly lower than 0.7. It is thus estimated at $c^S = 0.65$ and in terms of a range, we can have: $0.6 < c^S < 0.7$.

Proportions of Investment and Consumer Goods That Are Imported

Our model needs estimates of ϕ_I^T ≡ the proportion of the investment in physical capital that is imported by the tribe and ϕ_C^T ≡ the proportion of consumer goods and services (including those acquired by social assistance) that are imported by the tribe. To be more precise:

$$M_I^T = \phi_I^T I^T \tag{10}$$

$$M_C^T = \phi_C^T C^T \tag{11}$$

These proportions are expected to be very high, i.e., the tribe will tend to import a relatively large amount of investment goods and consumer goods that (by definition) are not produced in the tribal area. There are three, major possible exceptions, however: (1) A large share of the expenditures of low-income households is for housing. To the extent that tribal residents are home owners or they are renting a home that is owned by other tribal residents, none of these expenditures could be imports. (2) If the tribe is building structures made from materials (like lumber and stone) that are also produced in the tribal economy itself and if the work itself is being performed by a tribally affiliated organization, then imports will be much lower. (3) Similarly, if the tribal economy is also a significant "subsistence economy" (where tribal residents grow their own food, raise their own livestock for meat, or engage in their own fishing, etc.) then there will be much lower imports of consumer goods. Of course, other exceptions exist as well (such as some tribes having their own power sources for all their electrical power needs), though these other exceptions are less common.

No data appear to exist on such tribal imports, but one approach to the problem is for us to examine what low-income households typically spend on consumer products. From there we can roughly estimate what proportion of these would be produced in the tribal area as opposed to being imports from the state. Table 1 below does this, based on the Census Bureau's Consumer Expenditure Survey (for all households). The first column of numbers in the table shows the estimated expenditures per low-income individual in the United States in 2017 by type of expenditure.

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Table 1: How low-income consumers in the U.S. tend to spend their money, 2017

Average annual expenditures of low-income (Lowest 10 Percent) consumers, per consumer ($)		Estimated proportion not produced in tribal economy	Estimated amount not produced in tribal economy ($)
Average annual expenditures (TOTAL)	24,801	0.51[a]	12,757
Housing	9,864	0.25	2,466
Food	3,950	0.75	2,963
Transportation	3,460	1.00	3,460
Healthcare	2,119	0.25	530
Entertainment	1,298	0.75	974
Education	972	0.25	243
Apparel and services	882	0.75	662
Personal care products and services	339	0.75	254
Tobacco products and smoking supplies	266	0.75	200
Alcoholic beverages	164	1.00	164
Life and other personal insurance	132	0.75	99
Other	1,487	0.50	744

Source: Consumer Expenditure Survey, U.S. Bureau of Labor Statistics, September, 2018

Notes: a - Based on total of estimated amounts as a proportion of total expenditures.

The second column of numbers provides a rough estimate of the proportion of these products (in terms of value added) that would be imported. By rough estimate, we can see that these proportions are 25, 50, 75, or 100 percent. The only exception is the first, aggregate number in the column, which is the weighted average of the other numbers in the column (weighted by the expenditure levels in the first column). On the basis of these data and estimates, we can estimate ϕ_C^T to be this aggregate number, i.e., 0.51 (or 51 percent). We could place a reasonable range around this estimate of $0.41 < \phi_C^T < 0.61$.

With regard to the proportion of imports that enter into investments in physical capital in the tribal area, i.e., equipment and structures, there are even less data to work with and the type of investment could make an enormous difference in the tribe's relative reliance on imports. It is important to note, however, that tribes have been making substantial efforts to use their own local building materials and to hire tribal members as workers, which greatly reduces the project's dependency on imports. In addition, assuming the investments are taking place on tribal land, the value of the land itself as an input to production reduces the dependency on imports as well. Given all these considerations, it is estimated that the imports would account for only about 25 percent of these investments, i.e., $\phi_I^T = 0.25$, but with a wide range as follows, given the level of uncertainty: $0.15 < \phi_I^T < 0.50$.

Tribal Government Expenditure on Infrastructure as a Proportion of Production

We further need to estimate the parameter α in Equation 4: $G_I^T = \alpha Y^T + Z$. This parameter represents the percent of the tribe's production that would be devoted to the tribal government's investment on infrastructure. In the absence of any direct data on this parameter, one approach is to consider how the tribal government would finance this infrastructure, which would be primarily through tax revenue that it collects. Data from the Navajo Nation, shown in Table 2, indicate that tribes would collect in tax revenue approximately 4.7 percent of what is produced by the tribe (i.e., the GTP). It is reasonable to assume, however, that not all of this revenue will be spent on infrastructure; some will surely be spent on the normal operations of tribal government, and on tribally funded social assistance (which would be part of tribal consumption as it is not explicitly separated-out in this model). Thus, for the Navajo Nation and FOR most other tribes with low per-capita income levels, it appears that 4.7 percent would be an upper bound on α, from this tax-revenue approach to the problem. As a rough estimate, it would be reasonable to think of half of this percentage as being spent on infrastructure, i.e., α = 2.35 percent, but with a wide range, given the uncertainly involved, i.e., 0.02 < α <0.03.

