Poverty from Incomplete Property Rights:

Evidence from American Indian Reservations

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Abstract: Economists generally agree that more complete property rights lead to higher incomes, but rights are often constrained by other political and social goals. American Indian reservations provide a powerful example. Reservation poverty is often attributed to poor quality land as a result of expropriation and transfers to non-Indians, but a more complete explanation requires understanding how efforts to prevent further transfers shaped reservation land tenure. Under the Dawes Act of 1887, reservation lands were allotted to individual Indians, but held in trust by the federal government until allottees were deemed "competent" to hold fee-simple title. In 1934 the Indian Reorganization Act locked into trusteeship those lands that had not been released. We assess whether incomplete property rights resulting from trusteeship have affected reservation incomes using new panel data on income, land quality, and tenure. Our data reveal a U-shape between per capita income and the share of prime agricultural land on reservations. This is because reservations with relatively poor land were less likely to be allotted and, hence, remain under tribal control while reservations with high quality land were more likely to become fully privatized. Reservations with mid-quality land were allotted, but were less likely to be released from trusteeship. We conclude that incomplete property rights have stunted income growth for Native Americans, relative to local control, whether communal or private.

1. Introduction

Recent literature in economics attributes poverty of the world's least advantaged groups to historical events. Often, this literature documents the persistent effects of historical trauma inflicted by European colonists on indigenous societies. Historical episodes may have had lasting effects through the destruction of indigenous human and physical capital, as in regions of Africa

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targeted for the slave trade (Nunn 2008), or through colonization that installed bad institutions that have persisted over time (Acemoglu et al 2001).

The research connecting modern poverty to historical episodes emphasizes the indirect effects of natural resources. In some cases, inhospitable land turned out to be a blessing for indigenous populations because it attracted less attention from colonizers. This was the case with rugged land in Africa, which protected inhabitants from the slave trade (Nunn and Puga 2012). In other cases, land well-suited for agriculture was a curse because it attracted expropriation by colonizers, thus reducing the long-run growth potential for indigenous populations (Sokoloff and Engerman 2000).

These explanations of indigenous poverty also apply to Native Americans, where a dominant narrative focuses on repeated and systematic expropriation of tribal resources by the U.S. government on behalf of white settlers (Cornell and Kalt 1992).[2] Anderson and McChesney (1994) show that expropriation supplanted negotiation after the Civil War when a standing army made it more expedient to "raid" rather than "trade." Expropriation was also more prevalent where valuable minerals were at stake as documented by Dippel (2014), who shows that tribes were forcibly relocated to reservations thought to be devoid of gold and silver. The transfer of millions of acres of productive farmland from Indians to non-Indians through the allotment and privatization of reservation lands between 1887 and 1934 (Stuart 2005) is another oft-cited and prominent example on which we focus here.

The dominant narrative connecting allotment and indigenous poverty presupposes a positive relationship between resources and income and suggests that the poorest tribes are those

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[2] Overall, Native Americans on reservations experience rates of poverty that are more comparable to Cameroon or Zimbabwe than to the non-Indian U.S. population. In 2015, average household income on reservations was 68 percent below the U.S. average.

that retained the least and lowest quality land. This paper demonstrates that the relationship between land endowments and income is actually negative for many reservations, highlighting the need for a more complete understanding of the process through which land was transferred and the property rights that remained for indigenous people.

We quantify the amount of prime agricultural land on reservations in 1885 and assemble a new panel data set of American Indian per capita income on reservations from 1915 to 2010. Paradoxically, the data reveal a U-shaped relationship between modern income and historic endowments of prime agricultural land. As the amount of productive land increases across reservations, incomes decline up to a point, after which per capita incomes increase as the share of productive land increases. This relationship is not present across U.S. counties, where higher land quality is associated with higher incomes today, and it contrasts with simple narratives that attribute modern reservation poverty to poor land quality.

Using a series of empirical tests, we explain this paradox. The explanation has two parts. The first is that land quality affected the mix of land tenure on reservations today, because land quality determined if, when, and how much of each reservation was allotted during 1887 to 1934. The second is that the mix of land tenure affects modern income generation by affecting the transaction costs of resource use. This hypothesis is supported by our finding that the negative relationship between land quality and income vanishes once we control for land tenure. Indeed, some tenure institutions are so costly that reservations earn lower incomes per capita despite having more productive land.

We quantify the features of tenure associated with low incomes and provide new evidence on their emergence across and within reservations. The key issue is that mid quality agricultural lands were most often partially privatized, via federal policy, whereas low quality lands were not allotted and high quality lands were fully privatized. Partially privatized parcels, called allotted trust, are held in trust by the federal government and cannot be transferred to non-Indians. Allotted trust parcels also cannot be designated to a single heir in wills, which has led to fractionalized ownership as more and more heirs are granted equal land interests over time. These constraints raise the transaction costs of land use, reduce access to credit, and are predicted to reduce investment and economic activity relative to full privatization. The data show that transaction costs associated with trust constraints also reduce income per capita relative to systems of tenure devised locally, by tribes rather than the federal government.

The findings contribute to the literature on indigenous history, property rights, and natural resources in two main ways.[3] First, they show that trustee restrictions on property rights, which were promoted as a means of protecting Native Americans from expropriation in land markets and preventing further land transfers to non-Indians, have lowered incomes on reservations today. This is consistent with a broader literature emphasizing the incompatibility of promoting income generation through land privatization programs that also try to achieve other goals by maintaining some degree of state control (see de Janvry et al. 2014, McChesney 1990).[4] Second, our analysis suggests that tenure systems developed locally, at the tribal level, can promote income growth while also keeping land in Indian ownership.

[3] This literature includes papers that study the link between property rights to land and development on American Indian reservations (e.g., Trosper 1978, Anderson and Lueck 1992, Akee 2009, Akee and Jorgensen 2014) and studies of property rights and development on indigenous land outside of the U.S. (e.g., Alston et al. 1996, Field 2005, Alacantara 2005, Goldstein and Udry 2008, Galiani and Schargrodsky 2010, Chernina et al. 2014, de Janvry et al. 2015, Aragón 2015, Pendakur and Pendakur 2017).

[4] As we describe below, reservations with mid-quality agricultural land were the result of compromise between proponents of privatizing reservation land on one hand and those wanting to preserve Indian ownership and the Indian bureaucracy on the other. The result of this compromise was incomplete privatization.

2. The Dawes Act and Reservation Land Tenure

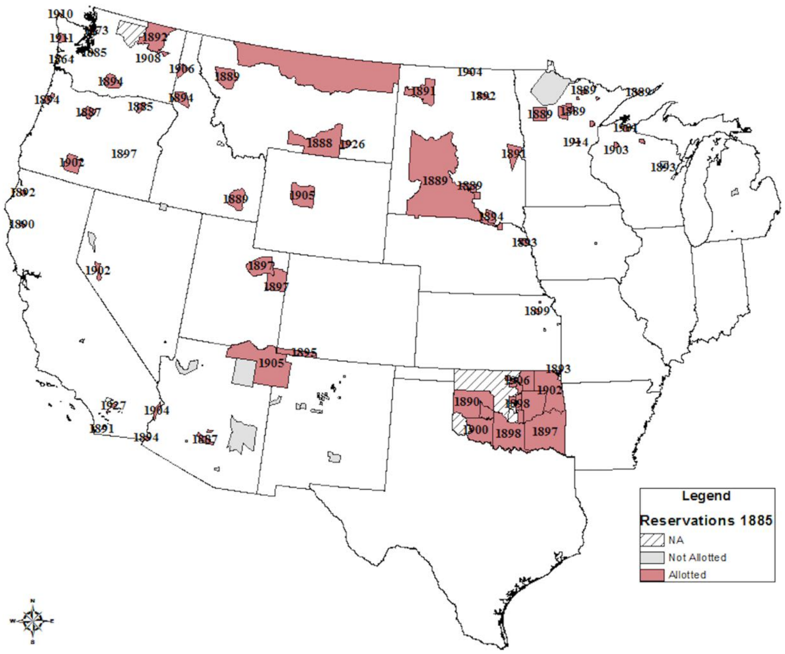
The Dawes Act, also known as the General Allotment Act of 1887, authorized agents from the Office of Indian Affairs to allot plots of reservation land, typically 160 acres, to individual Indian families. Allotment was compulsory at both the reservation and the individual level, and assignment of parcels was at the discretion of local Indian agents (Carlson 1981a). If reservation acreage exceeded what was necessary to fulfill the allotments, the balance was declared "surplus" land and opened for homesteading. The Act served the interests of two main coalitions, one seeking to "make Indians into farmers" and assimilate them into non-Indian society (Carlson 1981a),[5] and another wanting to make reservation land available for whites.

Most reservations in the northern Plains, Rocky Mountains, and Pacific Northwest states were allotted, while some of those in the Southwest were not. Figure 1, based on our digitization of a historical map from 1885, shows which and when reservations were allotted.

After land was allotted to individual Indians, it was held in trust by the federal government for 25 years or until the Indian agent declared an allottee "competent" to hold a fee simple title (Carlson 1981a). Lands remaining in trust are referred to as allotted trust. One rationale for trusteeship was that it would prevent non-Indians from taking advantage of Indians who might not have understood the value of their allotments and therefore might have sold their land to whites at unfavorable contractual terms for the allottee.[6]

[5] Senator Dawes argued that under communal ownership Indians had not "…got as far as they can go because they own their land in common, and under that [system] there is no enterprise to make your [land] any better than that of your neighbors." The quote is cited from Ambler (1990, p. 10).
[6] Akee (2009) notes that some American Indians lost their land because of nonpayment of property taxes or sold their lands unknowingly for less than market value. McChesney (1990) emphasizes that trusteeship kept work for the Indian Affairs bureaucracy, and argues that this also helps explain why land was kept in trusteeship.

Figure 1: Distribution and Timing of Allotment



Note: The large reservation in Northern Montana was split into several reservations, which were subsequently allotted. The same is true of the large reservation in Dakota territory. These appear as separate observations in our data sets. Information on which reservations were allotted and date of first allotment were obtained from a 1934 Land Planning Report and supplemented with information from a report by the Indian Land Tenure Foundation (ILTF) that reports the date of allotment as well as total allotted and "alienated" (fee simple) acres circa 1934.

By the 1920s, allotment received strong criticism for the pace at which non-Indians occupied Indian lands, either through buying or leasing allotted land or by homesteading surplus land. The "Meriam Report" concluded in 1928 that the Dawes Act was a failure for not promoting farming by Indians on reservations, not alleviating poverty, and not preventing Indian land from being transferred to non-Indians (Meriam 1928). Ultimately, these concerns led to the passage of the Indian Reorganization Act (IRA) in 1934. The IRA declared that all Indian land, either allotted trust not released from trusteeship by 1934 or land retained by the tribe, would remain in trust with the Bureau of Indian Affairs (BIA).

During the allotment era the Indian land base shrank considerably. Within reservations, 29,481,685 acres were retained by tribes as tribal trust land, 17,829,414 acres were remained as allotted trust, and 22,277,342 acres were declared fee simple, with many owned by non-Indians by 1933 (Flanagan et al. 2010). The IRA did set up a $10 million fund in 1934 for tribes that adopted IRA provisions to buy back some fee simple lands, but the resulting changes in tenure after 1934 were minor compared with transfers occurring between 1887 and 1934 (see Royster 1995, Frye and Parker 2016).

The large transfer of land from Indians to non-Indians has been the focus of most accounts of allotment, but the institutional legacy of the Dawes Act may be as consequential in terms of its effects on modern reservation economies. The end to allotment under the IRA left allotted reservations with a mix of tribal, allotted trust, and fee simple tenures.[7] Though retaining land in trust halted the transfer to non-Indians, it also increased the transaction costs associated with land use. Allotted trust lands could not be used as collateral on loans, could not be leased or transferred without approval from the BIA, and could not be willed to a single heir (Carlson 1981b). The first two restrictions immediately increased the transaction cost to allottees of leasing or changing land use and the third increased the transaction costs of agreement among allottees as the number of owners increased with each generation as trust lands were passed in equal shares to heirs (Shoemaker 2003).[8]

Other economists have estimated the causes and effects of allotment. Carlson (1981b) finds that states with higher population growth rates and more rainfall were allotted sooner and argues this was because settlers wanted more Indian lands opened for homesteading. Carlson (1981a) also finds a gap in farming activity between Indians and non-Indians, which increased over the allotment period, particularly after 1915, arguing that trusteeship undermined pre-

[7] Some reservations—particularly those in present-day Oklahoma—were so quickly and completely allotted that 100 percent of their land was converted to fee simple tenure.

