The Costs of 'Tenancy in Common': Evidence from Indian Land Allotment*

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Abstract

From 1906, the U.S. government's 'Indian allotment' policy re-assigned property rights over tribe-owned lands to individual Native American households in 160-acre parcels. Allotted land was initially kept in 'individual trust', to later be transferred into 'fee simple,' thereby giving full property rights. In 1934, this program was shut down prematurely, trapping millions of acres of land in trust status indefinitely. The descendants of the original allottees of in-trust land have rights to rents earned from the land, but have to agree near-unanimously to any changes in its use, or to its sale. They are exogenously, and almost unalterably, locked into 'tenancy in common'. We utilize exogenous variation in the legal status of individual 160-acre land parcels to estimate the inefficiencies arising from this tenancy form, using present-day satellite imagery.

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1 Introduction

Partible inheritance practices often take the form of dividing the testator's property amongst multiple heirs. This form of partible inheritance practices has been shown to cause under-development and poverty in agricultural settings because it leads, over time, to farm sizes that are too small to operate at efficient scale (Libecap and Alter, 1982; Foster and Rosenzweig, 2011, 2017; Palsson, 2018). We investigate another form of partible inheritance practices called 'tenancy in common' (colloquially called "heir's property"). Under tenancy in common, the testator's property is kept intact, but legal claims on it are divided in shares amongst multiple heirs. Tenancy in common gives all claimants veto rights on the usage and the sale of a shared property, and, over generations, leads to a potentially exponential increase in the number of claimants.

While dividing inherited land among many heirs creates inefficiencies by creating small-scale farms, tenancy in common creates inefficiencies through high transaction and coordination costs of managing one larger farm. Tenancy in common has largely escaped the attention of economists, but is ubiquitous in the rural United States, where between thirty-five to fifty percent of all Black-owned land in the rural South is held in tenancy in common. It is also common in other parts of the rural U.S. including (but not limited to) Native American reservations (Graber, 1978; Emergency Land Fund, 1980; Geisler, 1995; Rivers, 2006).[1] It is viewed as a major contributor to rural poverty in the U.S. South, but no causally identified effects have been estimated to date (Mitchell, 2000; Shoemaker, 2003; Chandler, 2005; Deaton, Baxter, and Bratt, 2009; Gaither and Zarnoch, 2017). One issue with providing such estimates is the lack of fine-grained spatial measures of land under tenancy in common, and another issue is the endogeneity of the testator's choice of inheritance form.

We provide causally identified estimates of the inefficiencies arising from tenancy in common in a setting where we have spatially fine-grained measures of land use and land tenure, and where land tenure was exogenously determined. Specifically, we use a natural experiment anchored in the U.S. government's policy of Indian land allotment, which, between 1906 and 1924, allotted millions of acres of previously tribe-owned land in 160-acre parcels to individual Native American

[1] The reason that this practice is common has less to do with testators' preferences than with states' inheritance laws when a land owner dies 'intestate' (not having made a will). In many U.S. states the property is passed as an undivided unit to all heirs.

households under the authority of the Dawes and Burke Acts.[2] All Indian allotments were first placed in a trust managed by the *Bureau of Indian Affairs* (BIA) local superintendents (the 'Indian Agents'). In-trust status limited allottees' title to the land and prevented them from selling. Following a stipulated period of being held in what was called 'individual trust', allottees who were declared "competent" had their land converted into fee-simple. The aim of allotment was to assimilate the Native Americans, and for this reason the conversion of individual trust land into was coupled with citizenship for the allottee.[3] It is also for this reason that when the Indian Citizenship Act (ICA) extended citizenship to all Native Americans in 1924, it brought land allotment and transferring to an almost complete stop. When the Indian Reorganization (or 'Howard-Wheeler') Act (IRA) legally ended Indian allotment in 1934, millions of acres of allotted land that had not been transferred into were almost unalterably locked into individual trust status. Importantly, BIA regulations determined that all land in individual trust (whether intestate or not) was to be bequeathed to all heirs equally and held under tenancy in common.

Our focus is on comparing individual trust land to fee-simple land on the same reservation, thus estimating the long-run costs of not having brought the process of Indian allotment to its conclusion. In practice, we also include into our analysis the tribal (communally owned and managed) reservation lands that were neither allotted nor opened to white settlement as surplus land.[4]

Tribal lands and individual trust lands share the problem that they cannot be collateralized at a bank (Anderson, 1995; Anderson and Parker, 2008) and are both subject to BIA oversight, but they differ in that tribal lands are managed by the tribal government instead of being under tenancy in common.

To measure the effects of land tenure on the extent and choice of land use at a spatial scale that corresponds to allotment size, we use high-resolution satellite imagery from the *National Land Cover Database* (NLCD) to determine whether land is developed or in agricultural production over

[2] Allotment nominally started with the 1887 Dawes Act, but in practice didn't really get going until the 1906 Burke Act. The time line of allotments and transfers is depicted in Online Appendix Figure 1.

[3] Another motive (which may well have been the primary motive for many) was to free up the left-over 'surplus' tribal land for white settlement. See also footnote 4.

[4] Reservation boundaries were largely unchanged by Indian allotment, so that reservations today encompass tribally owned lands, individual trust lands, and fee-simple lands which were originally allotted to tribal members but may have been sold to non-tribal members later. Once all households on a reservation had obtained their allotment, the remainder of reservations lands either went into tribal ownership or it was declared 'surplus' in which case it was sold to white settlers. In the latter case, unless surplus land was a big contiguous portion, it typically still remained within a reservation's jurisdictional boundaries.

the seven years for which data are available between 2001 and 2016.[5] Data on a land plot's tenure come from the *Bureau of Land Management*'s (BLM) database of General Land Office records, which includes the universe of all Indian allotments and can be mapped using the *Public Land Survey System* (PLSS). We observe the time when each individual allotment was made and the year it was transferred into (if ever), as well as individual characteristics of allottees at the time of their land allotment. In addition, we have a complete reservation-year panel of the exogenously rotating Indian Agents that managed allotments on individual reservations. Using these sources of information, we develop an identification strategy that generates exogenous variation in a land plot's legal title based on three factors: (*i*) the time span available from initial allotment to 1924, when transfering effectively ended (*ii*) the age of the original allottees, which dictated when they could be declared competent, and (*iii*) the sizable measured variation in individual Indian Agents' propensity to transfer land into .

Using this identification strategy, we find that individual-trust land is barren more often than tribe-owned lands, while tribe-owned plots are themselves barren more often than land, within the same reservation. This remains true when controlling for terrain and soil suitability.[6] The number of claimants under tenancy in common increases over time (assuming average fertility). As well, economic opportunities for land development on reservations have increased over the last fifteen years. Both of these facts lead us to expect that the efficiency costs of tenancy in common would have increased over time. We indeed find this to be the case: in a 2001, 2008, 2016 comparison, the differences in land use between individual trust land and the two other types of land became more pronounced, while the difference between tribe-owned lands and lands remained unchanged.

Our paper complements a large literature on land tenure and economic development (see, e.g. Besley and Ghatak 2010, and the references therein). One focus in this literature has been on insecure property rights, which lead to (*i*) under-investment (Banerjee, Gertler, and Ghatak, 2002; Goldstein and Udry, 2008), (*ii*) credit constraints because they prevent the holder of the land from collateralizing their land (De Soto, 2000), and (*iii*) inefficiently small farms by preventing land transfers (De Janvry, Emerick, Gonzalez-Navarro, and Sadoulet, 2015). The land tenure regimes

[5]The NLCD data are available for 2001, 2004, 2006, 2008, 2011, 2014, and 2016

[6] We use elevation data from the National Elevation Dataset (NED) and the Soil Productivity Index Grid developed by Schaetzl, Krist Jr, and Miller (2012).

of tribal ownership and individual trust have the same negative consequences but for reasons that have more to do with contracting, coordination, and transaction costs. The economic cost of communal (tribal) title is primarily that land cannot be collateralized (Anderson, 1995; Anderson and Parker, 2008).[7] In-trust land also cannot be collateralized, but additionally faces substantial transaction and coordination costs from being held under tenancy in common.[8] The problem of transaction and coordination costs arising from multiple claimants has antecedents in the literature on agricultural property rights, where it is sometimes summarized as the 'anti-commons' problem (see e.g. Rosenthal 1990; Bogart and Richardson 2009; Lamoreaux 2011 for important historical applications, and Posner and Weyl 2018 for a discussion of modern-day manifestations of this problem).

Our paper is of first-order importance to Native Americans but also to indigenous populations elsewhere that live under institutional arrangement similar to the U.S. reservations we study, i.e. with some degree of local autonomy that often combines a degree of local governance with collective land ownership.[9] Studies from a range of such settings are fairly unanimous in concluding that more private property rights would help indigenous communities (Anderson, 1995; Flanagan and Alcantara, 2003; Alcantara, 2007; Flanagan, Alcantara, and Le Dressay, 2010). Our study broadly supports this conclusion, in showing that land is more efficiently used than either tribal land or in-trust land. In addition, our study highlights the potential costs from a poorly conceived or half-heartedly implemented privatization of indigenous lands, in showing that in-trust land is considerably less efficiently used than even tribal land.