Tribes Attracting Business Investment

One of the mantras that one hears often in Indian Country (and in many other places as well) is that economic growth will depend on tribes' ability to "attract business investment." However, relatively little is said about how tribes should attract business investment, as if business investment were manna from heaven that only prayers or good fortune could bestow upon the tribe's economy. There is another perspective, however, which is probably more promising.

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Table 2: Navajo nation taxes in FY 2016 (in millions of dollars)

	Tax revenue (millions)	Tax rate (Percent)
Possessory Interest	$ 9.42	3.00
Business Activity	$ 3.91	5.00
Oil and Gas Severance	$ 3.50	4.00
Hotel Occupancy	$ 1.49	8.00
Tobacco Products	$ 0.23	14.29
Fuel Excise	$ 12.52	7.20
Sales - Non-Retail	$ 49.40	5.00
Sales – Retail	$ 10.42	5.00
Junk Food	$ 1.88	2.00
Alcohol	$ 0.07	3.25
Total Revenue and Weighted Average Rate	112.831	4.70

Notes: The tobacco tax rate was based on $1.00 tax per pack and average after-tax price in Arizona of $8.10. The rate for gasoline was based on a pre-tax price of $2.50 and tax of $0.18 per gallon.
Source: The Navajo Nation, "2009-2010 Comprehensive Economic Development Strategy."

McNichol (2019), of the nonpartisan, Center on Budget and Policy Priorities, wrote an article entitled "It's Time for States to Invest in Infrastructure." In it she mentions:

> The condition of roads, bridges, schools, water treatment plants and other physical assets greatly influences the economy's ability to function and grow. Commerce requires well-maintained roads, railroads, airports and ports so that manufacturers can obtain raw materials and parts and deliver finished products to consumers. Growing communities rely on well-functioning water and sewer systems. State-of-the art schools free from crowding and safety hazards improve educational opportunities for future workers. Every state needs infrastructure improvements that can pay off economically in private-sector investment and productivity growth (p. 1).

If we now take the above quotation and replace the word "state" in the last sentence by "tribe," then the revised paragraph would reign true for tribes just as well as it does for states.

Revisiting Equation 6, we had:

$$I^T = \beta Y^T + \gamma G_I^T \tag{6}$$

where, the parameters we need to estimate are:

β = the proportion of the tribe's income that is spent on private tribal investment (without or without any support from the state)

γ = the positive, independent effect that government expenditure on infrastructure has on private investment (such as a new road attracting businesses to develop on it)

In estimating these parameters we may take note that Y^T is, itself, a function of I^T and G_I^T, but we may simply view β,γ as showing the independent effects of income and government expenditures on infrastructure in private investment. If there is no change *other* than an increase in G_I^T, then $\Delta Y^T = \Delta G_I^T$ (plus secondary multiplier effects) and I^T will then actually increase from the *income* effect *of* the *infrastructure* effect, beyond the direct effect of the change in infrastructure. In other words, we need to look at γ as having a separate "infrastructure" effect above-and-beyond the income effect that would generally result from *any* increase in government spending.

The economic literature appears to provide little with regard to empirical analysis that could assist in the estimation of β and γ. There are two reasons: The first is that nearly all published studies on the topic of the economic effects of infrastructure development take a very limited, "short-cut" approach. This short-cut approach is to look at the statistical relationship between government expenditures on infrastructure and the final output of the economy, without looking at the interim effect of infrastructure enhancing private investment, which in turn, increases output. As a result, private investment, which is treated as a separate factor in these analyses, receives all of the "credit" (one way or another) for any increases in output that might result from that private investment, even though none of that private investment would have been possible without the government's initial investment in infrastructure.

For example, suppose a nation spends $1 billion on infrastructure (e.g., building a highway) which then induces private industry to invest $10 billion in various establishments along the highway, whose production generate an annual increase in GDP of $2 billion per year (reflecting a sort-of 20 percent annual return from those establishments, though not exactly). A typical economic study of the effect of the

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government infrastructure would tend to attribute that economic growth to the $10 billion in *private* investment that occurred, as if that were independent of the $1 billion spent on the highway, even though that highway made it all possible.