[8] The allotted trust parcels on Indian reservations today generally have multiple owners, sometimes more than 100 (Russ and Stratmann 2015).

existing systems of informal property rights. Anderson and Lueck (1992) find evidence that agricultural productivity on 39 reservations was highest on fee simple lands during the 1980s. Akee (2009) finds that allowing long-term leasing to non-Indians on lands in trust increased the value of trust lands on the Aqua Caliente reservation, because this is a work-around to the constraint on alienation. Russ and Stratmann (2015) analyze 12 reservations and find that fractionation correlates with lower per capita incomes at the reservation level, and with reduced lease income from farming at the parcel level. Russ and Stratmann (2016) also find that efforts to reduce fractionation have been unsuccessful.[9]

Our study connects the research on the causes of allotment with the research on the effects of allotment to understand the inadvertent effects of nineteenth-century land quality on modern reservation economies. The analysis focuses on how reservations' pre-Dawes agricultural land endowments determined allotment decisions, shaped land tenure, and ultimately affected economic development over the twentieth and early twenty-first century. Understanding how land quality affected allotment within and between reservations is essential for isolating the effects of land tenure on modern economic conditions from those of land quality.[10]

3. The Probability and Timing of Allotment

Whether allotment was motivated by an altruistic desire to promote Indian farming or by an effort to open reservation land for white settlement, reservations with more valuable resource

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[9] Using data on oil drilling on the Fort Berthold Reservation during 2005-2015, Leonard and Parker (2017) find that scattered ownership patterns and fractionation reduced potential income from oil development. Akee and Jorgensen (2014) find no differences in business investments between trust and non-trust parcels on Agua Caliente reservation in Palm Springs, California where long-term leasing of land is possible and ownership of allotted trust parcels are not highly fractionated.

[10] That is, appropriate assessment of land tenure effects requires controlling for selection on land quality. This is a point emphasized by economists who study land-tenure impacts in other settings (see, e.g., Besley 1995, Galiani and Schargrodsky 2010), and who study North American indigenous tenure systems in particular (see Akee 2009, Akee and Jorgensen 2014, Aragón 2015, Pendakur and Pendakur 2017, Aragón and Kessler 2017).

endowments would have been more likely to be allotted and more likely to be allotted sooner. In this section, we evaluate how historical resource endowments determined the probability and timing of allotment.

3.1 Land Quality

To measure pre-Dawes endowments of reservation land bases, we geo-reference and digitize an 1885 map of reservation boundaries and then use geographic information on rainfall and soil quality to construct a measure of prime agricultural land.[11] We use PRISM climate data over the years 1895 to 1935 to estimate long-term trends in spring and summer precipitation during the allotment era by calculating total rainfall in each 800-meter by 800-meter cell from March to August of each year and then averaging over 1895 to 1935.[12] Figure 2a shows average summer rainfall across our sample of reservations, aggregated into 5-inch rainfall bins.[13] The soil data come from Schaetzl et al. (2012), who developed a 21-point soil productivity index to measure soil quality. The index is an ordinal ranking from 0 to 20 of potential productivity of the soil based primarily on its structural characteristics and not its water or nutrient content. Figure 2b depicts the spatial variation in the index collapsed into low, medium, and high-quality soil.[14]

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[11] Lionel Pincus and Princess Firyal Map Division, The New York Public Library. "Map showing the location of the Indian reservations within the limits of the United States and territories" *The New York Public Library Digital Collections*. 1885. http://digitalcollections.nypl.org/items/510d47e2-0b69-a3d9-e040-e00a18064a99.

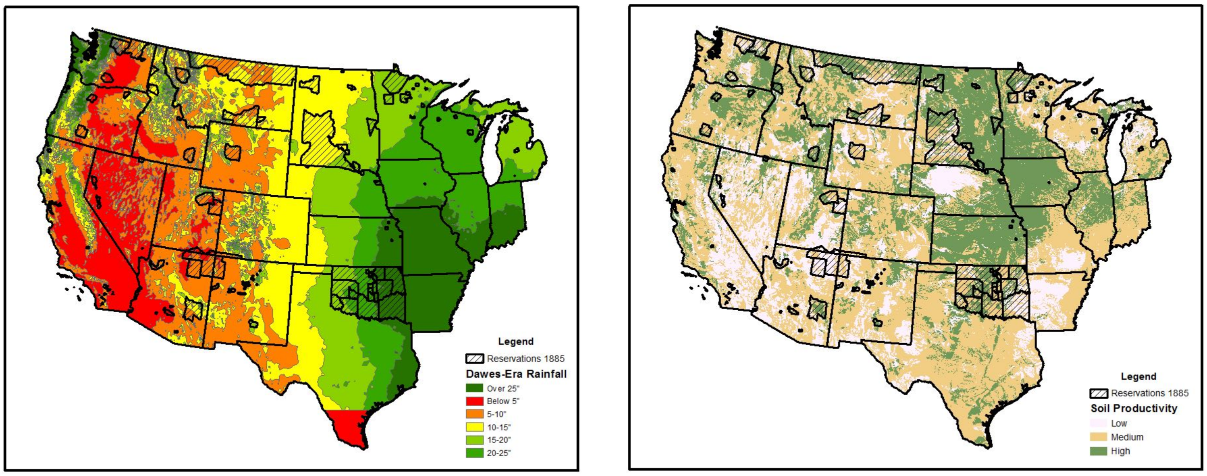
[12] PRISM Climate Group, Oregon State University, http://prism.oregonstate.edu, created 4 Feb 2004. 1895 is the first year for which the PRISM climate data is available.

[13] We aggregate in this way so that we can compare our measure to a rainfall map in the 1880 Statistical Atlas of the United States, which may better reflect on-the-ground knowledge at the time. Appendix Figure A5 provides a comparison.

[14] We compute the spatial intersection of our long-term precipitation measure and the soil quality index to measure the number of acres that fall into each rainfall-soil category on each reservation (resulting in a total of 126 rainfall-soil bins).

Figure 2: Reservation Rainfall and Soil Productivity in 1885

a) PRISM Rainfall Data **b) Soil Productivity index**



Importantly for our purposes, the Schaetzl et al. (2012) index is based on the geologic and structural characteristics of the soil and was designed to be invariant to nutrient, fertilizer, and moisture measurements (Schaetzl et al. 2012). This means that it does not reflect differences in management practices during 1885 to 2012, and is therefore predetermined with respect to land tenure arrangements created by the Dawes Act.

Because there is not a quantitative measure of what was considered "prime farmland" during the Dawes Era, we combine data on soil and rainfall to create a measure. We define "Prime farmland" as land that receives at least 15 inches of Spring/Summer rain and has a soil productivity index ranking of at least 13, and calculate the share of each reservation that is covered with prime farmland. This is the measure that best explains farm productivity off of Indian Reservations and pre-Dawes farming activity on reservations. Appendix Table A2 shows that our measure of prime farmland predicts about 40 percent of the within-year variation in farm value per acre at the county level in census years spanning 1890 to 1930.[15] Appendix Table A4

[15] Appendix Figure A1 depicts prime land and farm value per acre by county in 1890 and 1930 and Appendix Tables A2 and A3 assess the relationship between Percent Prime and farm value per acre.

shows that prime land is positively correlated with pre-Dawes measures of agriculture on a subset of 67 reservations for which data are available. Prime land explains 42% of the variation in the share of a reservation that was tilled in 1885 and is also positively correlated with the share of a reservation that was cultivated or broken and with corn yields.

3.2 Other Resource Endowments

Non-agricultural resource endowments such as gold, silver, coal, timber, oil, stream density, and topographical ruggedness also could have affected the probability and timing of allotment. We create measures of these by geo-referencing and digitizing maps from the 1880 Statistical Atlas of the United States. The original maps are provided in Appendix Figures B1 through B5. The share of each reservation having an estimated 50 cords or more of wood per acre is our measure of timber wealth. Following Dippel (2014), we combine state-level estimates of mineral output with the count of mines in each state to estimate the average value of each mine and sum over the number of mines on each reservation. Thirty square-meter resolution elevation data from the National Elevation Dataset allow us to calculate the standard deviation of elevation within each reservation as a measure of topographic roughness (Ascione et al. 2008). The density of perennial streams within each reservation based on stream classifications from the National Hydrography Dataset provide our measure of irrigation potential.

We also develop measures of population pressure and development near reservations over 1880 to 1890 that may have influenced allotment. Digitized maps of historic railroads (Atack 2016) show the density of railroads completed by 1890 within 10 miles of each reservation and provide a measure of market access (Donaldson and Hornbeck 2016). County-level population data from NHGIS show population growth from 1880 to 1890 in reservation-adjacent counties.[16] Finally, we digitize the location of military outposts and forts to count the number of forts within 10 miles of each reservation; this is possibly related to the supply of government personnel necessary to execute allotment.

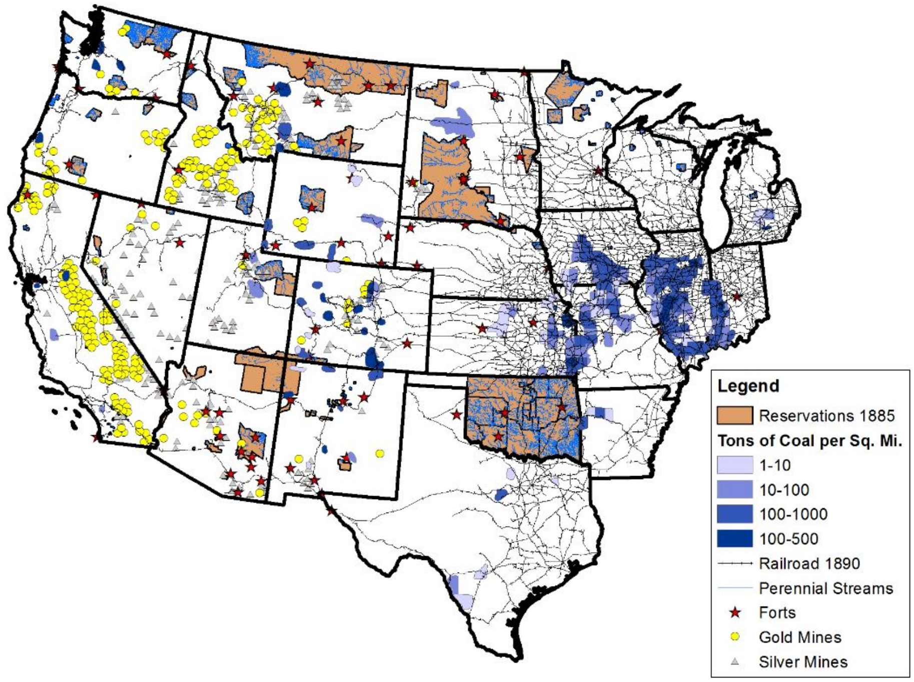
Table 1 shows summary statistics for these measures and Figure 3 maps reservations, mines, railroads, stream density, and military forts.

Table 1: Dawes-Era Summary Statistics

Variable	(1) N	(2) Mean	(3) S.D.	(4) Min	(5) Max
Resource Measures and Controls					
% Prime Land	146	0.257	0.343	0	1
% High-Yield Timber Lands	147	0.161	0.358	0	1
Value Gold & Silver Mines	147	26.51	99.24	0	547.3
Value of Coal Mines	147	0.0450	0.169	0	0.740
Stream Density	147	0.000540	0.000557	0	0.00423
Elevation	147	0.789	0.664	0	2.432
Ruggedness	147	0.115	0.116	0	0.458
Acres (100,000s)	147	19.61	51.34	0.0114	220.0
Rail Density 1890	147	54.37	94.06	0	558.1
Fort Dist.	147	59.32	58.17	0	252.3
Adj. County Pop. Growth, 1890	147	30.31	31.89	-11.75	126.4
Dawes Outcomes					
Allotted Indicator	142	0.718	0.451	0	1
Years from 1887 Until Allotted	138	35.59	18.54	-23	47

[16] Some counties are subdivided between 1880 and 1890. To address this, we separately determine the set of reservation-adjacent counties in each year and then sum total population in these counties in each year before taking the difference to arrive at our estimated changes in the population.

