Property Rights without Transfer Rights: A Study of Indian Land Allotment[*]

Christian Dippel[†] Dustin Frye[‡] Bryan Leonard[§]

February 5, 2023

Click Here For Up-To-Date Version

Abstract

Governments often institute transferability restrictions over property rights to protect owners and communities, but these restrictions impose costs: lowering property values, limiting investment, and increasing transaction costs. We study the long-run impacts of transferability restrictions using a natural experiment affecting millions of acres of Native American reservation land, by comparing non-transferable allotted-trust parcels with transferable fee-simple parcels. We use satellite imagery to study differences in land use across tenure types by leveraging fine-grained fixed effects to compare immediate neighbors. We find that fee-simple plots are 13% more likely to be developed and have 35% more land in cultivation.

Keywords: Non-Transferable Property Rights, Land Tenure, Indigenous Economic Development
JEL Codes: J15, Q15, N51

[*]We thank Doug Allen, Fernando Aragon, Lee Alston, Terry Anderson, Laura Davidoff, Donna Feir, Rob Gillezeau, P.J. Hill, Gary Libecap, Dean Lueck, John Matsusaka, Paulina Oliva, Dominic Parker, Marc Roak, Jessica Shoemaker, Martin Weiss, Gavin Wright and seminar participants at Indiana University's Ostrom Workshop, Univ. of Pittsburgh's Center for Governance and Markets, Univ. of Wisconsin, the Hoover Institution's Workshop on Renewing Indigenous Economies, the NBER Summer Institute, UCSB, UCSD, and USC for helpful conversations. We thank Jefferson Kuate, Courtney Geiss, Nika McKechnie, Ryan Duchemin, and Gwyneth Teo for excellent research assistance. Dippel and Frye acknowledge the National Science Foundation (NSF Award 2017946) for support. Frye thanks the Environmental Research Institute, the Elinor Nims Brink Fund, and the Ford Scholars Program at Vassar College for financial support.

[†]Ivey Business School (UWO), and NBER.

[‡]Vassar College

[§]Arizona State University

1 Introduction

Government programs that formalize the property rights of the poor often include provisions that limit the ability to transfer or alienate property for fear that property owners may sell their property under value or against their own long-term interest or the interests of their community. Legally speaking, owners enjoy *usufruct* rights, i.e. they can use their property and enjoy its "fruits," but they cannot transfer or alienate their property (Rose-Ackerman 1985, Ellickson 1993, Alston, Alston, Mueller, and Nonnenmacher 2018, ch2-3). Such transfer restrictions may be well-intentioned but they may also come at a heavy price: they can undermine a property's collateralizability, reduce the incentive to invest in improvements and, in our setting, interact with inheritance laws to cause ownership fractionation that raises coordination costs.

To investigate the long-run consequences of limits on transfer rights, we study a natural experiment that resulted from the policy of "Indian allotment" on American Indian reservations in the early 20th century. This policy generated a patchwork of land titles on reservations, with some Native households owning their land in non-transferable "allotted trust" and other immediately adjacent Native households owning land under full fee-simple property rights (Taylor, 1980; Carlson, 1981). Allotment ended with the *Indian Reorganization Act* (IRA) of 1934, creating a checkerboard of land tenures on reservations that persists to the present day.[1] To compare economic activity on plots with different title, we map the universe of historic land allotments recently digitized by the *Bureau of Land Management* (BLM) to the *Public Land Survey System* (PLSS) grid, and to high-resolution satellite data from the *National Wall-to-Wall Land Use Trends Database* (NWALT).

Endogeneity problems in the comparison of non-transferable allotted-trust and fee-simple lands on reservations arise from the fact that allotments may have been selectively converted into fee simple. The primary concern is selection on land characteristics: plots with certain characteristics may have been converted at a higher rate. Our primary approach to addressing these concerns is to rely on the fine-grained nature of our spatial data, which we leverage in both a high-resolution spatial fixed effect strategy and a series of matching estimators, comparing individual fee-simple plots to adjacent allotted-trust plots with very similar characteristics.

[1] Subsequent to 1934, moving land out of trust status remains a theoretical possibility but requires special approval from the Secretary of the Interior (Shoemaker, 2003; C.F.R.150.1-150.11, 1981).

The pattern of results suggests that comparing adjacent plots substantially undercuts potential endogeneity problems. With coarse reservation-level fixed effects, estimated coefficients change considerably with the inclusion of more controls and with the use of a matching estimator. In contrast, once we move to the smallest possible spatial fixed effects that compare only directly adjacent plots within square-mile PLSS "sections," estimated coefficients are unaffected by either the addition of controls or by various matching estimators. In our preferred specification, non-transferable fee-simple status increases the share of land in agricultural cultivation by four percentage points, and increases the probability of any non-agricultural development by 1.4 percentage points. This amounts to a roughly 35 percent increase in the share of land in agricultural cultivation relative to allotted-trust land, and a 13 percent increase in the probability of development. Our findings are robust to various forms of spatial correlation, including clustering by PLSS township, reservation, or spatial HAC standard errors proposed by Conley (1999, 2008). Spurious effects are ruled out using random inference permutation tests.

A separate potential selection concern is that *allottees* with certain characteristics (such as a higher proclivity for farming) may have had their plots converted at a higher rate before the policy ended in 1934, and that such characteristics continue to matter today. We address this concern by including (reservation-specific) family-name fixed effects in our baseline estimation. Family-name fixed effects add considerable explanatory power to the regressions, but their effect on our core estimates is marginal. Using a selection-on-observables exercise, we find it is highly unlikely that remaining unobservables could explain away our core results (Altonji, Elder, and Taber, 2005; Oster, 2019). This exercise also underscores the point that the scope for selection on unobservables is dramatically curtailed by the inclusion of PLSS section fixed effects.

Turning to mechanisms, we begin with a discussion of plausible channels (see Section 3). We place this discussion in the context of the broader literature on the security and transferability of property rights to show that the two main follow-on consequences of transfer restrictions on U.S. reservations are that (*i*) land cannot be collateralized for credit, and that (*ii*) tenancy-in-common inheritance rules lead to a proliferation of heirs with partial claims on land, i.e. the fractionation of ownership, which in turn causes major coordination and incentive problems that compound over time.

To get at the first channel, we leverage the fact that the NWALT satellite data exist in five decadal waves (1974, 1982, 1992, 2002, and 2012) for a panel analysis that leverages differential timing in the opening of reservation-serving financial institutions. In this exercise, we compare allotted-trust vs. fee-simple plots on banked vs. un-banked reservations, based on the logic that on un-banked reservations the collateralizability benefits of fee-simple land are muted or even non-existent. We find that the growth trajectory of land use on fee-simple plots is significantly higher than the the growth trajectory of trust plots on banked reservations relative to un-banked reservations, and that this effect accentuates over time. This is particularly true for land development, where the collateral channel is likely to be most important.

To get at the second channel, we need to measure fractionation at the plot level, but we cannot do so directly because land ownership records are kept confidential by the BIA.[2] We overcome this by constructing a measure of a plot's *latent potential* for fractionation. For this, we digitize a special Census of American Indians from the mid-1930s, where we can match individuals to allotment numbers from the land records. We then assign an indicator to a plot for whether the original allottees were deceased by the 1930s, to proxy for the process of fractionation starting earlier. After validating this measure of latent fractionation by cross-referencing to historical and modern reservation-level fractionation statistics, we find that it accentuates the negative effects of land being held in trust, but it has no effect on fee-simple land. This is consistent with fractionation amplifying the coordination problems that arise from trust status.

Our paper complements a large literature on land tenure and economic development (Alston, Libecap, and Mueller, 2000; Banerjee, Gertler, and Ghatak, 2002; Besley and Ghatak, 2010; Hornbeck, 2010). This literature has tended to focus more on property rights *security* than on *transferability* as the primary source of assurance, collateralizability, and realizability problems (De Soto, 2000; Goldstein and Udry, 2008; Besley, Burchardi, and Ghatak, 2012). In this literature, identifying the effect of non-transferability separately from insecurity has proved challenging because the two are typically bundled in the context of informal institutions that give the local chief or community (village or lineage group) the ability to prevent transfers *and* revoke or reassign use rights after an owner's passing (Migot-Adholla, Hazell, Blarel, and Place, 1991; Besley, 1995; Fenske, 2011). In contrast, tenure is completely secure in our context, so that our results isolate the effects of transfer-restrictions from the effect of insecurity.

[2] These records are managed by the BIA through the so-called *Trust Asset Accounting Management System*.

Our paper also speaks to a literature on indigenous economic development. Non-transferable property rights are particularly common among indigenous peoples, who historically had limited bargaining power in shaping their property rights. Examples include indigenous land rights in Mexico until recent *Procede* land reforms (De Janvry, Emerick, Gonzalez-Navarro, and Sadoulet, 2015), historical restrictions of Alaska Natives' transfer rights over their reindeer herds (Massey and Carlos, 2019), and many Native American households and tribes who historically did not, and today often still do not have transfer rights over their land. A number of studies suggest that more complete property rights could improve economic outcomes in indigenous communities (Trosper, 1978; Johnson and Libecap, 1980; Libecap and Johnson, 1980; Anderson, 1995; Alcantara, 2007; Dippel, 2014; Leonard, Parker, and Anderson, 2020).

Our study contributes to these by providing plausibly causal estimates of the cost of non-transferable land rights, using highly disaggregated spatial units of analysis. By including the near-universe of allotted reservations, we provide the average treatment effect on land use more broadly to complement a number of case studies comparing specific outcomes on trust-land and fee-simple land on specific reservations, including housing and business investment on Agua Caliente in California (Akee, 2009; Akee and Jorgensen, 2014), oil and gas development on Fort Berthold in North Dakota (Leonard and Parker, 2021), and irrigation on Uintah and Ouray in Utah (Ge, Edwards, and Akhundjanov, 2019). Our paper also relates to Aragón and Kessler (2020), who find that Canada's "certificates of possession," which are similar to allotted-trust rights, fall short of generating the benefits of full property rights.

2 Background

Following the establishment of the reservation system, *"Friends of the Indian"* reformers viewed assimilation as necessary for Native American survival (Carlson, 1981, p80).[3] Private property was seen as a key component in the path towards assimilation, and reformers viewed land allotment as the best way to introduce real property to Indians (Otis 2014).[4] The government concurred, and in 1886 Henry Dawes introduced an allotment bill to the Senate. On February 8, 1887, President

[3]The two main reformist groups were the *Indian Rights Association* and the *National Indian Defense Association*, respectively formed in 1882 and 1885.

[4]Most tribes had norms of private property, and the majority of tribes viewed their land as their tribal property, but no tribe had traditionally had private property rights over land (Demsetz, 1967).

Grover Cleveland signed the Dawes General Allotment Act into law. The Dawes Act authorized the president, through the *Office of Indian Affairs* (the BIA's precursor), to survey and allot reservation lands (Banner, 2009). Heads of household received 160 acres, and single persons over the age of 18, as well as orphans, received 80 acres. The policy put the land into an "allotted trust" until the reservation's local BIA agent determined that the allottee had acquired sufficient experience ("competence" was the word used) with private property, at which time they were granted full (i.e. fee simple) right to their land. As long as land was in trust, it could not be transferred or alienated.

On an allotted reservation, allotments were mandatory. There was no explicit policy about selecting land for allotment. Allottees could select a plot, but often did not, in which case the *allotting agents* determined the assignment of allotments (Banner, 2009; Otis, 2014; Carlson, 1981). *Allotting agents* often did not know much about the quality of the land because they were typically distinct from the reservation's resident BIA agent, and as such they only visited the reservations for the specific task of allotment (Bureau of Indian Affairs , 1887–1926). The process was characterized as follows: "*The original allotments of land to the Indians were generally made more or less mechanically. Some Indians exercise their privilege of making their own selections [...]; others failing to exercise this right where assigned land. Often Indians who exercise the privilege made selections on the basis of the utility of the land as a means of continuing their primitive mode of existence. Nearness to the customary domestic water supply, availability of firewood, or the presence of some native wild food were common motives. Few [...] selected land on the basis of its productivity when used as the white man used it. The allotting work was done too fast and on too wholesale a basis for the representative of the government to advise and lead [allottees]* " (Meriam, 1928, p470).

Even if there was indeed little evidence that allotted land was selectively different from unallotted land, it is a separate (and, for us, more important) question whether allottees were *selectively* declared competent and whether land was thus *selectively* converted into fee simple. It seems almost certain that this was the case, given that selection on "competence" was part of the policy design. Because our study's core comparison is between those allotted plots that were converted to fee simple and those allotted plots that were not, our empirical analysis will pay careful attention to selection into fee simple.

The allotment period began in 1887 and accelerated with the 1906 Burke Act. Between 1887 and 1934, but especially between 1906 and 1924, millions of acres of reservation lands were converted into allotments, and about half of these were converted into fee simple after some time. Figure A1 plots the time series of both events. However, by the late 1920s, sentiment within the BIA had turned against allotment. One reason may have been the failures of allotment reported in the 1928 Meriam report.[5] Another reason may have been that the BIA did not want to release allotted lands from its control as the trustee of the land (McChesney, 1990). Whatever the motivations behind the government's and the BIA's about-turn, in 1934 the Commissioner of Indian Affairs, John Collier, introduced the Indian Reorganization Act (IRA), which ended allotment. As a consequence of the IRA, reservations that the BIA had not yet managed to survey by 1934 were never allotted (unallotted reservations play no role in our empirics); the IRA froze allotted-trust land in its trusteeship status indefinitely; already-converted fee-simple land remained fee simple; and unallotted lands remained under tribal ownership. The IRA's legacy was to create a patchwork land tenure pattern on reservations of (*i*) individually owned allotted-trust plots, (*ii*) individually owned fee-simple plots, and (*iii*) tribally owned plots. This patchwork persists to the present day.

3 Land Tenure Issues on Allotted-Trust Land

How do the issues facing allotted trust land fit into the context of the existing literature on incomplete property rights over land? This literature, see e.g. Place and Swallow (2000); De Soto (2000); Goldstein and Udry (2008); Fenske (2011); Besley et al. (2012); Huntington and Shenoy (2021), has tended to focus on three primary impacts of incomplete property rights: an inability to borrow against the value of the land one owns, a reduced incentive to invest in the land if more productive land is more likely to be expropriated, and an inability to "realize" the full value of the property through exchange, which can be thought of as second reason for reduced incentives to invest in the land. Besley (1995) calls this trifecta of channels "collateral," "security," and "gains-from-trade."[6]

One major empirical challenge in the study settings above is that limits on transferability are

[5]Meriam's report was written for the Institute of Governmental Research, a precursor of Brookings Institution. The report was concerned with the socio-economic conditions on reservations, with special attention to allotment.

