Who Gains from Individual Property Rights? Evidence from the Allotment of Mapuche Reservations

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Individual property rights can improve economic efficiency but may expose marginalized groups to dispossession. We use a geographic regression discontinuity design to quantify the long-term impacts of individual rights on the socioeconomic conditions of the Mapuche, Chile's largest indigenous group. The allotment of communally-held titles into individual rights reduced Mapuche control over land, while improving land use efficiency and labor allocation. Although socioeconomic conditions within former reservations improved, exposure to dispossession when allotted parcels were sold prevented reservations' descendants from sharing in the economic benefits of individual property rights.

JEL: J15, K11, N26, N56, O13, O43, Q15, Q24

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Individual property rights are considered an important driver of economic growth, but may lead to dispossession in communities that face discrimination or are unfamiliar with their statutory rights. This tension has been an important consideration in contentious policy debates about how nations should recognize the land rights of indigenous peoples. While some have praised collective rights to land as the last line of defense against dispossession, others have blamed persistent poverty in indigenous reservations on a lack of access to individual property titles. Quantitative analysis of this potential trade-off has been limited by the endogenous allocation of individual property rights and the challenge of assessing impacts on the descendants of indigenous peoples who have migrated from their traditional territories. This paper fills this gap by leveraging a natural experiment with original data sources, allowing us to estimate the causal impact of individual property rights on the socioeconomic conditions experienced both within Chilean reservations, and among Mapuche families descending from these reservations.

Our study focuses upon the experience of the Mapuche people, Chile's largest indigenous group encompassing 1.7 million people as of 2017 (10% of Chile's population). Historically, Mapuche were a pastoralist society that inhabited the central and southern portions of present-day Chile and Argentina. In the late 19^{th} century, Chile forced Mapuche to settle in close to 3,000 reservations that represented a small fraction of the Mapuche's ancestral territory. Local chiefs were granted communal title to each reservation's land on behalf of their people, entitling each settler to an inheritable, transferable share. In 1930, Courts of Indians run by non-indigenous bureaucrats were created with the main purpose of allotting reservations, granting parcels with full property rights to each reservations' shareholders. The courts were also required to protect individuals from dispossession by verifying that sales of allotted parcels were consensual and beneficial to the indigenous seller, although this requirement was relaxed between 1943 and 1946.

Courts' capacities to allot reservations differed across the jurisdictions considered in this paper, opening a large gap in the share of reservations that were allotted before 1952. Further allotments were rare until 1979, when nearly all the remaining reservations were allotted within a span of 15 years. Thus, by the early 1970s, adjacent reservations separated by an historical judicial boundary were likely to have faced dramatically different property rights regimes over the previous 30 years.

We identify the impact of individual property rights on economic development in reservations' territories and descendants using a fuzzy geographic regression discontinuity design focused upon an historical judicial boundary that exhibited an especially sharp contrast in court congestion. The identification assumption is that only the historical congestion of Courts of Indians and the ensuing divergence in the share of allotted reservations varies discontinuously at this boundary. This is likely to hold along this study's selected judicial boundary, since a large segment of the boundary has not overlapped with any other provincial or judicial boundaries since 1938. We cannot detect discontinuities for a rich set of predetermined variables, as well as for outcome variables in areas outside reservations, providing strong empirical support to our identification assumption.

Due to the study design's requirements for fine-scaled spatial variation in outcome variables, we assembled a novel database detailing the evolution of socioeconomic conditions in Mapuche reservations since the late 19$^{\text{th}}$ century. This database integrates multiple datasets, including historical archival data, high-resolution census data, property registry data, and remotely sensed land cover maps. Many of our outcome variables describe social and economic conditions in reservations 40-70 years after the initial 1930 divergence in property rights regimes. As a result, we are able to provide new evidence on the long-term impacts of individual property rights.

Individual property rights resulted in a dramatic change in the control of land, decreasing the share of reservation land held by Mapuche families by the end of the 20th century by 18 percentage points. However, this territorial loss was accompanied by a transformation of reservations' economies. Changes in the use of land and labor provide evidence of a transition towards a more efficient allocation of resources within reservations. The size of estates increased as the number of families fell, suggesting that stronger claims to land facilitated outmigration and land consolidation. Schooling and off-farm, wage labor increased, suggesting that individual property rights supported human capital accumulation and labor's detachment from land. Livestock density and the use of erodible lands for grazing fell, suggesting that well-demarcated plots and enforceable land rights led residents to internalize the negative externalities of livestock production. Consistent with these improvements in productive efficiency, a census-based wealth index reveals that, by 1992, households living in reservations that were allotted earlier were wealthier.

However, shifts in the ethnic composition of the population play an important role in explaining improvements in average socioeconomic conditions. Indeed, we detect no improvements in socioeconomic conditions for Mapuche households within former reservation areas. A large body of qualitative research has documented that the allotment of reservations exacerbated the dispossession of Mapuche by their non-indigenous neighbors, especially between 1943 and 1946 when restrictions to buy allotted parcels were lifted (Ormeño and Osses, 1972; Almonacid, 2009; Aylwin et al., 2003; Pairicán, 2014). Hence, we cannot assume that those who left reservations sold their land willingly to outsiders and, as a result, cannot be confident that average improvements in economic efficiency weakly increased welfare for all parties.

To study how individual property rights impacted reservations' descendants, we combine data on the location of the residence of the universe of Chileans over 18 years old from the 2021 electoral registry with census georeferenced data on the average schooling of head of households at the block-group level, which we take as a proxy of socioeconomic status. We focus on 8,763 voters with georeferenced addresses, uncommon surnames, and that can be linked to a unique reservation to run the fuzzy regression discontinuity on this sample of descendants. We cannot detect an effect for descending from reservations allotted earlier (1930s-1940s) vs. later (1980s) on socioeconomic status.

We close the paper by exploring the role of dispossession in explaining why Mapuche families did not benefit from individual rights even as reservations' former territories experienced economic improvement. Exposure to dispossession is measured as the fraction of reservations' allotted parcels sold for the first time from 1943 to 1946, when restrictions to buy reservation land were lifted. Within descendants from reservations allotted before 1952, an increase of 10 percentage points in exposure to dispossession reduces their block group's head of households' schooling by 0.08 years.

To address the potential endogeneity of our exposure measure, we construct an instrument that exploits the fact that sales of allotted parcels pick up soon after reservations' allotments, and fall consistently thereafter. The instrument predicts, for each allotment year, the exposure to dispossession attributable to this pattern, after removing reservations' fixed effects and the effect of the lifting of restrictions on total sales. The instrument increases slowly up to 1938, then steps up to pick in 1943 and rapidly falls to reach zero in 1947. The results are similar to the OLS results, even after controlling for year-of-allotment and thus relying exclusively on the non-linearity of the instrument with respect to allotted years. These results strongly suggest that the lack of protection from dispossession played an important role in precluding Mapuche from benefitting from individual rights.

Related Literature: This paper relates to a large body of research that studies the impacts of property rights on economic development. In agricultural landscapes, several empirical studies have used quasi-experimental methods to document the relationship between individual property rights and investment (Jacoby and Minten, 2007; Goldstein and Udry, 2008; Ali et al., 2014; Goldstein et al., 2018; Christensen et al., 2021), agricultural productivity (Hornbeck, 2010; Newman et al., 2015; Bühler, 2023), labor mobility and its allocation between agricultural and non-agricultural activities (De Janvry et al., 2015; Chernina et al., 2014; Beg, 2022), the allocation of land among producers (Libecap and Lueck, 2011; Chen et al., 2022; Castro-Zarzur et al., 2020), women's access to land (Ali et al., 2014), political beliefs (De Janvry et al., 2014), and deforestation (Liscow, 2013).