Figure 3: Initial Reservation Endowments



3.3 Regression Estimates

Table 2 presents three sets of regressions estimating how the share of prime agricultural land on a reservation in 1885 affected the probability and timing of allotment. Columns 1 and 2 report the estimated marginal effects obtained from a logit regression where the dependent variable is an indicator equal to one if a reservation was allotted between 1887 and 1934 and zero otherwise. Columns 3 and 4 show censored tobit regressions where the dependent variable is the number of years elapsed between 1887 when the Dawes Act was passed and the date a reservation was first opened for allotment.[17] Finally, Columns 5 and 6 report hazard ratios from a Cox Proportional Hazard model where the time until allotment is the measured duration.

[17] This variable is censored from above at 47 years for reservations that were not allotted prior to the end of the allotment era in 1934.

Identification in these models relies on cross-sectional variation in land quality between reservations. The fixed nature of the resource endowment rules out simultaneity and reverse causality. Here the chief identification concern is unobserved heterogeneity across reservations that is correlated with reservations' share of prime agricultural land and affects the probability and timing of allotment. Our approach for addressing this concern is to control for the distance to the nearest military outpost in 1885, adjacent county population growth in 1890, miles of rails that were operable by 1890 within 10 miles of a reservation, overall size of the reservation, ruggedness, stream density, and other resource abundance measures. Columns 2, 4, and 6 also control for the geographic coordinate of each reservation's centroid to account for possible spatial patterns in the rollout of allotment that are not captured by population growth. Our coefficient estimates do not change significantly with the inclusion of controls, implying either that the estimates are well-identified or that our controls are uncorrelated with some unobserved factor that is highly correlated with the share of prime agricultural land.

Table 2: Estimates of the Probability and Timing of Allotment

	(1)	(2)	(3)	(4)	(5)	(6)
	Pr(Allotted)	Pr(Allotted)	Timing (Tobit)	Timing (Tobit)	Cox Prop. Haz.	Cox Prop. Haz.
% Prime Land	0.429^{***}	0.215^{*}	-21.17^{***}	-26.71^{***}	2.302^{***}	2.031^{**}
	(0.130)	(0.112)	(6.660)	(8.241)	(0.523)	(0.715)
Fort Dist.		-0.0000253		-0.00935		1.0009
Adj. Cty. Pop. Growth, 1890		0.00389^{**}		-0.0926		1.002
Rail Density 1890		0.00217^{*}		-0.0446^{*}		1.002^{**}
Acres (100,000s)		0.00107		-0.0657		1.007^{***}
Ruggedness		-0.153		18.29		0.732
Stream Density		-70.19		8697.0		0.0009
% High-Yield Timber		-0.122		13.37		0.505^{**}
Gold & Silver		0.000295		-0.0351^{**}		1.001^{**}
X Coordinate (1000s)		-0.0000818^{*}		0.00617		0.999
Y Coordinate (1000s)		0.000237^{***}		-0.0184^{***}		1.009^{***}
Constant			32.09^{***}	44.94^{***}		
Observations	142	142	142	142	133	133

Robust standard errors in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

The estimates show that the share of prime agricultural land within reservation boundaries in 1885 significantly increased the probability of allotment and reduced the time between the passage of the Dawes Act and the allotment of a reservation. The marginal effect of prime agricultural land reported in Column 2 implies that a change from 0 to 100 percent prime agricultural land would increase the probability of allotment by over 20 percentage points. This implies that the allotment process targeted reservations thought to have the most rent-generating potential. These were the reservations with prime agricultural land, near fast-growing counties and with greater railroad access.

Columns 3 and 4 indicate that reservations with a larger share of prime agricultural land in 1885 were opened for allotment earlier. Moving from 0 to 100 percent prime land reduces the time between the passage of the Dawes Act and initial allotment by 26 years—over half the total duration of the allotment era. Column 4 also indicates that reservations were allotted more quickly in areas with greater rail access by 1890. Reservations with higher-value gold and silver mines were also allotted earlier.

Columns 5 and 6 confirm these results using a Cox Proportional Hazard model. Here, the coefficients report the relative change in the probability of being allotted in a given year, conditional on having not been allotted yet. A coefficient greater than one indicates that allotment is more likely as the variable increases. Column 6 suggests that reservations with 100 percent prime agricultural land were twice as likely to be allotted in a given year than reservations with no prime land.

We find that prime agricultural land was a key determinant of the probability and timing of allotment. The findings are consistent with either an altruistic or land-grabbing motivation for allotment. If well-meaning reformers wanted privatization to succeed in lifting Native Americans out of poverty, they would prioritize the same reservations that land-hungry non-Indian settlers would prioritize: those with high quality lands, near population centers and rail lines.

4. Land Quality and Long Run Income

Did the Dawes-Era experiment in privatization increase income for tribes in the long run? To answer this question, we analyze whether reservations endowed with better agricultural land before the Dawes Act have earned higher incomes since allotment. If the Dawes Act created a uniform system of well-defined property rights, encouraging more efficient use of labor and capital, there should be a positive relationship between the quality of agricultural land and per capita income. If the Dawes Act raised the transaction costs of land use and of using it as collateral for credit, the relationship could actually be negative.

To estimate these effects, we have assembled a new panel data set of per capita American Indian income on reservations spanning 1915 to 2010, making it the longest available. The 1915, 1938, and 1945 data come from reports of the Bureau of Indian Affairs,[18] the 1969, 1979, 1989, 1999 from decadal U.S. Census reports, and the 2010 American Community Surveys.[19] We present income in 2010 dollars, adjusted by the national CPI.[20]

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[18] For 1915-1918, we are reporting the mean incomes over 1915, 1916, 1917, and 1918 based on income data from Bureau of Indian Affairs reports available online at http://digicoll.library.wisc.edu/cgi-bin/History/History-idx?type=header&id=History.AnnRep90&isize=M. The 1938 and 1945 means are calculated from data contained in Bureau of Indian Affairs reports located at the U.S. National Archives in Washington D.C. Because the 1945 reservation income estimates do not report reservation populations, we calculate per capita income by dividing 1945 aggregate income by the populations on reservation in 1943, which is the closest year to 1945 for which we have comprehensive Indian population data.

[19] The 2010 data come from the American Community Survey (ACS) which differs from the earlier decennial reservation census reports in certain ways. For geographic areas with populations less than 20,000, the ACS reports 5-year estimates (i.e. 2006-2010 averages). Because of this, the only data available for most reservations are the 5-year estimates which are what we use in our analysis.

[20] The census income does not include income in the form of noncash benefits such as food stamps, health benefits, subsidized housing, and goods produced and consumed on farm.

A tribe's agricultural land endowment is likely to have a direct effect on income by increasing rent-generating potential, but it is also likely to have affected land tenure. Because these two effects may have different signs and magnitudes, the net effect of resources on income may not be linear. For this reason, we estimate the regression model in Equation 1, which includes a quadratic term on the prime agricultural land variable.

$$(1)\ lnPCI_{irt} = \beta_0 + \beta_1 \%Prime1885_i + \beta_2 \%Prime1885_i^2 + \theta \vec{X}_{i,r,1885} + \alpha \vec{Z}_{i,s,t} + \lambda_{r,t} + \varepsilon_{i,r,t}.$$

The unit of observation is reservation *i* in BIA region *r* in year *t*={1915, 1938, 1945, 1969, 1979, 1989, 1999, 2010}. $X_{i,r,1885}$ is a vector of resource endowment and population pressure measures circa 1885, $Z_{i,r,t}$ are contemporaneous controls including log population and log per capita income in adjacent counties, casino gaming activity, and reservation governance, and $\lambda_{r,t}$ are BIA region-by-year fixed effects. Table 3 gives summary statistics of the time varying dependent variable and covariates.

Our main goal is to test for the existence of a positive relationship between prime agricultural land endowments and long-run income. The tests are credible if the model adequately controls for factors, other than prime agricultural land endowments, that have also affected income. For this reason, we include a suite of controls for i) resource endowments such as gold, silver, coal, timber, oil, and stream density; ii) regional economic conditions as accounted for by adjacent county per capita income and population density[21]; iii) presence and

[21] Population density and the per-capita income are for non-reservation residents living in any county adjacent to the county or counties containing the reservation. Because the census did not collect the county-level data in 1938 and 1945, we include state-level measures of per capita income as a control for regional economies in those years.

intensity of casino gaming[22]; iv) and non-tenure institutions.[23] The model also allows for BIA region-specific time effects to account for the possibility that unobserved, time variant factors that affect income growth are clustered into particular reservation regions. BIA-specific time effects control for regional differences in federal policy towards Native Americans over time.

The empirical analysis pools data across all 1970-2010 census years rather than focusing on income during one particular year. This helps smooth some of the periodic noise in reservation per capita incomes and identifies stable, long-term relationships. This smoothing is important for two reasons. First, reservation populations are small relative to U.S. counties and states which implies that income per capita calculations are sensitive to small changes in who responds to census enumerators. Second, census surveying practices of American Indian reservations varied across the different decades and it is not obvious *a-priori* which decadal reports represent the most reliable assessments of Native American income.[24] To address correlation across years in the pooled sample, we cluster standard errors by reservation.

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[22] Casino gaming activity on reservations is measured by the number of slot machines per American Indian in 1999 and 2010. The casino variable is zero prior to 1999 because reservations in the samples did not have casinos prior to 1999.Prior to the Indian Regulatory Gaming Act of 1988, casino gaming on reservations was virtually non-existent (Cookson 2010). The slot machines variable takes on a value of zero for all reservations prior to the 1989 Census. The data on slot machines for 1989 and 1999 were compiled by Anderson and Parker (2008) and also used in Cookson (2010). The data on slot machines in 2010 were compiled by the authors from www.500nations.com/Indian_Casinos.asp. This site provides the number of slots/gaming machines for all American Indian casinos in the U.S. Each casino can be tied to a reservation by looking at which tribe owns the casino and where the casino is located. We downloaded gaming machine data from the site in 2013, so our measure may include casinos built after 2010.

[23] To control for differences in political organization of tribes, we include an indicator variable for whether a tribe opted to reorganize under the Indian Reorganization Act (IRA) (see Cornell and Kalt 2000, Akee et al. 2015, Frye and Parker 2016) and whether the reservation is under state court jurisdiction through the application of Public Law 280 for the post 1945 years (Anderson and Parker 2008, Dimitrova-Grajzl et al. 2014, Brown et al. 2017). We also control for whether multiple tribes were forced to co-integrate on a single reservation, based on Dippel (2014). We do not include this variable in every specification because doing so limits sample size, as the variable is not coded for every reservation.

[24] For example, beginning in 2000, the U.S. Census gave survey respondents the option to select a single race or multiple races. (Throughout our analysis, we employ data for respondents who reported a single American Indian race). The census also changed practices after the 2000 such that geographic areas with populations less than 20,000 – which includes many Indian reservations, are reported not for 2010 but for 5-year estimates (i.e. 2006-2010 averages).

Table 3: Panel Summary Statistics by Year

Variable	1915	1938	1945	1969	1979	1989	1999	2010
Dependent Variables								
Ln(Per capita Income)	7.506	7.842	8.203	8.748	9.142	9.083	9.377	9.465
	(0.726)	(0.343)	(0.616)	(0.292)	(0.286)	(0.271)	(0.298)	(0.303)
Ln(Population)	7.152	7.052	6.635	6.948	7.143	7.369	7.224	7.556
	(0.835)	(1.111)	(1.350)	(1.047)	(1.026)	(0.981)	(1.345)	(1.016)
Time-Varying Covariates								
Slot Machines per Capita				0	0	0.075	0.236	0.807
				(0)	(0)	(0.628)	(0.526)	(1.629)
State Jurisdiction Indicator				0.307	0.356	0.360	0.406	0.352
				(0.464)	(0.482)	(0.483)	(0.494)	(0.480)
Ln(Adj. Cnty Pop Density)				2.580	2.966	3.084	3.363	3.474
				(1.138)	(1.303)	(1.38)	(1.476)	(1.506)
Ln(Adj. Cnty PCI)				14.423	19.124	20.721	24.153	24.272
				(2.185)	(3.065)	(4.249)	(4.513)	(4.349)
Time-Constant Covariates								
IRA Indicator		0.750	0.733	0.813	0.805	0.798	0.762	0.791
		(0.436)	(0.445)	(0.392)	(0.399)	(0.404)	(0.428)	(0.409)
Oil-Endowed Indicator	0.359	0.375	0.320	0.387	0.356	0.348	0.307	0.341
	(0.484)	(0.488)	(0.470)	(0.490)	(0.482)	(0.479)	(0.464)	(0.477)
FC (Dippel 2014)	0.755[a]	0.722[b]	0.730[c]	0.597[d]	0.590[e]	0.60[f]	0.581[g]	0.605[h]
	(0.435)	(0.452)	(0.447)	(0.494)	(0.495)	(0.493)	(0.496)	(0.492)
Observations	64	64	75	75	87	89	101	91

Notes: a) N=53; b) N = 54; c) N=63; d) N= 67; e) N=78; f) N=80; g) N=86; h) N=81

Table 4 reports the results of estimating Equation 1 separately in 1915 (Column 1), 1938/1945 (Column 2), and 1969 onwards (Columns 3-6). During allotment in 1915 and just after allotment ended in 1938 and 1945, the linear and quadratic terms on prime agricultural land are statistically indistinguishable from zero, but the pattern does not persist over time.