Lastly, our paper contributes to a literature on inheritance practices. Habakkuk summarized these as follows: impartible ('unigeniture') single-heir inheritance practices are intended to keep the family property intact, while partible ('common heirship') inheritance practices are intended

[7] Tribal land may also be inefficiently managed because of collective action problems associated with tribal governance, but this effect is likely to be quite limited. The seminal work in Ostrom (1990) clearly delineates many successful cases in which communal (tribal) land- or resource ownership can work well. Consistent with this, Aragón and Kessler (2018) compare tribal land with land under 'certificates of possessions' on Canadian reserves, and estimate relatively small gains from overcoming the collective action problems.

[8] At more aggregated spatial levels and without exogenous variation therein, Leonard and Parker (2017) and Leonard, Parker, and Anderson (2018) find evidence that trust-land on reservations is less efficiently used.

[9] Settings that are similar to U.S. reservations include First Nations reserves in Canada, Comarcas in Central America, Maori reserves in New Zealand, Aboriginal reserves in Australia, and Forced Resettlement Areas in South Africa. Where indigenous communities are organized in the same way as the general rural population (or constitute it), as in much of Mexico for instance, the relevant issues of land tenure are arguably different and approximate those that non-indigenous poor and rural populations face.

to keep the extended family intact (1955). The evidence suggests that partible inheritance practices indeed succeed in keeping the extended family spatially connected, as shown, for instance, in emigration patterns of both European and North American populations (Libecap and Alter, 1982; Wegge, 1999).[10] It is important to remember, however, that inheritance practices like all cultural norms evolved endogenously and over long time horizons to optimally regulate a groups' economic and social lives (Spolaore and Wacziarg, 2013; Galor and Özak, 2016; Becker, Enke, and Falk, 2018; Enke, 2019). By contrast, on Native American reservations as well as in the U.S. South partible inheritance into tenancy in common was exogenously imposed (by the BIA, or by intestacy law). In both cases, the result has been a proliferation in transaction costs that does not appear to have been offset by any of the potential attendant social benefits one might expect if partible inheritance over property were the testator's choice and an expression of an endogenously evolved social norm.

[10] Another piece of evidence comes from family structures. Pre-industrial England had by far the most impartible inheritance norms within Europe in the 18th and 19th century. In addition, in England, the law passed the entire property to the eldest son in the case of intestacy, while in France, the Napoleonic Code provided for the opposite, equal division, in the same case. Unsurprisingly, England is also where the 'nuclear family' developed as the standard 'family model', and Guinnane (1992) argues that the 'nuclear family' as a conceptual construct did not fit well the extended families prevalent in most parts of Europe with partible inheritance norms.

2 Background

2.1 Land Allotment on Reservations

Following the establishment of the reservation system, American Indian reformers considered land allotment as a requisite element in the assimilation of American Indians (Otis, 2014). Congress experimented with allotment clauses in treaties governing individual reservations starting in the 1850s.[11] These treaties formed the basis for the first general allotment acts, discussed by Congress and endorsed by the Office of Indian Affairs in the 1870s (Otis, 2014). Legislation stalled over the issues of citizenship, jurisdiction, and whether to immediately grant allotted Indians title to their land. In 1880, Senator Coke of Texas introduced a bill calling for the allotment of all reservation lands. This bill provided for the allotment of Indian lands following the designation of the president and a 2/3 majority vote in favor by the adult male members of the tribe Prucha (2014). The allocation of land varied by household type and age and allotments were inalienable for 25 years. The bill also allowed for the tribe to sell excess reservation lands to the government (Prucha, 2014). The bill found heavy support within Congress, the Office of Indian Affairs, and among reformers. The Coke bill passed in the Senate, but failed in the House due to opposition from western legislators that felt the bill was too generous to Indians (Carlson, 1981).

Henry Dawes introduced a modified allotment bill to the Senate in 1886. The bill quickly passed before moving to the House, where it passed after the addition of several amendments. On February 8, 1887, President Grover Cleveland signed the Dawes General Allotment Act into law. The Dawes Act authorized the president, through the Office of Indian Affairs, to survey and allot reservation lands deemed appropriate (Banner, 2009).[12] Heads of household received 160 acres, single persons over 18 received 80 acres, orphans under 18 received 80 acres, and other single individuals under 18 received 40 acres. If the land was only suitable for grazing the allotment amounts doubled. If a prior treaty specified larger allotments, the prior treaty acreages were applied. Allotments were mandatory and anyone not selecting an allotment within the first four years, would be assigned a parcel by the Indian Agent.

Once selected, allotments were approved by the Secretary of Interior and each Indian was

[11] By the late 1870s, nearly seventy treaties included clauses regarding the allotment of Indian lands (Prucha, 2014).
[12] Tribes in New York and Indian Territory were temporarily exempted from the Dawes Act.

issued a trust patent. This patent held the allotted land in trust for a trust period, during which the Indian or their heirs were the beneficiary of the allotment. Land held in trust could not be alienated or leased and was not subject to state or local taxes. At the end of trust period, the allotment would be transferred to the owner as fee-simple. Unallotted reservation land was designated as surplus and made available for outside settlement. The law required tribal approval of ceded surplus land, but tribes were rarely in a position to negotiate (Carlson, 1981).[13] Proceeds from the sales of the surplus land were held in trust and appropriated at the discretion of Congress for "education and civilization" (Banner, 2009).

The Dawes Act was amended in 1891 to grant 80 acres to every adult, instead of 160 acres to heads of households. It also gave the Secretary of Interior the authority to establish leasing regulations for allotted lands. Leasing agreements were managed by Indian Agents and the leasing of allotted lands was widely adopted across reservations (Carlson, 1981). Gradually the Dawes Act was amended to relax constraints on sales of trust lands. In 1903, the Office of Indian Affairs was authorized to sell allotments of deceased allottees with multiple heirs, and in 1907, they were authorized to sell allotments of original allottees under special circumstances. In 1906, the Burke Act granted the Commissioner of Indian Affairs the authority to shorten or lengthen the 25-year trust period for individual allotments. Shorter trust periods were often at the recommendation of the Indian Agent (Carlson, 1981). The Burke Act gave agents considerable authority over the process of converting land from trust status to fee-simple.

2.2 Administration on the Ground

Implementing the Dawes Act on an individual reservation was a complicated process. First, the allotting agent in charge of the reservation was tasked with determining the list of eligible tribal members entitled to an allotment and the household structure for every household within the reservation (Banner, 2009). These agents were also tasked with surveying and dividing the reservation into parcels. The agent possessed considerable authority over the assignment of allotments, even for those eligible Indians that desired an allotment. There are numerous accounts of outside settlers influencing agents to set aside the highest quality land for surplus (Banner, 2009; Otis, 2014; Carlson, 1981). In cases where the Indian did not select a plot, the agent assigned an allot-

[13] By 1903, tribal approval was no longer necessary.

ment. Each allotment was given an allotment number and a patent was filed with the Government Land Office upon approval by the President. These official patents specified the trustee, the specific plot location, the date, and the unique allotment number. Reservations were either allotted all at once or over a period of several years.

2.3 The End of the Allotment Era

The rapid expansion of allotment and concerns about the lack of development of Indian farmers, expansions in leasing, and sales of Indian land to settlers led to a change in public opinion regarding allotment. These concerns culminated in a review of the current social and economic conditions on reservations by Lewis Meriam of the Institute of Governmental Research in 1926. The Meriam Report, published in 1928, was critical of the support provided to Indians by the Office of Indian Affairs (Meriam, 1928). This report led to a shift in federal Indian policy, brought to fruition by President Roosevelt's new Commissioner of Indian Affairs, John Collier. Collier introduced a bill that fundamentally changed Indian policy. In 1934, the Indian Reorganization Act (IRA) ended the allotment of Indian reservations. The IRA returned unallotted lands back to tribal ownership and froze allotted trust land in it's trust status, creating a patchwork of land tenures within Indian reservations.

2.4 Legacy of the Allotment Era

In total, the government extended the Dawes Act to 118 reservations and issued over 245,000 patents covering nearly 41 million acres (Office of Indian Affairs, 1935). The policy resulted in a substantial transfer of land out of Native ownership. Prior to the Dawes Act, Indians controlled over 138 million acres of lands within their reservations. By 1934, Native land holdings had fallen to 52 million acres. Nearly 60 million acres were ceded as surplus and the remaining were sold as fee-simple or alienated by the Secretary of Interior (Office of Indian Affairs, 1935). Within reservations, the Dawes Act created considerable variation in the status of land tenure.

3 Data Sources

3.1 Allotment Data

Following approval from the President, each patent issued on the reservation was filed with the Government Land Office. These patents—subsequently digitized by the BLM—record the transfer of land titles from the federal government to individuals. Each patent contains information regarding the patentee's name, the specific location of the parcel(s), the official signature date, total acreage, and the type of patent issued. Patent types include cash sales, homestead entries, and Indian allotments. The patent also includes the Indian allotment number associated with the transaction.