Our paper contributes to this literature in two ways. First, most prior studies have estimated treatment effects over territories rather than people. Since one of the main channels by which individual property rights affect economic outcomes is through the reallocation of land (Besley, 1995; Chen et al., 2022), empirical estimates of impacts within territories are unlikely to provide a complete description of the impacts experienced by the people receiving property rights. We provide what is, to the best of our knowledge, the first evidence of the impact of individual property rights on the descendants of beneficiaries.[1] Second, the more than 40-year lag between treatment and outcomes allows us to estimate long-term impacts, complementing the small number of studies that provide such estimates with evidence from a novel population (Liscow, 2013; Christensen et al., 2021).[2]

The results also relate to a growing body of research in economics that studies the historical determinants of development in indigenous territories (Akee, 2009; Dippel, 2014; Akee and Jorgensen, 2014; De Janvry et al., 2015; Aragón, 2015; Akee et al., 2015; Feir, 2016; Akee, 2020; Leonard et al., 2020; Baragwanath and

[1] Galan (2020) exploits quasi-random variation in the allocation of parcels to rural families in the context of Colombia's land reform to study the causal impact of access to land on intergenerational mobility. In contrast to this study, the contrafactual in Galan (2020)'s study is not having land instead of owning land collectively.

[2] Studies that exploit differences between households, such as Goldstein and Udry (2008), do arguably capture long-term impacts as differences in the steady-state of households with different characteristics. However, their estimates cannot capture market-level dynamics, as treated and control households live side-by-side.

Bayi, 2020; Feir et al., 2022). While property rights institutions have been widely recognized as a key determinant of economic growth in indigenous territories, only a few studies offer quantitative estimates of the causal, long-term impacts of these institutions. Our paper contributes to these studies, adding estimates from a novel reform to evidence on the impacts of the United States's 1887 General Allotment Act (Akee, 2009; Akee and Jorgensen, 2014; Dippel et al., 2020), Mexico's 1992 PROCEDE program (De Janvry et al., 2015), Canada's First Nations' modern treaties and allotments (Aragón, 2015; Aragón and Kessler, 2020), and Brazil's recent formal recognition of indigenous territories (Baragwanath and Bayi, 2020; Baragwanath et al., 2023).

The setting we study most closely resembles that of Akee (2009), Akee and Jorgensen (2014), De Janvry et al. (2015), Akee (2020), and Dippel et al. (2020), as the quasi-random variations exploited in these studies also entail the comparison of territories with collective forms of property rights with those where formal individual property rights have been strengthened. While the specific *de-jure* form that collective property rights take differs across studies, they share the fact that informal local institutions are *de-facto* allowed to play a role in allocating and enforcing property rights in an environment where access to national property rights institutions is limited.

Most of these studies have estimated the impact of strengthening property rights on outcomes related to aggregate economic production in indigenous territories, that is, on *how* the land is used. However, the consolidation of formal, individual property rights has often been accompanied by the weakening of indigenous peoples' control over land (Carlos et al., 2022). The ensuing loss of indigenous control over land has been central to long-standing self-determination conflicts across the world (Cayul et al., 2022). An improved understanding of the distributional consequences of individual property rights over indigenous territories is thus central to the future of policies involving indigenous peoples and lands.

This paper contributes to this need by estimating *who* ends up owning land and benefiting from the allotment of indigenous territories.

To the best of our knowledge, only Aragón and Kessler (2020) and Akee (2020) have explicitly assessed how individual property rights have shifted reservation land ownership away from indigenous hands. Shifts in ownership, in the context of indigenous groups vulnerable to losing their land by deception, challenge the interpretation of results that show average economic improvements in indigenous territories as evidence that individual property rights have made the indigenous families that were entitled to them better off. Akee (2020) focuses on medium-term impacts in a context where indigenous people were banned from leaving reservations, thus credibly being able to estimate the impacts of allotment on indigenous households using longitudinal census data collected at reservations' territories. We expand the extant literature by estimating the impacts of individual property rights on reservations' descendants decades after allotments, finding that individual property rights did not improve the average socioeconomic conditions of indigenous families in the long term despite significant improvements in average socioeconomic conditions in former reservations areas. In addition, by exploiting historical variation in exposure to dispossession, we provide evidence that a lack of protection from dispossession was likely responsible for precluding Mapuche from benefiting from individual rights.

I. Conceptual Framework

This section presents a model to guide the empirical analysis. The model focuses on the potential for individual property rights to increase productivity by facilitating the reallocation of land among farmers, while incorporating the possibility that some transactions are fraudulent and hence not beneficial to the seller. The results show that fraud can make individual property rights detrimental for the average material welfare of indigenous people, even as average productivity and material welfare increase within the territory.

Consider a reservation populated by a continuum of indigenous families of mass one. Family i's productivity is given by the parameter θ_i, which is distributed uniformly between zero and one. The reservation land represents a small fraction of the total land in the market, and hence farmers take the market price of land, p, as given.

Potential buyers have an average productivity of $\lambda \geq p$. A fraction μ of potential buyers are dishonest, tricking families into selling them their land without paying the price. However, families believe that the share of dishonest buyers equals $\tilde{\mu} \leq \mu$. The rest are honest buyers that pay the full price when buying land.

Under collective ownership, indigenous families can sell their shares of a reservation at a price $p - k$, where k represents the higher transactions costs under collective ownership. However, dishonest buyers are deterred by collective ownership, as the rest of the shareholders will limit their capacity to exercise their acquired usufructuary rights after learning they have defrauded their way into the community. Given this, a family will sell their shares if $p - k \geq \theta_i$, and a fraction $p - k$ sells their shares. The average productivity in reservations and the average wealth of families after sales have taken place are

$$Y_c = (p-k)\lambda + \frac{1}{2}\left[1 - (p-k)^2\right], \quad (1)$$

$$W_c = (p-k)^2 + \frac{1}{2}\left[1 - (p-k)^2\right]. \quad (2)$$

Once a reservation is divided, families do not enjoy communities' protection from dishonest buyers, as the property right is defined over a specific tract of land where the buyer can call for law enforcement to claim his parcel. Hence, families will sell their parcel if $(1 - \tilde{\mu})p \geq \theta_i$, and a fraction $(1 - \tilde{\mu})p$ sells their shares. The average productivity in reservations and the average wealth of families after sales have taken place are

$$Y_p = (1-\tilde{\mu})p\lambda + \frac{1}{2}\left[1-(1-\tilde{\mu})^2p^2\right], \quad (3)$$

$$W_p = (1-\tilde{\mu})(1-\mu)p^2 + \frac{1}{2}\left[1-p^2(1-\tilde{\mu})^2\right]. \quad (4)$$

Subtracting 1 from 3 and 2 from 4, we calculate the average impact of individual property rights on productivity and families' wealth as

$$\Delta Y = [(1-\tilde{\mu})p-(p-k)]\left[\lambda - \frac{(1-\tilde{\mu})p+(p-k)}{2}\right], \quad (5)$$

$$\Delta W = [(1-\tilde{\mu})p-(p-k)]\left[\frac{(1-\tilde{\mu})p+(p-k)}{2}\right] - p^2(1-\tilde{\mu})(\mu-\tilde{\mu}). \quad (6)$$

The following results follow for the case when $k > \tilde{\mu}p$, that is, when the cost of collective ownership in terms of transaction costs is larger than the perceived cost of private ownership in terms of exposure to fraud.