[6]Brasselle, Gaspart, and Platteau (2002) refer to these alternatively as "collateralizability," "assurance," and "realizability." Huntington and Shenoy (2021) additionally emphasize the importance of transaction costs as a standalone element of transferability.

bundled with the issues of property insecurity. In Besley (1995), for example, communal land tenure systems in sub-Saharan Africa return property rights to the chief after a tenant passes away. In this case, non-transferability causes insecurity in an intergenerational sense. However, this system also gives the chief the ability to claim a tenant's land at *any* time they see fit (Goldstein and Udry, 2008). Hence, it is difficult to separately identify the effects of insecurity from non-transferability. Moreover, in this particular context, the relationship between between non-transferability and insecurity is bi-directional in the sense that insecurity would cause a property to become more difficult to sell even if transfer was technically allowed.

Panel A of Figure 1 illustrates the resulting issue: non-transferable property rights will have some direct negative effect on collateralizability (even if credit markets are informal) and on the incentive to invest (if the investments are long-run or inter-generational, e.g. planting new trees). However, the non-transferability of property rights is bundled with insecure property rights (which may themselves inhibit land transfers even where land is transferable in principle, as reflected in the arrow pointing left).

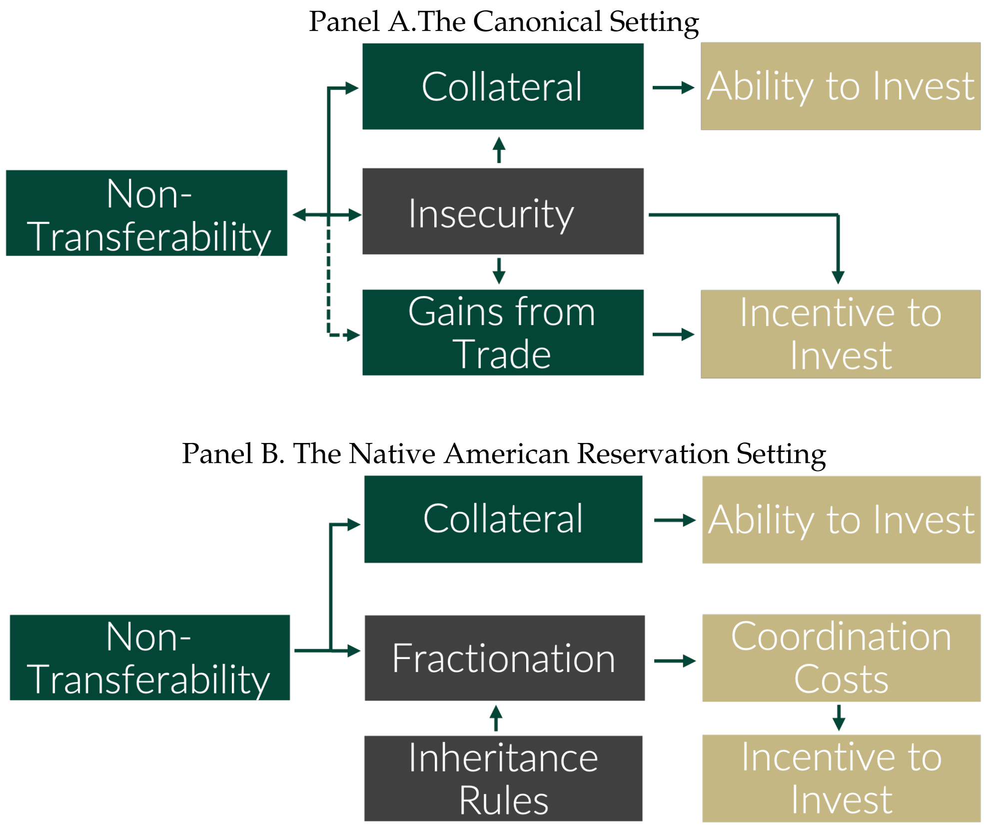
The empirical settings cited above therefore cannot identify the unique effects of non-transferability as distinct from insecurity. Our paper is arguably the first that does isolate the effect of non-transferability from the effect if property rights insecurity, because property rights security is unequivocal on reservations.[7] The downside of our setting is that our results may not generalize to other contexts. However, we emphasize that any study of incomplete property rights faces a challenge with external validity, particularly when internal validity rests on leveraging institutionally unique "natural experiments" for identification. This is because, ultimately, *any* form of incomplete property rights will interact with the surrounding institutional environment in shaping the *de facto* property regime that actually becomes salient in a given setting.

In the reservation context, non-transferability has interacted with states' legal rules governing inheritance to create problems of fractionated land ownership claims. The court presumption in the U.S. is *tenancy in common*: in the absence of a will stating otherwise, heirs receive equal interests in the land, which remains physically undivided, giving rise to common ownership.[8]

[7]On allotted-trust plots, the owners hold the *beneficial title* to their land, and their land automatically bequeathes to their heirs.

[8]Tenancy in common is *partible heirship into equal undivided* claims. According to Habakkuk (1955), the intention of an *impartible heirship* court presumption is to keep the family property intact. In contrast, the intention of an *partible heirship* into equal divided claims is to keep the family intact. The result is a fracturing of the original family property

Figure 1: Land Tenure Issues



With full transfer rights, this issue of undivided claims on a common property is easily resolved through the courts' probate systems because heirs either sell the inherited property and divide the proceeds, or one heir takes out a mortgage on the property to buy out the others. Historically, well-developed capital markets in the rural U.S. have allowed this mechanism to keep American farms at a larger scale relative to European farms (Libecap and Alter, 1982; Alston and Ferrie, 2012). On allotted-trust land, however, this path is closed because interests in trust property are non-transferable.[9]

On reservations, non-transferability has therefore interacted with heirship law to create, over generations, massive problems of fractionated ownership over land, with each inheritance amplifying fractionation because each heir may have multiple heirs themselves (Russ and Stratmann,

into many neighboring farm sizes connected by family relations. This was the case in most of continental Europe in the 19th century, and is the case in India today, where farm sizes are often too small to operate at efficient scale (Libecap and Alter, 1982; Foster and Rosenzweig, 2011, 2022).

[9]This issue is amplified by the fact that will-writing was uncommon among Native Americans in the early parts of the twentieth century; and was apparently actively discouraged by the BIA, resulting in widespread use of the default tenancy in common rule (Stainbrook 2016, p2, Shumway 2017, p648).

2014). Today, the average allotted-trust plot has 13 claimants, but there are many instances of trust plots with hundreds of claimants on them (Department of Interior, 2013). Shoemaker (2003, p746) cites a 1987 report prepared for the Supreme Court that provides a compelling example: "*Tract 1305 (on the Sisseton-Wahpeton Lake Traverse Sioux reservation) is 40 acres. [...] It has 439 owners, one-third of whom receive less than $0.05 in annual rent and two-thirds of whom receive less than $1. The largest interest holder receives $82.85 annually.*"

Panel B of Figure 1 illustrates the bundle of on-the-ground issues the comprise the *de facto* property regime on allotted trust land. Non-transferable property rights directly undermine an owner's ability to borrow against their property (the collateral channel), and therefore their ability to invest (Treuer, 2012; Feir and Cattaneo, 2020). In a scenario where each generation had only had a single heir, the collateral problem and the resulting constraints on investment might well have been the only major land management issue on reservations. In practice, however, because there typically were multiple heirs to a plot of trust land, fractionation emerged as a separate major land management issue that created coordination problems and subsequently reduced the incentive to invest because of free-riding. The upshot of these comparisons is that the *de facto* property regime in Panel B looks very different from that in Panel A, although both bundles may originate from the non-transferability of property rights. This is why no estimate—regardless of the setting—should be viewed as *the one causal effect* of non-transferable land rights, even when the estimate is internally valid.

4 Data

Allotment data: Following approval from the President, each patent issued on a reservation was filed with the General Land Office (GLO). These patents—subsequently digitized by the Bureau of Land Management (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. These patents include—among other things—cash sales, homestead entries, and Indian allotments. These Indian allotments include a unique federally issued allotment number. An important feature of the GLO data is that we can see the date on which each allotment was issued and the date on which it was converted into fee simple, if ever. This ability to follow the individual allotments and when they were converted to fee simple allows us to identify them as either allotted-trust or fee-simple lands today. Appendix-Figure A1 depicts the aggregate annual flow of allotments issued and converted into fee simple from 1887–1934.

The Public Land Survey System: The GLO allotment data describe the location of each land allotment within the Public Land Survey System (PLSS), a rectilinear grid that divides (most of) the United States into 6×6-mile townships, each with a unique identifier.[10] 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 allotment. For example, an allotment with an aliquot part of SW$\frac{1}{4}$NW is the southwest quarter of the northwest quarter-section.

We focus on 160-acre quarter sections, which we refer to as *plots*, as the basic unit of analysis because quarter sections were the size of a standard Indian allotment and because quarter-sections are a standard unit of analysis that has been used previously in the literature to analyze land use decisions with satellite data (see, e.g., Holmes and Lee 2012; Allen and Leonard 2021).[11] Of the universe of allotments with a potentially matchable aliquot part variable in our data, we successfully matched over 95% to quarter sections in the PLSS using an aggregated shapefile from individual state BLM offices.[12] Figure A2 depicts the location of all allotted plots across the Western United States. In most cases, these clusters of allotments trace out the boundaries of present-day reservations. In some rare cases, clusters of allotments trace out the boundaries of former reser-

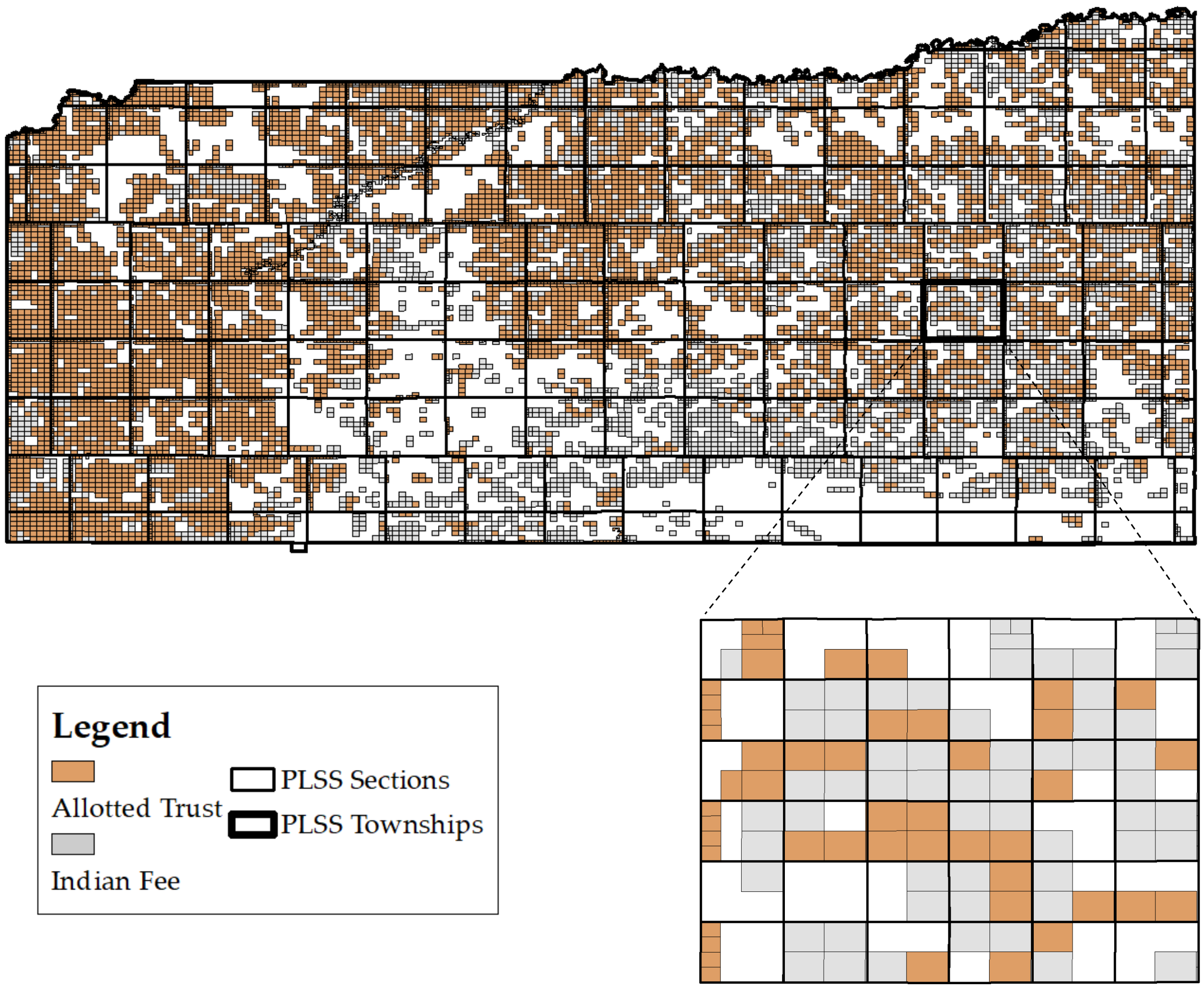
[10] Each township is referenced by a township number and direction that indicate its North-South position and a range number and direction that identifies its East-West position relative a prime meridian.

[11] While our typical feature is the 160-acre quarter section. The full PLSS contains other features types, like government lots, and smaller Indian Parcels. In our empirical approach we account for these differences by including fixed effects for PLSS feature type.

[12] 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. In some cases the aliquot part is either missing, corrupted, or not not formatted in a way that allows matching to quarter-sections. Some quarter sections in our data are associated with more than one allotment, but we only use quarter sections that are mapped to a unique land tenure type.

vations or rancherias that were subsequently terminated. This is true, for example, of the more dispersed looking clouds of allotments in Central and Northern California. Oklahoma, which is in fact densely covered by allotments, is the only gap in our spatial allotment data.[13]

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 GLO data. Overlaying the reservation is a township grid. Each township is 36 square miles and contained in each are 144 ($= 36 \times 4$) quarter sections, each of which is 160 acres (one-quarter of a square mile) large. The figure depicts only the allotted quarter sections. Appendix Figure A3 depicts a more detailed map of all land ownership types.

Once allotments are geo-located, we track the history of BIA transactions associated with each

[13] 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 under an alternative allotment agreement however, these allotments were not filed with the General Land Office because the land was already owned in fee-simple by the tribes at the time of allotment. We exclude the Western Oklahoma and the Osage reservation because allotments outside of the Five Civilized Tribes were not consistently categorized as 'Indian Patents' by the BLM.

allotment to code whether it was converted from allotted trust to fee simple. Figure 2 depicts an example of our data on the Pine Ridge Reservation in South Dakota.[14] Dark/orange plots are still in allotted-trust status, whereas light/grey plots have been converted to fee simple. The larger square outlines are the boundaries of 6×6-mile PLSS townships (nearly 150 can be seen on Pine Ridge). Unshaded areas correspond to quarter sections that are not associated with an allotment and therefore do not play a role in our analysis. There are three types of quarter sections for which this is true: (*i*) land was never allotted and is thus tribally owned; (*ii*) surplus land that was made available to white settlers;[15] (*iii*) quarter sections which we are unable to match to the BLM data.[16] Appendix Figure A3 shows a version of Figure 2 that separately identifies these other land types.