The second reason for the difficulty in finding studies to help us with β and γ, is that the vast majority of published empirical analyses of the economic effects of government infrastructure would not apply to the poorest parts of Indian Country. Instead, they pertain primarily to infrastructure that replaces other infrastructure in middle-class and upper-class communities, where the impact of that replacement is largely negligible (at least on the surface). For example, suppose there is an old bridge over the Raritan River, between New Brunswick and Highland Park, New Jersey. If the county or state then decides that this old bridge is not worth renovating and that it is economically more efficient simply to build a new, modern bridge to replace it, then this infrastructure will be purchased. However, as soon as the new bridge is operational and the old bridge is demolished, the economy of New Jersey would not “feel the difference.” From the standout of the superficial macroeconomic statistics, as opposed to the engineering physical reality of the situation, the new bridge had no economic benefits, unless we look deeper into what would have happened if the new bridge were never built.

What is needed in the current analysis, with regard to Indian Country, is for us to take the approach that the infrastructure we are studying is the same basic kind that is built for developing countries. (Remember, we have defined the domain of our study as “low income tribes” which, essentially, does make them developing countries in many respects.) Therefore, we need to explore the kind of situation that is *not* like that of the state building a second road, parallel to an existing road, for the simple purpose of easing traffic. The type of situation we must explore is when a road should be built where there *are no roads.* Or, at least, perhaps more realistically, a paved road should be built where there is now only a dirt road. Along the same lines, we are exploring the installation of broadband Internet capability where none currently exists, or, in some cases, even a water supply where none currently exists, etc.

To find the kind of economic studies that are relevant in this respect, one would need to look at the economic development literature that examines specifically the problems of developing nations (e.g., UNCTAD, 2018).

One study was found, however, that provided estimated parameters that were very closely related to β and γ, on the basis of data on several developing countries. Erden and Holcombe (2006) estimated the following (using the variable symbols that we have been using for our own model rather than their symbols):

$$\Delta\log\left(I^T\right) = \beta'\Delta\log\left(Y^T\right) + \gamma'\Delta\log\left(G_I^T\right) + V \qquad (6*)$$

where V denotes (for our purposes here) the other variables that Erden and Holcombe had in their model which are not in our model, such as the “cost of capital,” a “measure of uncertainty,” and the “flow of external credits.” These other factors are more relevant for their model than ours for various reasons having to do with fact that they were estimating the parameters on the basis of regression analyses of cross-sectional data on developing nations.

In their findings (in Table 1 on page 488 of their article, showing the long-term equilibrium effect) they estimate β′ at 0.763 and γ′ at 0.534. In their analysis, the first parameter estimate was not statistically significant, while the second one was highly statistically significant, at a 1 percent significant level. In addition, we should note that their estimates are associated with a “different model” than the one here, involving less developed countries as opposed to tribal nations in the United States. Their study was also published in 2006, based on data from 1982-1997. Their findings therefore apply to some, but not all, types of government infrastructure investment that exist today. (For instance, it would not include the development of infrastructure to support broad-band Internet access, which was not around in the years of their data.).

Another important difference between the models is that the coefficients in their model are with respect to *logarithms* of private investment, government infrastructure and income. That is, they estimated that, for every 1 percent increase in existing income, there would be a 0.763 percent increase in private investment and for every 1 percent increase in existing government infrastructure, there would be a 0.534 percent increase in private investment.

We then have:

$$\beta' = \frac{\Delta log(I^T)}{\Delta log(Y^T)} = \frac{\Delta I^T / I^T}{\Delta Y^T / Y^T} = \beta\frac{Y^T}{I^T} = 0.763$$

$$\gamma' = \frac{\Delta log(I^T)}{\Delta log(G_I^T)} = \frac{\Delta I^T / I^T}{\Delta G_I^T / G_I^T} = \gamma\frac{G_I^T}{I^T} = 0.534$$

As previously discussed, the average propensity to consume out of income was estimated at around 0.8, meaning only about 20 percent of income is not spent on consumption. This suggests that the most I^T/Y^T could be is 0.20, unless we think of investment as being funded by borrowing, in which case it could exceed this level. On the other hand, I^T/Y^T could be near 0 if there is no confidence among investors in the tribal economy. (If tribal members invest outside the tribal economy then that action implicitly becomes a leakage out of the tribal economy in the form of savings to the tribal members. In a much more complicated model we could include it in terms of "financial flows" in our two-country model, but such extra complexity would not be worth it in this case.) We could then estimate I^T/Y^T as being approximately 0.1 (instead of the quasi upper-bound of 0.2) but with a range between 0.05 and 0.15. As a result, our midpoint estimate of β would be approximately 0.08 (from 0.1 times 0.763).