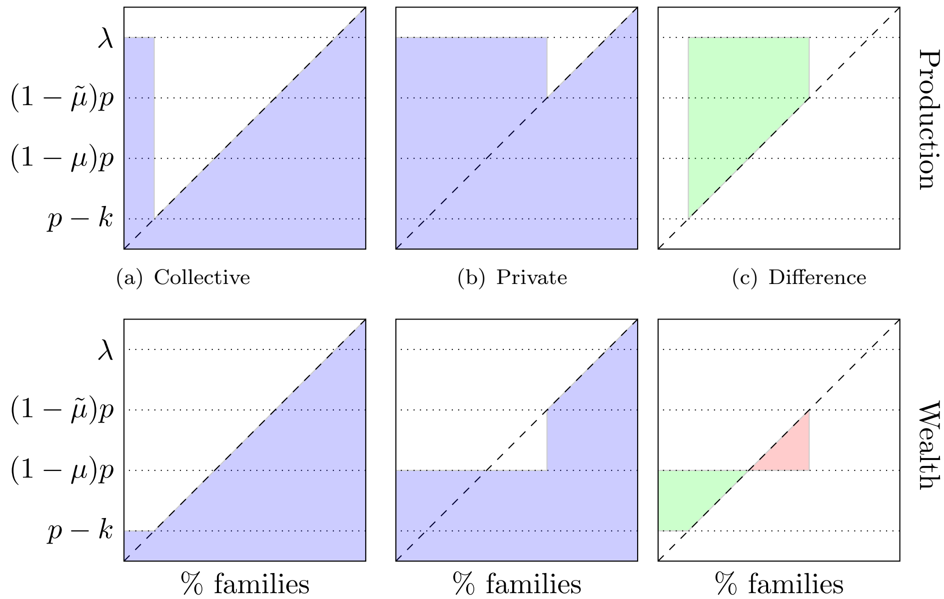
Result 1: Individual property rights increase the fraction of land sold and average productivity.[3]

Result 2: If families' beliefs about the share of dishonest buyers are correct ($\tilde{\mu} = \mu$), individual property rights increase families' average wealth.

Result 3: If the gap between farmers' beliefs and the actual fraction of dishonest buyers, $\mu - \tilde{\mu}$, is larger than $\frac{(1-\tilde{\mu})^2p^2-(p-k)^2}{2p^2(1-\tilde{\mu})}$, individual property rights reduce farmers' average wealth.

Figure 1 illustrates the results graphically. Each panel shows families on the horizontal axis, ordered by their productivity, and productivity or wealth on the vertical axis. Panels a and b show productivity in blue under collective and individual property rights, while panel c displays the difference in green. The assumption that $k > \tilde{\mu}p$ means that families' expected loss due to the possibility

[3]This result is implied by the assumption that $k > \tilde{\mu}p$. We focus on this case because we find that private property led to a sizable reduction in the share of Mapuche-owned land.



(a) Collective (b) Private (c) Difference

(d) Collective (e) Private (f) Difference

Figure 1. : Impact of individual property on average productivity and wealth

of being defrauded under individual property rights is smaller than the secure transaction costs under collective ownership. Hence, more farmers decide to sell their land. Their parcels are transferred to farmers that are more productive on average, increasing average productivity.

Panels d and e show families' expected wealth after sales have taken place. Under collective property rights, a fraction $p-k$ of families sell their lands, receiving $p-k$. Under individual property rights, a larger fraction $(1-\tilde{\mu})p$ sell their land, receiving on average $(1-\mu)p$. Panel f shows in green and red the expected gains and losses from individual property rights. For families with productivity below $(1-\mu)p$, the sale under individual property rights leads to an expected gain even though they underestimate the fraction of dishonest buyers. However, this underestimate of the fraction of dishonest buyers induces families with productivity above $(1-\mu)p$ and below $(1-\tilde{\mu})p$ to sell their land despite the fact that sales yield an expected loss in family wealth. The fraction of families with an expected loss is zero when

$\tilde{\mu} = \mu$ and increases as the gap between $\tilde{\mu}$ and μ widens. Hence, individual property rights may increase or reduce families' average wealth, depending upon the accuracy with which the community judges the honesty of potential buyers.

II. Property rights in Mapuche reservations since forced settlement

A. *Property rights before and during forced settlement (1866-1929)*

Prior to their conquest by Chilean armies in 1884, Mapuche were organized across a flexible network of interconnected but independent lineages. Lineages constituted the locus of economic activity, which was centered on cattle raiding and raising. Each lineage was led by a chief, whose prestige was proportional to the size of his group and livestock holdings (Titiev, 1951, pp. 53-57; Faron, 1961, pp. 22-23, 69-101).

The constant state of war to fend off colonization by Spain and Chile encouraged political centralization, consolidating large networks of alliances under the leadership of prominent chiefs (Titiev, 1951, pp. 51-52; Bengoa, 2000, pp. 63-68). Nevertheless, local chiefs controlled who settled in their territories and where they could clear land to grow crops (Bengoa, 2000, pp. 60-63).

Chile took effective control of the Mapuche homeland in 1884. In preparation for the planned conquest of Mapuche territory, the Chilean government passed a law in 1866 to establish a legal framework for the establishment of property rights (República de Chile, 1866). The law promised collective titles to Mapuche over the lands they had used continuously for over a year. Untitled surplus lands would be declared fiscal property and auctioned. Settlers rushed to the frontier in anticipation to secure titles, prompting Congress in 1874 to establish a prohibition zone where no settler was allowed to acquire land directly from Mapuche by any means (República de Chile, 1874). These land acquisition restrictions have been in place to varying degrees through to the present day, with the exception of a brief period from 1943 to 1946 when all restrictions were lifted.

After colonization, Mapuche were forcibly settled into reservations over the period spanning 1884 to 1929. Titles were granted to close to 3,000 local chiefs on behalf of their communities over a small fraction of their ancestral territories. All settlers had a transferable, inheritable share that entitled the owner to usufructuary rights over reservation land. While not formally recognized, local institutions were allowed to allocate specific parcels to families: local chiefs allocated land among families, and the head of each family distributed land among its members (Faron, 1961, pp. 110-116).

A radical transformation of Mapuche society followed forced settlement. The imposition of Chilean institutions as the ultimate source of authority undermined traditional institutions (Stuchlik, 1976, pp. 203-204). At the same time, reservation inhabitants had limited access to Chilean institutions to resolve conflicts, leading to the emergence of lingering conflicts. There was broad support for allotting reservations as a solution by the early 20$^{\text{th}}$ century, both among Mapuche and governmental officials.

B. Allotment leads to diverging property rights regimes (1930-1942)

The first law allowing for the allotment of reservations was sponsored by Manuel Manquilef, a Mapuche congressman, as the last reservations were being established. Passed in 1927, the law defined a unique court charged with allotting all reservations. It was opposed by many Mapuche, who wanted to have a say in whether to allot reservations, as well as non-indigenous settlers, who felt their rights threatened (Almonacid, 2008). Only a handful of reservations were allotted under this law.