In our empirical analysis, we focus on fine spatial variation and primarily compare plots of different tenure regimes within a section (with 36 such sections in the township zoom-in on the bottom right of the figure). It is therefore important to note that land tenure regimes vary within close proximity of one another in Figure 2; i.e. most allotted-trust plots have at least one fee-simple direct neighbor and vice versa. This pattern is representative of most reservations.

Land use satellite imagery data: Our main outcome data on land use come from the *National Wall-to-Wall Land Use Trends* Database (NWALT). A collection of federal agencies known as the *Multi-Resolution Land Characteristics Consortium* produces the NWALT by combining satellite images from the LandSat database with remote processing techniques. The resulting database provides estimates of land cover at a 60×60-meter resolution for 1974, 1982, 1992, 2002, and 2012. We focus our attention on two main land cover classes in the NWALT: development and cultivated crops.[17] These two measures—development and cultivation—comprise the majority of "productive" uses of land that may be affected by restrictions on transferability.[18] Developed pixels in

[14] To simplify the analysis, we focus on plots which are matched to either all fee simple or all allotted trust, but not a mix. We also omit observations that converted from allotted-trust to fee-simple title after 1934, a rare occurrence that required special approval from the Secretary of the Interior. (See footnote 1).

[15] The vast majority of surplus lands is outside of reservations, because it was ceded from reservations as large tracts. We always omit surplus land inside modern reservation boundaries from our analysis. 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).

[16] Reservation-level data obtained from Anderson and Parker (2008) indicates that 32% of the land on Pine Ridge is held in tribal trust and therefore falls into category (*i*).

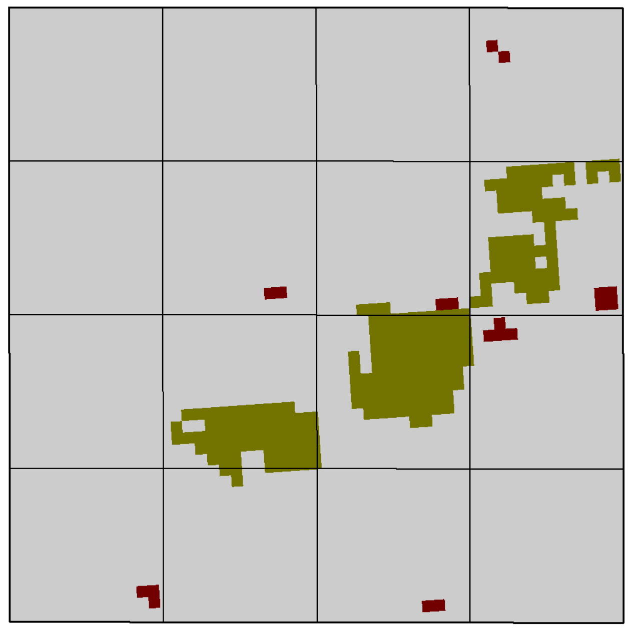
[17] Pixels coded as cultivated by the NWALT include annual crop production, orchard crops, and any land that is being tilled. The NWALT also codes a variety of other land cover types including pasture, scrub/brush, forests, wetlands, perennial snow/ice, water, and "barren" land comprised of bedrock, talus, or sand dunes. For our land use measures, we exclude water from a plot's area: the denominator of each parcel's share-variable is land only.

[18] Another productive land use is extraction of natural resources such as coal or oil, but this is highly dependent on the location of valuable deposits.

NWALT reflect capital investments in the construction of durable structures that may be associated with manufacturing, commercial activity, or private residences, and other scholars have used similar measures to study economic activity and growth at a fine spatial scale (Burchfield, Overman, Puga, and Turner, 2006; Saiz, 2010).

Figure 3 depicts our coding of land use from the NWALT data on a subset of the Fort Berthold reservation in North Dakota. The figure depicts four sections comprised of sixteen individual quarter-section plots. We express land use as a share of total usable parcel area, and define this denominator as the total number of pixels in a parcel excluding water and perennial snow/ice.[19]

Figure 3: NWALT Land Use Data



Notes: This figure depicts our outcome measure of cultivated and developed land in the NWALT data. The figure depicts 16 quarter-sections of 160 acres each. A one quarter-section plot is our primary unit of analysis (compare figure-notes in Figure 2).

Plot-level covariates: As controls, we construct a variety of variables for each plot. First, we measure the *geographic characteristics* of each plot. We use 30×30-meter elevation data from the *National Elevation Dataset* (NED) to measure the mean and standard deviation of elevation in each plot. 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). We use the soil productivity index developed by Schaetzl, Krist Jr, and Miller (2012) and estimate the average of the soil index within each plot. The soil productivity index ranges from 0 to 21, with soil index values greater than 10 representing highly productive soils (Schaetzl et al., 2012). We measure average annual precipitation and temperature using the 1980–2010 "climate normal" from the PRISM climate data set (Prism Climate Group, 2014). Finally, we calculate the distance from the centroid of each plot to

[19] We recognize that the NWALT data only allow us to capture changes in land use at the *extensive* margin; i.e, bringing new land into agricultural production or development. Improvements such as intensifying irrigation and agricultural use, or buildings constructed over an empty parking lot are not measured. As a result, our estimates will likely understate the full effect of non-transferability.

the nearest perennial stream using the National Hydrography Dataset (U.S. Geological Survey , 2019).

In addition to the geographic controls listed above, we also estimate distances from each plot to *historically significant features* that may have affected conversion to fee simple. These include the nearest historical railroad completed by 1911 from Atack (2016), the nearest battlefield site from the Indian Wars (McConnell, 1919), the nearest exploratory route in the early 1800s (McConnell, 1919), and the nearest reservation boundary. We also calculate the latitude and longitude of each plot's centroid as a way of proxying for unobservables that are systematically correlated across space. Finally, we calculate the acreage of the PLSS polygon associated with each plot.[20]

5 The Effect of Transferable Property Rights

This section presents our baseline identification strategy and results, where we leverage both a fine-grained spatial fixed effect strategy and a series of matching estimators to compare individual fee-simple plots to only allotted-trust plots of very similar spatial characteristics. While we view geographic selection as the primary identification threat, we are also concerned about selection on allottees' characteristics, and we address this concern by conditioning our results on (reservation-specific) allottee last names to absorb potential confounding variation from unobservable family-traits within a reservation.

We estimate the effect of non-transferability on land utilization, using the following linear regression model

$$y_{ij} = \theta \times \text{FeeSimple}_i + \kappa_j + \lambda' X_i + \varepsilon_{ij}, \tag{1}$$

where y_{ij} is the outcome of interest on plot i in spatial region j in 2012. FeeSimple_i is an indicator equal to 1 if a plot is under fee-simple ownership, and the outcome y_{ij} is a measure of land use. The coefficient of interest is θ, which represents the average difference in land use for fee simple versus nearby allotted-trust plots within the same spatial neighborhood κ_j. The vector X_{it} includes various controls, as discussed below. Standard errors are clustered at the reservation level to account for potential spatial correlation.

[20] Our empirical approach also includes fixed effects for different PLSS features types, like aliquots, government lots, and smaller Indian Parcels.

For land use outcomes y_{ij}, we focus on developed land and cultivation. For developed land use, y_{ij} is an indicator equal to one if a plot contains *any* developed pixels. For cultivation, y_{ij} is the share of pixels on a plot that are cultivated. This decision is motivated by the nature of the variation in our measures of developed and cultivated land use. As Figure A4 illustrates, the primary variation in developed land use is at the *extensive* margin: 79% of plots with any development have less than 10% of pixels developed. In contrast, there is much greater *intensive*-margin variation for cultivation, where just 16% of plots have less than 10% of pixels developed, reflecting the fact that share cultivated is much more uniformly distributed from 0 to 100%.

One concern with the comparison in equation (1), which we discuss in Section 2, is that the geographic characteristics of a plot could have played a role in BIA agents' historical decision to convert it from allotted-trust to fee simple, and could have at the same time influenced contemporary land utilization directly.

Columns 1–2 of Table 1 display mean and standard deviations of geographic characteristics on allotted-trust and fee-simple land. Columns 3–4 report differences between fee-simple and allotted-trust land, conditioning on reservation fixed effects in column 3, and conditioning on section fixed effects in column 4.[21] The unconditional differences reported in column 3 of Table 1 suggest that when all data are pooled, and we only compare within a reservation, higher-quality lands were more likely to transition out of allotted-trust status: fee simple plots are at lower elevation, are less rugged (by about a standard deviation), and have higher soil quality (by half a standard deviation).[22] This is consistent with previous findings by Leonard et al. (2020). They are also warmer, closer to water sources, and more connected to the outside world (as proxied by proximity to historical railway lines). These differences become noticeably less pronounced in column 4, when we condition on fine-grained section fixed effects: the number of differences that are statistically significant shrinks, and among the differences that do remain statistically significant, the magnitude of the difference is reduced by a factor of 10 for most variables. While differences remain statistically significant as we add finer spatial fixed effects, they arguably become economically insignificant: for example, within sections, fee simple plots are only 15 meters closer to the

[21] According to the Office of Indian Affairs (1935), there were 119,000 allotments made in Oklahoma. which is home to several relocated tribes. As we discuss in Section 4, Oklahoma is not included in the data because its allotments were administered separately (through the so-called *Dawes Rolls*), and as a result *every single allotment* was converted to fee simple, so that Oklahoma allotments would not contribute to the allotted trust vs fee simple comparison.

[22] Elevation and ruggedness are expressed in 1,000s of meters in our regression models.

nearest railroad line.

Table 1: Baseline Differences and Variable Selection Model

	(1)	(2)	(3)	(4)	(5)	(6)
			Difference: Fee - Trust		Variable Selection	
	Trust	Fee	Res FE	Sect FE	Res FE	Sect FE
Elevation	0.926	0.652	-0.014	-0.001	0.083	-0.137
	(0.487)	(0.301)	[0.013]	[0.001]	[0.151]	[0.097]
Ruggedness	8.144	4.540	-2.026***	-0.299***	-0.006***	-0.002***
	(9.206)	(5.731)	[0.638]	[0.107]	[0.002]	[0.000]
Soil	9.490	11.527	1.409***	0.089**	0.013***	0.003***
	(4.518)	(4.004)	[0.263]	[0.035]	[0.002]	[0.001]
Precipitation	480.048	564.524	-3.542	-0.260		
	(281.052)	(223.368)	[5.240]	[0.243]		
Temperature	7.942	6.947	0.019	0.001	0.023	
	(2.917)	(2.019)	[0.046]	[0.001]	[0.022]	
Dist. Streams (kms)	6.006	4.133	-0.107	-0.008	-0.002	
	(7.306)	(4.200)	[0.316]	[0.012]	[0.002]	
Dist. RRs (kms)	22.839	15.799	-2.843***	-0.015*	-0.003**	-0.006**
	(17.717)	(15.438)	[0.667]	[0.009]	[0.001]	[0.003]
Dist. Wars (kms)	110.495	138.064	1.917	0.006	0.001	
	(85.484)	(77.591)	[2.464]	[0.009]	[0.000]	
Dist. Trails (kms)	18.757	21.273	0.756	-0.007	0.002*	
	(15.727)	(17.651)	[1.169]	[0.009]	[0.001]	
Dist. Boundary (kms)	10.622	9.817	-0.508	-0.003	-0.002**	
	(8.941)	(8.777)	[0.352]	[0.010]	[0.001]	
Longitude	-106.364	-101.778	0.092	0.000	0.079**	
	(6.620)	(7.420)	[0.061]	[0.000]	[0.036]	
Latitude	44.535	45.674	0.010	-0.000	0.048	
	(3.651)	(2.021)	[0.015]	[0.000]	[0.074]	
Feature Size	105.439	100.060	4.963*	4.354***	0.000**	0.000***
	(60.213)	(61.147)	[2.747]	[1.315]	[0.000]	[0.000]
Observations	65,228	26,212	91,433	85,491	91,425	85,488

Notes: This table reports on baseline differences in land characteristics. Columns 1–2 present mean and standard deviations by land tenure. Column 3 reports differences conditional on reservations fixed effects, column 4 reports differences conditional on section fixed effects. Columns 5–6 apply a variable selection model to the same tuple of fixed effects. Significance levels are denoted by * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

To get a better handle on the residual differences, i.e. those differences that remain when we condition on all other differences, we also run a variable-selection model to tell us agnostically which land characteristics are most different across the two land-types in residual variation.[23] Columns 5–6 report the results of this exercise:. Variable selection models tend to reduce observed differences, by virtue of conditioning them on other observed differences which are often corre-

[23]For the mechanics of variable selection models, see for instance, Lindsey, Sheather, et al. 2010.

lated. This is true in column 5, and becomes even more true in column 6, where the model selects only five land characteristics as being meaningfully different between fee and trust once we condition on section fixed effects in the last column. Again, those differences are also significantly compressed in magnitude relative to column 3. Nonetheless, some imbalance obviously remains even in column 6, and this fact informs our empirical approach.

Figure 4 reports the results of estimating equation 1 for the two outcomes of interest, with 95 percent confidence intervals around each estimate. In both panels of this figure, columns 1–2 use reservations fixed effects, while columns 3–8 use section fixed effects.[24] In each block, the first specification (col 1 and 3) estimates OLS with only spatial fixed effects, and the second specification (col 2 and 4) adds the controls selected by the variable selection model in Table 1.[25] For the finer section fixed effect, we run a series of matching estimators. Column 5 runs a propensity-score matching estimator that matches on all controls selected by the variable selection model in Table 1. The remaining columns report on additional matching-estimator variations, first broadening the set of allowed matches that satisfy the common support restriction (col 6), and then using multi-dimensional matching through Mahalanobis distance matching on the same set of variables in columns 7 and 8 (Rosenbaum and Rubin, 1985). Across columns, we cluster standard errors at the reservation level.

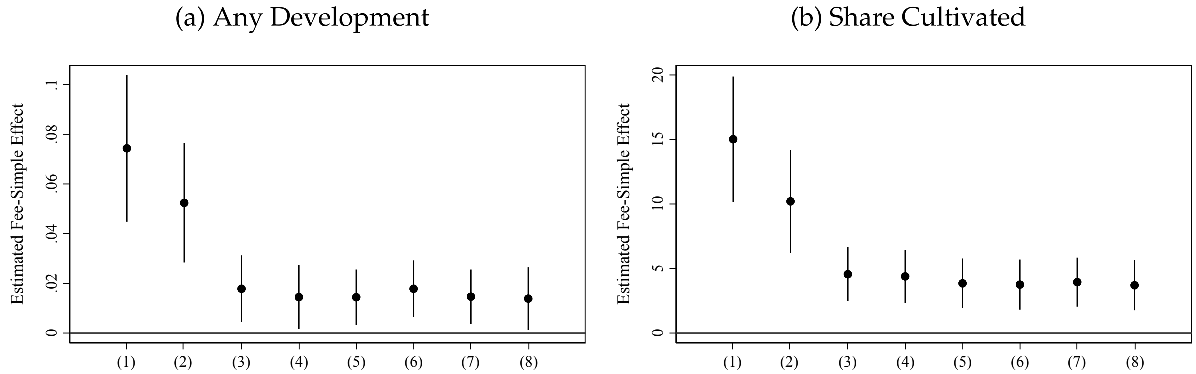
The key observation is that the results in both panels follow a "hockey stick" pattern: with reservation-level fixed effects, estimated coefficients change considerably with more controls. In contrast, once we move to the section fixed effects, estimated coefficients are unaffected by both the addition of controls and by various matching estimators. In the flat portion of the "hockey stick," Panel (a) suggests that transferable fee-simple status increases the probability of there being any non-agricultural development by 1.4 percentage points, and Panel (b) suggests that fee-simple status increases the share of land in agricultural cultivation by four percentage points.[26] Table A1 helps contextualize the magnitude of these results. Transferability leads to a 13 percent increase in the probability of development and a 35 percent increase in the share of cultivated land relative

[24] Every specification also includes feature-type fixed effects.