We had estimated earlier that G_I^T is approximately 2.35 percent of tribal income plus the state's contribution to the tribe's infrastructure. It is unlikely that the state's contribution to the tribe's infrastructure, in the initial conditions of this model, would exceed the level of the tribe's own contribution to its own infrastructure. Therefore as a rough estimate, we could have G_I^T as being about 4 percent of the tribe's total income (the percent from the tribe's own government funding plus, initially, the state's contribution that is most likely less than 2 percent of the tribe's rather-low income). We had, from the above discussion that I^T/Y^T is approximately 0.1. It then follows that $I^T / G_I^T = 0.1Y^T / 0.04Y^T = 2.5$. In other words, we could roughly estimate that the ratio of private investment to government infrastructure expenditures is about 2.5 to 1. As a heuristic, we can interpret this finding as follows: For every $1 million dollars the government already spent on a road, sewer system, electric grid, etc., within the tribal economy, private industry has already invested $2.5 million dollars in facilities and equipment in the tribal economy that relies upon that infrastructure. It is important to note that this is a ratio of what already exists, not a marginal (or differential effect) of more investment, which we can deduct from the prior equation as having roughly half this effect. In other words, we are estimating that the marginal, proportional effect of G_I^T on I^T, which is γ, where $\gamma = 2.5 \cdot 0.534 = 1.3$ (from the above equation, roughly estimated). Conservatively and given the relative uncertainty level around this parameter, we can simply estimate the range for γ as being: $1 < \gamma < 2$.

Estimating Social Assistance Parameters

As previously discussed, we would expect the social assistance payments to the tribe, *S*, from the state, to be a function of the per capita income of the tribe, where the lower it is, the greater these payments would be. One approach would be to define *S* as follows, for some parameter δ, with $0 < \delta < 1$, where P^T and P^S represent the populations of the tribe and the non-tribal (NT) state residents, respectively, and Y^T and Y^S represent their respective total income levels:

$$\frac{S}{P^T} = \delta\left(\frac{Y^S}{P^S} - \frac{Y^T}{P^T}\right) \tag{7}$$

The left-hand side of the equation denotes the amount of the state's social assistance to the tribe per capita. This per-capita assistance level is seen as proportional (by the proportion δ) to the difference between the per-capita income of the NT state and the per-capita income of the tribe. The greater δ is, the more altruistic the state is in its social assistance. Of course, this assumes $Y^S/P^S > Y^T/P^T$ since we assume, for this model, that the tribe is a "low income" tribe.

When we derive a reduced form of the model we find that this part of the model leaves us with two parameters whose values we need to estimate: δ and $\left(\frac{P^T}{P^S}\right)$.

Two problems that we would have in estimating δ are that it could surely vary by state and it would be very difficult to acquire relevant data and interpret those data accurately. We can, however, estimate δ on the basis of simple logic, at least to some extent. We know that $0 < \delta < 1$; if it were more than 1, the state's nontribal residents would make the tribal residents richer than they are and if it were less than 0, the state would take money from the tribe. Furthermore, it is reasonable to assume that δ is much closer to 0 than to 1since the NT state residents would not be willing to elevate the tribal income to an income level comparable to theirs, through a transfer of income from them to the tribal members.

The relationship displayed in Equation 7 is "linear," but one might argue it should not be linear, but skewed more toward greater assistance, the greater the discrepancy in per-capita incomes. For example, if the average tribal per-capita income is as high as 50 percent of the NT state per-capita income, then perhaps the state policy would be to offer no social assistance. On the other hand, if the average tribal per-capita income were 10 percent of the NT state per-capita income, the assistance might be quite substantial. However, under the 50 percent situation we would have $\frac{S}{P^T} = \delta\left(\frac{Y^S}{P^S} - \frac{Y^T}{P^T}\right) = \delta\left(\frac{Y^S}{P^S} - (0.5)\frac{Y^S}{P^S}\right) = (0.5)\delta\frac{Y^S}{P^S}$ and under the 10 percent situation we would have $\frac{S}{P^T} = \delta\left(\frac{Y^S}{P^S} - \frac{Y^T}{P^T}\right) = \delta\left(\frac{Y^S}{P^S} - (0.1)\frac{Y^S}{P^S}\right) = (0.9)\delta\frac{Y^S}{P^S}$ in which case the 10-percent situation would give tribal members only about 45 percent more assistance than the 50-percent situation.

For this kind of analysis, however, it is important to note that not all tribe members, nor NT state residents, have the same income, i.e., each population has a distribution of income in which there are many people whose incomes are far above, or far below, the average for their population group. For statistical reasons, this gives greater credence to the simple "linear" relationship shown Equation 7. In any case, the linear relationship is believed to be a reasonable approximation given the data and analytical limitations we are facing in the development and estimation of this model.

As a heuristic, consider the state's contribution to Medicaid. The Rosebud Tribe in South Dakota provides a good example of this, where data can be relatively easy to acquire, due to the fact that the vast majority of the tribe's members who are living in the tribal area are living in Todd County, South Dakota. Conversely, the vast majority of people who reside in Todd County are members of the tribe.

As simply a hypothetical exercise, let us pretend that Todd County is the only tribal area in the state of South Dakota. This counterfactual assumption will be explored only for the moment in order to help us to understanding Equation 7 above. After this exercise, we will then remove this assumption. Likewise, let us assume, only for the moment, that state contributions to Medicaid are the *only* form of social assistance. Again, we will remove this assumption shortly thereafter.