A second law adopted in 1930 and modified by a 1931 decree redefined the number and function of courts, specifying five Courts of Indians that would allot reservations when requested by at least a third of shareholders (República de Chile, 1930a, 1931a).[4] Initiated by the request, the allotment trial involved list-

[4]Courts of Indians were run by non-indigenous bureaucrats. They were named Courts of Indians

ing reservations' shareholders, adjudicating conflicting claims with reservations' non-indigenous neighbors, drawing parcels for shareholders living in the reservation with values proportional to their share, and creating credits in favor of absent shareholders, payable by allottees and enforceable by mortgages on their parcels. This cumbersome process overwhelmed courts' limited resources, leading to trials that could take decades. In addition, the law mandated courts to authorize the sale of parcels and shares from allotted and not-allotted reservations, respectively.

Three Courts of Indians were established within the 1874 prohibition zone, where this paper focuses: Victoria in the north, Temuco in the southeast, and Nueva Imperial in the southwest (Figure 2). Only a year had passed when, due to budgetary constraints, Nueva Imperial's court was closed and its jurisdiction appended to Temuco's. Although this merger meant that the Temuco court's jurisdiction included more than double the number of reservations of the Victoria court's jurisdiction, the courts were allocated similar staff resources (República de Chile, 1931b). While the number of reservations allotted per year followed similar trends between both remaining jurisdictions, a large wedge in the fraction of allotted reservations grew among them in the following 20 years (Figure 3a).[5]

C. *Temporary spike in dispossession (1943-1946)*

The allotment of reservations was meant to integrate Mapuche land and people into the Chilean market economy (Almonacid, 2009). To avoid "the serious social problem that would arise if a large part of the indigenous population were to lose ownership or possession of their lands" (República de Chile, 1930b, p. 1), the 1930 law required courts to review all sales of reservation land from Mapuche families. This protection was considered a necessary but temporary precaution, and was originally set to expire in 1940. Congress extended these protections

because they heard civil cases related to reservations.

[5]Temuco's court was staffed with a judge, a secretary, two land surveyors, two officers, and one assistant attorney. Victoria's court was similarly staffed, only missing the assistant attorney. The government recognized the disparity in court capacity in a 1948 decree, moving the judicial boundary south to transfer part of Temuco's jurisdiction to Victoria's (República de Chile, 1948).

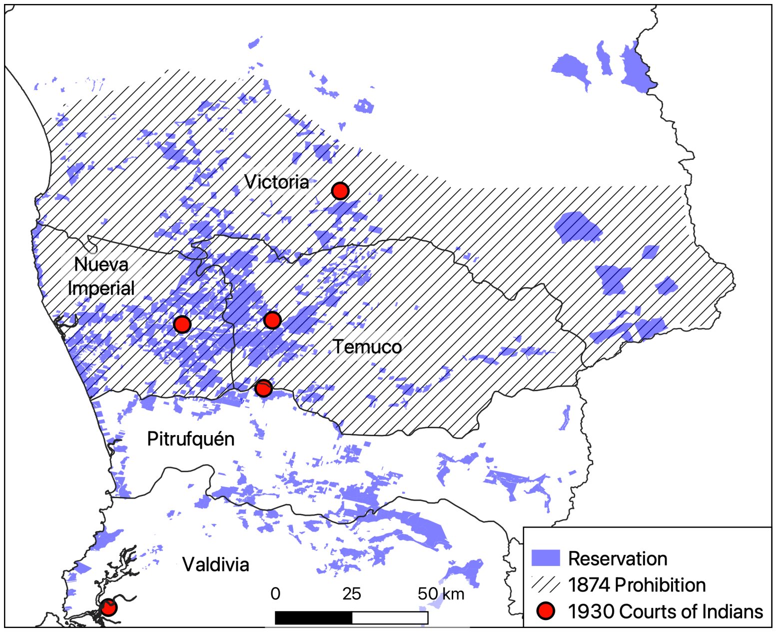


Figure 2. : 1874 prohibition zone, 1930 Courts of Indians, and reservations

for two years, until the bill to extend it another year failed to pass in February 1943. In the following years, property sales of parcels in allotted reservations increased dramatically. In response to this surge of sales, Congress reintroduced protections against dispossession in February 1947. While Congress sought to retroactively invalidate all prior sales that had occurred without court authorization, the Supreme Court struck down this retroactive effect.

The attempt of Congress to reestablish reservations' property rights as of 1943 reflected a broadly shared belief that the flood of sales that took place between 1943 and 1946 included numerous cases of fraud. Ormeño and Osses (1972) estimates that about a fifth of reservation land was sold during this period. Our data shows a remarkable spike in the sale of allotted parcels in this period, shown in Figure 3b. Muñoz (1948) notes that numerous buyers used deceptive tactics to convince Mapuche to sell their land at below-market rates. One documented form of fraud was to file a sale contract in place of an annual lease without fully informing the original Mapuche property owner (Aylwin et al., 2003, p. 407).

There is a broad consensus today on the ubiquity of dispossession through fraud, as stated in the conclusions of the Commission for Historical Truth and New Deal with Indigenous Peoples (*Comisión Verdad Histórica y Nuevo Trato con los Pueblos Indígenas*), which advocates for "the restitution of property losses that occurred—this is the conviction that the Commission has reached—in many cases illegitimately, through fraud against the legal system, and with obvious harm to justice" (Aylwin et al., 2003, p. 576). Through the lens of Section I's model, we expect a higher fraction of dishonest buyers (μ) during this critical period.

D. Pause to allotments (1947-1978)

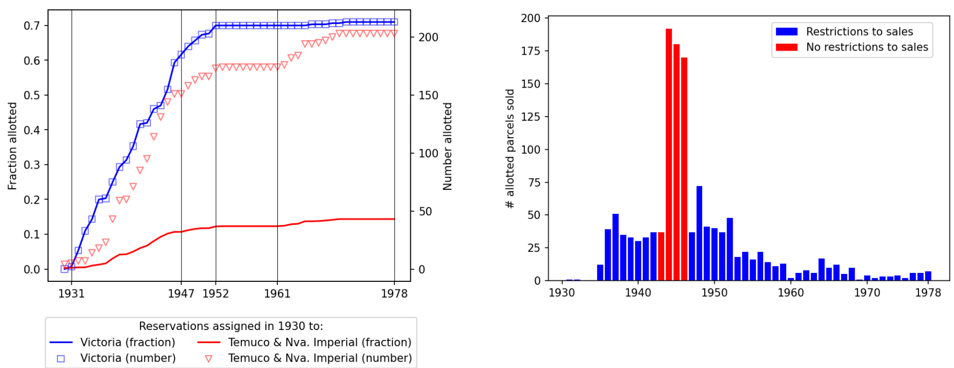
1947 marks an inflection point in the liberalization of transactions of reservation land. The law that reestablished the requirement for court authorization of sales was sponsored by a Mapuche congressman who opposed allotments, Venancio Coñuepan. He became Minister of Land and Colonization in 1952 and head of the Bureau of Indigenous Affairs in 1953, freezing further allotments. Given the consequent reduction in court cases, Victoria's court was closed in 1952 and its jurisdiction was appended to Temuco's (República de Chile, 1952). As a result, differences in the probability of allotment between reservations assigned to Victoria in 1930 and those assigned to Temuco and Nueva Imperial were locked in place for the following three decades (Figure 3a).

A new law was published in 1961, implementing minor modifications to the process of allotment, limiting the transfer of shares to members of reservations, maintaining the requirement of court authorization for the sale of allotted parcels, and reopening courts that had been closed since 1930 with some modifications to their judicial boundaries (República de Chile, 1961).[6] Only a few reservations were allotted under this law.