For the 1970 to 2010 period, there is a U-shaped relationship between tribes' pre-allotment agricultural endowments and long-run income. Beginning with Column 3 of Table 4, the coefficient for the linear effect of % Prime is negative and statistically significant, while the quadratic term is positive and statistically significant, suggesting an initially downward-sloping, convex relationship. The results in Column 4, which includes additional controls for modern conditions, are similar.

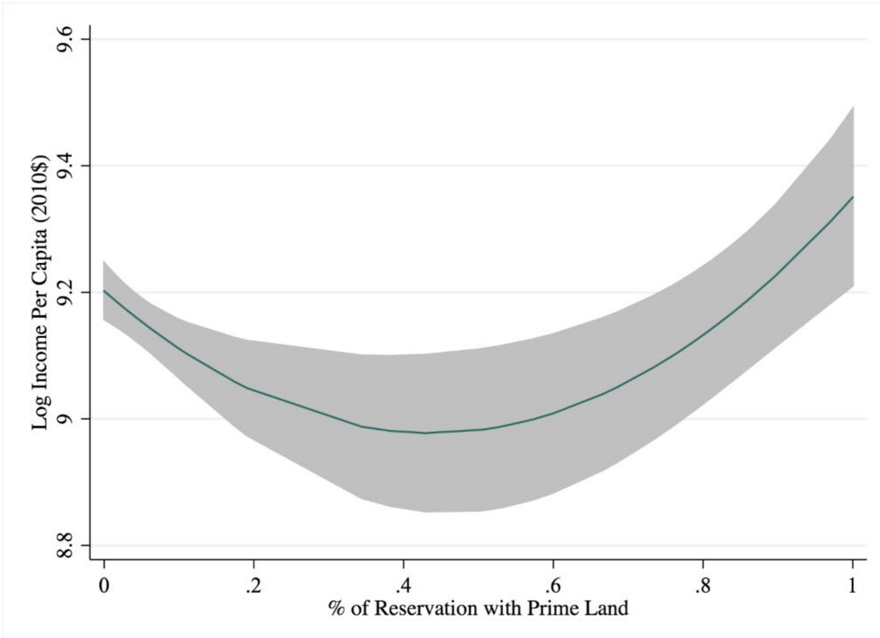
Table 4: Prime Agricultural Land and Income on Reservations

	1915	1945 & 1938	1970 to 2010	1970 to 2010	1970 to 2010	1970 to 2010
	(1)	(2)	(3)	(4)	(5)	(6)
% Prime Land	1.345	0.183	-1.053***	-1.028***		
	(1.593)	(0.519)	(0.298)	(0.302)		
% Prime Land^2	-2.286	-0.232	1.097***	1.176***		
	(1.873)	(0.532)	(0.327)	(0.313)		
PrimeT1					0.208**	0.162**
					(0.0831)	(0.0808)
PrimeT3					0.134	0.203**
					(0.0972)	(0.0870)
Controls						
Resource Endowments	x	x	x	x	x	x
Reservation Pop.	x	x	x	x	x	x
Adj. County Conditions				x		x
Slot Machines per Capita				x		x
Political and Legal Oversight				x		x
Dippel's FC Variable				x		x
BIA by Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	64	139	443	391	443	391
Adjusted R^2	0.277	0.438	0.573	0.660	0.560	0.648

Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$ Standard errors are clustered by reservation. Resource endowments controls are time invariant and include timber, coal, stream density, ruggedness, acres, railways, population growth from 1880-1890, and an indicator for energy resources. Controls for adjacent county conditions are time variant and include population density and per-capita income, both logged. The political and legal oversight variables are controls for tribes that opted into the IRA, and who had state jurisdiction imposed upon them by P.L. 280. Dippel's (2014) variable is a measure of forced co-integration (FC). The number of observations declines with its inclusion due to incomplete reservation coverage. The designation of BIA regions has changed over time, but here we rely on a division prevalent during the mid-1900s. Under that division, there are eight BIA regions, named after the headquarter city, which are: Aberdeen, Albuquerque, Billings, Eastern, Minneapolis, Phoenix, Portland, and Sacramento. The years in the 1970 to 2010 sample are 1969, 1979, 1989, 1999, and 2010.

Figure 4 shows the U-shaped relationship, based on the Column 4 coefficients. Long-run incomes are lowest where prime agricultural land makes up about 44 percent of the reservation. The U-shape implies that reservations with relatively low or relatively high agricultural endowments in 1885 have higher incomes today than reservations with median endowments. On average, for reservations with less than 44 percent prime agricultural land in 1885, an increase in the share of prime agricultural land is associated with lower income today, whereas reservations with at least 44 percent prime agricultural land exhibit a positive relationship between their initial endowment and modern per capita income. This means that for the average reservation in our sample with 24 percent prime agricultural land in 1885, a better endowment was a curse.[25]

Figure 4: Prime Agricultural Land and 1970-2010 Income on Reservations

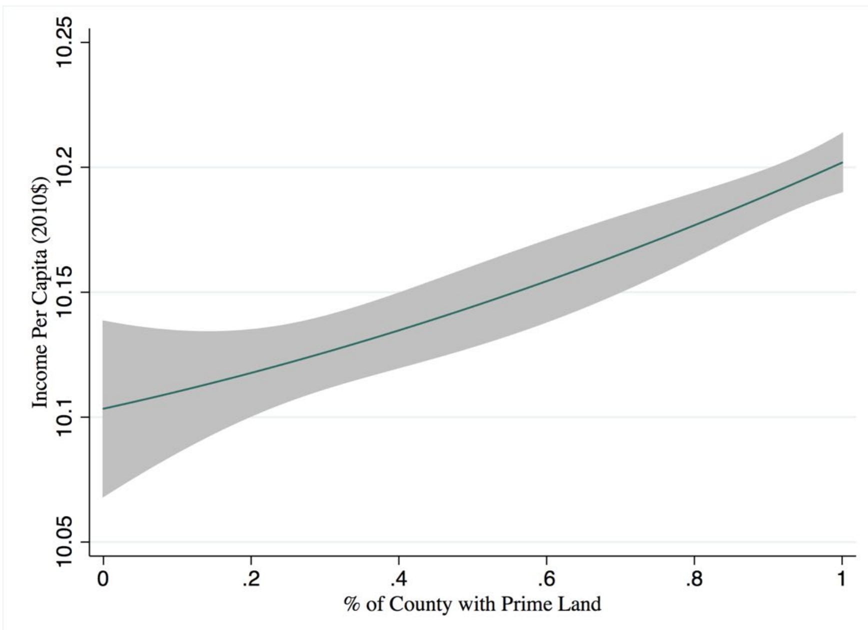


As a semi-parametric test for whether these differences are statistically significant, we create indicators for whether reservations have less than 33 percent prime agricultural land or greater than 66 percent prime agricultural land and treat reservations with between 33 percent and 66 percent prime agricultural land as the omitted category. The results, reported in Columns 5 and 6 of Table 4, show that low-endowment reservations have incomes about 16 percent higher than medium-endowment reservations, while high-endowment reservation earn 20 percent more.

[25] Other research suggests that good soil may be a curse for African countries (Wantchekon and Stanig 2016).

We also estimate the relationship between the share of prime agricultural land in 1880 and per capita income over 1970-2010 for U.S. counties. This serves as a test for whether the results in Table 4 are driven by omitted regional characteristics of reservations that happen to correlate with the share of prime agricultural land and also drive patterns of income growth. Summary statistics are available in Appendix Table D1.

Figure 5: Prime Agricultural Land and 1970-2010 Income on Counties



Regression results in Table 5 show the contrast between non-reservation counties and reservations and show that the relationship between the share of prime agricultural land and per capita income in U.S. counties do not exhibit the U-shaped result discussed above. Column 1 allows for the basic quadratic formulation on reservations, controlling only for the covariates that are also available at the county level. Column 2 tests for a quadratic effect of prime agricultural land on modern per capita income in counties, and Figure 5 depicts the estimated marginal effects from Column 2 of Table 5. The figure indicates that the relationship off of reservations is positive and linear.

Table 5: Prime Agricultural Land and Income on Reservations vs. Counties

	Reservations	Counties	Linear DD	Tritiles
	(1)	(2)	(3)	(4)
% Prime Land	-0.816***	0.0650	0.106***	
	(0.300)	(0.0707)	(0.0164)	
% Prime Land^2	0.734**	0.0335		
	(0.335)	(0.0567)		
PrimeT1				-0.0521***
				(0.0160)
PrimeT3				0.0384***
				(0.0116)
Reservation Indicator			-1.071***	-1.325***
			(0.0556)	(0.0829)
Res × % Prime			-0.260***	
			(0.0828)	
Res × PrimeT1				0.249***
				(0.0825)
Res × PrimeT3				0.0690
				(0.0975)
Controls	x	x	x	x
BIA by Year FE	x	x	x	x
Observations	518	6208	6726	6726
Adjusted R^2	0.277	0.438	0.573	0.648

Notes: Standard errors are clustered by county/reservation and reported in parentheses* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. All specifications control for population, ruggedness, acres, and stream density. The years included in the sample are 1970, 1980, 1990, 2000, and 2010

Column 3 provides linear difference-in-difference estimates that formally test for whether or not the effect of prime agricultural land on income differs on versus off reservations. It shows that, if a linear relationship is imposed, prime land is positively related to off-reservation income, but negatively related to income on reservations. Column 4 shows that differences persist using the semi-parametric, tritile approach employed in Table 4. The negative coefficient on PrimeT1 means that, for counties, incomes are lowest in the bottom-tritile of the land quality distribution. The positive coefficient on PrimeT3 means that incomes are highest in the top tritile. The large, positive coefficient on Res x PrimeT1 means that reservations deviate from the rank ordering of incomes observed for counties across land quality tritiles. As shown in Table 4, reservations with low-quality land have higher incomes than reservations with mid-quality land. Across all estimation procedures, we reject the null hypothesis that the relationship between historic prime land and modern income is the same for counties and reservations.

5. Allotment, Land Tenure, and Income Growth

What mechanism explains the U-shaped relationship between prime agricultural land and income? Here we test a two-part hypothesis. First, land quality affected land tenure through its effects on the probability and timing of allotment. Second, modern land tenure affects income through its effects on the transaction costs of resource use.

To test this two-part hypothesis, we employ data on the percent of land that is owned by the tribe, held in allotted trust, or held in fee simple title as of 2003 (see Anderson and Parker 2008). We also gathered data on fractionation from a 2013 report by the U.S. Department of Interior. Fractionation is particularly important because the number of owners per allotted tract and the number of tracts with multiple owners has increased over time (see Russ and Stratmann 2016). Table 6 gives tenure summary statistics.

Table 6: Tenure Summary Statistics

Variable	N	Mean	S.D.	Min	Max
Allotment Indicator	142	0.718	0.451	0	1
Tenure Variables					
% Allotted Trust Land	111	0.114	0.175	0	0.871
% Tribal Land	111	0.554	0.406	0	1
% Fee Land	111	0.338	0.367	0	1
Fractionation Variables					
% Highly Fractionated Land	111	0.097	0.150	0	1
Highly Fractionated Tracts	78	71.856	157.559	0	951
Unique Owners	78	3,391.564	4,162.875	2	22,594
Purchasable Interests	78	28,352.24	46,811.71	2	227,133
Avg. Interests per Tract	78	36.683	23.939	1.571	115.059

5.1 Effects of Prime Land on Tenure and Fractionation

As shown above, the timing and probability of allotment and the resulting mosaic of tenures is partly a function of pre-Dawes resource endowments. Reservations with very little prime agricultural land were unlikely to be allotted at all and remained in complete tribal trust tenure. Reservations with the most prime agricultural land were allotted the earliest, providing ample time for it to be converted to fee simple. Reservations with mid-quality land endowments were likely to be allotted late in the Dawes Era and therefore likely to have more allotted trust land today.