A nice feature of the BLM data is that we can see the exact date on which each patent was issued (in trust) and the date on which it transferred into fee-simple, if ever. This ability to "follow individual trusts" and when they were converted to fee-simple allows to identify parcels as either in trust or fee-simple today. Online Appendix Figure 1 depicts the process by which allotted land transferred into fee-simple in the aggregate.

3.1.1 The Public Land Survey System

The BLM allotment data also describe the location of each land patent within the Public Land Survey System (PLSS). The PLSS a rectilinear grid that divides (most of) the United States into 36-square mile townships, each with a unique identifier.[14] Each township is composed of 36 square-mile sections numbered 1 to 36. Hence, any individual square mile of land within the PLSS can be referenced using the township identifier and section number.

These numbered sections, which are 640 acres, were often divided into smaller "aliquot parts" when transferred to private ownership. The most common division is the quarter-section, which is a 160-acre, $\frac{1}{2} \times \frac{1}{2}$-mile square referenced by a direction within a section (e.g. NE refers to the northeast corner of the section). Land could be further subdivided smaller than a quarter-section, but the relevant quarter-section can still be extracted from the aliquot part listed in the BLM patent. For example, a patent with an aliquot part of SW$\frac{1}{2}$NW is the southwest half of the north-west

[14] Each township is referenced by a township number and direction that indicate its North-South position and a range number and direction that identifies its East-West position relative a prime meridian.

quarter-section.

To simplify the analysis and improve the quality of our matches, we focus on 160-acre quarter sections as the basic unit of analysis, which matches the size of a standard Indian allotment. Of the 412,900 patent-transactions with a potentially matchable aliquot part variable in our data, we successfully matched 403,197, or 97.7% to quarter sections in the PLSS.[15] Figure 1 depicts the location of our matched quarter sections. In most cases, these clusters of allotments trace out the boundaries of present-day reservations (with the gaps filled in mostly by tribal lands). In some rare cases, clusters of allotments trace out the boundaries of a former reservation that was later terminated. This is true, for example, of the more dispersed looking 'clouds' of allotments in Central and Northern California. Eastern Oklahoma was covered by reservations for the 'Five Civilized Tribes' (the Cherokee, Chickasaw, Choctaw, Creek, and Seminole) who had been relocated there in the 1830s. These tribes were fully allotted and we have their individual allotment records, but for some reason their patents were either not filed with the Government Land Office or not digitized by the BLM. Eastern Oklahoma which is in fact densely covered by allotments, is the only gap in our spatial allotment data.[16]

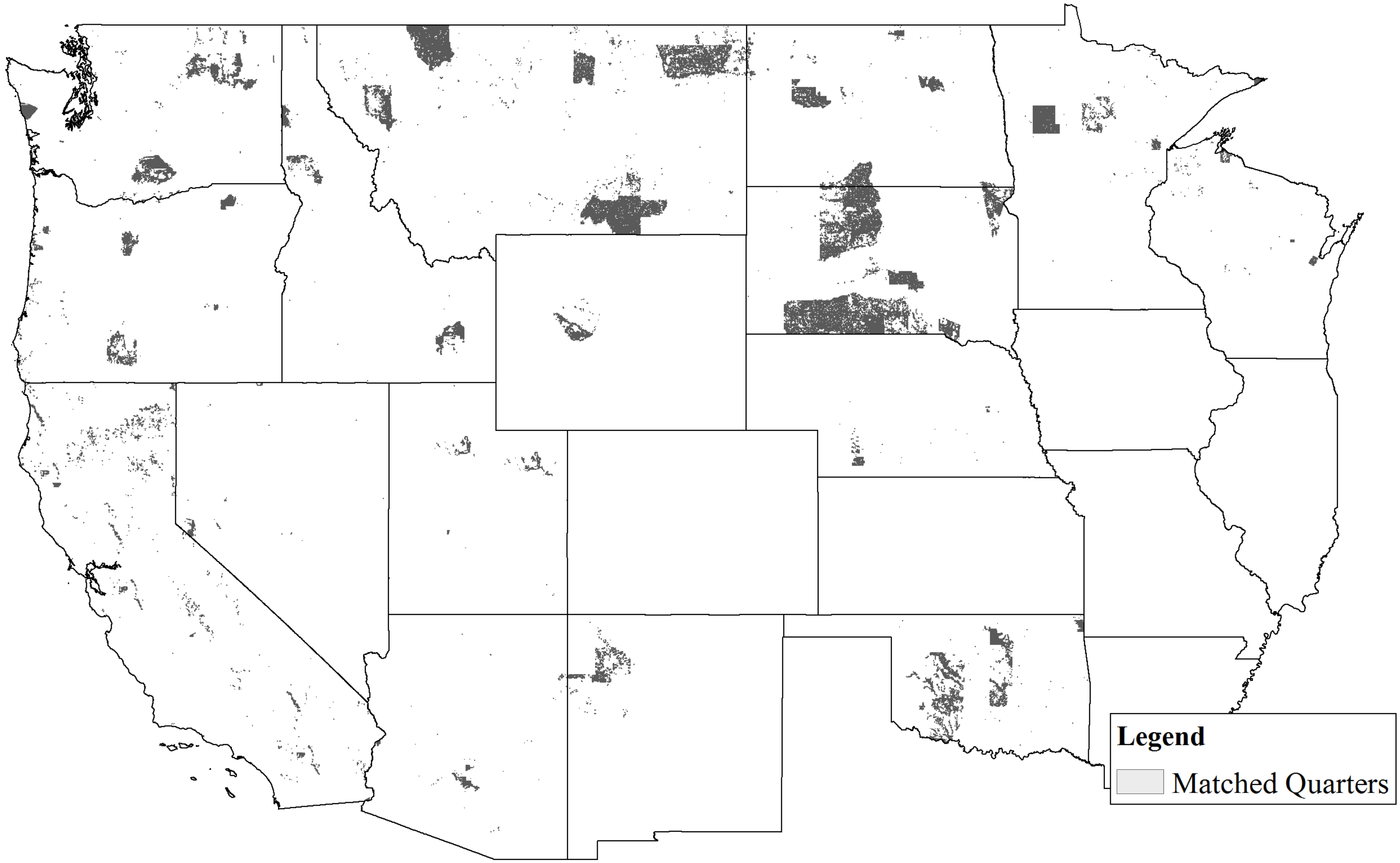
After matching patents to quarter sections, we track the history of transactions associated with each patent to determine when it transferred from trust to fee-simple, if ever. For the present analysis, we are most interested in the tenure status of a patent as of 2001 (when land cover data become available). Every patent in our sample begins in trust status, but only some convert to fee-simple by 2001. We define a patent as "fee-simple" whenever we see a transaction converting the original trust patent, and as "allotted trust" if we do not observe transfer to fee-simple status. We impose two additional restrictions on the sample to simplify the analysis. First, we focus on quarter sections which are matched to a single original patent that is approximately 160 acres, allowing us to avoid mixed-tenure observations. Second, we omit observations that converted from trust status to fee-simple during our study period of 2001 to 2016 (these are rare).

Figure 2 depicts an example of our matched, cleaned data on the Pine Ridge Reservation in South Dakota. Orange parcels are still in allotted trust status, whereas grey parcels have been

[15] In some cases the aliquot part is either missing, corrupted, or not not formatted in a way that allows matching to quarter-sections.

[16] Our match rate is above 99% for most states, with notably lower match rates for New Mexico (where the PLSS grid is less cleanly defined) and Wisconsin.