[25] Table A3 uses the specification from column 4 to assess the robustness of our results to potential spillovers from fee-simple land to trust land. Panel A demonstrates that trust plots with more fee simple neighbors do not have a higher probability of development, but they do have more cultivation, suggesting positive spillovers in agriculture that may bias our main estimates toward zero. Panel B confirms that our core results are robust to controlling for the number of neighboring fee parcels, a proxy for large spillovers.

[26] Estimates are reported in Table A2.

Figure 4: Transfer Restrictions and Land Use



	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Fixed Effects	Reserv.	Reserv.	Section	Section	Section	Section	Section	Section
Method	OLS	OLS	OLS	OLS	PSM	PSM	MD	MD
Neighbors	NA	NA	NA	NA	1	Any	1	Any
Match Vars	NA	NA	NA	NA	VSelect	VSelect	VSelect	VSelect
Covariates	None	VSelect	None	VSelect	None	None	None	None
Observations	91,431	91,425	85,488	85,488	91,440	91,440	91,440	91,440

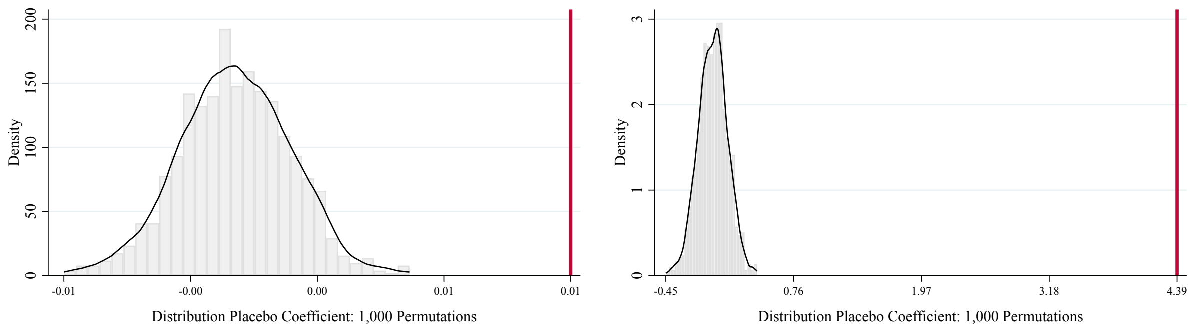
Notes: Both panels of this figure report on eight variations of estimating equation 1, for two separate outcomes. Columns 1–2 use reservations fixed effects, while columns 3–8 use section fixed effects. Every specification also includes feature-type fixed effects. In each block, the first specification (col 1 and 3) estimates OLS with only spatial fixed effects, and the second specification (col 2 and 4) adds the controls selected by the variable selection model in Table 1. For the finer section fixed effect, we run a series of matching estimators. Column 5 runs a propensity-score matching estimator that matches on all controls selected by the variable selection model in Table 1. The remaining columns report on additional matching-estimator variations, first broadening the set of allowed matches that satisfy the common support restriction (col 6), and then using multi-dimensional matching through Mahalanobis distance matching on the same set of variables in columns 7 and 8 (Rosenbaum and Rubin, 1985). Across columns, we cluster standard errors at the reservation level. The figure report 95 percent confidence intervals.

to the mean on allotted-trust plots.[27]

As an additional robustness check, we use randomization inference to rule out spuriously correlated effects through a permutation test. For this purpose, we replace the actual over $26,000$ fee-simple plots with an equal number of randomly drawn plots (from all plots), and then re-estimate our preferred specification from column 4 above with selected controls and section fixed effects. We repeat this experiment 1,000 times, comparing the distribution of the estimated placebo effects to the fee-simple effect. Figure 5 shows the result of this permutation exercise: the permuted distribution is centered around a mean of zero, and even the 99-th percentile of the distribution is far to the left of the actual estimates from column 4 of in Figure 4.

[27] Table A5 reports estimation results using the two alternative measures of development and cultivation discussed earlier. They reveal a similar "hockey stick" pattern to our preferred outcomes.

Figure 5: Randomization Inference



(a) Any Development

(b) Share Cultivated

Notes: The figure shows the distribution of 1,000 coefficients from randomization inference estimations where we replace the actual fee-simple plots with an equal number of randomly drawn plots. In contrast to the distribution, the vertical line shows the magnitude of the actual estimated coefficients from column 4 of Figure 4.

Selection on allottees A remaining challenge that is not addressed by our identification strategy so far is that allottees' characteristics (or actions) could have played a role in the BIA agents' historical decision to convert trust land into fee simple, and that these same characteristics or actions could have had some independent long-run effects on the their heirs' future land utilization. We address this concern by conditioning equation (1) on (reservation-specific) fixed effects for allottees' last names. This is common way of addressing unobservable productivity differences in the literature on land tenure and productivity; see e.g. Deininger and Ali (2008). This approach is particularly salient in an environment with strong family social ties, or where characteristics or decisions are clustered at the level of the family.

Our setting includes many large reservations, such that individuals with a common last name may not be directly related, or may be associated with physically distant and dissimilar plots. Indeed, the average number of observations per reservation-by-family-name group is 35. Therefore, as a final refinement we include family name-by-township fixed effects that identify the effect of fee simple property rights by comparing individuals with the same last name who received plots within the same 6×6-mile neighborhood. These finer fixed effects include an average of 5 observations per group.

The results of including family fixed effects are presented in Table 2. Columns 1 and 5 report the results with baseline section fixed effects results previously reported in column 3 of Figure 4.

Columns 2 and 6 introduce controls from the variable selection model. Columns 3 and 7 add the reservation level family-name fixed effects. Columns 4 and 8 include the family name-by-township fixed effects. Within each outcome, the Adjusted R^2 suggests that family-name fixed effects add considerable explanatory power to the regressions, but their effect on our core estimates is marginal, as the reported coefficients are qualitatively very similar to those in Figure 4.[28]

We formalize this intuition using the approach proposed by (Altonji et al., 2005; Oster, 2019): we report the estimated Oster δ for each model that includes control variables. This parameter corresponds to the proportional degree of selection on *unobservables* that would have to be present for $\hat{\theta}$ to be zero, based on the selection on *observables* estimated from the data. The estimated values suggest that selection on unobservables would have to be 13–27 times the estimated selection on our observed covariates to undermine the estimated effect for development (23–71 for cultivation).[29]

Table 2: Adding Fixed Effects for Allottees' Family Names

	Any Development				Share Cultivated			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
FeeSimple	0.018**	0.014**	0.015**	0.019**	4.558***	4.389***	4.515***	4.174***
	(0.007)	(0.007)	(0.008)	(0.009)	(1.053)	(1.037)	(1.263)	(1.232)
Oster δ		13.022	14.741	27.814		23.830	29.929	71.258
HAC SEs (25 kms)	(0.005)	(0.005)	(0.006)	(0.008)	(0.585)	(0.581)	(0.666)	(0.842)
HAC SEs (100 kms)	(0.006)	(0.005)	(0.006)	(0.007)	(0.782)	(0.774)	(0.903)	(1.013)
Adj. R^2	0.3539	0.3594	0.3928	0.4072	0.7697	0.7717	0.7933	0.8117
Observations	85,488	85,488	77,834	67,309	85,488	85,488	77,834	67,309
FE Type	Section	Section	Section	Section	Section	Section	Section	Section
# Spatial FEs	21,553	21,553	19,917	17,415	21,553	21,553	19,917	17,415
# Name FEs	0	0	9,509	17,209	0	0	9,509	17,209
Covariates	None	VSelect	VSelect	VSelect	None	VSelect	VSelect	VSelect

Notes: This table extends the OLS columns from Figure 4, where columns 3 and 6 add (reservation-specific) fixed effects for allottees' last names. Significance levels are denoted by * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Lastly, we provide evidence that our inference is not sensitive to our treatment of the standard errors. Our preferred approach clusters by reservation, allowing all plots within a reservation to be arbitrarily correlated. However, clustering in this manner may not match the extent of spatial spillovers, particularly among adjacent reservations, like those in Washington State and the

[28]The number of observations drops because of unique names among allottees within reservations.

[29]Following Oster (2019), we use a value of "rmax" that is 1.3 times the observed R^2 in the controlled regression where we condition on PLSS feature type and spatial fixed effects.

Southwest, where there are many neighboring reservations. In these instances, clustering may insufficiently address spatial correlation (Kelly, 2019, 2020). As an alternative, we report spatial HAC standard errors following Conley (2008) and Hsiang (2010) under two alternative distance thresholds. The first uses a 25 km threshold, that allows for narrow spillovers in space, while the second applies a 100 km threshold that allow for spillovers across a larger area (Smith, 2022). This larger threshold allows the error terms to be correlated across nearby but distinct reservations.

6 Mechanisms

As discussed in Section 3, the two main follow-on consequences of transfer-restrictions on U.S. reservations are that (*i*) land cannot be collateralized for credit, and that (*ii*) tenancy-in-common inheritance rules lead to a proliferation of heirs with partial claims on land, i.e. the fractionation of ownership, which in turn causes coordination and incentive problems over time. Without inter-generational fractionation, non-transferability should affect development primarily through the collatral channel (Panel B of Figure 1). And indeed, collateralizability has long been viewed as a significant impediment to investment on reservations (Community Development Financial Institutions Fund, 2001).[30]

Collateral Channel: To get at the collateral channel, we leverage the fact that the NWALT satellite data exist in five decadal waves (1974, 1982, 1992, 2002, and 2012) This allows us to perform a panel analysis, in which we exploit the opening of new banks over time to compare allotted-trust vs fee-simple plots on banked vs. un-banked reservations, based on the logic that on un-banked reservations the collateralizability benefits of fee simple land are muted or even non-existent. We estimate the following equation,

$$y_{ijt} = \sum_{t=1974}^{2012} \gamma_t (FeeSimple_i \times Unbanked_{rt} \times \tau_t) + \sum_{t=1974}^{2012} \psi_t (FeeSimple_i \times Banked_{rt} \times \tau_t) ...$$
$$+ \sum_{t=1974}^{2012} \delta_t (Unbanked_{rt} \times \tau_t) + \sum_{t=1974}^{2012} \rho_t (Banked_{rt} \times \tau_t) + \kappa_j + \kappa_j \times Banked_{rt} + \lambda' X_i + \varepsilon_{ijt}, \quad (2)$$

which introduces year fixed effects, τ_t, and a time varying indicators for whether a reservation has

[30]It also creates distortions. For example, Native Americans have by far the highest rate of mobile-home ownership in the U.S. because mobile homes can be repossessed whereas permanent structures built on trust land cannot be repossessed any more than the land itself (Treuer, 2012; Feir and Cattaneo, 2020).

access to banking, $Banked_{rt}$. The coefficients of interest are associated with the two main sets of interaction terms. The first set, $\sum_{t=1974}^{2012} \gamma_t (FeeSimple_i \times Unbanked_{rt} \times \tau_t)$, is a series of interactions between these year effects, the fee-simple indicator, and an indicator for whether a reservation is un-banked in year t. The parameters γ_t capture the difference between allotted-trust and fee-simple plots on un-banked reservations over time. The second set, $\sum_{t=1974}^{2012} \psi_t (FeeSimple_i \times Banked_{rt} \times \tau_t)$, is a series of interactions between the year fixed effects, the fee-simple indicator, and a time-varying indicator for whether a reservation is banked in year t. The ψ_t coefficients estimate the difference between fee-simple and allotted-trust plots on banked reservations. The specification also allows for flexible time paths for both banked and un-banked reservations by estimating both δ_t and ρ_t. Finally, the specification includes spatial fixed effects, κ_j and an interacted $\kappa_j \times Banked_{rt}$ fixed effect. Standard errors are clustered by both plot and year.

An additional advantage of the panel data structure is that it allows us to let κ_j be *plot* fixed effects, where $j = i$, and thus absorb all unobserved differences in time-invariant characteristics between allotted-trust and fee-simple plots. We consider both land development and the share of land cultivated as outcomes, but hypothesize that the collateralizability and credit-access channel should curtail development more than agriculture because building structures is much more capital-intensive than agricultural cultivation (De Soto, 2000), and because allotted-trust lands can, at least in principle, be leased to outsiders for cultivation.

To create a measure of whether a reservation is banked, we collect information on two kinds of financial institutions. The first class includes specialized *Native Community Development Financial Institutions* (NCDFIs), whose business is geared towards helping Native-owned businesses on reservations. Specifically, the Fed characterizes a bank as an NCDFI if more than 50% of its business is with Native Americans. We obtain data on all NCDFIs from the Federal Reserve's Center for Indian Country Development (CICD), and determine whether each reservation has at least one NCDFI within ten miles of its border in each decade, based on the banks' opening dates.

Because the classification of banks as NCDFI's is not necessarily defined at the branch level, it may miss some reservation-serving branches of regional banks that do significant on-reservation business at the branch level that is ultimately dwarfed by off-reservation transactions across the bank's entire network. We therefore augment the NCDFI measure with the stock of all banks within reservation boundaries in each decade. We obtain data on the opening dates and precise locations of all commercial banks from the *Federal Deposit Insurance Corporation* (FDIC), to determine which banks opened within a reservation, and when. Our resulting variable, $Banked_{rt}$ is equal to one if reservation r has an FDIC bank within its borders *or* a NCDFI within ten miles in year t. Figure A6 shows the expansion of these banks in our data over time. In the early 1970s, less than 25 percent of reservations in our sample were banked, but by 2012 that more than doubled.