In 2016 South Dakota's contribution to Medicaid totaled \$385.18 million, for 117,190 average monthly recipients of Medicaid payments in that year in assignable counties. Of these recipients, 5,403 (4.61 percent) were in Todd County, suggesting that an estimate of total Medicaid payments by the state to Rosebud Tribal members is approximately 4.61 percent of \$385.18 million, which equals \$17.76 million. (This assumes that there is no systematic difference, in terms of Medicaid costs, between tribal and nontribal members.) This leaves \$367.42 million in Medicaid Payments to the NT state residents (under our heroic assumptions for the moment).

The population of the State of South Dakota in 2016 is 862,890, which includes a population of 10,099 in Todd County. This implies the NT population is 852,791. According to Census Bureau data for 2016, the average per capita income in the state was \$27,516, while for the tribe it was \$11,821. It follows that the per-capita income of the NT population is (862,890 x \$27,516–10,099 x \$11,821)/852,791 = \$27,702.

We can now solve for δ in Equation 7 as follows:

$$\frac{\$17,758,576}{10,099} = \delta(\$27,702 - \$11,821) \quad \rightarrow \quad \delta = 0.1107$$

Now let us relax some of these unrealistic assumptions. First of all, there are many other tribes and tribal members in the state. Assuming, safely this time, that those other tribal members will tend to have average per-capita incomes that are lower than the average per-capita incomes of NT state residents, this would imply that $\frac{Y^S}{P^S}$ is substantially higher than the above estimate of \$27,702 (since the above estimate "mixed-in" low-income tribe members, from other tribes, into the calculation). However, the average state Medicaid payment *per capita*, across all the tribal members of all tribes in South Dakota, may be about the same as it was for the members of the Rosebud Tribe. Moreover, if it is different, we would not have any reason to think it should be higher or lower. Thus, if we account for all the other tribes in South Dakota, then $\frac{S}{P^T}$, now pertaining to all of them, should be about the same and so should $\frac{Y^T}{P^T}$. However, $\frac{Y^S}{P^S}$ should be higher, which implies, in turn, that δ should be lower. To be precise, if $\frac{Y^S}{P^S}$ is greater by Δ when we remove the assumption that Rosebud is the only tribe, while $\frac{S}{P^T}$ and $\frac{Y^T}{P^T}$ (now in reference to all low-income tribes and tribal members in the state) are roughly the same, and we have:

$$\frac{\$17,758,576}{10,099} = \delta\left[(\$27,702 + \Delta) - \$11,821\right] \rightarrow$$
$$\delta = \frac{\$1,758}{\Delta + 15,881} < 0.1107$$

However, since tribal members will continue to represent only a small minority of the population of South Dakota (approximately 9 percent), the Δ in the above equation will remain relatively small. This is because the extent to which the tribal members affect the per–capita income of the state is relatively small, given their small share of the population.

Most importantly, however, the state's social assistance expenditures include much more than Medicaid Payments alone, such as child care services, including adoption and foster care which are more prevalent (per each 1,000 residents) in poor communities. Another example of social assistance by the state is energy and weatherization assistance to help low-income households pay their heating bills. It is also important to note that various federal programs that provide social assistance, such as Temporary Assistance for Needy Families (TANF) and the Supplemental Nutrition Assistance Program (SNAP, commonly known as "food stamps") also involve states spending some of their own funds to supplement the assistance, or to administer the program (USDA, 2016). For example, the U.S. Department of Health and Human Services, Office of Family Assistance, notes: "As a condition of receiving federal TANF funds, states are required to spend a certain amount of their own funds (MOE) on TANF-allowable categories. Many states spend additional funds above the required amount." Similarly, with regard to the SNAP program, states are responsible for paying "approximately 50 percent of State agency administrative costs to operate the program" (HHS, 2016).

Although administrative costs to the state do not belong to the variable *S* in the sense that they would not contribute to tribal consumption (as in Equation 3) they certainly contribute at least as much to consumption in the broader sense of them enabling the tribe to receive corresponding benefits from the federal government. Likewise, these administrative costs are, indeed, costs to the state that cuts down on the state's NT consumption (as in Equation 5). In theory, we could make the model much more complicated by adding in these administrative costs as being distinct from other costs associated with social assistance and federal contributions as distinct from state contributions, adding more variables and equations to what we already have. However, the small gains from this added complexity would not be worth the effort, especially since the parameters for the additional equations would be rather difficult to estimate and the effects they measure would be relatively minor in comparison to the major effects that we are measuring already.

The important takeaway, however, is that a reasonable lower bound for δ would be 0.10 (or 10 percent), given the above considerations and allowing for other cases to be different from that of the Rosebud Tribe in particular (where δ could be a bit lower). If Medicaid assistance represented, overall, about half of all state social assistance to low-income tribes, then this would bring δ to about 0.2 on the basis of the above discussion (technically $2\times0.11 = 0.22$, but with the slight reduction in δ from NT-per capita income being higher when all other tribes in the state are considered). The estimated range for δ is then $0.1< \delta <0.3$.