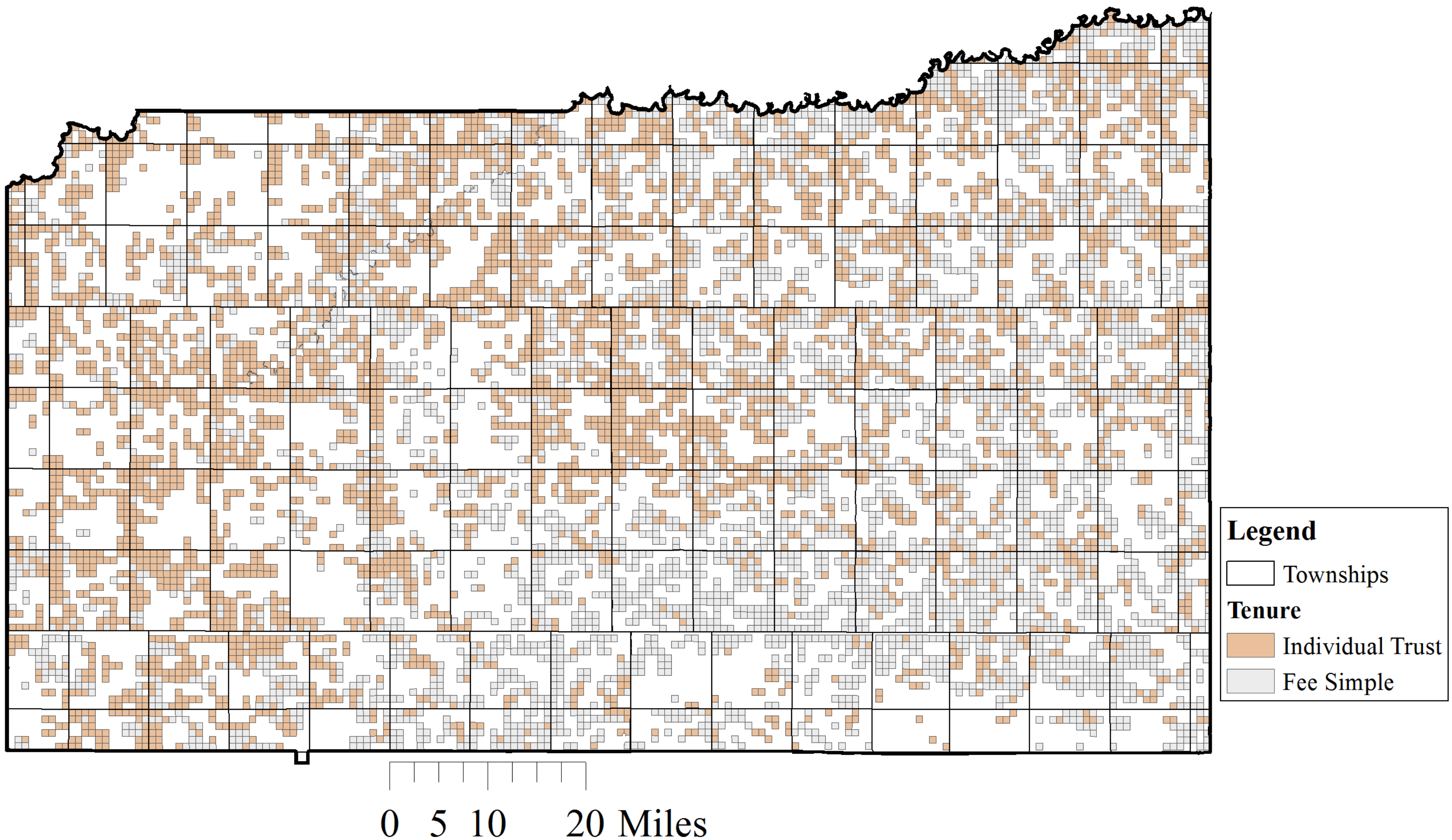
Figure 1: Allotted Quarter Sections and Reservations



Notes: This figure depicts the location of allotments which we are able to match to an individual 160-acre quarter section in the Public Land Survey System (PLSS). The parcels depicted include land in allotted trust as well as fee-simple lands.

converted to fee-simple. Unshaded areas represent tribally owned land, which we omit from the present conference draft. The larger black outlines are the 6×6-mile township boundaries. Tenure regimes are notably in close proximity to one another, often in a checkerboard fashion. Although there some concentrations of fee vs. allotted trust land in certain areas, in most cases each allotted trust parcel has at least several fee neighbors. This pattern is representative of many reservations. In our empirical analysis, we will focus on within-township variation and compare only nearby parcels of different tenure regimes.

Figure 2: Checkerboard Pattern of Land Tenure on the Pine Ridge Reservation



Notes: Distribution of Land tenure on the Pine Ridge reservation by allotment parcel (quarter-section) in the BLM data. The reservation is divided into 36-square mile townships. A township itself consists of 36 one-square-mile sections, and a quarter-section corresponds to a 160-acre allotment.

3.2 The National Land Cover Database

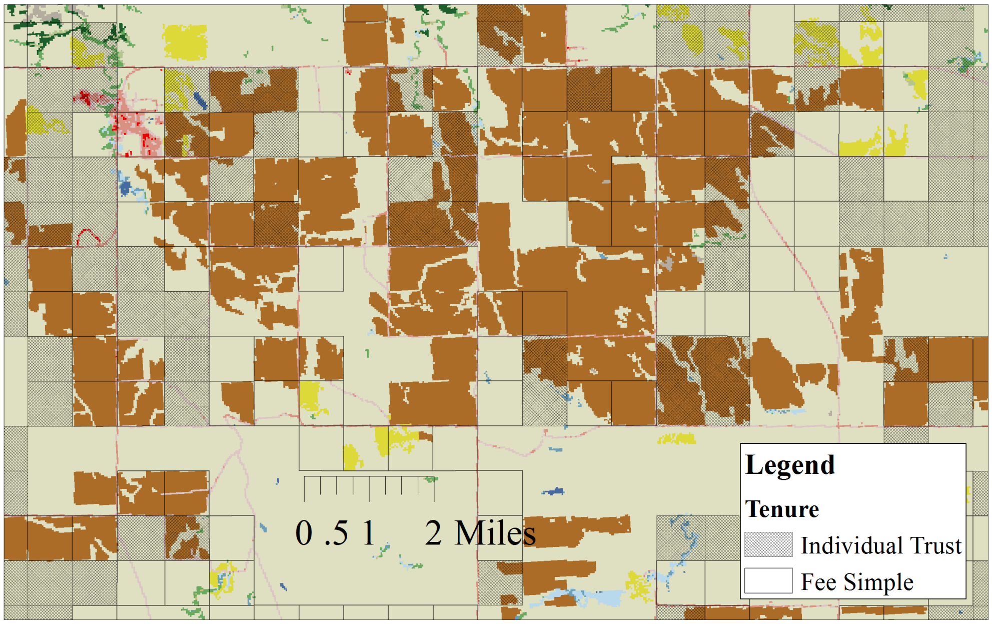
Our outcome data on land use come from the National Land Cover Database (NLCD). A collection of federal agencies known as the Multi-Resolution Land Characteristics Consortium produces the NLCD by combining satellite images from the LandSat database with remote processing techniques. The resulting database provides estimates of land cover at a 30×30-meter resolution for 2001, 2004, 2006, 2008, 2011, 2013, and 2016.

We focus our attention on two land cover classes in the NLCD: development and cultivated crops. The NLCD codes 4 different levels of development ranging from "developed, open space" which is comprised primarily of residential areas to "developed, high intensity" where people reside and/or work in large numbers. Pixels coded as cultivated by the NLCD include annual crop production, orchard crops, and any land that is being tilled. The NLCD also codes a variety of other land cover types including pasture, scrub/brush, forests, wetlands, perennial snow/ice, water, and "barren" land comprised of bedrock, talus, or sand dunes.

Figure 3 depicts an example of the land cover data on a subset of the Pine Ridge reservation. Cross-hatched parcels are in allotted trust and unshaded parcels are in fee-simple. Shading of the 30×30-meter pixels indicates different land uses. Dark brown areas are cultivated crops, pink and red areas are developed (either residential, urban, or built infrastructure), yellow areas are pasture, and tan areas are brush. Green areas indicate forested lands and blue areas indicate water.

We focus on development and cultivation for our measures of productive land uses. We call a pixel "Developed" if it falls into any of the four development classes and simply adopt NLCD's definition of cultivation. We do not wish to take a stand on development vs. cultivation given the spatial heterogeneity in our sample, so we designate pixels as "in use" if they are coded as either developed or cultivated. This is our primary outcome of interest. We express land use as a share of total usable parcel area, which we calculate as the total number of pixels in a parcel excluding water and perennial snow/ice.

Figure 3: Land Cover Data



Notes: This figure depicts the land tenure in addition to land use data from the National Land Cover Database for a subset of the Pine Ridge Reservation. Cross-hatched parcels are in allotted trust and unshaded parcels are in fee-simple. Shading of the 30×30-meter pixels indicates different land uses. Dark brown areas are cultivated crops, pink and red areas are developed (either residential, urban, or built infrastructure), yellow areas are pasture, and tan areas are brush. Green areas indicate forested lands and blue areas indicate water.

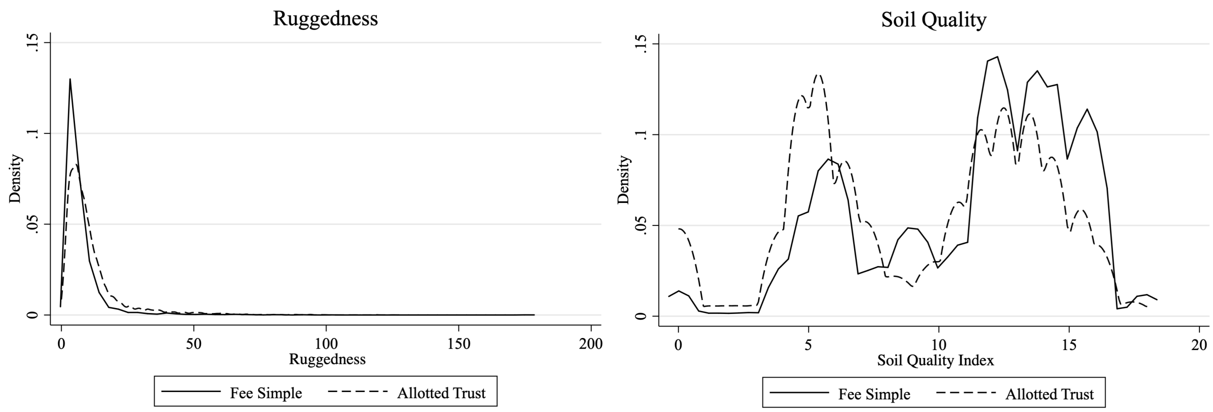
3.3 Other Geographic Covariates

We also estimate terrain characteristics and soil quality for each quarter-section. We use 30×30-meter elevation data from the National Elevation Dataset (NED) to measure the mean and standard deviation of elevation in each section. We define the variable Ruggedness as the standard deviation of elevation, a commonly-used measure of terrain ruggedness (Ascione, Cinque, Miccadei, Villani, and Berti, 2008).[17] We use the soil productivity index developed by Schaetzl et al. (2012) and estimate the average of the soil index within each quarter section. The soil productivity index ranges from 0 to 21, with soil index values greater than 10 representing highly productive soils (Schaetzl et al., 2012).