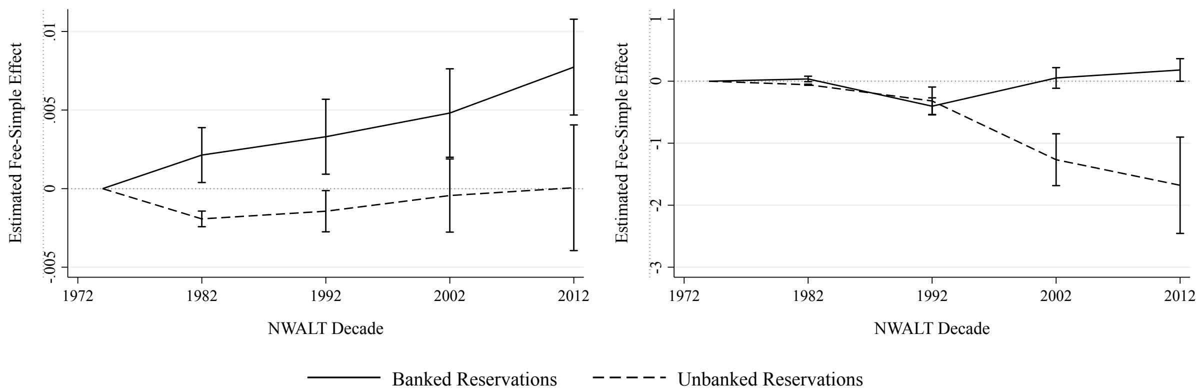
Figure 6 depicts the results of estimating equation 2 for developed and cultivated land use with plot fixed effects by graphing the estimated effect of fee-simple title on land use for banked (solid) and un-banked (dashed) plots relative to allotted plots on reservations of the same banking exposure. With plot fixed effects, estimates for both banked and un-banked reservations in 1974 are excluded and each estimated line reflects the relative difference between fee-simple and allotted plots within banking exposure type relative to 1974.

Panel (a) shows a consistent and monotonic divergence between fee-simple and allotted-trust plots on *banked* reservations, in contrast to a relatively flat trend over time for *un-banked* reservations, and relative to their 1974 difference. This finding provides evidence for the importance of collateralizibility for development, because it suggests that the differences between fee-simple and allotted-trust lands become much less pronounced on un-banked reservations where neither type of land can functionally be used as collateral.

Table A4 reports the estimation results from a modified equation 2, using section instead of plot fixed effects. The results in columns 1 and 2 confirm the visual differences in panel (a) of Figure 6, where development differences between fee-simple and trust land are concentrated in banked reservations. Table A4 also shows that there were differences in development between fee-simple and trust plots in 1974 (column 1) on banked reservations, but not on unbanked reservations.

Panel (b) of Figure 6 depicts the results for cultivated land use. Qualitatively, the results are similar to development insofar as there are significant differences between the effect of fee-simple property rights on banked vs. un-banked reservations that appear to be increasing over time. Two critical differences stand out, however. First, the differences between banked and un-banked reservations do not materialize until 2002. Column 3 of Table A4 highlights that there were significant differences in cultivation between fee-simple and allotted trust plots in 1974 and that those differences were slightly larger on banked reservations, but those early differences between banked and un-banked reservations remained unchanged until the early 2000s. Second, beginning in the

Figure 6: The Collateralizability Channel



Notes: The two panels plot the estimated coefficients of interest from equation 2 specifying the change in the estimated differences between fee simple and allotted trust between banked (solid) and unbanked (dashed) reservations for each outcome relative to 1974. The figure plots separate coefficients for each available NWALT year and includes 95 percent confidence intervals.

early 2000s, the share of cultivated land levels off and ceases to grow for both fee-simple and allotted-trust plots on banked reservations. In contrast, there is a post-2000 increase in the share of cultivated land for allotted-trust plots relative to fee-simple plots on *unbanked* reservations.

The leveling off of cultivated land for banked reservations is likely explained by the general trend of structural transformation on reservations over this period, where reservation economies diversified out of their focus on agriculture to include a variety of other industries.[31] The fact that cultivation continued to grow on trust land on *unbanked* reservations may be explained by the fact that the BIA overhauled regulations governing the pricing and enforcement of leases after these factors were identified as impediments to agriculture on trust land in the 1990s.[32]

Fractionation Channel: To get at the second channel, we must overcome the fact that we cannot measure fractionation directly because land ownership records are kept confidential by the BIA.[33] Instead, we construct a measure of a plot's *latent* potential for fractionation using

[31] While until early 1970s, practically *all* economic activity on reservations was agricultural (Carlson, 1981; Trosper, 1978; Anderson and Lueck, 1992), the *Harvard Project on American Indian Economic Development* has carefully documented the subsequent emergence of wide-ranging manufacturing activities in electronics, cement, fish canneries, saw mills, and auto parts, as well services, particularly a variety of tourism activities (two Apache reservations each run their own ski resorts) (Cornell and Kalt, 1987, 1992). In 1988, Congress passed the Indian Gaming and Regulatory Act. While only a handful of reservations have grown rich from gambling, many have used the modest but steady casino revenues to finance and encourage the development of other businesses (Jorgensen 2007, Treuer 2012, ch6).

[32] See https://www.gao.gov/products/rced-99-165.

[33] These records are managed by the BIA through the so-called *Trust Asset Accounting Management System*.

a newly digitized historical reservation census, the mid-1930s *Indian Census Rolls* (ICR), which contains allotment information. Specifically, we assume that allotments that we cannot find in the mid-1930s *Indian Census Rolls* (ICR) belonged to allottees that had already passed away by then, implying that those allotments were more likely to become highly fractionated over time because the process of fractionation started earlier and because earlier deaths were more likely to occur without a will, as discussed in Section 2. We validate this assumption in Appendix D.2, where we show that *(i)* sequential allotment numbers are highly correlated with age within a reservation and *(ii)* it is systematically the early allotment numbers that we cannot find in the ICR. (See Figure A7.).

Let the indicator "D(not in ICR)$_i$" denote whether plot i's allotment number can be found in the mid-1930s ICR. This indicator is similarly distributed across fee-simple and allotted-trust lands: we match 47 percent of all fee-simple plots and 40 percent of all allotted-trust plots to the ICR. Given the evidence in Figure A7, we interpret this indicator as a measure of latent or potential fractionation, which we use in the absence of observable plot-level measures of fractionation. We gain confidence in this interpretation from relating the indicator to reported two reservation-aggregate measures of fractionation. First, we digitized a 1935 land tenure report, which included information on the number and acreage associated with deceased allottees (Office of Indian Affairs, 1935). These acreage totals are highly correlated (0.944) with our own estimated deceased acreages based our latent fractionation. Second, we obtain from a 2013 BIA report the total acreage of tracts subject to fractionation on each reservation. Figure A8 shows that the extent of modern fractionation correlates well with our plot-level measures of latent fractionation when they are aggregated to the reservation level.

We construct an additional, complementary measure of latent fractionation for plots that we *do* match to the ICR. If we do observe a plot's owner in the ICR, then we know their age directly. For plots whose owners are still alive in the 1930s, we would expect the latent potential for fractionation to be higher on plots whose owners are older than those whose owners are younger, because there is more potential for additional generation turnover between the 1930s and today if owners were nearer to death in the 1930s. Hence, our second measure of latent fractionation is a dummy that is equal to one if a plot's owner was born before 1864.[34]

We then interact both alloted-trust and fee-simple indicators with our latent fractionation indi-

[34] In cases where there are multiple owners associated with a plot, we use the earliest birth year.

cators to test whether they mattered on allotted- trust parcels , but not on fee-simple land (where wills could be written and inheritance could be handled in the same way as on off-reservation land). We estimate a modified version of our preferred specification of equation (1) with section fixed effects using the 2012 NWALT cross-section:

$$
\begin{aligned}
y_{ij} = \theta \times \text{FeeSimple}_i + \quad & \theta^T_{\text{frac}} \times \text{Trust}_i \times \text{D(Latent Frac)}_i + \\
& \theta^F_{\text{frac}} \times \text{FeeSimple}_i \times \text{D(Latent Frac)}_i + \kappa_j + \lambda' X_i + \varepsilon_{ij},
\end{aligned} \tag{3}
$$

where our hypothesis is that $\theta^T_{\text{frac}} < 0$, and $\theta^F_{\text{frac}} = 0$, because latent fractionation is much more likely to cause actual fractionation on allotted-trust plots than on fee-simple plots for the reasons discussed at the end of Section 2.

Hence, we test for the fractionation channel at the *intensive margin*, i.e. by comparing allotted-trust plots of differing degrees of fractionation to one another. Russ and Stratmann (2014) show that the extent of fractionation on an allotment negatively impacts agricultural *income*, and we hypothesize that a similar effect might be observable for land utilization. We expect any effect of fractionation to be concentrated in agriculture because all allotted-trust plots lack access to the credit needed to finance development, regardless of how fractionated they are. In agriculture, by comparison, fractionation increases the transaction costs of reaching leasing agreements as well as agreement on the various recurring decisions involved in agricultural land use (e.g., crop choice, irrigation strategies, and fallowing rotations).

Table 3 shows the results of estimating equation (3). Focusing first on columns 1 and 3, we see that our hypotheses are borne out: when y_{ij} is a plot's share of land under agricultural cultivation; $\widehat{\theta^T_{\text{frac}}} < 0$, and $\widehat{\theta^F_{\text{frac}}} = 0$, implying that allotted-trust parcels with higher latent fractionation see less agricultural cultivation than allotted-trust parcels with lower latent fractionation (the omitted category). Moreover, the difference in latent fractionation is not important for fee-simple plots (as predicted). When y_{ij} is the development indicator, both interactions are near zero and statistically insignificant, consistent with the fractionation problem being secondary to the collateralization problem for development. Columns 2 and 4 show broadly similar results when we also include our second measure of latent fractionation that is based on age.

Table 3: The Fractionation Channel

	Any Development		Share Cultivated	
	(1)	(2)	(3)	(4)
FeeSimple	0.021**	0.020**	4.533***	4.568***
	(0.010)	(0.010)	(1.021)	(1.123)
Trust × D(Latent Frac, Deceased)	-0.001	-0.001	-0.622*	-0.681*
	(0.004)	(0.004)	(0.350)	(0.364)
Fee Simple × D(Latent Frac, Deceased)	-0.010	-0.009	0.349	0.249
	(0.013)	(0.013)	(0.749)	(0.782)
Trust × D(Latent Frac, Elderly)		0.011		-0.705*
		(0.010)		(0.417)
Fee Simple × D(Latent Frac, Elderly)		0.012		-1.026
		(0.015)		(1.456)
Adj. R^2	0.3489	0.3489	0.7818	0.7818
Observations	66,020	66,020	66,020	66,020
Fixed Effects	Section	Section	Section	Section
#Fixed-Effects	16,969	16,969	16,969	16,969
Covariates	VSelect	VSelect	VSelect	VSelect

Notes: The table reports results from estimating equation 3 for the two outcomes of interest. Columns 1 and 3 report results with a single binary interaction term for latent fractionation based on the likelihood the allottee is deceased by 1934. Columns 2 and 4 introduce an additional binary measure of latent fractionation that identifies elderly allottees. Other elements in the model follow from the preferred OLS specification in column 5 of Figure 4.

7 Conclusion

This paper estimates the long-run cost of non-transferable property rights, comparing land without transfer rights to land with full property rights on Native American reservations from 1974 to today. We leverage a natural experiment in the allocation of property rights to individual households in the early part of the 20th century that left a patchwork of different land tenures on reservations which persists to the present day. We find that the probability of developed land use is about 1.4 percentage points higher on fee-simple land than on non-transferable trust land. Similarly, we find that the share of land cultivated is about 4percentage points higher on fee-simple land than on trust land. We provide evidence that transfer restrictions affect land use through *at least* two channels: reduced access to credit and problems associated with competing ownership claims. External credit conditions accentuate the difference between allotted-trust and fee-simple plots, and this difference primarily affects development. We also find that an exogenous predictor of ownership-fractionation inhibits agricultural land use on allotted-trust plots (where it cannot be resolved) but not on fee-simple plots (where it can).

It is important to be careful when considering the implications of these findings. Our results suggest that converting allotted-trust land to full fee-simple individual property rights would generate significant economic gains. However, the alternative—returning allotted-trust land to tribal control—could also deliver some efficiency gains by freeing land from individual credit constraints and by reducing fraction. There is evidence that tribal land outperforms individual trust land from previous case studies (e.g., Leonard and Parker 2021). Returning land to tribal control may also better safeguard the territorial integrity of tribes' land base that converting allotted-trust lands to fee simple. This creates tradeoffs.

From a practical standpoint, there is a workable precedent for conversion to tribal control because it is already happening on some reservations: under the 2014 'Cobell settlement', the Department of Interior (DOI) has been allocated 1.9 billion dollars to buy fractionated allotted-trust claims and return them to tribal control, in close consultation with tribes.

In contrast, conversion to fee simple is legally challenging under the 1934 IRA and there remains the practical difficulty of untangling the potentially hundreds of claims on some plots. Fortunately, there is a related legal precedent that is paving the way for changing this: the *Uniform Law Commission*'s *Uniform Partition of Heirs Property Act* (UPHPA) has recently been enacted into law in 14 states for the purpose of untangling fractionated claims on heir's property (Mitchell, 2019). Given the similarities between heir's property and allotted-trust land discussed in Section 3, legal statutes modeled on the UPHPA could be applied to untangling claims on reservations, and the ULC is actively working on a uniform Indian probate code to apply to reservations.

Lastly, it is worth noting that any movement away from allotted-trust land need not be a binary choice. One can imagine giving owners of trust land fully transferable property rights (thus maximizing the value from these lands) but leaving it to tribes to decide whether this transferability should extend only within the tribe or beyond. Mexico's second land reform (*Procede*) offers a useful template in this regard: from 1993–2006, indigenous farmers were given full title to the land that they had long held usufruct rights to, but it was the communities *ejidos* who then decided whether these rights would be transferable only within the ejido or whether land could also be transferred to non-ejidatarios (De Janvry et al., 2015). We see such a solution as eminently workable on American Indian reservations.

References

Akee, R. (2009). Checkerboards and Coase: The Effect of Property Institutions on Efficiency in Housing Markets. *The Journal of Law and Economics 52*(2), 395–410.

Akee, R. and M. Jorgensen (2014). Property Institutions and Business Investment on American Indian Reservations. *Regional Science and Urban Economics 46*, 116–125.

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.

Allen, D. W. and B. Leonard (2021). Property Right Acquisition and Path Dependence: Nineteenth-Century Land Policy and Modern Economic Outcomes. *The Economic Journal 131*(640), 3073–3102.

Alston, E., L. J. Alston, B. Mueller, and T. Nonnenmacher (2018). *Institutional and Organizational Analysis: Concepts and Applications*. Cambridge University Press.

Alston, L. J. and J. P. Ferrie (2012). Family Matters: The Agricultural Ladder, Inheritance, and Rural-to-Urban Capital Mobility. *NBER working paper*.

Alston, L. J., G. D. Libecap, and B. Mueller (2000). Land Reform Policies, the Sources of Violent Conflict, and Implications for Deforestation in the Brazilian Amazon. *Journal of environmental economics and management 39*(2), 162–188.

Altonji, J. G., T. E. Elder, and C. R. Taber (2005). Selection on observed and unobserved variables: Assessing the effectiveness of catholic schools. *Journal of political economy 113*(1), 151–184.