Courts of Indians were closed and regular courts took over their role in 1972

[6] Also, Courts of Indians were renamed Civil Courts of Indians. For simplicity, we stick with the first name throughout the paper.

(República de Chile, 1972). Further divisions remained frozen until 1979, when Pinochet's dictatorship published a decree to divide the remaining reservations (República de Chile, 1979). By 1989 almost all reservations within our study area had been divided, evening the fraction of allotted reservations across judicial boundaries.



(a) Allotments by court (b) Sales of parcels in allotted reservations

Figure 3. : Allotment and sales of allotted parcels, 1930-1978

III. Empirical Framework

A. *Estimating the impacts of allotments*

The quasi-experimental nature of the variation at the historical judicial boundary that separated Victoria from Temuco and Nueva Imperial in 1930 motivates a Fuzzy Geographic Regression Discontinuity (FGRD) estimator to study the long-term causal effects of reservations' allotment into private titles:

$$Private_j = \alpha_0 + \alpha_1 Victoria_j + g(lon_j, lat_j) + \mathbf{X_j}\Lambda + \eta_j, \tag{7}$$

$$y_{ij} = \beta_0 + \beta_1 \hat{Private}_j + f(lon_j, lat_j) + \mathbf{X_j}\Theta + \varepsilon_{ij}, \tag{8}$$

where y_{ij} is an outcome variable for observation i from reservation j, $Victoria_j$ is a dummy equal to one if reservation j is located within Victoria's jurisdiction and zero otherwise, $Private_j$, is equal to 1 if reservation j was allotted before 1979 and zero otherwise, $g(lon_j, lat_j)$ and $f(lon_j, lat_j)$ are functions of reservation j's longitude and latitude, $\mathbf{X_j}$ is a vector of additional controls for reservation j, and η_j and ε_{ij} are zero-mean disturbances. Equations 7 and 8 are the first and second stage of a Two-Stages Least Square Estimator. β_1 captures the average causal effect of private titles at the judicial boundary, under the standard identification assumptions of the FGRD estimator.

In our baseline specification, we estimate the model with a local linear regression that uses distance to the judicial boundary as the running variable, a triangular kernel, and a 50 km bandwidth. We also check whether the results are robust to different bandwidths, kernels, and a linear model with a first-order polynomial in longitude and latitude (Appendix C). All regressions include dummies for regions along the judicial boundary and predetermined variables in $\mathbf{X_i}$. We exclude reservations in the Andes mountains and foothills, as they are far from the rest of reservations and the historical judicial boundary (see Appendix A for details on regions along the judicial boundary and sample selection). For inference, we use Conley Spatial HAC standard errors with a triangular kernel and a 50-km cutoff (Conley, 1999).

The specific judicial boundary we analyze is particularly well-suited for the validity of our identification strategy. As with the rest of the historical judicial boundaries, the boundary is defined by the provincial boundaries established in the late 19^{th} century. However, this administrative division is unlikely to bias our results since a large section of the provincial boundary, comprising the eastern half of the selected study region, was modified in 1938, resulting in differences between the judicial and other administrative boundaries during our study period. Appendix C shows that the results are robust to estimating the discontinuity at the section of the boundary that does not coincide with the provincial boundary, and that discontinuities are rarely detected at the section of the provincial boundary that does not coincide with the historical judicial boundary, as well as in the judicial boundary for populated locations that lie outside reservations.

Additional threats to identification relate to whether the boundary was originally established based on discontinuities in geographical characteristics or characteristics of the native population, or whether forced settlement was implemented differently on either side of the boundary. These possibilities are unlikely. The boundary was defined shortly after Mapuche's territory was incorporated into Chile, when state presence in the area was still weak (e.g. no trains nor telegraph lines) and national authorities had limited knowledge about the region. Indeed, the boundary cuts perpendicularly through the territory of the two main Mapuche confederations at the time (Abajinos on the west and Arribanos on the east), leaving reservations from both groups on either side of the boundary. In addition, the process of forced settlement was implemented by the Indigenous Settlement Commission (*Comisión Radicadora de Indígenas*), whose activities were not governed by the provincial boundaries.[7] In Section V.A, we provide empirical evidence that there were no significant discontinuities in geographical conditions, pre-treatment characteristics of the Mapuche population, or the conditions of forced settlement across the judicial border.

B. Estimating the impacts of exposure to dispossession

We measure exposure to dispossession as the fraction of allotted parcels sold for the first time between 1943 to 1946, when restrictions on the purchase of reservation land were lifted. For identification, we take advantage of the fact that most parcels are sold for the first time shortly after allotment, as families eager to sell do so quickly once they have been allotted individual parcels. This 'rush-to-sale' creates a non-linear relation between the year of allotment and exposure

[7]The only interaction this agency had with public officers at the provincial level was with the Protector of Indians (*Protector de Indígenas*), an attorney charged with representing the interests of the indigenous population inhabiting the provinces under his jurisdiction. Until 1909 both provinces were served by the same Protector of Indians. The assignment to different Protectors of Indians across the judicial boundary after 1910 is unlikely to have played a significant role in the process of forced settlement, since over 80% of reservations in our study region had been settled before 1910.

to dispossession, allowing us to estimate the impact of dispossession conditional on the year of allotment. First, we estimate

$$y_{ij} = \gamma_0 + \gamma_1 EXP_j + \gamma_2 Allotted_j + \mathbf{X_j \Lambda} + \nu_{ij}, \tag{9}$$

where y_{ij} is an outcome variable for individual i that descends from reservation j, EXP_j is the fraction of reservation j's allotted parcels sold for the first time between 1943 and 1946, X_j are reservation j's predetermined controls, $Allotted_j$ is the year reservation j was allotted, and ν_{ij} is a zero-mean disturbance.

γ_1 captures exposure to dispossession. The set of variables in X_j includes variables describing reservations' topography and climate, pre-colonial characteristics of the Mapuche population, and the conditions of forced settlement, plus a second-degree polynomial in the longitude and latitude of the centroid of reservations. This rich set of controls ensures that we compare similar reservations with different levels of exposure to dispossession along a broad set of observed characteristics. Critically, the specification controls for the year of allotment. Thus γ_1 is not confounded by systematic differences between reservations allotted in different years.

The OLS estimator presents two challenges. First, reservations that sold a larger share of parcels for the first time with no restrictions can still systematically differ among dimensions that are not measured. For instance, buyers seeking to purchase parcels when restrictions were lifted might have targeted reservations that were better connected to markets or had higher agricultural potential. A second concern relates to the interpretation of the estimate. If the suspension of restrictions deferentially increases the total number of sales across reservations, γ_1 would reflect both the impact that restrictions had on the likelihood of selling, as well as the impact that restrictions had on the outcome of interest conditional on selling.

To address these concerns, we construct an instrument for exposure based on the year of allotment by estimating

$$(10) \qquad S_{jt} = \lambda_j + \sum_{k=0}^{T} \delta_k \mathbf{1}(t - Allotted_j = k) + \rho No\ Res_t + \psi No\ Res_t * Allotted_j + \epsilon_{jt},$$

where S_{jt} is the fraction of reservation j's allotted parcels sold for the first time in year t, $No\ Res_t$ is a dummy equal to 1 if t falls within the period when restrictions were suspended (1943-1946), and λ_j are reservations' fixed effects. Only reservations allotted before 1952 are considered, for which observations after allotment and up to 20 years since allotment are selected to obtain a balanced sample.