Figure 4 depicts the distribution of ruggedness and average soil productivity across quarter sections in our sample for each tenure type. Although the distributions are fairly similar, there is evidence that fee-simple land tends to be of higher quality than land that has remained in allotted

[17]Both elevation and ruggedness are expressed in 1,000s of meters in our regression models for notational convenience.

Figure 4: Land Quality



Notes: This figure depicts the distribution of terrain ruggedness and soil quality across quarter sections in the matched sample. Ruggedness is measured as the standard deviation of elevation in a quarter section (Ascione et al., 2008). Soil quality is the quarter-section mean of the Productivity Index generated by Schaetzl et al. (2012). The bi-modality of the soil quality distribution comes from the underlying data and not from differences in reservations.

trust. In terms of ruggedness, there is a much larger mass of fee parcels on the least rugged land, and the distribution of allotted trust land has a noticeably fatter tail. In terms of soil quality, both fee and allotted trust land exhibit a bi-modal distribution that is typical of the Schaetzl et al. (2012) productivity index in other samples. However, fee parcels have a larger mass of parcels with above-average productivity, whereas a larger mass of allotted trust parcels are on low-quality lands. These comparisons of land quality are consistent with Leonard et al. (2018), who document a positive relationship between land quality and the transition of land into fee-simple ownership across reservations.

Table 1 presents summary statistics for the estimation sample, reported separately for allotted trust and fee-simple quarter sections. Variable definitions and descriptions are provided in the figure note.

Table 1: Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
			Allotted Trust		
Elevation	87,635	1.002683	.567679	.0666844	2.698626
Ruggedness	87,635	.0110071	.0116823	0	.1288639
Soil Quality	87,635	.0092252	.0047831	0	.018
$\mathbb{1}$(In Use)	87,635	.3282935	.4695949	0	1
$\mathbb{1}$(Developed)	87,635	.1712444	.3767245	0	1
$\mathbb{1}$(Cultivated)	87,635	.1609745	.3675095	0	1
Share In Use	87,635	.0987568	.2500729	0	1
Share Developed	87,635	.0117668	.0306226	0	.9707522
Share Cultivated	87,635	.08699	.24182	0	1
			Fee-Simple		
Elevation	88,939	.7226359	.267268	.0595389	2.447307
Ruggedness	88,939	.0079171	.0166378	0	.6754085
Soil Quality	88,939	.011259	.0041563	0	.018
$\mathbb{1}$(In Use)	88,965	.6614624	.473215	0	1
$\mathbb{1}$(Developed)	88,965	.3124487	.4634943	0	1
$\mathbb{1}$(Cultivated)	88,965	.4876187	.4998495	0	1
Share In Use	88,939	.2913742	.3688953	0	1
Share Developed	88,939	.0206779	.0379754	0	.9861112
Share Cultivated	88,939	.2706963	.3615155	0	1

Notes: This table presents the summary statistics for our estimation sample that consists of quarter-sections which only have a single tenure type and do not change tenure over 2001 to 2016. $N = 25,225$ parcels over $T = 7$ years. Variables are defined as follows: elevation and ruggedness are measured in 1,000s of meters. Soil quality is $\frac{1}{1000}$ times the soil productivity index from Schaetzl et al. (2012). $\mathbb{1}$(Developed) is a dummy equal to 1 if there are developed pixels in a parcel, $\mathbb{1}$(Cultivated) is a dummy equal to 1 if there are cultivated pixels in a parcel, and $\mathbb{1}$(In Use) is a dummy equal to 1 if there are either developed *or* cultivated pixels in a parcel. Share "X" is the number of pixels of type X in a parcel divided by the total number of land pixels in a parcel (omits water and "barren" pixels that are not developable according to NLCD.

4 Initial Empirical Analysis and Results

In the future, we plan to exploit exogenous drivers of the probability that a parcel was allotted and remained in trust using the identification strategy described in the introduction. For the present conference draft, we focus on initial OLS results to establish differences in land utilization across allotted trust vs. fee-simple quarter sections. We also provide evidence that tenancy in common is likely to be the main driver for observed differences in land use by looking at the relative performance of allotted trust vs. fee-simple land over time. Because tenancy in common leads to additional fractionation of ownership each time a claimant dies, our theory predicts that the costs of common ownership relative to fee-simple grow over time. We exploit the 7 years of available land cover data to test this hypothesis.

4.1 Estimation Strategy

We estimate the effect of tenure on land use at the quarter section-level using the following linear regression model:

$$y_{ijt} = \beta_0 + \vec{\lambda} X_{it} + \theta Allotted_{it} + \kappa_j + \tau_t + \varepsilon_{ijt} \tag{1}$$

where y_{ijt} is the outcome of interest in quarter section i in township j in period t. We focus on both extensive and intensive measures of overall land use, development, and cultivation. X_{it} is a vector of controls that includes ruggedness, soil quality, and alternative land uses (for the models that focus on either development or cultivation). We include township and year fixed effects (κ_j and τ_t) so that our identifying variation comes from within-year differences in land use within a 6×6-mile township where land quality and distance to urban areas or other import infrastructure are unlikely to differ dramatically. $Allotted_{it}$ is an indicator equal to 1 if a quarter section has not transferred into fee-simple ownership prior to our study period. The coefficient of interest is θ, which represents the average difference in land use for allotted trust vs. nearby fee-simple parcels averaged over 2001, 2004, 2006, 2008, 2011, 2013, and 2016.

4.2 Pooled OLS Results

We estimate Equation (1) on the following outcomes using OLS: $\mathbb{1}$(In Use), $\mathbb{1}$(Developed), $\mathbb{1}$(Cultivated), Share in Use, Share Developed, and Share Cultivated, where $\mathbb{1}(x)$ is an indicator equal to 1 if parcel i has at least 1 pixel of type x. The results are reported in Table 2. Columns 1-3 focus on the extensive margin, whereas columns 4-6 focus on the share of land in each type of use. Standard errors are clustered by parcel in every specification, although the results are robust to clustering by township.

Table 2: Pooled OLS Estimates of the Effect of Tenure on Land Use

	Extensive Margin			Intensive Margin (Shares)		
	(1)	(2)	(3)	(4)	(5)	(6)
	$\mathbb{1}$(In Use)	$\mathbb{1}$(Developed)	$\mathbb{1}$(Cultivated)	In Use	Developed	Cultivated
Allotted	-0.0752***	-0.0144**	-0.0766***	-0.0857***	-0.00300***	-0.0798***
	(0.00593)	(0.00603)	(0.00523)	(0.00407)	(0.000488)	(0.00401)
$\mathbb{1}$(Cultivated)		0.129***				
		(0.00871)				
$\mathbb{1}$(Developed)			0.0917***			
			(0.00621)			
Cultivated					0.00876***	
					(0.000869)	
Developed						0.595***
						(0.111)
Ruggedness	-7.744***	-2.769***	-5.854***	-3.598***	-0.128***	-3.346***
	(0.417)	(0.349)	(0.290)	(0.505)	(0.0286)	(0.470)
Elevation	-0.0209	-0.211***	0.198***	-0.251***	-0.00833***	-0.234***
	(0.0614)	(0.0505)	(0.0401)	(0.0105)	(0.00136)	(0.0103)
Soil Quality	19.97***	9.147***	16.45***	20.51***	0.904***	18.80***
	(0.882)	(0.841)	(0.750)	(0.435)	(0.0585)	(0.431)
Constant	0.416***	0.321***	0.0495	0.271***	0.0152***	0.243***
	(0.0521)	(0.0429)	(0.0345)	(0.00965)	(0.00130)	(0.00967)
Township FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	176,575	176,575	176,575	176,575	176,575	176,575
Adjusted R^2	0.589	0.365	0.624	0.329	0.146	0.319

Notes: Standard errors are clustered by parcel and reported in parentheses.The results are also robust to clustering by township rather than parcel. The estimation sample is limited to quarter-sections composed of a single tenure (allotted trust or fee-simple) that do not change tenure over 2001 to 2016. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Across all six specifications, allotted trust land appears to be significantly under-utilized relative to nearby fee-simple land. The coefficient estimate in column 1 indicates that allotted trust parcels are 7.5 percentage points less likely to have any productive land use than fee-simple parcels. Columns 2 and 3 suggest that much of this difference is driven by agricultural land use—

allotted trust parcels are 7.6 percentage points less likely to be cultivated at all, whereas they are only 1.4 percentage points less likely to be developed.