The only remaining parameter that needs to be estimated before testing the model appears in Equations 17 and 21, which is the ratio of the tribal population (for low-income tribes only) to the NS-state population, $\frac{P^T}{P^S}$. This will vary, of course, depending on the state, where a reasonable range might be $0.02 < \frac{P^T}{P^S} < 0.06$ given what we know about tribal populations and the populations of states in which they reside. This range, in turn, suggests a rough, midrange estimate of $\frac{P^T}{P^S} = 0.04$.

Summary of Parameter Estimates and Their Effects

Table 3 below presents our parameter estimates for the nine "structural parameters" in our model. All of the other parameters are simply functions of these nine. From the calculations specified above, these nine parameters will *translate* into four crucial "coefficients" on ΔZ in the four Equations 12-15, i.e.,

$$\Delta Y^T = B^{YT}\Delta Z;\ \Delta Y^S = B^{YS}\Delta Z;\ \Delta C^T = B^{CT}\Delta Z;\ \Delta C^S = B^{CS}\Delta Z \quad (12'\text{-}15')$$

where, for instance, $B^{YT} = \omega(\psi\theta + \lambda\pi)$ in accordance with Equation 12 and similarly for B^{YS}, B^{CT} and B^{CS} in accordance with Equations 13-15, respectively. These equations calculate how much a change in state-funded, tribal infrastructure (ΔZ) will affect four other variables, namely tribal income (ΔY^T), state income (ΔY^S), tribal consumption (ΔC^T) and state consumption (ΔC^S).

As an example, if $B^{YT} = 1.5$, then this means that, if the state increases its support for tribal infrastructure by \$1 million (i.e., ΔZ = \$1,000,000) then tribal income will increase by \$1.5 million (i.e., ΔY^T = \$1,500,000).

We can look at the findings in Table 3 as offering many possibilities with regard to whether any one parameter has the value of its midrange estimate, lower bound, or upper bound. It would be useful for us to see the results of all of these possibilities to understand the range of possible effects that might occur when the state supports tribal infrastructure for a low-income tribe. From all of these possibilities, we might be particularly interested in the "midrange estimate" (based on the midrange values of the parameters) and we might also ask what the highest and lowest possible values might be for the four coefficients that were just mentioned.

To derive these findings, we may first notice that, with three possibilities for each of the nine parameters, we have a total number of $3^9 = 19{,}683$ possibilities.

Figure 1 shows the overall approach that was then taken to process these possibilities. The columns under "Possibilities" present a base-3 number, in nine columns, which helped to "lookup" the values of the structural parameters to the right of those columns. In this way, all of the possibilities could be generated and processed.

The table had 19,683 rows (not counting the header rows) to account for every possibility. In the figure shown here, however, rows 11-19,676 were left out, for obvious reasons (the main one being that the figure is only designed to serve as an illustration of the methodology). In the table, the Reduced Form Parameter Values and the four Coefficients on ΔZ, were simply derived as functions of the structural form parameters, in accordance with the equations of the model.

Table 3: Structural form parameter estimates

Variable number	Name	Symbol	Midrange	Lower bound	Upper bound
1	Marginal Propensity to Consume (in Tribal Economy)	c^T	0.70	0.65	0.75
2	Marginal Propensity to Consume (in State Economy)	c^S	0.65	0.60	0.70
3	Proportion of Physical Capital Invested that Is Imported (Tribal Economy)	$\varphi_I{}^T$	0.25	0.15	0.50
4	Proportion of Consumer Products that Is Imported (Tribal Economy)	$\varphi_C{}^T$	0.51	0.41	0.61
5	Proportion of Tribe's Production Devoted to Infrastructure Investment	α	0.0235	0.02	0.03
6	Proportion of Tribe's Income that is Spent on Private Tribal Investment	β	0.08	0.05	0.15
7	Independent Effect of Government Infrastructure on Private Investment	γ	1.30	1.00	2.00
8	Proportion of the Difference in Per-Capital Income as Social Assistance	δ	0.20	0.10	0.30
9	Ratio of Tribal to Nontribal Population (in State)	P^T/P^S	0.04	0.02	0.06