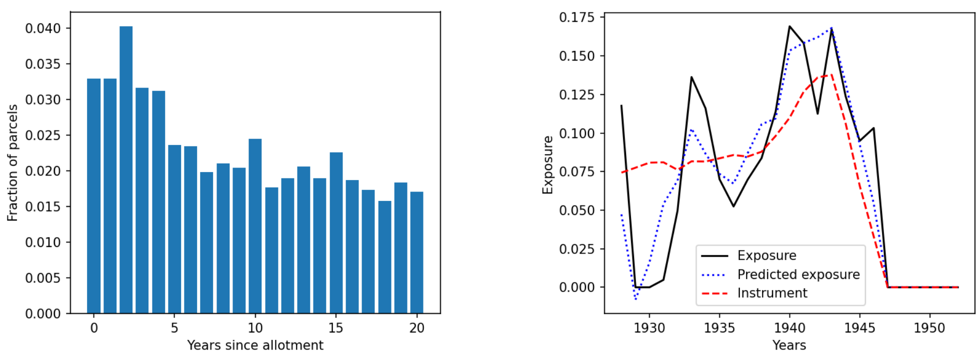
Given the estimates of equation 10, the instrument for exposure to dispossession in reservation j is given by

$$(11) \qquad I_j = \sum_{k=0}^{T} \mathbf{1}\left(Allotted_j + k \in [1943, 1946]\right) \hat{\delta}_k,$$

where $\hat{\delta}_k$ is the predicted additional fraction of parcels sold for the first time k years after allotment. The instrument is solely based on the timing of allotment, which is orthogonal to other characteristics of reservations that are uncorrelated with the year of allotment. As in the OLS estimation of equation 9, controlling for the year of allotment exploits the non-linear relationship between this variable and the instrument to identify the effect of exposure while allowing for reservations allotted on different years to have different potential outcomes.

By exploiting only variation in the fraction of exposed sales attributable to the year of allotment in relation to the average pace of sales from allotment in the absence of restrictions, the instrument does not capture the mass of parcels that were induced to sell by the suspension of restrictions. Hence, the instrument identifies the effect of restrictions conditional on selling.

Panel a of Figure 4 shows the predicted fraction of sales k years after allotment for the average reservation. Most sales are concentrated in the first five years, after which the fraction of sales consistently fall. Panel b plots average exposure, predicted exposure using all the coefficients of equation 10, and the instrument, by year of allotment. The instrument closely follows the general exposure pattern, while omitting year-by-year fluctuations driven by reservations with unusually high exposure values, also picked up by the unrestricted prediction of exposure.



(a) Predicted sales by years since allotment

(b) Instrument and exposure

Figure 4. : Predicted sales by years since allotment, instrument, and exposure

IV. Data

A. *Location of reservations and the date of their allotment*

Our primary unit of observation is a reservation, a tract of land granted as communal property to a specific set of Mapuche individuals. The Chilean General Archive of Indigenous Affairs (*Archivo General de Asuntos Indígenas*, AGAI) has digitized the original geospatial boundaries of 2,900 out of 3,011 reservations, and have made these data publicly available from their website.[8] We use these geospatial boundaries to determine assignment to specific courts, as well as to

[8]Most of the reservations that were not digitized only existed legally, that is, they were never officially granted to Mapuche families. Information about reservations' locations can be accessed at http://siti.conadi.cl/.

extract geospatial information from a variety of datasets described below.

To define treatment, we gathered data detailing the date on which each of the 2900 reservations was formally allotted into individual parcels. We started with a database of over 250,000 pages of primary documentation provided by AGAI. We then trained a classifier to recognize different types of documents, and recover the date of division for almost all reservations in the regions of interest.[9]

B. Courts of Indians' jurisdictions and 1874 prohibition zone

Courts of Indians' jurisdictions are georeferenced using the list of the administrative units encompassing each court, defined in República de Chile (1930b), the descriptions of Chile's 1928-1975 internal administrative boundaries, defined in República de Chile (1928), and vector data reflecting the administrative division as of 1940 obtained from the Chilean National Institute of Statistics. The 1874 prohibition zone is georeferenced from its boundaries as defined in the law that established the prohibition (República de Chile, 1874), using the boundaries of the administrative units that are mentioned, defined in República de Chile (1869).

C. Sale of allotted parcels

In order to identify each reservation's exposure to elevated dispossession, we needed data detailing the timing of property transactions within reservations. We obtained this data from reports found among AGAI's primary documentation. These reports detail all transfers of allotted parcels through the 1980s. We use these reports to extract the year in which each parcel was first sold (if it was ever sold before the report was written).

D. Conditions of forced settlement

As one test of the validity of our identifying assumptions, we quantified whether reservations assigned to different courts differed in the conditions of forced settle-

[9]We used Google's Inception-v3 Python API and trained the model with the default options with the publicly available retrain.py script, and achieved recall and accuracy rates above 99%.

ment prior to allotment. To gather this data, we digitized information contained within each reservations' original title. These titles include information detailing the area allocated to a reservation and the number of settlers; whether a reservation filed a petition for an amendment of its conditions of forced settlement or a request to obtain an informal partition of the reservation among its members between 1884 and 1927; and a list of reservations' original settlers. Using these data, we derived multiple variables describing the social structure of these communities. Additional details on how these data were collected and the algorithm used to identify patrilineal groups can be found in Jordán Colzani (2021). We complement these data with biophysical characteristics of the region. Elevation and slope were obtained at 30 meter resolution from Farr et al. (2007), while historic monthly data on temperature and precipitation between 1970 and 2000 were obtained at 30 arc second resolution (∼1 km) from Fick and Hijmans (2017). Summary statistics of these data were calculated for each reservation.

E. *Control of land*

One important focus of our study is to document how allotment affects the share of land controlled by Mapuche. To identify control of land, we primarily rely upon georeferenced parcel ownership data from the Chilean Ministry of Agriculture's Center of Information on Natural Resources (*Centro de Información de Recursos Naturales*, CIREN). This dataset includes the geospatial boundary of each parcel, and the name of the parcel's owner.

We classify reservation land as owned by either Mapuche individuals, not-Mapuche individuals, individuals with unknown ethnicity, collective Mapuche ownership (indigenous communities), or collective not-Mapuche ownership (firms, publicly owned property, and churches). To do so, we use regular expressions on the name of the owner to distinguish collectively-owned land from individually-owned land, and classify collective lands into their subclasses. Then, to identify land owned by Mapuche individuals, we compare the surnames of parcel owners against surnames from the list of either (a) that reservation's original settlers; or (b) Mapuche surnames compiled by the Mapuche Data Project from the work of Amigo and Bustos (2008) and Painemal Morales (2011). We define the ethnicity of a parcel owner as Mapuche when either the parental or maternal surname match a surname on at least one of these two lists.[10] If the parcel owner is labeled with only a single, not-Mapuche surname, we code the owner's ethnicity as unknown.

The CIREN data report no ownership information for 13% of plots, representing 14% of reservation area in the study region. Given that we are uncertain of the data generating process that determines whether owner names are included within CIREN's property registry, we conduct additional bounding exercises and robustness tests to quantify how this missing data might affect estimates of ethnic control of land. As part of these analyses, we predict ethnicity of the owner of parcels with no information or unknown ethnicity using a random forest model, using parcels for which there is information on ethnicity for training. The model predicts, for each parcel for which we have no information or unknown ethnicity, the probability that it is owned by a Mapuche individual. This probability is used to split the area of these parcels into Mapuche and not-Mapuche owned reservation land and estimate the fractions of Mapuche-owned reservation land including all parcels. The model is trained oversampling the minority class (not-Mapuche), and reaches an out-of-sample accuracy of 87.6%.[11]

In the reservations within our study area, 72% of parcels reflect ownership as of 1999, 5% as of 2009, 21% as of 2013, and the remaining 2% as of 2018. Seven of the 1,550 reservations located within 50 km of the judicial bandery and for which we know the year of allotment do not overlap with the parcel data and are

[10]It was not uncommon for Mapuche people at the time of forced settlement to have Spanish surnames. Using surnames from reservations' original titles allows us to identify these cases, as done by Aylwin et al. (2003).