Turning to the intensive margin, allotted trust parcels have about 8.6 percentage points less land utilization that fee-simple parcels. This is a 41% reduction relative to the average land utilization rate of 21 percent. Allotted trust parcels have 0.3 percentage points less development, which is a 15% reduction relative to the mean of 2%. Finally, allotted trust parcels have a 7.9 percentage point lower cultivation rate, which is a 42% reduction relative to the mean of 19%.

The controls included in Table 2 have the expected signs. Rugged land is less likely to be utilized, but the effect is larger for agriculture than for development. Land with higher soil quality is also more likely to be utilized, especially in agriculture. Land at higher elevations is also less likely to be utilized.

4.3 The Effects of Tenure Over Time

The results in Table 2 reveal striking differences in the pattern of land use across allotted trust vs. fee-simple land *within* small geographic areas on reservations, conditional on land quality. We recognize that one needs to be careful when interpreting these OLS results causally because the process by which land transfers out of allotted trust into fee-simple is not exogenous.

In the next iteration of this paper, we will add tribal lands to to the above comparison. The comparison between fee-simple land and tribal land with establish the land use inefficiencies that arise solely from having land that cannot be collateralized, and that is held in trust with the federal government. By contrast, the comparison between individual trust land and tribal land will isolate the land use inefficiencies that arise from tenancy in common. For the present conference draft, where we have not adequately measured tribal lands yet, we pursue a different strategy to provide some preliminary evidence that fractionation associated with tenancy in common is the most likely mechanism for the large differences in land use reported in Table 2. This strategy is anchored on the logic that a variety of factors could lead to large *level* differences between allotted trust and fee-simple lands, tenancy in common has the unique feature that it mechanically worsens over time as claimants pass away and have their individual interests further subdivided. If tenancy in common increases the transaction costs of land use decisions by increasing the number of claimants with veto power, a clear theoretical prediction is that the costs of tenancy in common should grow over time, leading to an increasing difference between fee-simple and allotted trust lands. On the other hand, it is not obvious why federal trusteeship or the ability to provide collateral for loans should lead to constantly increasing differences over time.

To explore the hypothesis that the differences between fee-simple and allotted ownership increase over time, we estimate the following model:

$$y_{ijt} = \beta_0 + \vec{\lambda} X_{it} + \theta Allotted_{it} + \sum_{t=2001}^{2016} \gamma_t (Allotted_{it} \times \tau_t) + \kappa_j + \tau_t + \varepsilon_{ijt} \tag{2}$$

where $\sum_{t=2001}^{2016} \theta_t (Allotted_{it} \times \tau_t)$ is a series of interactions between the allotted trust indicator and the year fixed effects. All other variables are defined as before. This specification allows the effect of allotted trust on land use to be different in each year, and these effects are captured by the γ_t coefficients. θ captures the difference between allotted trust and fee-simple in 2001. Our theory predicts that $\gamma_t < 0 \quad \forall t$ *and* that $|\gamma_t|$ is increasing in t. In words, we predict that allotted trust parcels consistently perform worse than fee-simple parcels, and that the difference between allotted trust and fee should be increasing over time.

Table 3 presents the results of estimating Equation 2. We focus our discussion on the extensive-margin results in columns 4-6; although the the extensive-margin results are largely similar. Beginning in column 4, allotted trust parcels were less utilized than fee-simple parcels beginning in 2001, with the difference growing monotonically over time in every year except for 2004. The development and cultivation results in columns 5 and 6 shows that this pattern holds within each land use type. Consistent with our theory, there is strong evidence that the gap in land utilization between allotted trust and nearby fee-simple parcels has grown substantially over 2001 to 2016.

Figure 5 plots the predicted values and 95% confidence intervals from the regression in column 4 for allotted trust and fee-simple parcels separately to illustrate the divergence. There are two points worth emphasizing. First, there were already large differences in land utilization between allotted trust and fee-simple parcels by 2001, this suggests that land tenure is an essential part of the puzzle associated with reservation poverty. Second, the gap between nearby parcels with different land tenure increases substantially, nearly doubling over the 15-year period from 2001 to 2016.

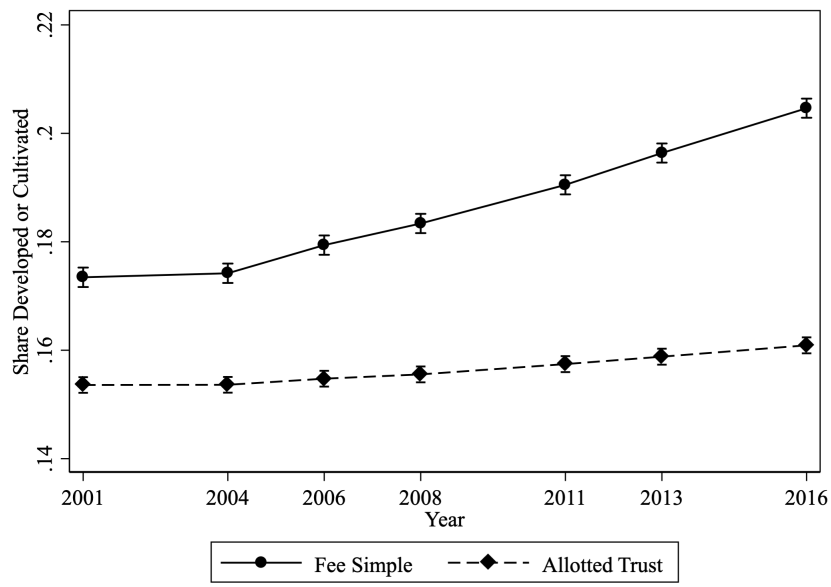
It is possible that the estimated effects in Table 3 and the differences in land use over time

Table 3: OLS Estimates of the Effects of Tenure on Land Use Over Time

	Extensive Margin			Intensive Margin (Shares)		
	(1)	(2)	(3)	(4)	(5)	(6)
	𝟙(In Use)	𝟙(Developed)	𝟙(Cultivated)	In Use	Developed	Cultivated
Allotted	-0.0723***	-0.0124**	-0.0714***	-0.0366***	-0.0000493	-0.0366***
	(0.00597)	(0.00604)	(0.00528)	(0.00368)	(0.000525)	(0.00364)
Allotted×2004	0.000836	-0.000291**	0.00246***	-0.000288	0.0000447**	-0.000333
	(0.000586)	(0.000123)	(0.000918)	(0.000368)	(0.0000220)	(0.000367)
Allotted×2006	-0.000219	-0.00174***	-0.0000614	-0.00397***	-0.0000696**	-0.00389***
	(0.000854)	(0.000423)	(0.00127)	(0.000632)	(0.0000354)	(0.000631)
Allotted×2008	-0.00116	-0.00150***	-0.00195	-0.00699***	-0.000108***	-0.00687***
	(0.00101)	(0.000433)	(0.00146)	(0.000762)	(0.0000305)	(0.000761)
Allotted×2011	-0.00451***	-0.00363***	-0.00733***	-0.0120***	-0.000305***	-0.0117***
	(0.00123)	(0.000728)	(0.00174)	(0.000973)	(0.0000779)	(0.000973)
Allotted×2013	-0.00599***	-0.00311***	-0.0110***	-0.0165***	-0.000302***	-0.0162***
	(0.00132)	(0.000738)	(0.00187)	(0.00115)	(0.0000738)	(0.00115)
Allotted×2016	-0.00981***	-0.00341***	-0.0185***	-0.0227***	-0.000530***	-0.0221***
	(0.00156)	(0.000871)	(0.00217)	(0.00131)	(0.000106)	(0.00131)
𝟙(Cultivated)		0.129***				
		(0.00872)				
𝟙(Developed)			0.0917***			
			(0.00621)			
Cultivated					0.000525	
					(0.00137)	
Developed						0.0281
						(0.0752)
Ruggedness	-7.744***	-2.769***	-5.854***	-5.337***	-0.314***	-5.011***
	(0.417)	(0.349)	(0.290)	(0.215)	(0.0320)	(0.211)
Elevation	-0.0209	-0.211***	0.198***	0.230***	-0.00570	0.236***
	(0.0614)	(0.0505)	(0.0401)	(0.0281)	(0.00428)	(0.0272)
Soil Quality	19.97***	9.147***	16.45***	11.50***	0.651***	10.83***
	(0.882)	(0.841)	(0.750)	(0.504)	(0.0674)	(0.497)
Constant	0.414***	0.320***	0.0470	-0.0593**	0.0173***	-0.0770***
	(0.0522)	(0.0429)	(0.0345)	(0.0239)	(0.00358)	(0.0233)
Township FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	176,575	176,575	176,575	176,575	176,575	176,575
Adjusted R^2	0.589	0.365	0.624	0.595	0.333	0.582

Notes: Standard errors are clustered by parcel and reported in parentheses.The results are also robust to clustering by township rather than parcel. The estimation sample is limited to quarter-sections composed of a single tenure (allotted trust or fee-simple) that do not change tenure over 2001 to 2016.* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Figure 5: Within-Township Changes in Land Use



Notes: This figure plots the predicted values from the regression model in Column 4 of Table 3 with the associated 95% confidence intervals. The identifying variation comes from changes in land use over time, within 6×6-mile townships.

depicted in Figure 5 are driven by underlying differences in land quality. Notably, there is almost no observable increase in land utilization on allotted land between 2001 and 2016 in Figure 5. It is possible that unobserved heterogeneity in land quality not captured by our controls is strongly correlated with tenure so that allotted trust lands are fundamentally unproductive, whereas fee lands have more productive capacity. In this case, the finding depicted in Figure 5 may be partly driven by unobserved differences in land quality.