As a result, the effect of land quality on modern land tenure varies across reservations. We predict a negative relationship between a reservation's share of prime agricultural land and the reservation's modern share of tribal trust land, but a positive relationship between prime agricultural land and the reservation's share in fee simple tenure. The relationship between prime agricultural land and allotted trust tenure is ambiguous for two reasons. First, an increase in the share of prime agricultural land increases the probability of allotment and therefore increases the share of allotted trust land relative to reservations that were not allotted and remained under tribal tenure. Second, an increase in the share of prime agricultural land caused land to be allotted sooner making it less likely to be frozen in trust status in 1934.

Table 7 reports the results of a series of tobit regressions—censored from below at 0 and from above at 1—assessing the effect of the share of prime agricultural land in 1885 on the modern share of tribal, allotted trust, and fee tenure.[26] Columns 1-3 report the results estimated on the full sample of reservations for which there are overlapping covariates, and Columns 4-6 report the results for only those reservations that were allotted.

The reduced form relationships between prime agricultural land and tenure reported in Table 7 are sensible, given the effects of prime agricultural land on allotment and timing. Column 1 demonstrates that reservations with larger shares of prime agricultural land ultimately have less tribally owned land. Similarly, Column 2 shows that more prime land leads to more fee simple ownership. The effect of prime land on allotted trust tenure is not distinguishable from zero in the full sample. Reservations that adopted the IRA have larger shares of tribal land, which is as expected because those reservations were eligible to buyback lands using a revolving fund (Frye and Parker 2016).

Columns 4-6 focus on tenure shares only on those reservations that were allotted. Unlike Columns 1-3, these estimates do not include effects associated with a change in the baseline probability of allotment. Within this subset of reservations, we expect more prime agricultural land to be associated with more fee land and less allotted trust land because reservations with more prime agricultural were allotted sooner and therefore allotted parcels were less likely to remain in trust.

[26] The pattern and statistical significance of the results is unchanged when OLS is used instead.

Table 7: Prime Agricultural Land and Modern Tenure

	All Reservations			Allotted Reservations		
	(1)	(2)	(3)	(4)	(5)	(6)
	% Tribal	% Fee Simple	% Allotted Trust	% Tribal	% Fee Simple	% Allotted Trust
% Prime Land	-0.348**	0.495***	-0.126	-0.218*	0.525***	-0.238**
	(0.169)	(0.169)	(0.0831)	(0.129)	(0.161)	(0.0947)
Fort Dist.	-0.000244	-0.000134	0.0000320	0.000712	-0.000194	-0.000638
Adj. Cty Pop. Growth, 1890	-0.00305	0.00476**	0.00000628	-0.000746	0.00336	-0.00132
Rail Density 1890	-0.00108	-0.0000212	0.00101*	-0.0000248	-0.00112	0.000793
Acres (100,000s)	-0.000394	-0.00100	0.000789	-0.000400	-0.000641	0.000722
Ruggedness	0.816*	-0.494	-0.335	1.440***	-0.679	-0.686**
Stream Density	92.70	-115.2	13.83	-1.546	-120.2	91.73
% High-Yield Timber	-0.263**	0.111	0.173**	-0.0678	-0.0125	0.0928
Gold & Silver	-0.00130***	0.00138***	0.000155	-0.000941**	0.00105**	0.00000138
Coal 1890	-0.199	0.0846	-0.0254	-0.137	0.0948	-0.0572
IRA Indicator	0.362***	-0.275***	-0.104*	0.171*	-0.181*	-0.0111
Constant	0.474***	0.354**	0.120	0.152	0.548***	0.272***
Observations	110	110	110	73	73	73

Notes: Robust standard errors in parentheses* $p < 0.1$, ** $p < 0.05$, *** $p < 0.0$

Columns 5 and 6 confirm that an increase in the historical share of prime agricultural land increases the modern share of fee land and decreases the share of allotted land. The negative relationship between percent tribal and prime agricultural land, conditional on allotment, is consistent with low-quality land being designated as surplus land, but not being claimed by non-Indian settlers and therefore left in tribal ownership.

Appendix C uses parcel-level data obtained from the BIA for over 124,000 parcels across 15 reservations in the Great Plains Region to show that the same patterns present in Table 7 are also present within reservations. Appendix Table C1 provides a list of these reservations and the number of parcels and tenure breakdown on each reservation. Focusing on within-reservation variation in tenure overcomes the obstacle of unobserved heterogeneity across reservations and allows us to employ a more flexible measure of land quality. With these parcel level data, we estimate the within-reservation effects of land quality on the probability of being allotted and the subsequent probability of becoming fee simple, conditional on being allotted.

Appendix Table C3 shows that within reservations, parcels on prime farmland are 11 percent less likely to be held in tribal ownership today, because they were more likely to be allotted. Conditional on being allotted initially, prime, high-quality parcels are 17 percent more likely to be held in fee simple today, rather than in allotted trust. Consistent with Carlson (1981a, 1981b), these results provide the first definitive empirical evidence that the pattern of allotment was driven by land quality, even within reservations.

The primary hypothesis for why allotted trust tenure might be a mechanism for the relationship between prime agricultural land and income is that allotted trust lands are heavily fractionated and subject to BIA oversight today. The results in Table 7 suggest that reservations with either little or abundant prime agricultural land would be least exposed to fractionation problems because they are comprised primarily of tribal and fee simple tenure, respectively. Accordingly, we test for a non-linear relationship between prime agricultural land and several measures of fractionation such as the number of unique owners of fractional interests (Column 1), the total number of purchasable interests (Column 2), the number of highly fractionated tracts (Column 3), and the average number of purchasable interests per fractionated tract (Column 4).

The results in Table 8 indicate a statistically significant inverted U-shape relationship between prime agricultural land and fractionation. Initial increases in prime agricultural land lead to more fractionation, but after percent prime exceeds 40-50 percent, further increases in the share of prime agricultural land on a reservation decrease the extent of fractionation. We emphasize that these most heavily fractionated reservations—the ones with mid-quality land—are also those with the lowest per capita incomes as shown in Figure 3.

Table 8: Prime Agricultural Land and Fractionation

	(1)	(2)	(3)	(4)
	Unique Owners	Purchasable Interests	Highly Fractionated Tracts	Avg. Interests per Tract
% Prime Land	14438.8***	74661.0**	277.8**	92.02**
	(2830.3)	(28890.1)	(111.3)	(37.58)
% Prime Land^2	-15204.6***	-90387.7**	-318.9**	-79.62*
	(3007.0)	(36869.6)	(140.7)	(43.11)
Fort Dist.	-6.926	-101.8	-0.402	0.00918
Adj. County Pop. Growth, 1890	-25.58**	-352.1*	-1.171	-0.0267
Rail Density 1890	10.60	301.9**	1.043**	-0.0641
Acres (100,000s)	58.13***	476.0**	1.908**	0.00495
Ruggedness	-4003.8	15001.9	9.409	-26.74
Stream Density	-913231.1	-7144465.3	-26214.5	-14076.0*
% High-Yield Timber	-451.2	3891.6	18.57	-5.288
Gold & Silver	-1.567	0.705	0.0620	0.0150
Coal 1890	1148.1	10399.8	27.68	9.985
IRA Indicator	-1536.9*	-10791.9	-36.17	1.890
Constant	4545.5***	31046.4***	107.3***	41.07***
Observations	77	77	77	77
Adjusted R^2	0.517	0.390	0.381	0.083

Notes: Robust standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

5.3 Effect of Tenure and Fractionation on Income

To assess the extent to which land tenure explains the U-shaped relationship between prime agricultural land and income, we add four variables to the model described in equation (1). The first is an indicator for whether a reservation was allotted. For the main sample, the mean of this variable is 0.71, indicating that the majority of reservations were allotted. The second variable measures the proportion of modern reservation acreage held in allotted trust status. Conditional on a reservation being allotted, the mean proportion in allotted trust is 0.18 with a standard deviation of 0.17. The third variable measures the extent to which land in allotted trust status is fractionated.[27] Conditional on a reservation being allotted, the mean number of interests per tract is 33.6 with a standard deviation of 21.3. The fourth variable is the proportion of land remaining in tribal trust. Conditional on a reservation being allotted, some land may remain in

[27] This variable is the number of separate purchasable land interests divided by the number of allotted trust land tracts with at least two owners.

tribal trust because not all surplus and allotted land were claimed, because not all of the reservation was allotted or because some land was acquired by tribes after 1934. Conditional on being allotted, the mean proportion of a reservation held by the tribe is 0.41 with a standard deviation of 0.31.

Table 9 presents estimates that utilize the panel of income from the 1970-2010 decennial census reports. Columns 1-3 do not control for 1915 per capita income, but Columns 4-6 do, which reduces the sample size from 437 to 294 observations. Including 1915 income is important because it helps control for differences in prosperity before land on reservations became fractionated and before much of it was freed from trust and alienated.[28] Columns 7-9 control for Dippel's (2014) indicator for whether multiple tribes were forcibly co-integrated (FC) onto a single reservation. Co-integration is important because it leads to lower incomes, but including FC reduces the sample size from 294 to 255 observations.

Certain patterns are evident across all columns of Table 9. First, inclusion of the tenure variables causes the U-shape to flatten and become statistically insignificant. This is especially apparent when comparing Column 5 to 6, and when comparing Column 8 to 9. With the inclusion of the tenure controls, there is actually a positive, linear relationship between income and land quality in Column 9.[29] These results demonstrate that the U-shaped relationship is a direct result of land tenure institutions.

[28] Ideally we would like to control for 1885 per capita income but 1915 is the first year for which income data are available for a large number of reservations.
[29] When we omit the squared term from the Column 9 specification, the coefficient on % Prime is positive and statistically significant at $p < 0.01$.

Table 9: 1970-2010 Income on Reservations and Land Tenure

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Land Tenure									
Allotment Indicator	0.2403***		0.1909***	0.1983**		0.1209	0.2745***		0.1778**
	(0.067)		(0.0664)	(0.0780)		(0.0807)	(0.0801)		(0.0816)
Avg. Interests per Tract	-0.0033***		-0.0026***	-0.0028***		-0.0021**	-0.0027**		-0.0016*
	(0.0009)		(0.0009)	(0.0009)		(0.0010)	(0.0011)		(0.0009)
% Allotted Trust Land	-0.0891		-0.0786	-0.2704**		-0.2466*	-0.2867		-0.1537
	(0.1124)		(0.1063)	(0.1309)		(0.1253)	(0.1790)		(0.1593)
% Tribal Land	-0.0088		0.0033	0.0264		0.0669	-0.0473		0.0053
	(0.0777)		(0.0739)	(0.0806)		(0.0815)	(0.1162)		(0.1046)
Land Quality									
% Prime Land		-1.0759***	-0.7603***		-0.6759**	-0.4678		-0.7868**	-0.3010
		(0.2871)	(0.2753)		(0.3235)	(0.3165)		(0.3341)	(0.3367)
% Prime Land		1.1294***	0.8151***		0.8096**	0.5675		1.0549***	0.5519
		(0.3115)	(0.3027)		(0.3598)	(0.3576)		(0.3423)	(0.3367)
Controls									
Reservation Pop. & Acres	x	x	x	x	x	X	x	x	x
Resource Endowments	x	x	x	x	x	X	x	x	x
Adjacent County Conditions	x	x	x	x	x	X	x	x	x
Slot Machines per Capita	x	x	x	x	x	X	x	x	x
Political and Legal Oversight	x	x	x	x	x	X	x	x	x
Per Capita Income in 1915				x	x	X	x	x	x
Dippel's (2014) FC Variable							x	x	x
BIA Region-by-Year FE	x	x	x	x	x	X	x	x	x
Observations	437	437	437	294	294	294	255	255	255
Adj. R-square	0.635	0.628	0.646	0.725	0.714	0.730	0.745	0.754	0.760

Notes: * p<0.1, ** p<0.05, *** p<0.01. Standard errors are clustered by reservation. Resource endowments controls are time invariant and include timber, coal, stream density, ruggedness, acres, railways, population growth from 1880-1890, and an indicator for energy resources. Controls for adjacent county conditions are time variant and include population density and per-capita income, both logged. The political and legal oversight variables are controls for tribes that opted into the IRA, and who had state jurisdiction imposed upon them by P.L. 280. Dippel's (2014) variable is a measure of forced co-integration (FC). The number of observations declines with its inclusion, and with the inclusion of the income in 1915, due to incomplete reservation coverage. The designation of BIA regions has changed over time, but here we rely on a division prevalent during the mid-1900s. Under that division, there are eight BIA regions, named after the headquarter city, which are: Aberdeen, Albuquerque, Billings, Eastern, Minneapolis, Phoenix, Portland, and Sacramento. The years in the sample are 1969, 1979, 1989, 1999, and 2010.