[11]The predictors include the reservation-level predetermined controls shown in the header of Table 2, plus the area of the parcels, the share of the area within the reservation, and dummies for the year the parcel was included in the data. The hyperparameters (number of trees, maximum depth, minimum sample split, and minimum sample leaf) are selected using a grid search to maximize cross-validation accuracy. Out-of-sample precision is 93 and 55% for Mapuche and Not-Mapuche predicted plots, and out-of-sample recall is 93% and 55% for Mapuche and Not-Mapuche plots.

excluded from the analysis. While all reservations had already been allotted by the time these data were collected, restrictions were put in place in 1979 to prevent further transfers of land out of Mapuche control.[12] Thus, the data should reflect ownership along ethnic lines as of 1978, when there was still a large difference in the dominant form of property rights across the historical judicial boundary. To further support this claim, we conduct additional robustness tests using data from Chile's 1974 Indigenous Agricultural Declaration which was collected prior to the convergence of property rights systems across the judicial boundary. This dataset details the area of land used by families in 558 reservations within the study area. Although this survey was well-timed for our analysis, the area accounted for only represents 65% of each reservations' land on average. Based on this limitation, our main analysis of changes in the control of land focuses upon the CIREN ownership data.

F. Economic activity within reservations

We compile multiple datasets detailing how allotment has transformed economic activity within reservations. Demographic and production data in the early 1970s come from the 1974 Indigenous Agricultural Declaration. These data were collected by school professors at the beginning of Pinochet's dictatorship. For each family using land in the surveyed reservations, the declaration specifies the name, age, and marital status of the head of household, the number of adults and children, whether the family lived in the reservation, the number of hectares used inside and outside the reservation, the number of hectares planted with different crops (wheat, barley, oat, pulses, potato, and other), the number of animals raised (horses, cows and oxen, sheep and goats, pigs, and poultry), and the number of agricultural tools owned by the family (e.g. carts, plows, harrows).[13]

[12] Parcels allotted after 1979 could not be sold for 20 years. In 1993, a new indigenous law banned sales of Mapuche-owned reservation parcels to not-Mapuche, thus freezing the share of Mapuche ownership in reservations (República de Chile, 1993).

[13] The original folders containing the responses to this declaration were found by one of the authors of this study among the uncategorized documents at AGAI's storage rooms. Each table was independently entered by two tabulators using a custom-built web platform, which automatically cross-checked entries

To convert survey results into a measure of aggregate livestock grazing pressure within a reservation, we calculate a standardized stocking rate by dividing the Livestock Unit Index (LSU) by the total area used by households within their reservation. The LSU aggregates livestock from different species into an index using weights that reflect equivalent units in terms of the grazing needs of an adult dairy cow producing three tons of milk annually. Hence, the index constitutes a sensible aggregation of livestock given our interest in livestock pressure on land.[14]

To explore how changes in livestock production systems change environmental conditions within reservations, we combine a map of erosion potential from Centro de Información de Recursos Naturales de Chile (2010) with remotely sensed measures of land cover in 1999 from Graesser et al. (2022). Together, these two datasets allow us to explore the share of highly-erodible lands allocated to land uses with a high risk of erosion (e.g. grasslands) or land uses that are more resilient to erosion (e.g. forests).

We used microdata from the 1992 General Population Census to estimate labor market conditions, educational attainment, and relative wealth within reservations. Although the microdata are available from the Chilean National Institute of Statistics (*Instituto Nacional de Estadística*), the geospatial boundaries of *sectores*, the most disaggregated, rural census units, are only available in the form of printed maps used by the agency to plan the implementation of the census. In order to link census data to individual reservations, we digitized and georeferenced the boundaries of *sectores* from these maps. *Sectores* generally include around 30 households, and a reservation typically overlaps with one or more *sectores*. We aggregate the data at the reservation level by adding the *sectores* each reservation overlaps with, weighting each sector by the share of the reservations' population

and sent to a third reviewer cases with disagreements. To the best of our knowledge this data source was previously unknown to academic researchers.

[14]For more details on the LSU see the glossary of the index in the Eurostat webpage at https://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:Livestock_unit_(LSU). For each species, we use the average weight reported for the different type of animals, omitting Ostriches from the poultry class as Mapuche do not raise them. The resulting weights are: 0.78 for cows and oxen, 0.8 for horses, 0.1 for sheep and goats, 0.26 for pigs, and 0.02 for poultry.

living within the sector assuming people are uniformly distributed within each sector.[15] Wealth was measured using an assent-based index created by the Census Bureau, based on a PCA of household characteristics (see Ramos et al. (2004) for methodological details). The index is scaled to have an average of zero and a standard deviation of .

G. *Socioeconomic status of reservations' descendants*

We combine three datasets to measure the socioeconomic status of reservations' descendants. The first database comes from reservations' original property titles and contains, for each reservation, a list of the surnames of all men settled in the reservation. The second database is the 2021 electoral registry, containing the full names and addresses of all Chilean residents 18 years or older in 2021.[16] We select individuals with uncommon paternal surnames (frequency below 150 in 2021) that can be found only in one reservation's list of historical surnames. Third, we use 2017 Census data to impute, as a measure of socioeconomic status, the average schooling of head of households in the block group where each address is located. Together, these three databases allow us to explore differences in the socioeconomic status of Mapuche households as a function of the reservation from which that household has descended.

[15] Consider a hypothetical example where two *sectores*, A and B, overlap with a reservation. Sector's A area within the reservations as a share of its total area is 25%, while the same figure is 50% for Sector B. If there are 20 and 10 persons reported to live in each sector, and average schooling is 10 and 8 in each sector, the imputed years of schooling in the reservation is given by $10 \times \left(\frac{0.25\times20}{0.25\times20+0.5\times10}\right) + 8 \times \left(\frac{0.5\times10}{0.25\times20+0.5\times10}\right) = 9$.

[16] This data was gathered and processed by Depetris-Chauvin and González (2023). We are grateful to the authors for sharing these data. We manually georeferenced addresses not georeferenced by the authors in our selected sample.