To address this concern, we add parcel fixed effects to the regression model in Equation (2). In doing so, we can no longer estimate θ because the parcel fixed effects absorb the effect all time-invariant parcel characteristics, which includes the tenure variable $Allotted_{it}$ that does not change over 2001 to 2016.

However, we can still use interaction terms $\sum_{t=2004}^{2016} \gamma_t (Allotted_{it} \times \tau_t)$ to test whether there is a difference between allotted trust and fee-simple lands over time, *after accounting for unobserved characteristics of individual parcels.* Now, the identifying variation comes from changes in land use within a parcel over time, and the γ_t variables report the average difference in land use change for allotted relative to fee. As before, we predict $\gamma_t < 0 \quad \forall t$ *and* that $|\gamma_t|$ is increasing in t..

Table 4 reports the results of estimating Equation 2 with the addition of individual parcel fixed effects. Once again, the differences in overall land use between allotted trust and fee-simple in column 4 increase monotonically over time (except 2004, the first year of divergence). Once again, the results are very similar for both development and cultivation. These results indicate that individual parcels are much less likely to see increased utilization over 2001 to 2016 if they are in allotted trust than in fee-simple, even after for controlling for unobserved parcel characteristics (such as land quality) that could lead to different rates of development over time.

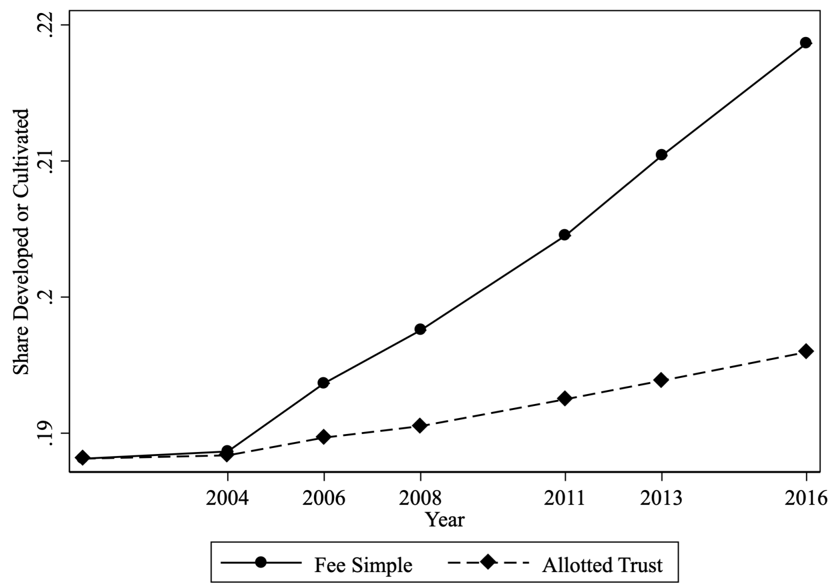
Figure 6 plots the predicted values from the regression model in column 4 of Table 4. Confidence intervals are also included but are too small relative to the scale of the graph to be visible. The 2001 difference in land use is normalized to 0 by the parcel fixed effects, and few differences emerged by 2004. After 2004, there is a striking divergence between allotted trust and fee-simple land use. Importantly, allotted trust lands are increasing in utilization over time, suggesting that there are at least attempts at productive land use. Despite the normalization in 2001, by 2016 the average fee-simple parcel as about about 0.03 more utilized than the average allotted trust parcel—a 14% difference relative to the mean utilization rate.

Table 4: Within-Parcel Estimates of the Effects of Tenure on Land Use Over Time

	Extensive Margin			Intensive Margin (Shares)		
	(1)	(2)	(3)	(4)	(5)	(6)
	$\mathbb{1}$(In Use)	$\mathbb{1}$(Developed)	$\mathbb{1}$(Cultivated)	In Use	Developed	Cultivated
Allotted×2004	0.000709	0.00000773*	0.00236**	-0.000288	0.0000431*	-0.000318
	(0.000622)	(0.00000417)	(0.000981)	(0.000391)	(0.0000236)	(0.000390)
Allotted×2006	-0.000380	-0.00181***	-0.000409	-0.00399***	-0.0000849**	-0.00394***
	(0.000908)	(0.000408)	(0.00136)	(0.000676)	(0.0000378)	(0.000675)
Allotted×2008	-0.00139	-0.00182***	-0.00235	-0.00704***	-0.000131***	-0.00697***
	(0.00107)	(0.000408)	(0.00156)	(0.000816)	(0.0000324)	(0.000816)
Allotted×2011	-0.00468***	-0.00475***	-0.00797***	-0.0120***	-0.000341***	-0.0118***
	(0.00132)	(0.000734)	(0.00187)	(0.00104)	(0.0000922)	(0.00104)
Allotted×2013	-0.00632***	-0.00476***	-0.0117***	-0.0165***	-0.000356***	-0.0163***
	(0.00141)	(0.000735)	(0.00201)	(0.00123)	(0.0000904)	(0.00123)
Allotted×2016	-0.00997***	-0.00604***	-0.0193***	-0.0227***	-0.000593***	-0.0223***
	(0.00167)	(0.000865)	(0.00233)	(0.00141)	(0.000126)	(0.00141)
$\mathbb{1}$(Cultivated)		-0.00363***				
		(0.000894)				
$\mathbb{1}$(Developed)			-0.0245***			
			(0.00552)			
Cultivated					-0.00198*	
					(0.00119)	
Developed						-0.322***
						(0.0885)
Constant	0.492***	0.242***	0.324***	0.188***	0.0165***	0.177***
	(0.000434)	(0.000260)	(0.00142)	(0.000348)	(0.000192)	(0.00147)
Parcel FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	176,575	176,575	176,575	176,575	176,575	176,575
Adjusted R^2	0.987	0.995	0.971	0.979	0.988	0.978

Notes: Standard errors are clustered by parcel and reported in parentheses. The estimation sample is limited to quarter-sections composed of a single tenure (allotted trust or fee-simple) that do not change tenure over 2001 to 2016. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Figure 6: Within-Parcel Changes in Land Use



Notes: This figure plots the predicted values from the regression model in Column 4 of Table 4 with the associated 95% confidence intervals (they are too small to see). The identifying variation comes from changes in land use over time, within individual parcels.

4.4 Future Work

This draft was prepared for conference circulation in early June 2019. We plan to undertake two extensions which are not yet incorporated into the current draft.

First, we will bring the other two types of land on reservations—tribal and non-Native 'surplus'—into the analysis. These land types form a non-trivial portion of reservations lands. Bringing them into the analysis is important beyond this fact, however: This is because individual-trust land differs from fee simple land not only in being held under 'tenancy in common'. In addition, it differs in that individual-trust cannot be collateralized and is largely managed by the BIA in conjunction with the tribal government. Assuming tribal management and BIA management are broadly similar, the comparison between tribal land and fee simple land can serve as a benchmark estimate of any costs associated with these two features, non-collateralizability and non-private management. Stated differently, we expect a ranking in land-use efficiently (confirmed in some preliminary data analysis that is not included in this draft), whereby fee simple land is the most efficiently used, tribal land is less efficiently used because of its non-collateralizability and potential managerial inefficiencies, and individual trust land is least efficiently used, partly for the same reasons as tribal land, but additionally because of being held under tenancy in common.

Second, we plan to provide bounds on reasonable dollar-estimates of the cumulative cost of the land-use inefficiencies that arose from having land "trapped" in individual trust rather than having been transferred into fee simple. Our reasoning for wanting to do this is that the U.S. government took on the responsibility of being the warden of tribes and reservations. The federal government could have chosen not to allot reservation lands to individuals, preserving reservations in tribal ownership. Once it chose to allot lands, it could have seen the process through to its completion, by transferring all allotted lands into fee simple. Through its choice of abolishing the process of allotment mid-way through it having run its course, it locked the non-transferred lands into individual trust. Given the ongoing poverty and economic underdevelopment of Native American reservations in the U.S., it seems that a plausible range of dollar-estimates of the cumulative cost of having abolished the process of allotment is necessary to discipline any policy debate that may ensue from our findings.

5 Conclusion

TBA

References

Alcantara, C. (2007). Reduce transaction costs? yes. strengthen property rights? maybe: The first nations land management act and economic development on canadian indian reserves. *Public Choice 132*(3-4), 421–432.