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

Anderson, T. L. and D. Lueck (1992). Land Tenure and Agricultural Productivity on Indian Reservations. *The Journal of Law and Economics 35*(2), 427–454.

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 (2020). Property Rights on First Nations' Reserve Land. *Canadian Journal of Economics 53*.

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.

Atack, J. (2016). "Historical Geographic Information Systems (GIS) Database of U.S. Railroads for 1860-1911". https://my.vanderbilt.edu/jeremyatack/data-downloads/.

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.

Besley, T. (1995). Property Rights and Investment Incentives: Theory and Evidence from Ghana. *Journal of Political Economy 103*(5), 903–937.

Besley, T. and M. Ghatak (2010). Property Rights and Economic Development. In *Handbook of Development Economics*, Volume 5, pp. 4525–4595. Elsevier.

Besley, T. J., K. B. Burchardi, and M. Ghatak (2012). Incentives and the de Soto Effect. *The Quarterly Journal of Economics 127*(1), 237–282.

Brasselle, A.-S., F. Gaspart, and J.-P. Platteau (2002). Land Tenure Security and Investment Incentives: Puzzling Evidence from Burkina Faso. *Journal of Development Economics 67*(2), 373–418.

Burchfield, M., H. G. Overman, D. Puga, and M. A. Turner (2006). Causes of Sprawl: A Portrait from Space. *The Quarterly Journal of Economics 121*(2), 587–633.

Bureau of Indian Affairs (1887-1926). Annual Reports of the Commissioner of Indian Affairs .

Carlson, L. A. (1981). *Indians, Bureaucrats, and Land: the Dawes Act and the Decline of Indian Farming*. Number 36. Praeger Pub Text.

C.F.R.150.1-150.11 (1981). *Code of Federal Regulations*.

Community Development Financial Institutions Fund (2001). The Report of the Native American Lending Study. Technical report, U.S. Department of the Treasury.

Conley, T. G. (1999). GMM Estimation with Cross Sectional Dependence. *Journal of Econometrics 92*(1), 1–45.

Conley, T. G. (2008). Spatial Econometrics. In *The New Plagrave Dictionary of Economics*.

Cornell, S. and J. P. Kalt (2007). Two Approaches to the Development of Native Nations: One Works, the Other Doesn't. In M. Jorgensen (Ed.), *Rebuilding Native Nations: Strategies for Governance and Development*. University of Arizona Press.

Cornell, S. E. and J. P. Kalt (1987). *The Redefinition of Property Rights in American Indian Reservations: a Comparative Analysis of Native American Economic Development*, Volume 3. Malcolm Wiener Center for Social Policy, John F. Kennedy School of . . . .

Cornell, S. E. and J. P. Kalt (1992). *What Can Tribes Do? Strategies and Institutions in American Indian Economic Development*. American Indian Studies Center, UCLA.

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.

Deininger, K. and D. A. Ali (2008). Do Overlapping Land Rights Reduce Agricultural Investment? Evidence from Uganda. *American Journal of Agricultural Economics 90*(4), 869–882.

Demsetz, H. (1967). Toward a Theory of Property Rights. *American Economic Review 62*, 347–359.

Department of Interior (2013). Updated Implementation Plan: Land Buy-Back Program for Tribal Nations.

Dippel, C. (2014). Forced Coexistence and Economic Development: Evidence from Native American Reservations. *Econometrica 82*(6), 2131–2165.

Dippel, C., D. Frye, and B. Leonard (2022). Bureaucratic discretion in policy implementation: evidence from the allotment era. *Public Choice*, 1–19.

Ellickson, R. C. (1993). Property in Land. *Yale Law Journal*, 1315–1400.

Feir, D. and L. Cattaneo (2020). The Price of Mortgage Financing for Native Americans. *Journal of Race, Economics, and Policy, Forthcoming*.

Fenske, J. (2011). Land Tenure and Investment Incentives: Evidence from West Africa. *Journal of Development Economics 95*(2), 137–156.

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 (2022). Are there too many farms in the world? labor market transaction costs, machine capacities, and optimal farm size. *Journal of Political Economy 130*(3), 636–680.

Ge, M., E. C. Edwards, and S. B. Akhundjanov (2019). Irrigation Investment on an American Indian Reservation. *American Journal of Agricultural Economics*.

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.

Habakkuk, H. J. (1955). Family Structure and Economic Change in Nineteenth-Century Europe. *The Journal of Economic History 15*(1), 1–12.

Herrendorf, B., R. Rogerson, and A. Valentinyi (2014). Growth and Structural Transformation. In *Handbook of economic growth*, Volume 2, pp. 855–941. Elsevier.

Holmes, T. J. and S. Lee (2012). Economies of Density versus Natural Advantage: Crop Choice on the Back Forty. *Review of Economics and Statistics 94*(1), 1–19.

Hornbeck, R. (2010). Barbed Wire: Property Rights and Agricultural Development. *The Quarterly Journal of Economics 125*(2), 767–810.

Hsiang, S. M. (2010). Temperatures and Cyclones Strongly Associated with Economic Production in the Caribbean and Central America. *Proceedings of the National Academy of sciences 107*(35), 15367–15372.

Huntington, H. and A. Shenoy (2021). Does insecure land tenure deter investment? evidence from a randomized controlled trial. *Journal of Development Economics 150*, 102632.

Johnson, R. N. and G. D. Libecap (1980). Agency Costs and the Assignment of Property Rights: The Case of Southwestern Indian Reservations. *Southern Economic Journal*, 332–347.

Jorgensen, M. (2007). *Rebuilding Native Nations: Strategies for Governance and Development*. University of Arizona Press.

Kelly, M. (2019). The Standard Errors of Persistence. Technical report.

Kelly, M. (2020). Understanding Persistence.

Leonard, B. and D. Parker (2021). Fragmented Ownership and Natural Resource Use: Evidence from the Bakken. *Economic Journal*.

Leonard, B., D. P. Parker, and T. L. Anderson (2020). Land quality, land rights, and indigenous poverty. *Journal of Development Economics 143*.

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.

Libecap, G. D. and R. N. Johnson (1980). Legislating Commons: The Navajo Tribal Council and the Navajo Range. *Economic Inquiry 18*(1), 69–86.

Lindsey, C., S. Sheather, et al. (2010). Variable selection in linear regression. *Stata Journal 10*(4), 650.

Massey, C. and A. M. Carlos (2019). Reindeer and Aboriginal Economic Development: Alaska 1940.

McChesney, F. S. (1990). Government as Definer of Property Rights: Indian Lands, Ethnic Externalities, and Bureaucratic Budgets. *The Journal of Legal Studies 19*(2), 297–335.

McConnell, J. (1919). *McConnell's Historical Maps of the United States*. McConnell Map Co. Retrieved from Library of Congress, https://www.loc.gov/item/2009581130/.

Meriam, L. (1928). *The Problem of Indian Administration: Report of a Survey Made at the Request of Honorable Hubert Work, Secretary of the Interior*. Number 17. Johns Hopkins Press.

Migot-Adholla, S., P. Hazell, B. Blarel, and F. Place (1991). Indigenous Land Rights Systems in Sub-Saharan Africa: a Constraint on Productivity? *The World Bank Economic Review 5*(1), 155–175.

Mitchell, T. W. (2019). Historic Partition Law Reform: A Game Changer for Heirs' Property Owners. *Texas A&M University School of Law Legal Studies Research Paper No. 19-27*.

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.

Oster, E. (2019). Unobservable Selection and Coefficient Stability: Theory and Evidence. *Journal of Business & Economic Statistics 32*(2), 187–204.

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

Place, F. and B. M. Swallow (2000). Assessing the Relationship between Property Rights and Technology Adoption in Smallholder Agriculture: A Review of Issues and Empirical Methods. Technical report.

Prism Climate Group (2014). Oregon state u. https://prism.oregonstate.edu/. [Accessed Jan 2020].

Rose-Ackerman, S. (1985). Inalienability and the Theory of Property Rights. *Columbia Law Review 85*(5), 931–969.

Rosenbaum, P. R. and D. B. Rubin (1985). Constructing a control group using multivariate matched sampling methods that incorporate the propensity score. *The American Statistician 39*(1), 33–38.

Russ, J. and T. Stratmann (2014). Creeping Normalcy: Fractionation of Indian Land Ownership. *CESifo Working Paper No. 4607*.

Saiz, A. (2010). The Geographic Determinants of Housing Supply. *The Quarterly Journal of Economics 125*(3), 1253–1296.

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.

Shumway, S. B. (2017). Intestacy law - the dual generation dilemma - wyoming 's interpretation of its 130-year-old intestacy statute - matter of fosler. *Wyoming Law Review*, 641–674.

Smith, C. (2022). Land concentration and long-run development in the frontier united states. Technical report, Mimeo.

Stainbrook, C. (2016). Message from the indian land tenure foundation president.

Taylor, G. D. (1980). *The New Deal and American Indian Tribalism: The Administration of the Indian Reorganization Act, 1934-45*. U of Nebraska Press.

Treuer, D. (2012). *Rez Life: An Indian's Journey Through Reservation Life*. Grove/Atlantic, Inc.

Treuer, D. (2019). *The Heartbeat of Wounded Knee: Native America from 1890 to the Present*. Riverhead Books.

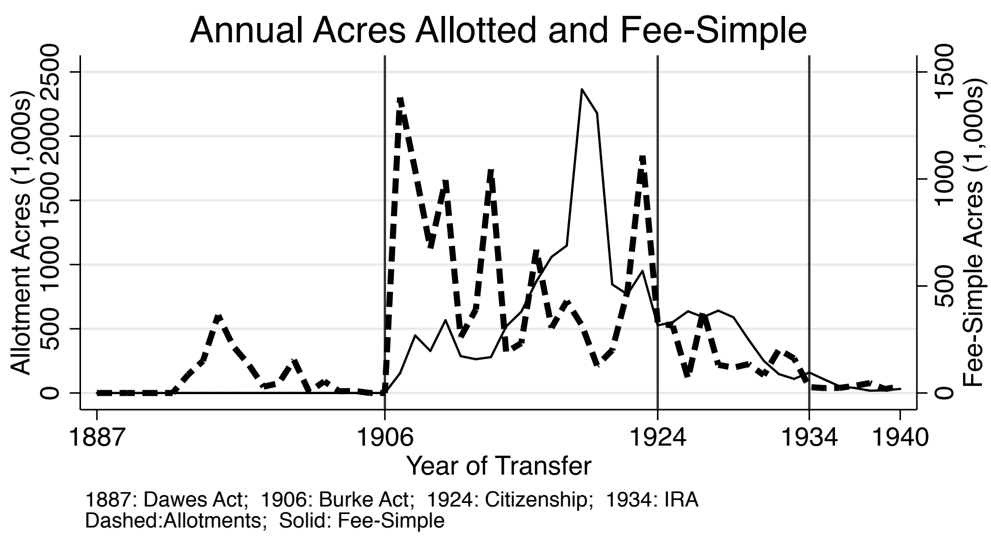
Trosper, R. L. (1978). American Indian Relative Ranching Efficiency. *The American Economic Review 68*(4), 503–516.

U.S. Geological Survey (2019). National hydrography dataset (ver. usgs national hydrography dataset best resolution (nhd) for hydrologic unit (hu) 4 - 2001 (published 20191002)). https://www.usgs.gov/national-hydrography/national-hydrography-dataset. [Created Feb 2014. Accessed Jan 2020].

Appendix A   Appendix to Section 2

Figure A1 is reproduced from Dippel, Frye, and Leonard (2022) and tracks the flow of total acres that were allotted and the flow of acres subsequently converted into fee simple in the BLM data; discussed in Section 2.

Figure A1: Flow of Allotments and Transfers into Fee Simple



Notes: This figure is reproduced from Dippel et al. (2022) and tracks the flow of total acres that were allotted and the flow of acres subsequently transferred into fee simple in the BLM data.

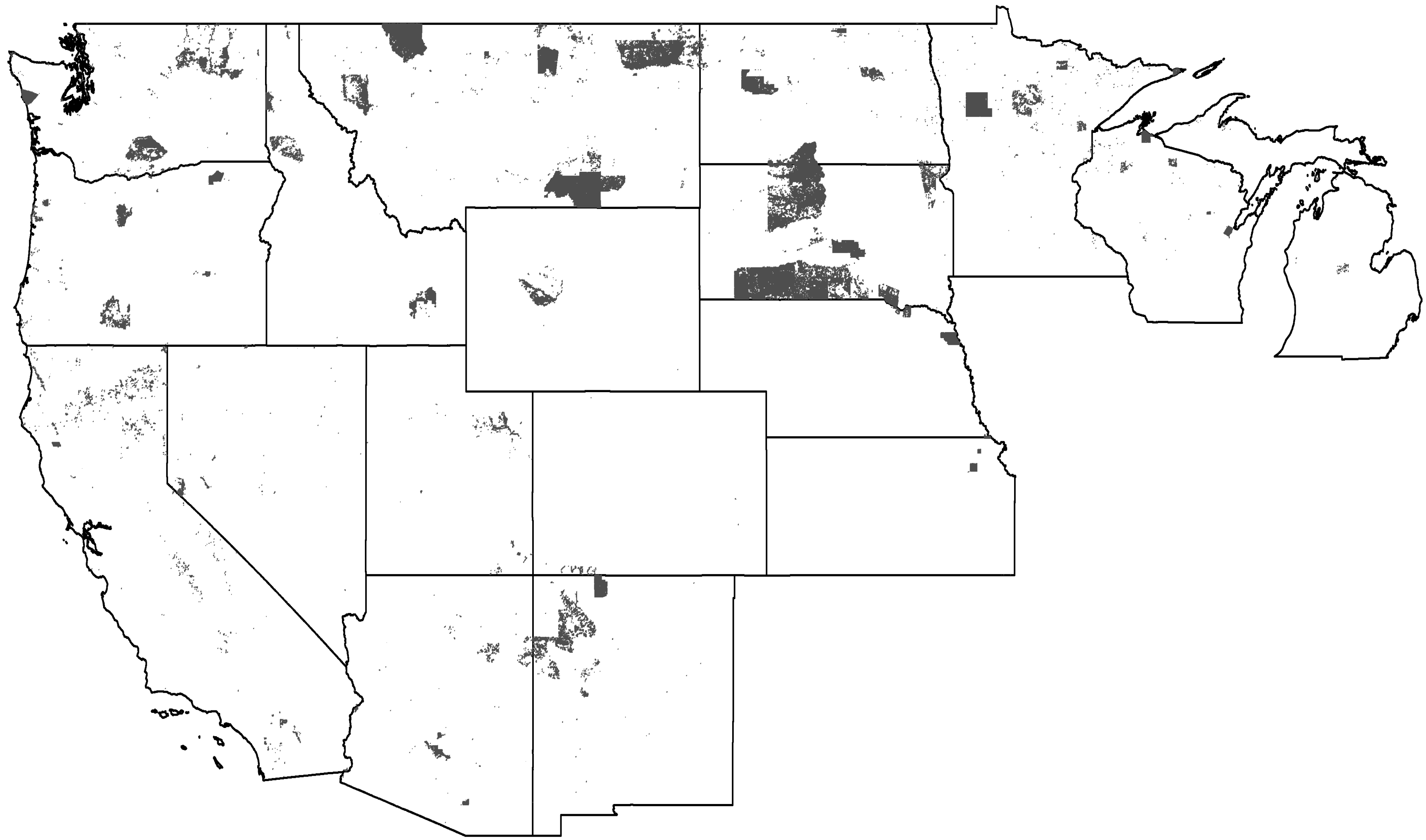
Appendix B Appendix to Section 4

Figure A2 depicts the location of allotments matched to 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. Oklahoma, which is in fact densely covered by allotments, is the only gap in our spatial allotment data.[35] 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 under an alternative allotment agreement however, these allotments were not filed with the General Land Office because the land was already owned in fee-simple by the tribes at the time of allotment. We exclude the Western Oklahoma and the Osage reservation because allotments outside of the Five Civilized Tribes were not consistently categorized as 'Indian Patents' by the BLM.