	Possibilities									Structural Parameter Values								
	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
Number	Base 3: Mid-range=0, Lower=1, Upper=2									c^T	c^S	$\varphi_I{}^T$	$\varphi_C{}^T$	α	β	γ	δ	P^T/P^S
1	0	0	0	0	0	0	0	0	0	0.7	0.65	0.25	0.51	0.0235	0.08	1.3	0.2	0.04
2	0	0	0	0	0	0	0	0	1	0.7	0.65	0.25	0.51	0.0235	0.08	1.3	0.2	0.02
3	0	0	0	0	0	0	0	0	2	0.7	0.65	0.25	0.51	0.0235	0.08	1.3	0.2	0.06
4	0	0	0	0	0	0	0	1	0	0.7	0.65	0.25	0.51	0.0235	0.08	1.3	0.1	0.04
5	0	0	0	0	0	0	0	1	1	0.7	0.65	0.25	0.51	0.0235	0.08	1.3	0.1	0.02
6	0	0	0	0	0	0	0	1	2	0.7	0.65	0.25	0.51	0.0235	0.08	1.3	0.1	0.06
7	0	0	0	0	0	0	0	2	0	0.7	0.65	0.25	0.51	0.0235	0.08	1.3	0.3	0.04
8	0	0	0	0	0	0	0	2	1	0.7	0.65	0.25	0.51	0.0235	0.08	1.3	0.3	0.02
9	0	0	0	0	0	0	0	2	2	0.7	0.65	0.25	0.51	0.0235	0.08	1.3	0.3	0.06
10	0	0	0	0	0	0	1	0	0	0.7	0.65	0.25	0.51	0.0235	0.08	1	0.2	0.04
…																		
19,677	2	2	2	2	2	2	2	0	2	0.75	0.7	0.5	0.61	0.03	0.15	2	0.2	0.06
19,678	2	2	2	2	2	2	2	1	0	0.75	0.7	0.5	0.61	0.03	0.15	2	0.1	0.04
19,679	2	2	2	2	2	2	2	1	1	0.75	0.7	0.5	0.61	0.03	0.15	2	0.1	0.02
19,680	2	2	2	2	2	2	2	1	2	0.75	0.7	0.5	0.61	0.03	0.15	2	0.1	0.06
19,681	2	2	2	2	2	2	2	2	0	0.75	0.7	0.5	0.61	0.03	0.15	2	0.3	0.04
19,682	2	2	2	2	2	2	2	2	1	0.75	0.7	0.5	0.61	0.03	0.15	2	0.3	0.02
19,683	2	2	2	2	2	2	2	2	2	0.75	0.7	0.5	0.61	0.03	0.15	2	0.3	0.06

	Reduced Form Parameter Values							Coefficients on ΔZ for			
Number	Θ	λ	μ	π	ρ	ψ	ω	ΔY^T	ΔY^S	ΔC^T	ΔC^S
1	1.975	0.004	0.649	-0.325	0.413	0.351	4.423	**3.06**	**2.67**	**1.55**	**1.47**
2	1.975	0.002	0.649	-0.325	0.413	0.351	4.414	3.05	2.67	1.54	1.47
3	1.975	0.006	0.649	-0.325	0.413	0.352	4.431	3.07	2.68	1.57	1.47
4	1.975	0.002	0.600	-0.325	0.399	0.351	4.775	3.30	2.83	1.99	1.40
5	1.975	0.001	0.600	-0.325	0.399	0.350	4.770	3.30	2.83	1.98	1.40
6	1.975	0.003	0.600	-0.325	0.399	0.351	4.780	3.31	2.83	2.00	1.39
7	1.975	0.006	0.698	-0.325	0.427	0.352	4.118	2.85	2.54	1.17	1.54
8	1.975	0.003	0.698	-0.325	0.427	0.351	4.107	2.84	2.53	1.15	1.54
9	1.975	0.009	0.698	-0.325	0.427	0.353	4.130	2.86	2.54	1.19	1.53
10	1.750	0.004	0.654	-0.400	0.411	0.351	4.386	2.69	2.01	1.36	0.99
…											
19,677	2.000	0.005	0.651	0.300	0.581	0.301	5.178	3.13	7.02	1.80	4.59
19,678	2.000	0.002	0.612	0.300	0.572	0.300	5.471	3.29	7.26	2.17	4.59
19,679	2.000	0.001	0.612	0.300	0.572	0.300	5.461	3.28	7.24	2.15	4.59
19,680	2.000	0.002	0.612	0.300	0.572	0.301	5.481	3.30	7.27	2.19	4.59
19,681	2.000	0.005	0.690	0.300	0.590	0.301	4.882	2.95	6.77	1.41	4.60
19,682	2.000	0.002	0.690	0.300	0.590	0.301	4.858	2.92	6.73	1.36	4.60
19,683	2.000	0.007	0.690	0.300	0.590	0.302	4.906	2.97	6.80	1.46	4.60

Fig. 1: Processing the 19,683 Possibilities

Conclusion

Table 4 presents the summary findings from the table illustrated in Fig. 1. Namely, it shows the coefficient values for the midrange estimates and then the minimum and maximum values of all of the four coefficients *across all of the* 19,683 possibilities. These findings are very revealing.

In the midrange case, if the state funds a $1 million infrastructure project for the tribe, then that would result in a net increase in the tribe's income of over $3 million, a net increase in the state's income of about $2.7 million, a net increase in the tribe's consumption of about $1.6 million and a net increase in the state's consumption of about $1.5 million.