Estimates in Table 9 control for land quality and correct for otherwise biased estimates of land tenure effects.[30] As shown in Columns 4 and 6, the coefficient on the allotment indicator decreases from a significant 0.19 to a marginally significant 0.12 because some of the effects of land quality on allotted reservations were otherwise being attributed to the allotment policy. The coefficients on the fractionation and allotted trust variables become less negative after controlling for land-quality because fractionated lands and allotted trust are of lower quality.

The coefficients on the land tenure variables suggest the effects of allotment on long-run income depend critically on whether allotted land was released from trust on a particular reservation.[31] They imply that, if all land had passed to fee simple, income per capita would have increased by 12 percent (p value of 0.14). For the mean reservation that was allotted, the effects are indistinguishable from zero.[32] For an allotted reservation two standard deviations above the mean in term of fractionation and allotted trust tenure, the effects of allotment were negative, reducing long-run income by about 15 percent (p value of 0.09).[33] Appendix Table D2 provides a series of robustness checks and shows that this general conclusion holds with alternative

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[30] In separate regressions estimates, not shown here, we find that the differences between column 6 and column 9 are driven by the changing sample size, rather than the inclusion of the FC variable.

[31] To estimate the effects of tenure and fractionation on income, conditional on land quality, we must rely on residual variation in tenure and fractionation that is not explained by prime agricultural land and the other controls. Some of this variation results from other dimensions of land quality that are unobserved by the econometrician, or from idiosyncratic differences in the timing of allotment and differences in family sizes across reservations. However, some of the residual variation may be endogenously determined; for example, perhaps tribes that are well-suited for income generation in modern times were also able to prevent land from later becoming fractionated. We control for this possibility, in part, by including 1915 income in the regressions. Still, we recommend caution in interpreting the tenure coefficients. To us, they represent suggestive patterns rather than precise causal estimates.

[32] Using the coefficients in Column 6, we can estimate the effect of allotment on income as follows: 0.12 + 33.6(-0.0021) + 0.18(-0.246) + 0.41(0.066) = 0.033. This estimate is not statistically distinguishable from zero, as the p value of the F-test for joint significance is only 0.59.

[33] This is based on the following calculation: 0.12 + 76.3(-0.0021) + 0.51(-0.246) + 0.24(0.066) = -0.151. This calculation assumes that the two standard deviation increase in the proportion of allotted trust land—which is an increase of 0.32—is reallocated and split equally between tribal and fee simple lands.

specifications, such as those employing state-by-year effects and control for ethnic assimilation.[34]

Because tribal members who transferred their land to non-Indians may have moved off the reservation, we estimate the relationship between Indian populations on reservations and allotment as another measure of the effect of allotment and the IRA. Table 10 estimates the log of reservation Indian population as a function of land tenure controls and American Indian population in 1890. The -0.646 coefficient on the allotment indicator implies that there would have been a 64 percent decline in American Indian populations if all land had been converted to fee simple. In other words, though full privatization may have led to higher incomes per capita, it would have also reduced the number of American Indians on reservations.[35]

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[34] The general conclusions are not directly comparable to previous literature on land tenure cited in Section 2, but we make the following observations. First, the results are consistent with Russ and Stratmann (2015) who find that lease income declines with greater fractionation on twelve reservations. Second, the results are not entirely consistent with Anderson and Lueck (1992) who find that agricultural productivity, as opposed to per capita income more generally, on 39 reservations is highest under fee simple land and lowest under tribal tenure. The findings here indicate that tribal tenure outperforms allotted trust in terms of overall, per capita income. This may suggest that tribal tenure better facilitates income from sources other than agriculture, such as oil, gas, or coal (see Leonard and Parker 2017), or that tribes may be able to overcome some of the higher costs of trusteeship in their dealing with the BIA. Third, the results contrast with those of Akee and Jorgensen (2015) who find that parcel-level business investment is no less likely on trust lands of the Agua Caliente Indian Reservation when compared to fee simple lands, though we do not measure direct business investment. The different findings likely imply that tenure restrictions and fractionation problems are less severe on Agua Caliente when compared to the average reservation. We also emphasize that the impacts of tenure could differ at the reservation level (our study) versus the parcel level (Akee and Jorgensen 2015) due to checkerboarding and other spatial spillovers.

[35] For the mean allotted reservation, the effects on Indian population size was about a 50 percent decrease, relative to not being allotted, based on the following calculation: -646 + 33.6(-0.0077) + 0.18(0.274) + 0.41(0.879) = -0.538. This estimate is statistically different from zero with a p value of 0.04 on the F-test for joint significance. The positive sign on the percent of land in tribal ownership indicates that this tenure type is associated with sustaining higher levels of Native populations over time. The negative sign on land interests per parcel indicate that fractionation is associated with fewer American Indians living on reservations in recent decades.

Table 10: 1970-2010 American Indian Population Sizes and Tenure

	Y = ln(American Indian Population), 1970-2010
	(1)
Land Tenure	
Allotment Indicator	-0.6460**
	(0.299)
Land Interests per Parcel	-0.0077*
	(0.004)
% Allotted Trust Land	0.2740
	(0.495)
% Tribal Land	0.8791***
	(0.293)
Controls	
Same as baseline	x
1890 Am. Indian Population	x
Observations	294
Adj. R-squared	0.730

Notes: * p<0.1, ** p<0.05, *** p<0.01. Standard errors are clustered by reservation. All regressions included the same set of controls and fixed effects as in Column 3 of Table 9, unless otherwise noted. The observations are for 1970, 1980, 1990, 2000, and 2010.

To summarize, the evaluation of allotment depends on how one measures success. If measured by small, prosperous Native American populations living on reservations, then allotment into 100 percent fee simple lands dominates individual trusteeship with the associated fractionation, and it may outperform complete tribal ownership. If measured by large Native American populations, then full tribal ownership dominates either fee simple or individual trusteeship with fractionation. The effect impact of fractionation is negative by either metric.

6. Conclusion

This study provides evidence that incomplete privatization of reservation lands from 1887 to 1934 led to a U-shaped relationship between historical land endowments and modern per capita income of Native Americans on reservations. Though per capita incomes across U.S.

counties increase continuously as the proportion of prime agricultural land increases, reservations with small shares of prime land actually generate higher incomes for Indians when compared to reservations with medium shares. This finding contrasts with explanations of reservation poverty that attribute it to a dearth of high quality land on reservations. The downward sloping part of the U-shape results from trusteeship restrictions and incomplete property rights to allotted parcels, disproportionally attached to mid-quality lands. Trusteeship raises the transaction costs of resource allocation and increases fractionation, both of which contribute to reservation poverty.

Privatization subject to trusteeship has been rationalized on the grounds that it will improve income while preventing the transfer of Indian lands to non-Indians. Similar reasons have been given to justify federal control over indigenous property rights in other parts of the world (see de Janvry et al. 2014). Our findings suggest, however, that allotment reduced income unless land was fully privatized and released from trust, thereby subjecting it to transfer risk. The findings also show that transfers to non-indigenous groups can be prevented without the negative effects on income. Reservations that were kept under tribal tenure, rather than allotted and not fully privatized, achieved higher incomes per capita.

This finding raises questions about why tribal tenure has worked better than individual trusteeship and suggests avenues for future research. It would be useful to better understand how individual allotment undermined preexisting informal arrangements of ownership and tenure like those studied by Carlson (1981) on reservations and by Ostrom (1990) more broadly. It would also be useful to know how and whether tribal governments overcome collective action problems and how they might reduce the bureaucratic costs of dealing with the federal government. Under what conditions were tribal institutions better suited to adapt to new income opportunities since allotment ended, relative to the rigid system of allotment under trusteeship? Because Native Americans may have goals in addition to increasing incomes, a better understanding of tribal institutions and their performance will require the study of outcomes beyond the income and population data amassed here.

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Appendix A: Assessing Prime Land

We assess the validity of our measure of prime farmland by analyzing its strength as a predictor of historical agricultural activity both off and on reservations. First, we show that prime farmland is a good predictor of farm value per-acre in counties over the period 1890 to 1930. Second, we show that prime farmland is highly correlated with farming activity in 1885 on a subset of reservations for which we were able to collect data

We assemble a panel data set of counties over the period 1890 to 1930 using county shapefiles for 1890, 1900, 1910, 1920, and 1930 provided by NHGIS to estimate the share of each county covered with prime farmland. We combine this geographic information with agricultural census data compiled by Haines et al. (2015). We use their measure of total farm value and acres in farms to create the variable "Farm Value Per Acre" (FVPA) and assess the degree to which our measure of prime farmland predicts farm value per acre over the period 1890 to 1930, which roughly corresponds to the Dawes Era. County-level summary statistics are available in Table A1 and Figure A1 depicts the spatial variation in FVPA

Table A2 presents the results of a series of regressions estimating the relationship between the share of prime land in a county and the per-acre value of farms (FVPA). We estimate the models as a pooled cross section and exclude outliers in terms of FVPA, which we define as observations exceeding the 99th percentile (Table A3 reports the results using the full sample). Columns 1 through 3 are estimated using an unbalanced panel and Columns 4 through 6 are estimated on a balanced panel that uses only counties that do not change over time. The estimated coefficient on % Prime is positive and statistically significant in all specifications. The magnitude of the coefficient is roughly equal to the mean of FVPA. Columns 1 and 4 are estimated with no fixed effects and show that % Prime explains 15% of the cross-sectional and time-series variation in FVPA. Columns 2 and 5 include year fixed effects and show that % Prime does even better within-year, explaining roughly 40% of the within-year variation in FVPA.

Next, we collect data on farming on reservations from the 1885 Annual Report to the Commissioner of Indian Affairs for the 67 reservations included in the report. The report details the total number of acres tilled, cultivated, and broken and separately reports acres broken or cultivated by Indians in particular. It also includes total corn production in 1885. We combine these data with our measures of reservation size to construct measures of the share of each reservation that is tilled, broken, or cultivated in 1885 in addition to corn yield, measured in bushels per acre. Summary statistics are available in Table A1.

Table A4 presents the results of a series of univariate regressions using each measure of agricultural activity as the dependent variable, using % Prime as the only regressor. % Prime is a statistically significant predictor of each of our six measures of agricultural activity on reservations in 1885 and explains at least 10% of the variation in each variable. % Prime is an especially strong predictor of % Tilled, explaining over 40% of the variation. Together, these results suggest that our measure of prime farmland is a good predictor of agricultural activity and output. Moreover, our ability to calculate this measure across nearly 150 reservations allows us to analyze the impact of land quality on both institutions and economic outcomes across a much broader set of reservations than would be possible if we relied on the 1885 ARCIA data alone.