Figure A3 shows a version of Figure 2 where we separately identify surplus land inside the reservation. (The vast majority of surplus lands lies outside of reservations, because it was ceded from reservations as large tracts.) The larger black outlines are the boundaries of 6×6-mile PLSS townships.

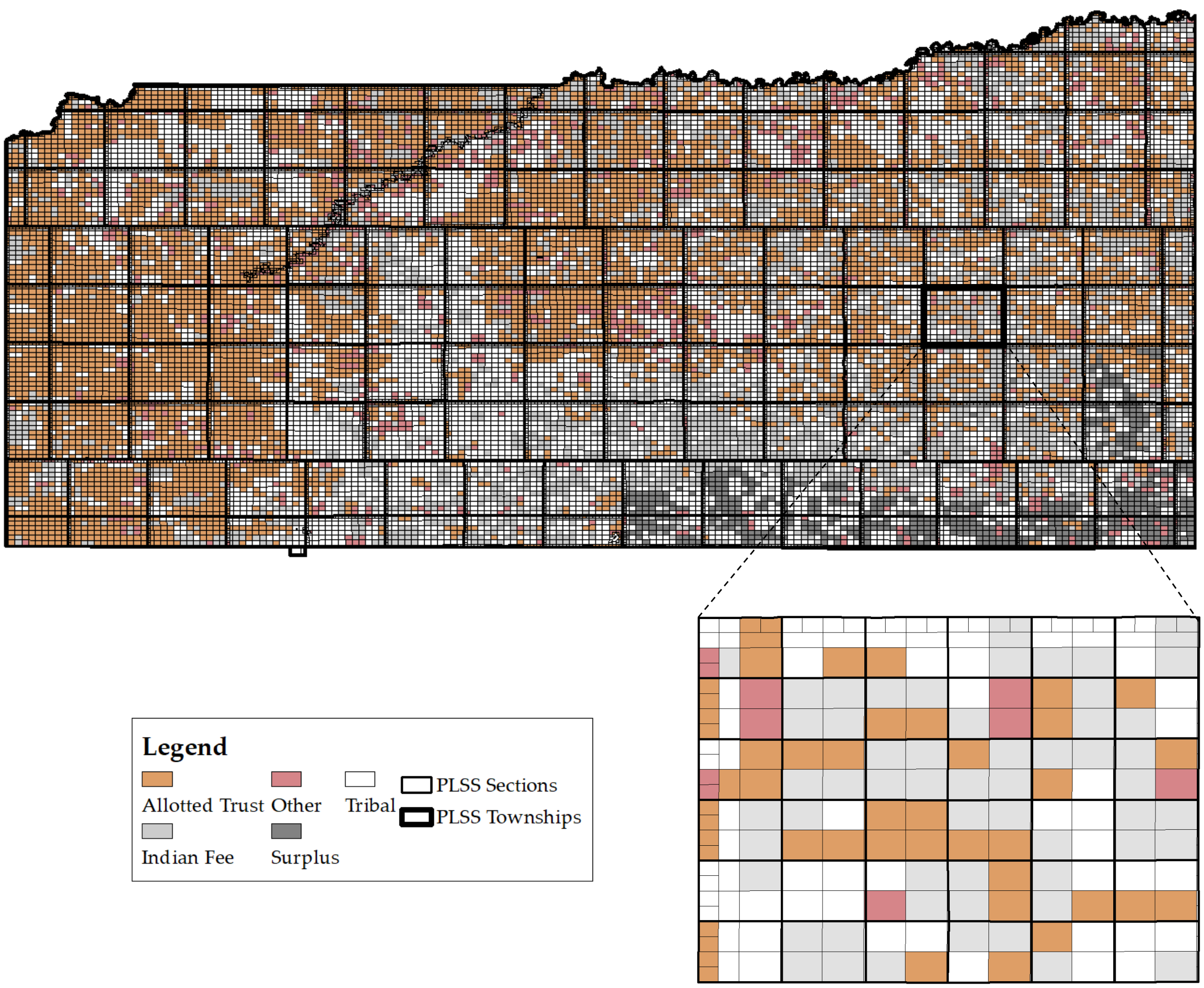
[35] Our match rate is above 99% for most states, with notably lower match rates for New Mexico (where the PLSS grid is less cleanly defined) and Wisconsin.

Figure A2: Allotted Quarter Sections



Notes: This figure depicts the location of allotments across the U.S. The main omission is Oklahoma, where the Five Civilized Tribes (and the Osage) were allotted, but their allotments where not included in the GLO data. The parcels depicted include land in allotted-trust as well as fee-simple lands.

Figure A3: Checkerboard Pattern of Land Tenure on the Pine Ridge Reservation



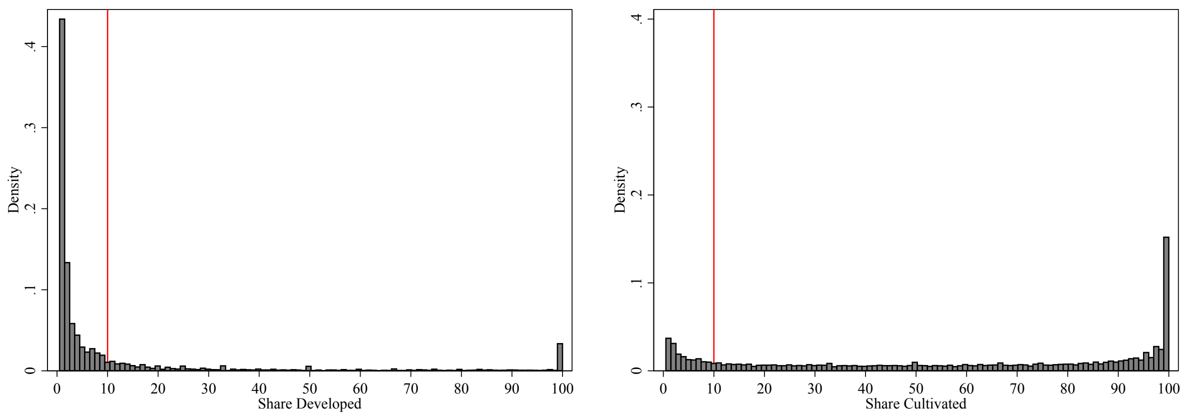
Notes: Distribution of Land tenure on the Pine Ridge reservation by allotment parcel (quarter-section) in the GLO data. Overlaying the reservation is a township grid. Each township is 36 square miles and contained in each are 144 ($= 36 \times 4$) quarter sections, each of which is 160 acres (one-quarter of a square mile) large.

Appendix C   Appendix to Section 5

Figure A4: Distribution of Land Use by Major Type

(a) Developed Land Use

(b) Cultivated Land Use



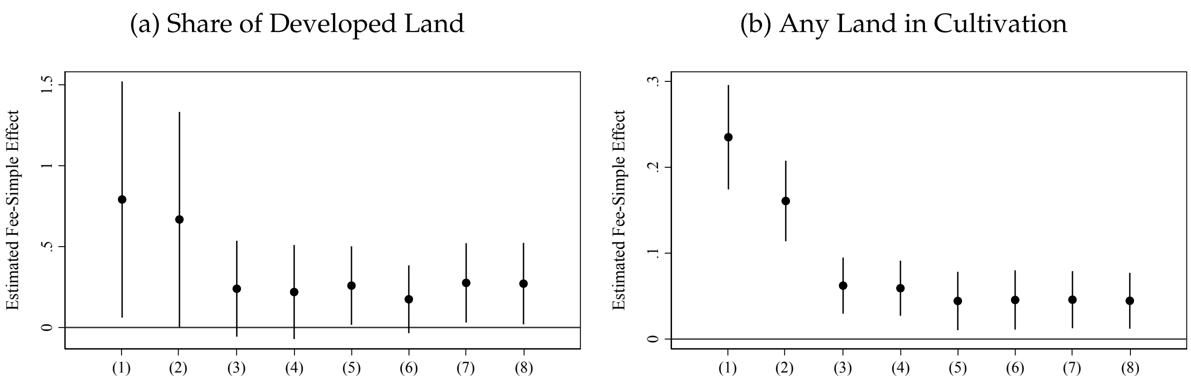
Notes: This figured depicts the histograms of the share of developed land use (panel a) and cultivated land use (panel b) across plots in our data. The red line in each figure indicates 10% of pixels devoted to a given land use.

Table A1: Land Use Differences in 2012

	(1)	(2)	(3)	(4)	(5)
			Difference: Fee - Trust		
	Trust	Fee	No FE	Res FE	Sect FE
Any Development	0.106	0.202	0.096***	0.077***	0.020***
	(0.308)	(0.402)	[0.018]	[0.014]	[0.007]
Share Cultivated	11.153	31.471	20.318***	15.134***	4.600***
	(27.562)	(39.426)	[2.521]	[2.486]	[1.052]
Share Developed	1.038	2.641	1.603	0.776**	0.231
	(7.360)	(12.796)	[1.090]	[0.365]	[0.149]
Any Cultivation	0.206	0.515	0.309***	0.238***	0.064***
	(0.405)	(0.500)	[0.029]	[0.032]	[0.016]
Observations	65,228	26,212	91,440	91,433	85,491

Notes: This table reports differences in land use by tenure type. Columns 1–2 present mean and standard deviations by land tenure. Column 3 reports unconditional differences, column 4 reports differences conditional on reservations fixed effects, column 5 reports differences conditional on section fixed effects. Standard errors are clustered at the reservation level and reported in brackets. Significance levels are denoted by * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Figure A5: Alternative Measures of Land Use



	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Fixed Effects	Reserv.	Reserv.	Section	Section	Section	Section	Section	Section
Method	OLS	OLS	OLS	OLS	PSM	PSM	MD	MD
Neighbors	NA	NA	NA	NA	1	Any	1	Any
Match Vars	NA	NA	NA	NA	VSelect	VSelect	VSelect	VSelect
Covariates	None	VSelect	None	VSelect	None	None	None	None
Observations	91,431	91,425	85,488	85,488	91,440	91,440	91,440	91,440

Notes: Both panels of this figure report on eight variations of estimating equation 1, for two separate outcomes. Columns 1–2 use reservations fixed effects, while columns 3–8 use section fixed effects. Every specification also includes feature-type fixed effects. In each block, the first specification (col 1 and 3) estimates OLS with only spatial fixed effects, and the second specification (col 2 and 4) adds the controls selected by the variable selection model in Table 1. For the finer section fixed effect, we run a series of matching estimators. Column 5 runs a propensity-score matching estimator that matches on all controls selected by the variable selection model in Table 1. The remaining columns report on additional matching-estimator variations, first broadening the set of allowed matches that satisfy the common support restriction (col 6), and then using multi-dimensional matching through Mahalanobis distance matching on the same set of variables in columns 7 and 8 (Rosenbaum and Rubin, 1985). Across columns, we cluster standard errors at the reservation level. We report 95% confidence intervals.

Table A2: Transfer Restrictions and Land Use Estimates

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: Any Development								
FeeSimple	0.074***	0.052***	0.018**	0.014**	0.018***	0.014**	0.014**	0.015***
	(0.015)	(0.012)	(0.007)	(0.007)	(0.006)	(0.006)	(0.006)	(0.006)
Panel B: Share Cultivated								
FeeSimple	15.022***	10.205***	4.558***	4.389***	3.753***	3.852***	3.702***	3.944***
	(2.446)	(2.011)	(1.053)	(1.037)	(0.979)	(0.972)	(0.979)	(0.958)
Fixed Effects	Reserv.	Reserv.	Section	Section	Section	Section	Section	Section
Method	OLS	OLS	OLS	OLS	PSM	PSM	MD	MD
Neighbors	NA	NA	NA	NA	1	Any	1	Any
Match Vars	NA	NA	NA	NA	VSelect	VSelect	VSelect	VSelect
Covariates	None	VSelect	None	VSelect	None	None	None	None
Observations	91,431	91,425	85,488	85,488	91,440	91,440	91,440	91,440

Notes: Both panels of this figure report on eight variations of estimating equation 1, for two separate outcomes. Columns 1–2 use reservations fixed effects, while columns 3–8 use section fixed effects. Every specification also includes feature-type fixed effects. In each block, the first specification (col 1 and 3) estimates OLS with only spatial fixed effects, and the second specification (col 2 and 4) adds the controls selected by the variable selection model in Table 1. For the finer section fixed effect, we run a series of matching estimators. Column 5 runs a propensity-score matching estimator that matches on all controls selected by the variable selection model in Table 1. The remaining columns report on additional matching-estimator variations, first broadening the set of allowed matches that satisfy the common support restriction (col 6), and then using multi-dimensional matching through Mahalanobis distance matching on the same set of variables in columns 7 and 8 (Rosenbaum and Rubin, 1985). Across columns, we cluster standard errors at the reservation level. Significance levels are denoted by * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A3: Addressing Spillovers Between Tenure Types