To understand fully what is meant by "net" here, consider Equation 5:

$$C^S = A^S + c^S\left(Y^S - S - Z\right) \tag{8}$$

This equation alone implies that any increase in state funding of tribal infrastructure, ΔZ, will lead to an immediate loss in the "disposable income" of nontribal (NT) state residents, as reflected by the minus sign in front of the Z in the equation. In short, when the state supports tribal infrastructure, the state residents "have less money to spend *on themselves*" as the initial, noticeable effect. This is, indeed, the basis for a possible political perspective within the state that would be opposed to the state's support of tribal infrastructure. However, that perspective would be short-sighted and it would completely miss the "big picture."

The findings in the table show is that, in the long run, the state residents wind up being *better off* from that $1 million support they provide for tribal infrastructure. Specifically, under the midrange estimate, non-tribal state residents will have $1.5 million dollars *more* in their own consumption than if they did not provide that support. This is $1.5 million *net*, i.e., they are *not* $0.5 million dollars better off after subtracting the $1 they spent-in terms of consumption, they are $1.5 million dollars better off after subtracting the $1 they spent and they are about $1.6 million dollars better off, *net*, in terms of income.

Table 4: Summary of findings with regard to the coefficients on ΔZ

Change ($ millions) for every $1 million spent by the state on tribal infrastructure				
Variable	Tribal income and output	State income and output	Consumption by tribal residents	Consumption by state residents
Symbol	ΔY^T	ΔY^S	ΔC^T	ΔC^S
Midrange	$ 3.061	$ 2.672	$ 1.552	$ 1.471
Minimum	$ 1.860	$ 1.040	$ 0.662	$ 0.287
Maximum	$ 6.677	$ 7.270	$4.381	$4.598

What is especially telling is that, even in the worst-case scenario—the worst among all of the 19,683 calculated possibilities—the NT state residents still come out as winners, with a net increase of about $0.3 million in consumption and over $1.0 million in income. Notice that the ranges of the parameters (in terms of upper and lower bounds) were fairly wide, implying that these worst-case scenarios are "robust" statistically, meaning that they do well to cover the full realm of reasonable possibilities. Of course, all of these calculations assume that the funding of infrastructure will be well planned and responsibly managed. If, instead, the state squanders money on a foolhardy project, then of course bad things could happen, but such is true about anything that involves planned economic activity. In short, it is reasonable to assume the money will be well-spent.

Some observers might also wonder whether the analysis was deficient in examining only the upper and lower bounds on the ranges, while there might be a pivot point (or discontinuity) within the range that could reverse the effect. For example, perhaps there is a value of a parameter that is in-between the midpoint and the lower bound of that parameter that might render a lower minimum coefficient value than the one we obtained from only the possibilities that we examined. However, such an effect would not be possible because of the linearity of all of the equations involved. That is, we should expect that all other possible values of the parameters, which are within the ranges specified, will lead to coefficient estimates that are within the ranges of the possible outcomes that have already been measured.

Not surprisingly, the tribal community benefits greatly from the injection of $1 million to their infrastructure. On the basis of the midpoint estimate, the tribe will experience a gain in income of more than $3 million and a gain in consumption of $1.6 million.

With regard to the NT state residents benefitting from their funding of tribal infrastructure, some state policy makers might then ask, "How could these findings be so positive for the *state's non-tribal residents*, when they spend their own money to help the *tribe*, instead of themselves?" The answer is already explained in our model.

When the state spends money on tribal infrastructure, it raises tribal government expenditure on that infrastructure from the money the tribe received (Equation 4). That purchase of infrastructure then increases tribal income (Equation 1), thereby increasing tribal consumption (Equation 3) and tribal investment (Equation 6), which further increases tribal income, as a "multiplier effect." These increases in tribal investment and consumption imply that the tribe will import more goods and services from the state, thereby increasing the state's production and income. In simpler terms, when the state gives money to the tribe to develop its infrastructure, the state gets most of that money back because the tribe will spend most of that money buying products that the state sells.

In addition, when the tribal residents get richer from this infrastructure-induced, economic growth, the tribal community becomes less in need of social assistance from the state (Equation 7). This is especially the case if the tribe's economic growth increases tribal employment, or gives tribal residents better jobs than they had before. State assistance then declines, putting more money into the pockets of NT state residents, enabling them to consume more. Thus, the reduction in social assistance countervails the initial negative effect (on state consumption) of the state's support for tribal infrastructure (Equation 5, again). In conclusion, when states provide low-income tribes with funding for badly needed infrastructure, this becomes a win-win situation for both tribal residents and non-tribal state residents.

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[1] In accordance with the classification of citations in this paper, based on Payson (2019), the essential citation was Erden and Holcombe (2006), and the relevant citations were Fisher et al (2016) and NMIAD (2019).