Table A1: Summary Statistics for Assessment of Prime Land

Variable	(1) N	(2) Mean	(3) S.D.	(4) Min	(5) Max
County Summary Statistics, 1880-1930					
Farm Value per Acre	8,504	40.10	63.54	0.0698	3,437
% Prime Land	10,401	0.275	0.351	0	1
Reservation Summary Statistics, 1885					
% Tilled Land	65	0.239	0.293	0.001	0.984
% Cultivated Land	67	0.015	0.028	0	0.129
% Cultivated or Broken Land	67	0.017	0.031	0	0.142
% Cultivated Land by Indians	67	0.015	0.027	0	0.128
% Cultivated or Broken Land by Indians	67	0.016	0.030	0	0.139
Bushels of Corn per Acre	67	0.086	0.346	0	2.731
% Prime Land	67	0.355	0.389	0	1

Table A2: Prime Land and Farm Value Per Acre

	(1)	(2)	(3)	(4)	(5)	(6)
	Unbalanced			Balanced		
% Prime Land	41.27***	43.22***	42.46***	41.76***	42.99***	42.65***
	(1.070)	(0.930)	(1.128)	(1.124)	(0.954)	(1.184)
Constant	25.11***	7.002***	34.87***	25.55***	7.099***	34.28***
	(0.475)	(0.803)	(1.372)	(0.514)	(0.811)	(1.392)
Year FE		X	X		X	X
State FE			X			X
Observations	8,332	8,332	8,332	7,574	7,574	7,574
Adjusted R^2	0.151	0.361	0.524	0.154	0.391	0.538

Standard errors are clustered by county and reported in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table A3: Prime Land and Farm Value Per Acre (Full Sample)

	(1)	(2)	(3)	(4)	(5)	(6)
	Unbalanced			Balanced		
% Prime Land	43.64***	44.84***	44.78***	44.52***	44.71***	45.05***
	(1.070)	(0.930)	(1.128)	(1.124)	(0.954)	(1.184)
Constant	27.88***	7.227***	39.04***	28.22***	7.303***	38.40***
	(0.475)	(0.803)	(1.372)	(0.514)	(0.811)	(1.392)
Year FE		X	X		X	X
State FE			X			X
Observations	8,420	8,420	8,420	7,657	7,657	7,657
Adjusted R^2	0.058	0.151	0.242	0.060	0.167	0.250

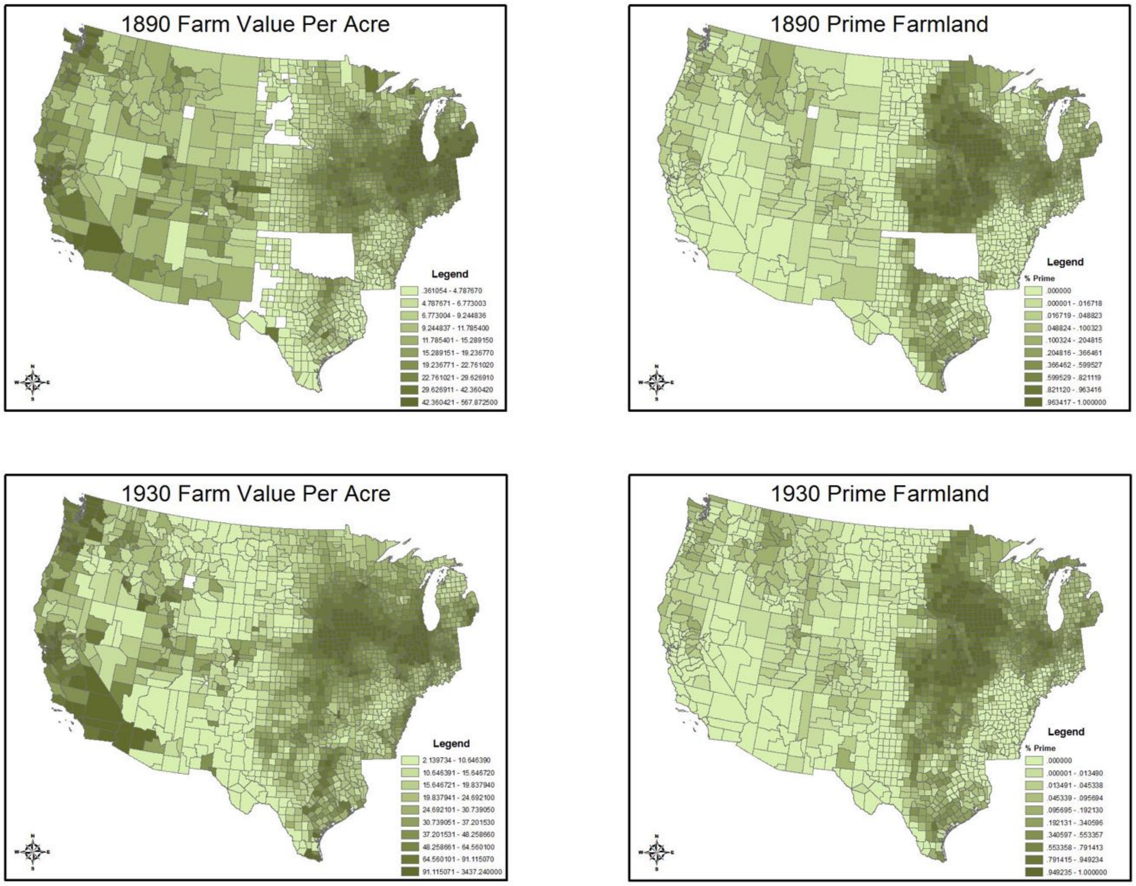
Standard errors are clustered by county and reported in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table A4: Prime Land and 1885 Agriculture on Reservations

	(1) % Tilled	(2) % Cultivated	(3) % Cultivated or Broken	(4) % Cultivated by Indians	(5) % Cultivated or Broken by Indians	(6) Bushels of Corn per Acre
% Prime Land	0.467***	0.0287***	0.0313***	0.0281***	0.0307***	0.263***
	(0.0663)	(0.00649)	(0.00718)	(0.00635)	(0.00705)	(0.0765)
Observations	65	67	67	67	67	67
Adjusted R^2	0.428	0.217	0.212	0.216	0.211	0.139

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Figure A1: Farm Value Per Acre vs. Prime Land