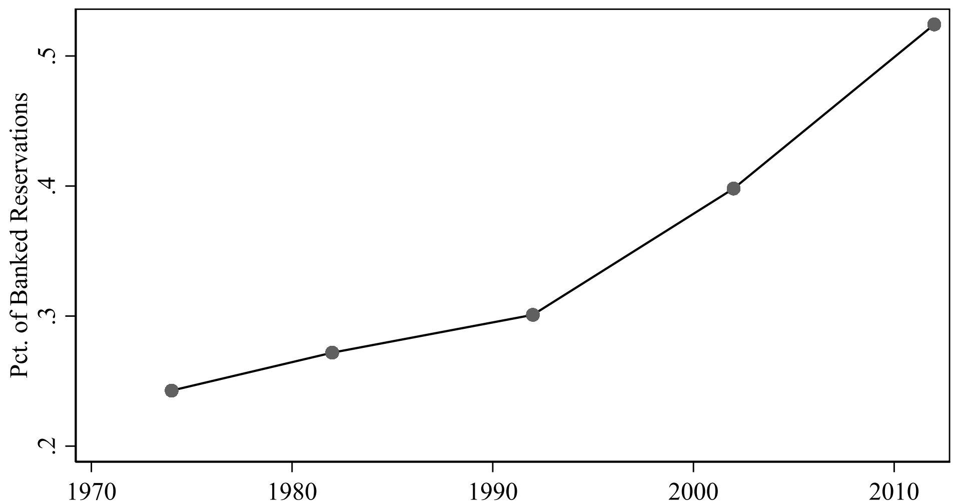
	Any Development		Share Cultivated	
	(1)	(2)	(3)	(4)
Panel A: Spillovers from Fee Simple to Trust Plots				
Number Fee Neighbors	0.0006		0.3113**	
	(0.0017)		(0.1480)	
Pct. Fee Acres		0.0002		0.0332*
		(0.0002)		(0.0180)
Adj. R^2	0.3831	0.3831	0.7801	0.7800
Observations	59,149	59,149	59,149	59,149
# Spatial FEs	15,780	15,780	15,780	15,780
Panel B: Spillovers and Main Effects				
FeeSimple	0.0144**	0.0172**	4.4576***	4.6937***
	(0.0071)	(0.0071)	(1.1181)	(1.1058)
Number Fee Neighbors	0.0001		0.0888	
	(0.0019)		(0.1956)	
Pct. Fee Acres		0.0004**		0.0421***
		(0.0002)		(0.0133)
Adj. R^2	0.3594	0.3595	0.7717	0.7718
Observations	85,486	85,486	85,486	85,486
# Spatial FEs	21,553	21,553	21,553	21,553

Notes: Panel A reports estimation results from a modified equation (1), where the regressor of interest measures the intensity of fee simple exposure within one mile of each trust plot. The regression estimates the effect of neighboring fee simple exposure on land use on *only* trust plots. Columns 1–2 estimate spillovers in development and columns 3–4 estimate spillovers in the share of cultivation. Odd numbered columns measure neighboring fee simple exposure through the *number* of neighboring fee simple plots, whereas even number columns measure neighboring fee simple exposure through the *share* of fee simple acreage among neighboring plots. Panel B re-estimates equation (1), introducing the two previously defined measures of neighboring fee simple exposure. The estimation sample in Panel B includes all fee simple parcels and trust parcels. The estimation results in both panels include section fixed effects, PLSS feature type fixed effects, and the full set of controls from the variable selection model. Across all columns, we cluster standard errors at the reservation level. Significance levels are denoted by * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Appendix D Appendix Materials for Section 6 (Mechanisms)

Appendix D.1 Banking Access

Figure A6: Share of Reservations with Bank Access over time



Notes: Figure illustrates the expansion of local credit access on reservations. Local credit access is defined as a reservation having an FDIC bank within its borders or a Native Community Development Financial Institution within 10 miles.

Table A4: Banking

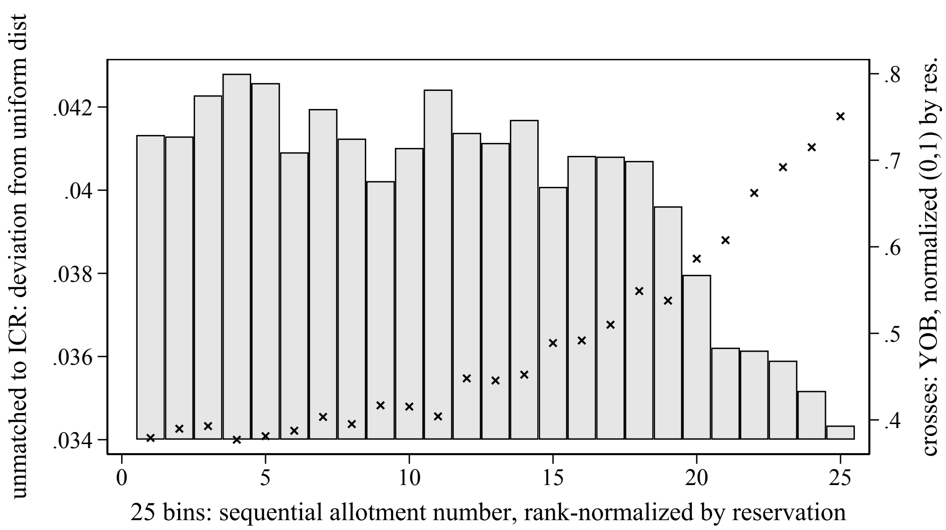
	Any Development		Share Cultivated	
	(1)	(2)	(3)	(4)
$\hat{\gamma}$: Fee Simple	0.004		3.401***	
	(0.006)		(0.430)	
$\hat{\gamma}_{1982}(FeeSimple_i \times \tau_{1982})$	-0.003*	-0.002***	0.041	-0.057***
	(0.001)	(0.000)	(0.059)	(0.003)
$\hat{\gamma}_{1992}(FeeSimple_i \times \tau_{1992})$	-0.007**	-0.001**	-0.104	-0.318**
	(0.002)	(0.000)	(0.117)	(0.080)
$\hat{\gamma}_{2002}(FeeSimple_i \times \tau_{2002})$	-0.007*	-0.000	-0.902**	-1.266***
	(0.003)	(0.001)	(0.222)	(0.145)
$\hat{\gamma}_{2012}(FeeSimple_i \times \tau_{2012})$	-0.006*	0.000	-1.650***	-1.678***
	(0.003)	(0.001)	(0.308)	(0.272)
$\hat{\gamma}(FeeSimple_i \times Banked)$	0.009		1.202*	
	(0.007)		(0.509)	
$\hat{\gamma}_{1982}(FeeSimple_i \times \tau_{1982} \times Banked)$	0.006**	0.004***	-0.122	0.093***
	(0.002)	(0.001)	(0.081)	(0.018)
$\hat{\gamma}_{1992}(FeeSimple_i \times \tau_{1992} \times Banked)$	0.011***	0.005***	-0.480**	-0.084
	(0.002)	(0.001)	(0.110)	(0.089)
$\hat{\gamma}_{2002}(FeeSimple_i \times \tau_{2002} \times Banked)$	0.011***	0.005**	0.748**	1.319***
	(0.002)	(0.001)	(0.199)	(0.160)
$\hat{\gamma}_{2012}(FeeSimple_i \times \tau_{2012} \times Banked)$	0.013***	0.008**	1.641***	1.859***
	(0.002)	(0.002)	(0.275)	(0.260)
$\hat{\tau}_{1982}$	0.003***	0.003***	0.397***	0.415***
	(0.000)	(0.000)	(0.009)	(0.003)
$\hat{\tau}_{1992}$	0.004***	0.003***	0.794***	0.827***
	(0.000)	(0.000)	(0.027)	(0.048)
$\hat{\tau}_{2002}$	0.005***	0.004***	1.654***	1.714***
	(0.000)	(0.000)	(0.028)	(0.086)
$\hat{\tau}_{2012}$	0.007***	0.006***	1.644***	1.656***
	(0.000)	(0.001)	(0.060)	(0.106)
$\hat{\tau}_{1982} \times Banked$	-0.001***	-0.001***	-0.581***	-0.630***
	(0.000)	(0.000)	(0.012)	(0.003)
$\hat{\tau}_{1992} \times Banked$	-0.002***	-0.001*	-0.761***	-0.850***
	(0.000)	(0.000)	(0.026)	(0.053)
$\hat{\tau}_{2002} \times Banked$	-0.001**	-0.000	-1.424***	-1.548***
	(0.000)	(0.001)	(0.023)	(0.096)
$\hat{\tau}_{2012} \times Banked$	0.000	0.001	-1.316***	-1.386***
	(0.000)	(0.001)	(0.050)	(0.110)
Adj. R^2	0.5063	0.9783	0.8217	0.9797
Observations	456,079	445,100	456,079	445,100
Fixed Effects	Section	Parcel	Section	Parcel
# Spatial FEs	27,499	91,440	27,499	91,440
Covariates	VSelect	None	VSelect	None

Notes: The table reports the estimation results for the two outcomes of interest from a modified equation 2 using both section (cols 1 & 3) and plot (cols 2 & 4) fixed effects. Specifications with section fixed effects include the set of controls from the variable selection model. Every specification includes the five NWALT waves. Standard errors are clustered by plot and year. Significance levels are denoted by * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Appendix D.2 Measuring Latent Fractionation

Our measure of latent fractionation rests on the assumption that allotments *not* matched to the ICR correspond to individuals who are decreased by 1930.[36] We can validate this assumption by leveraging the fact that allotment numbers were issued *sequentially*, which allows us to show that, *within* a reservation, smaller allotment numbers belonged to older allottees and were associated with a higher likelihood of not being recorded in the mid-1930s ICR. Figure A7 bins each reservation's rank-normalized allotment numbers into 25 bins on the horizontal axis and plots normalized birth-year by bin to show that smaller allotment numbers were associated with earlier birth-years for the allotments that we *do* match to the ICR.[37] The figure also plots the distribution of unmatched allotments to illustrate that it is skewed towards low allotment numbers, relative to a distribution of *all* allotments that is uniform by definition (because it splits the data into equal-sized bins). This is evidence that allotments that we do not find in the ICR disproportionately belonged to older individuals who where more likely to be deceased by the mid-1930s.

Figure A7: Original Allottees' Age and Sequential Allotment Number

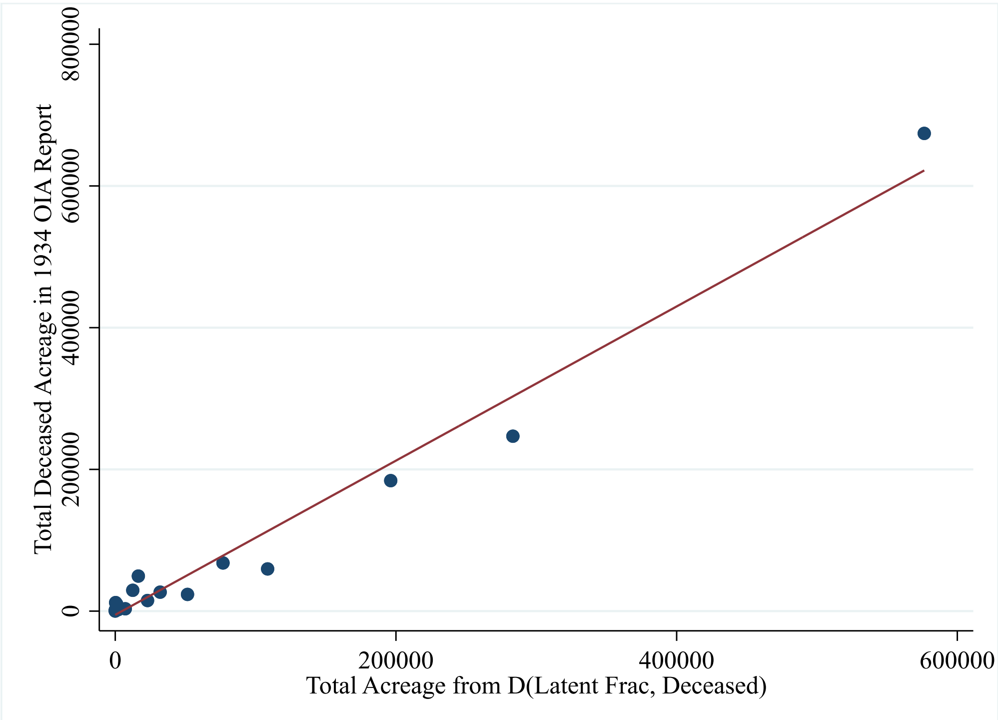


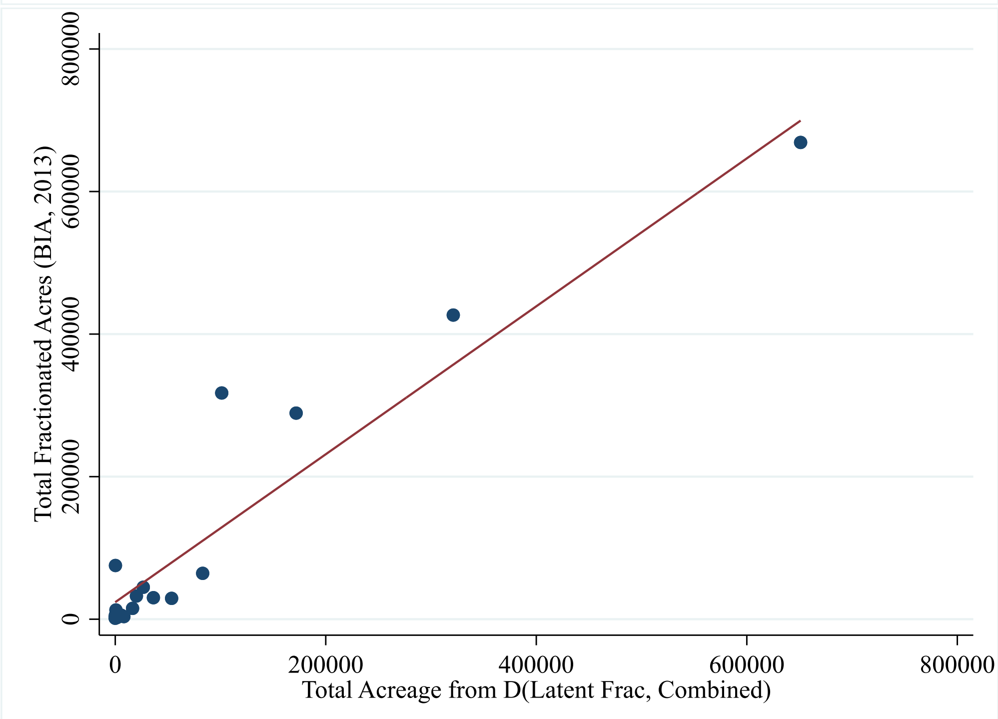
Notes: This figure shows that, *within* each reservation, smaller allotment numbers belonged to older allottees (see scatter plot) and were associated with a higher likelihood of not being recorded in the mid-1930s ICR.

[36]When linking between the ICR and BLM recorded allotment numbers we were careful to not overstate deaths due to misreporting of allotment numbers in the BLM data. We excluded any reservation where we were concerned that the number of unmatched BLM patents was too large relative to the number of unmatched ICR patents.

[37]Normalization (0–1) by reservation is needed because some reservations were allotted decades before others.

Figure A8: Relating Reservation Reported Fractionation to Latent Fractionation





Notes: The top graph plots the relationship between latent fractionation and the Office of Indian Affairs (1935) reported Deceased Acreage held in trust in 1935. The estimated slope coefficient ≈ 1.08 and is statistically indistinguishable from 1, supporting the relationship between our measure of latent fractionation and the true level of deceased fractionation. The bottom graph plots the relationship between latent fractionation and the acreage classified as highly fractionated in Department of Interior (2013). The estimated slope coefficient ≈ 1.03 and is statistically indistinguishable from 1. This supports that our measure of latent fractionation continues to reflect current levels of fractionation.