Anderson, T. L. (1995). *Sovereign Nations Or Reservations?: An Economic History of American Indians*. Pacific Research Institute.

Anderson, T. L. and D. P. Parker (2008). Sovereignty, credible commitments, and economic prosperity on american indian reservations. *The Journal of Law and Economics 51*(4), 641–666.

Aragón, F. M. and A. S. Kessler (2018). Property rights on first nations' reserve land.

Ascione, A., A. Cinque, E. Miccadei, F. Villani, and C. Berti (2008). The plio-quaternary uplift of the apennine chain: new data from the analysis of topography and river valleys in central italy. *Geomorphology 102*(1), 105–118.

Banerjee, A. V., P. J. Gertler, and M. Ghatak (2002). Empowerment and efficiency: tenancy reform in west bengal. *Journal of political economy 110*(2), 239–280.

Banner, S. (2009). *How the Indians lost their land: Law and power on the frontier*. Harvard University Press.

Becker, A., B. Enke, and A. Falk (2018). Ancient origins of the global variation in economic preferences. Technical report, National Bureau of Economic Research.

Besley, T. and M. Ghatak (2010). Property rights and economic development. In *Handbook of development economics*, Volume 5, pp. 4525–4595. Elsevier.

Bogart, D. and G. Richardson (2009). Making property productive: reorganizing rights to real and equitable estates in britain, 1660–1830. *European review of economic history 13*(1), 3–30.

Carlson, L. A. (1981). *Indians, bureaucrats, and land: the Dawes Act and the decline of Indian farming*. Number 36. Praeger Pub Text.

Chandler, A. B. (2005). The loss in my bones: Protecting african american heirs' property with the public use doctrine. *Wm. & Mary Bill Rts. J. 14*, 387.

De Janvry, A., K. Emerick, M. Gonzalez-Navarro, and E. Sadoulet (2015). Delinking land rights from land use: Certification and migration in mexico. *American Economic Review 105*(10), 3125–49.

De Soto, H. (2000). *The mystery of capital: Why capitalism triumphs in the West and fails everywhere else*. Basic Civitas Books.

Deaton, B. J., J. Baxter, and C. S. Bratt (2009). Examining the consequences and character of "heir property". *Ecological Economics 68*(8-9), 2344–2353.

Dippel, C. and D. Frye (2019). The effect of land allotment on native american households during the assimilation era. Technical report, Working Paper.

Emergency Land Fund (1980). The impact of heir property on black rural land tenure in the southeastern region of the united states. *The Emergency Land Fund*.

Enke, B. (2019). Kinship, cooperation, and the evolution of moral systems. *The Quarterly Journal of Economics 134*(2), 953–1019.

Flanagan, T. and C. Alcantara (2003). Individual property rights on canadian indian reserves. *Queen's LJ 29*, 489.

Flanagan, T., C. Alcantara, and A. Le Dressay (2010). *Beyond the Indian Act: Restoring Aboriginal Property Rights*. McGill-Queen's Press-MQUP.

Foster, A. D. and M. R. Rosenzweig (2011). Are indian farms too small? mechanization, agency costs, and farm efficiency. *Unpublished Manuscript, Brown University and Yale University*.

Foster, A. D. and M. R. Rosenzweig (2017). Are there too many farms in the world? labor-market transaction costs, machine capacities and optimal farm size. Technical report, National Bureau of Economic Research.

Gaither, C. J. and S. J. Zarnoch (2017). Unearthing 'dead capital': Heirs' property prediction in two us southern counties. *Land Use Policy 67*, 367–377.

Galor, O. and Ö. Özak (2016). The agricultural origins of time preference. *American Economic Review 106*(10), 3064–3103.

Geisler, C. C. (1995). Land and poverty in the united states: Insights and oversights. *Land Economics*, 16–34.

Goldstein, M. and C. Udry (2008). The profits of power: Land rights and agricultural investment in ghana. *Journal of political Economy 116*(6), 981–1022.

Graber, C. S. (1978). Heirs property: the problems and possible solutions. *Clearinghouse Rev. 12*, 273.

Guinnane, T. W. (1992). Intergenerational transfers, emigration, and the rural irish household system. *Explorations in Economic History 29*(4), 456–476.

Habakkuk, H. J. (1955). Family structure and economic change in nineteenth-century europe. *The Journal of Economic History 15*(1), 1–12.

Lamoreaux, N. R. (2011). The mystery of property rights: A us perspective. *The Journal of Economic History 71*(2), 275–306.

Leonard, B. and D. Parker (2017). Creating anticommons: Historical land privatization and modern natural resource use.

Leonard, B., D. Parker, and T. Anderson (2018). Poverty from incomplete property rights: Evidence from american indian reservations.

Libecap, G. D. and G. Alter (1982). Agricultural productivity, partible inheritance, and the demographic response to rural poverty: An examination of the spanish southwest. *Explorations in Economic History 19*(2), 184–200.

Meriam, L. (1928). *The problem of Indian administration*. Number 17. Johnson Reprint Corp.

Mitchell, T. W. (2000). From reconstruction to deconstruction: undermining black landownership, political independence, and community through partition sales of tenancies in common. *Nw. UL Rev. 95*, 505.

Office of Indian Affairs (1935). Indian land tenure, economic status, and population trends. In *Part X of the Report on Land Planning*. Washington: Department of Interior.

Ostrom, E. (1990). *Governing the commons*. Cambridge university press.

Otis, D. S. (2014). *The Dawes Act and the allotment of Indian lands*, Volume 123. University of Oklahoma Press.

Palsson, C. (2018). Small farms, large transaction costs: Incomplete property rights and structural change in haiti. Technical report, Working Paper.

Posner, E. A. and E. G. Weyl (2018). *Radical markets: Uprooting capitalism and democracy for a just society*. Princeton University Press.

Prucha, F. P. (2014). *American Indian policy in crisis: Christian reformers and the Indian, 1865–1900*. University of Oklahoma Press.

Rivers, F. R. (2006). The public trust debate: Implications for heirs' property along the gullah coast. *Southeastern Environmental Law Journal 15*, 147.

Rosenthal, J.-L. (1990). The development of irrigation in provence, 1700-1860: the french revolution and economic growth. *The Journal of Economic History 50*(3), 615–638.

Schaetzl, R. J., F. J. Krist Jr, and B. A. Miller (2012). A taxonomically based ordinal estimate of soil productivity for landscape-scale analyses. *Soil Science 177*(4), 288–299.

Shoemaker, J. A. (2003). Like snow in the spring time: Allotment, fractionation, and the indian land tenure problem. *Wis. L. Rev.*, 729.

Spolaore, E. and R. Wacziarg (2013). How deep are the roots of economic development? *Journal of economic literature 51*(2), 325–69.

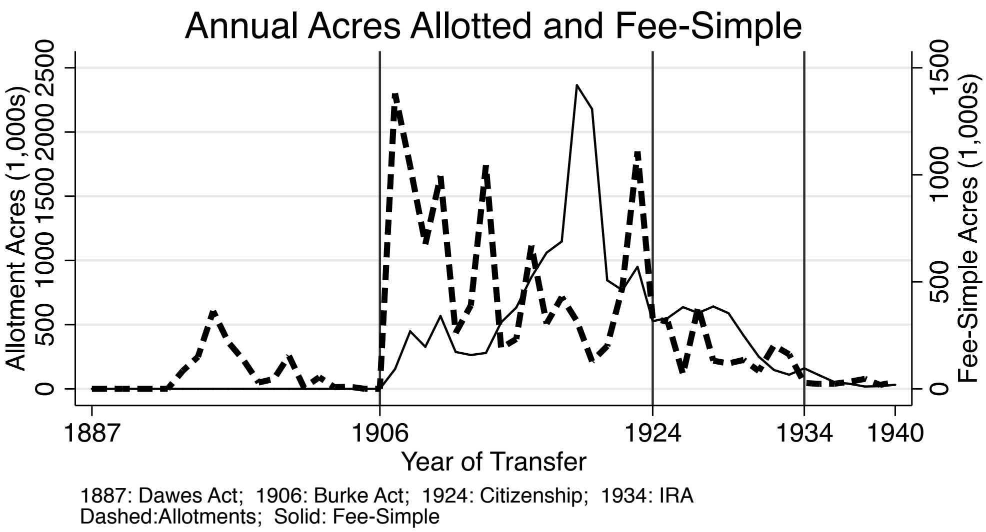
Wegge, S. A. (1999). To part or not to part: emigration and inheritance institutions in nineteenth-century hesse–cassel. *Explorations in economic history 36*(1), 30–55.

Online Appendix

to

The Costs of Tenancy in Common: Evidence from Indian Land Allotment

Figure Online Appendix Figure 1: Flow of Allottments and Transfers into Fee Simple



Notes: This figure is Figure 1 from Dippel and Frye (2019). It tracks the flow of total acres that were allotted and the flow of acres subsequently transferred into fee simple in the BLM data.

Online Appendix A Online Data Appendix