Appendix B: Historic Maps Used for Data Creation

Figure B1: Geo-Referencing 1885 Reservations

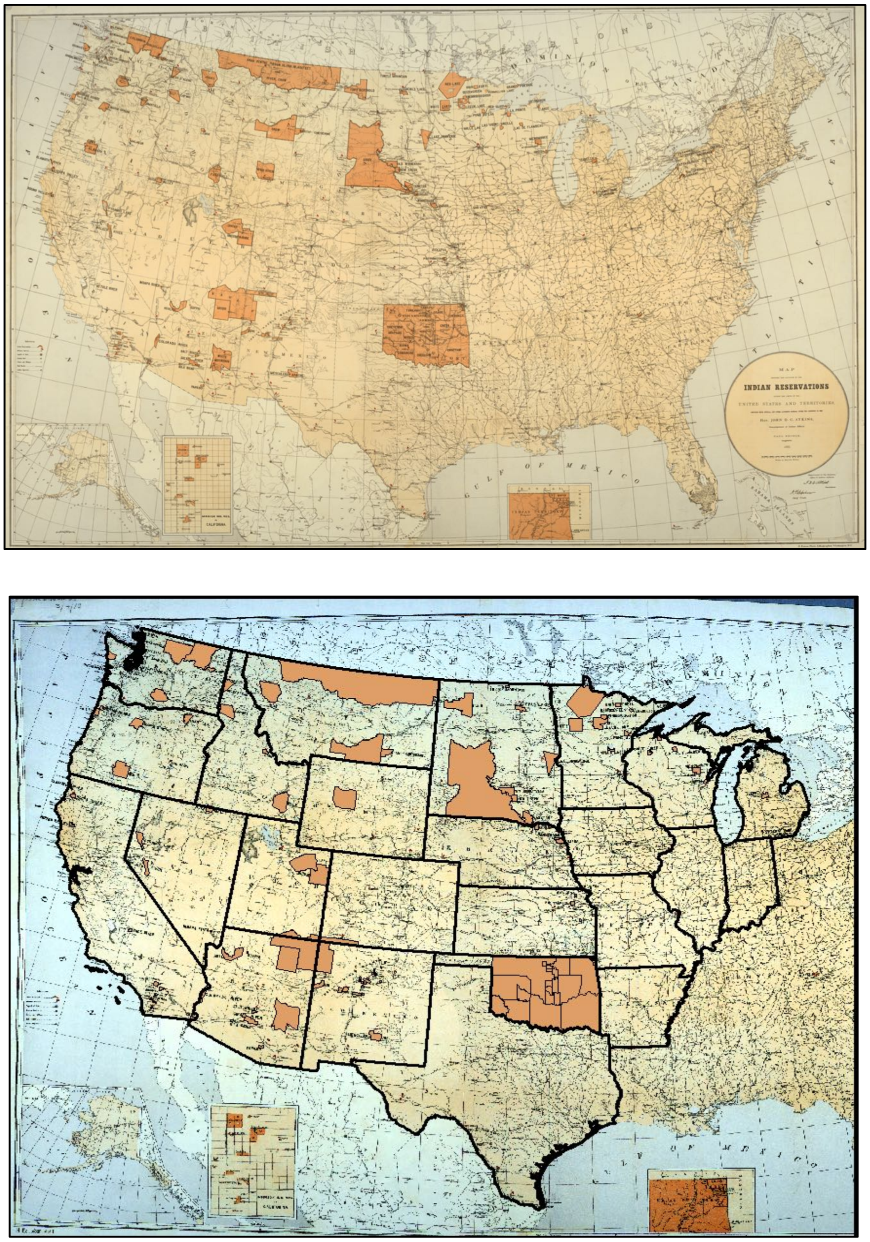


Table B2: 1880 Gold Mines

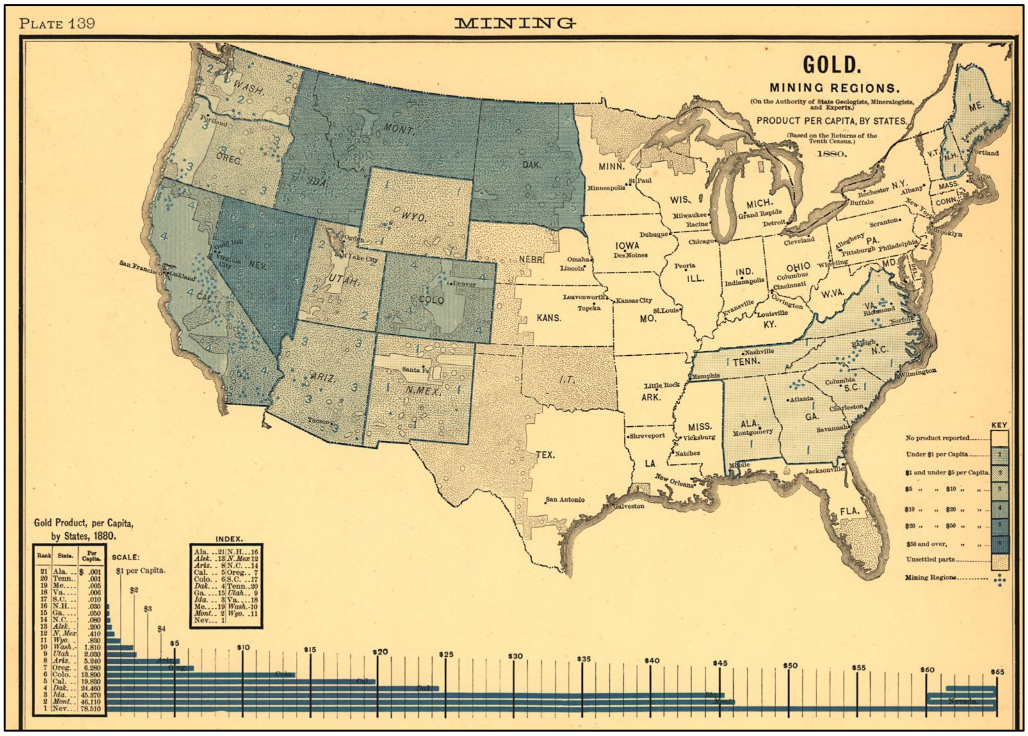


Table B3: 1880 Silver Mines

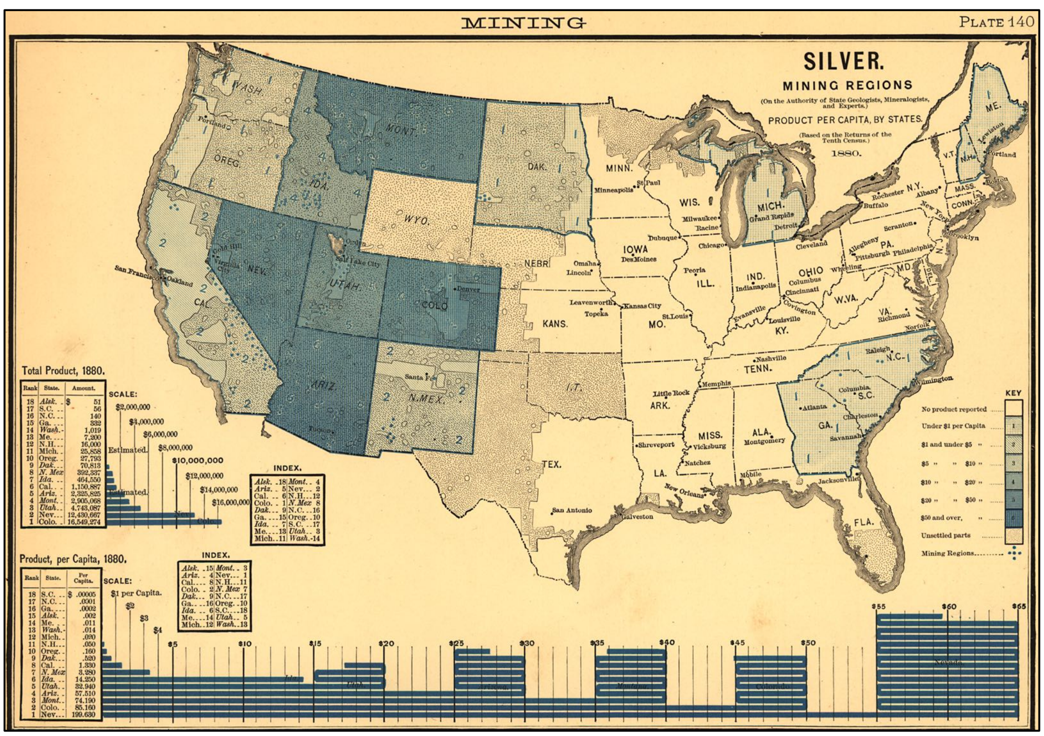


Table B4: 1880 Timber

Table B5: 1890 Coal

Appendix C: Parcel-Level Analysis of Prime Land and Tenure

GIS parcel-level data on land tenure for 15 reservations in the Great Plains Region show modern individual parcel boundaries and tenure—tribal, allotted trust, and fee simple for over 124,000 parcels. Table C1 provides a list of these reservations and the number of parcels and tenure breakdown on each reservation.

Table C1: Reservations in Parcel Dataset

Reservation	*N* Parcels	% Tribal	% Allotted Trust	% Fee
Cheyenne River	19,599	0.369	0.212	0.419
Crow Creek	3,413	0.221	0.480	0.299
Flandreau	53	0.321	0.00	0.679
Fort Berthold	17,475	0.502	0.498	0.00
Fort Totten	2,664	0.135	0.523	0.342
Lower Brule	3,939	0.452	0.286	0.262
Omaha	1,033	0.216	0.437	0.348
Pine Ridge	26,542	0.241	0.556	0.203
Ponca	200	0.01	0.00	0.99
Rosebud	17,889	0.299	0.304	0.397
Sisseton	4,201	0.103	0.501	0.396
Standing Rock	22,457	0.193	0.457	0.351
Turtle Mountain	1,770	0.097	0.818	0.085
Winnebago	1,158	0.100	0.674	0.227
Yankton	1,984	0.102	0.506	0.392

Notes: Fee parcels are not available in the Fort Berthold shapefile. However, our results include reservation fixed effects and are robust to dropping Fort Berthold

Geographic data described above allow us to calculate parcel-level measures of resource quality. Most parcels fall into a single rainfall and soil category, from which we sort parcels according to the soil indexes—low (0-6), medium (7-13), and high (14-20) quality. The parcels fall into 10-15, 15-20, and 20-25-inch rainfall bins. To identify whether the approximately 100,000 parcels meet our definition of prime land, we calculate elevation and ruggedness the 30-by-30 meter data from the NED. Summary statistics are presented in Table C2.

From this data set we can estimate the within-reservation relationship between prime land and tenure. Focusing on within-reservation variation in tenure overcomes the obstacle of unobserved heterogeneity across reservations. Relative to cross-reservation analysis, assessing the relationship between resource quality and land that was actually selected for privatization provides a more precise test of the hypothesis that higher quality land was targeted for allotment under Dawes, which is crucial to our interpretation of the "U" shape presented in Section 4. The interpretation of our results implies that high-quality parcels are more likely to be allotted and less likely to remain in tribal ownership and that higher quality parcels are more likely to become fee simple, conditional on being allotted.

Table C2: Parcel Summary Statistics

Variable	(1) N	(2) Mean	(3) S.D.	(4) Min	(5) Max
Tenure Variables					
Tribal Indicator	124,366	0.428	0.495	0	1
Allotted Trust Indicator	124,366	0.290	0.454	0	1
Fee Simple Indicator	124,366	0.281	0.450	0	1
Land Quality Variables					
Rain_10_15 Indicator	124,357	0.874	0.332	0	1
Rain_15_20 Indicator	124,357	0.109	0.311	0	1
Rain_20_25 Indicator	124,357	0.0176	0.132	0	1
Low-Quality Soil Indicator	124,366	0.459	0.498	0	1
Medium-Quality Soil Indicator	124,366	0.236	0.425	0	1
High-Quality Soil Indicator	124,366	0.305	0.460	0	1
Prime Land Indicator	124,366	0.0730	0.260	0	1
Main Soil Index Category	124,357	8.940	5.394	0	17
Other Controls					
Meters to Nearest Railroad	124,366	23,630	16,864	0	77,763
Meters to Nearest Stream	124,366	5,529	5,059	0	26,581
Meters to Res. Boundary	124,366	12,258	10,144	0	42,489

To account for factors that may affect the selection of parcels into different tenure types, other than prime land, we control for distance to the nearest stream, distance to the nearest railroad (operable by 1930), and distance to the reservation border. Reservation fixed effects allow us to isolate within-reservation variation in land quality and tenure.

Table C3 reports the estimated marginal effects of land quality on the probability that a parcel became fee simple (Columns 1-3) and the probability that a parcel became fee simple, conditional on it having been allotted initially (Columns 4-6). The dependent variable in

Columns 1-3 is equal to one if a parcel is either allotted trust or fee simple and zero if it is tribal. The dependent variable in Columns 4-6 is equal to one if a parcel is fee simple and zero if it is allotted trust.[36] Columns 1 and 4 measure land quality using an indicator for parcels that meet our definition of prime land. Columns 2 and 5 control linearly for soil quality and for rainfall where the indicators are one for all rainfall bins except the 10-15 inch bin which is the omitted category. Columns 3 and 6 include the same rainfall indicators in addition to indicators for whether a parcel is the middle or top third of the soil quality index with the bottom third of the index being the omitted category.

Table C3: Parcel-Level Outcomes of Dawes

	(1)	(2)	(3)	(4)	(5)	(6)
	Pr(Allotted)			Pr(Fee| Allotted)		
Prime Indicator	0.112***			0.176***		
	(0.00702)			(0.00907)		
Rain_15_20		0.0562***	0.0609***		0.172***	0.186***
		(0.00685)	(0.00692)		(0.00952)	(0.00965)
Rain_20_25		0.284***	0.280***		-0.601***	-0.639***
		(0.0199)	(0.0199)		(0.0186)	(0.0187)
Soil Index		0.00705***			0.00801***	
		(0.000258)			(0.000402)	
Medium Quality Soil			0.0252***			0.0313***
			(0.00359)			(0.00508)
High Quality Soil			0.0818***			0.156***
			(0.00338)			(0.00499)
Controls						
Dist. to Rail	-0.000702***	-0.000463***	-0.000360***	-0.00623***	-0.00620***	-0.00589***
Dist. to Stream	0.00235***	0.00201***	0.00205***	0.00424***	0.00479***	0.00492***
Dist. to Res. Border	-0.00163***	-0.00217***	-0.00183***	-0.00749***	-0.00831***	-0.00815***
N	124366	124357	124357	79297	79290	79290

Notes: Robust standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

[36] Tribal parcels are excluded from the models in Columns 4-6.

The results in Columns 1 through 3 are consistent with the intuition that the highest quality land was targeted for privatization. Column 1 shows that prime parcels are 11 percent more likely to be privatized than non-prime parcels. As shown in Column 2, parcels with 15 to 20 inches of spring and summer rain are 5 percent% more likely to be privatized than parcels with only 10 to 15 inches, and parcels with 20 to 25 inches are nearly 30 percent more likely to be privatized. A one-unit increase in the soil quality index increases the probability of privatization by just under 1 percent. Column 3 indicates that relative to parcels with low-quality soil, medium-quality parcels are 2.5 percent more likely to be privatized while high-quality parcels are 8 percent more likely to be privatized.[37]

Columns 4 through 6 show that higher quality allotted parcels are more likely to have become fee simple. Prime parcels are 17 percent more likely to be converted from trust to fee simple status than non-prime parcels. Increases in soil quality are monotonically associated with increases in the probability of becoming fee simple (Columns 5 and 6). Though parcels with 15 to 20 inches of rain are about 17 percent more likely to have been converted to fee simple than parcels with 10 to 15 inches, parcels with 20 to 25 inches are 60 percent less likely to be converted to fee simple, conditional on soil quality. Consistent with Carlson (1981a, 1981b), these results provide the first definitive empirical evidence that the pattern of allotment was driven by land quality, even within reservations.

[37] The other estimated marginal effects in Columns 1 through 3 also conform to intuition. Parcels are less likely to be privatized if they are farther from existing rail networks. This is consistent with the idea that parcels with better market access would be targeted for privatization. Parcels that lie further inside the reservation boundary are also less likely to be privatized, which is consistent with the notion that part of the motivation for Dawes concerned making land available for white settlers from outside the reservation. Parcels near streams were less likely to be privatized, again consistent with the fact that many stream-adjacent lands are too rugged for agriculture in the Western U.S. (Leonard and Libecap 2017).

Appendix D: Robustness Checks and Other Tables

Table D1: County Summary Statistics

Variable	(1) N	(2) Mean	(3) S.D.	(4) Min	(5) Max
Per capita Income ($ 2010)	6,290	26,890.44	7,418.95	0	83,232
ln(Per capital Income)	6,288	10.163	0.276	9.021	11.329
% Prime Land	6,256	0.642	0.373	0	1
ln(Population)	6,288	10.095	1.318	5.318	16.101
Acres (100,000s)	6,256	616,710.7	964,654.7	14.233	1,720,000
Stream Density	6,336	$1.12\text{x}10^{-7}$	$1.09\text{x}10^{-7}$	0	$1.12\text{x}10^{-6}$

Table D2: Robustness of Allotment and Land Tenure Effects

		adding and subtracting variables			*different geography and time effects*		
	Baseline (col. 6 of table 7)	Does not control for population	Drops slot machine variable	Adds ethnic assimilation	No BIA-region specific year effects	Adds state fixed effects	Adds state-by-year fixed effects
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Land Tenure							
Allotment Indicator	0.1209	0.1174	0.1302	0.2344***	0.1137	0.2833*	0.3292*
	(0.081)	(0.080)	(0.081)	(0.074)	(0.092)	(0.152)	(0.165)
Avg. Interests per Tract	-0.0021**	-0.0019**	-0.0024**	-0.0035***	-0.0015	-0.0043***	-0.0045***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
% Allotted Trust Land	-0.2466*	-0.2799**	-0.2054	-0.1994	-0.3193**	-0.3205*	-0.2842
	(0.125)	(0.136)	(0.125)	(0.121)	(0.130)	(0.191)	(0.202)
% Tribal Land	0.0669	0.0567	0.0649	-0.0239	0.0810	0.0134	-0.0103
	(0.081)	(0.079)	(0.080)	(0.061)	(0.076)	(0.129)	(0.139)
Observations	294	294	294	294	294	294	294
Adj. R-squared	0.730	0.730	0.711	0.711	0.713	0.746	0.742

Notes: * p<0.1, ** p<0.05, *** p<0.01. Standard errors are clustered by reservation. All regressions included the same set of controls and fixed effects as in Column 6 of Table 7, unless otherwise noted. Column 1 is the baseline specification (col. 6 of Table 7). Column 2 drops the potentially endogenous control for population size (of Native Americans) on the reservation. Column 3 adds to the baseline specification a measure of ethnic assimilation in 1938, which is constructed from BIA blood quantum data. Column 4 drops the potentially endogenous measure of casino gaming, which is slot machines per capita. Column 5 includes country-wide year effects, rather than BIA region specific year effects. Column 6 adds state fixed effects. Column 7 adds state-by-year fixed effects.