V. The impacts of individual rights on reservation territories and descendants

A. Validity of first Stage and continuity of pre-determined variables

Court capacity was higher in reservations assigned to Victoria as compared to those assigned to Temuco and Nueva Imperial in 1930, leading to divergent paths in the dominant form of property rights (Figure 3a). Table 1 shows that lower historical congestion in Victoria led to a large increase of 62 percentage points in the fraction of reservations that had abandoned collective ownership in favor of formal individual property rights by 1952 and 1978 (columns 1-2). By 1993 the gap was closed, as Pinochet's dictatorship allotted almost all non-allotted reservations during the 1980s (column 3). The freeze of allotments between 1952 and 1979 led to a large discontinuity across the historical judicial boundary on the timing of allotment, with reservations on the Victoria side of the boundary being allotted 27 years earlier on average (column 4).[17]

Table 1—: First stage: Victoria Court and allotment

Dep. Var.	Allotted by:			Year allotted
	1952	1978	1993	
	(1)	(2)	(3)	(4)
Victoria (low congestion)	62.56	61.77	-0.09	-27.16
	(8.56)***	(8.22)***	(0.24)	(3.70)***
Mean high congestion	14.43	16.60	99.53	1977
Reservations	1,550	1,550	1,550	1,546

Unit of analysis is a reservation. Victoria row presents treatment effects estimates of Victoria's jurisdiction dummy on the dependent variable in the column's header, using a Geographic Discontinuity Design with local linear regression on distance to the judicial boundary as running variable, regions-along-the-boundary fixed effects, and a 50-km triangular kernel. Mean high congestion reports mean of dependent variable for reservations in Temuco's jurisdiction. Conley standard errors (50 km bandwidth) shown below point estimates. Statistical significance reported next to standard errors: *p<0.1, **p<0.05, ***p<0.01.

In Table 2, we provide evidence supporting the assumption that the judicial

[17]There are four reservations in the sample for which we could infer from the available documentation whether they were allotted before 1952 or after 1978, but could not exactly determine the year of allotment. This explains the difference in the number of reservations between columns 1-3 and column 4.

boundary does not coincide with confounding discontinuities in pre-determined characteristics or the process of forced settlement. It presents estimates of the reduced-form effect of $Victoria_i$ on the outcomes of the headers in the first row, using the baseline specification and 14 variables covering several relevant dimensions: the topography of reservations (e.g. elevation, standard deviation of the slope, and percentage of land classified as erodible in columns 1-3), climate (average temperature and precipitation in columns 4-5), conditions of forced settlement (year settled, area allocated, number of persons settled, population density when settled, having more than one patrilineal group, fractionalization index *à la* Alesina et al. (2003) between patrilineal groups at the time of forced settlement, having asked for an informal partition of the reservation between 1884 and 1927, and having asked for amendments to the collective property title between 1884 and 1927 in columns 6-13), or a proxy of wealth (maximum number of wives among original Mapuche settlers in column 14). The $Victoria_i$ dummy is only significant at 10% for the area of the reservation. We control for all these predetermined variables in our results to increase statistical power.

B. Declining Mapuche control over land

Control over Mapuche's ancestral territory in general, and reservation land in particular, has played a central role in the conflict between the State, Not-Mapuche landholders, and Mapuche (Correa and Seguel, 2010; Pairicán, 2014). The intensity of this conflict has increased in recent decades, with some actors turning to violence (Cayul et al., 2022). A better understanding of the role that formal individual property rights have had on Mapuche's territorial loss can help inform this and similar debates across Latin America.

Table 3 reports the impact that individual property rights have had on the distribution of land across different types of owners using parcel-level data. Columns 1-3 report estimates of the impact of private property rights on the fraction of reservation land owned by individuals of different ethnicities. Over 80% of reser-

Table 2—: Continuity of predetermined variables across judicial boundary

Dep. var.	Elevation	Slope (std)	% Erodible	Tempera-ture	Precipita-tion	Year settled	Hectares
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Victoria (low congestion)	15.29	0.39	-0.06	0.29	3.22	0.64	63.26
	(12.89)	(0.51)	(0.07)	(0.45)	(4.30)	(2.64)	(34.05)*
Mean high congestion	125.07	3.40	0.35	11.87	103.20	1903.06	150.42
Reservations	1,567	1,567	1,567	1,567	1,567	1,567	1,567
Dep. var.	Persons settled	Pop. Density	> 1 Lineage	Frac. Index	Partition	Amended	Max Wives
	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Victoria (low congestion)	6.87	-1.80	-0.05	-0.02	0.10	0.01	0.01
	(5.66)	(1.15)	(0.04)	(0.03)	(0.08)	(0.05)	(0.04)
Mean high congestion	33.70	24.81	0.66	0.37	0.14	0.15	0.16
Reservations	1,567	1,567	1,558	1,558	1,558	1,558	1,558

Unit of analysis is a reservation. Victoria row presents treatment effects estimates of Victoria's jurisdiction dummy on the dependent variable in the column's header, using a Geographic Discontinuity Design with local linear regression on distance to the judicial boundary as running variable, regions-along-the-boundary fixed effects, and a 50-km triangular kernel. Mean high congestion reports mean of dependent variable for reservations in Temuco's jurisdiction. Conley standard errors (50 km bandwidth) shown below point estimates. Statistical significance reported next to standard errors: *p<0.1, **p<0.05, ***p<0.01.

vation land is owned by Mapuche individuals in reservations allotted after 1979, while only 6 and 2% is owned by Not-Mapuche individuals and individuals with unknown ethnicity. Column 1 indicates that earlier allotment led to a 26 percentage point (p<1%) decline in the share of land owned by Mapuche individuals. Columns 2 and 3 present increases of 14 (p<1%) and 1.5 (not significant) percentage points in the land owned by Not-Mapuche individuals and individuals with unknown ethnicity.

Columns 4 and 5 report estimates of the impact of private property rights on the fraction of reservation land owned collectively by Mapuche and Not-Mapuche. Less than 2% of reservation land is owned collectively in reservations allotted after 1979. Column 4 reports a reduction of 2.28 percentage points in Mapuche collectivelly-owned land, large compared to the average in reservations allotted after 1979 (0.85) but not significant at conventional levels. Column 5 reports an increase of 0.93 percentage point in the share of land owned collectively by not-Mapuche, large compared to the average in reservations allotted after 1979 (0.98) but not significant at conventional levels

Column 6 shows that the share of reservation land for which we have no information is 12.8 percentage points larger in reservations with individual property rights (p<10%). Thus, the estimated reduction of 29 percentage points in Mapuche ownership obtained by adding up the estimates of columns 1 and 4 represents an upper bound for Mapuche's territorial loss. A lower bound is obtained by assuming that the additional land with no information and owned by individuals with unknown ethnicity in reservations allotted after 1979 as compared to those allotted before were owned entirely by Mapuche. If this was the case, the territorial loss would be 14.7 percentage points. To obtain a point estimate within this range, we impute missing ownership using a machine learning model to predict the ethnicity of each property's owner (Column 7). This model estimates that individual property rights led to an 18 percentage point reduction in the fraction of reservation land owned by Mapuche (p<1%).

Table 3—: Control of land

Dep. var. % land	Individual			Collective			
	Mapuche	Not-Mapuche	Unknown	Mapuche	Not-Mapuche	No Info	Predicted Mapuche
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Private	-26.75	13.79	1.51	-2.28	0.93	12.79	-17.98
	(4.50)***	(2.94)***	(1.70)	(1.59)	(2.36)	(7.35)*	(3.72)***
$\overline{Y}$ collective	81.28	5.82	2.42	0.85	0.98	8.66	90.26
Reservations	1543	1543	1543	1543	1543	1543	1543

Unit of analysis is a reservation. Private row presents treatment effects estimates of reservations being allotted before 1979 on the dependent variables in the columns' headers, using the baseline Fuzzy Regressions Discontinuity Design (equations 7 and 8) with Conley standard errors (50-km bandwidth) below point estimates. $\overline{Y}$ collective reports average of dependent variable in reservations allotted after 1979. The dependent variables in columns 1-6 represent the share of reservation land under the type of owner described in the header. The dependent variable in column 7 is the share of Mapuche land estimated after imputing the ethnicity of owners of parcels with no information on ethnicity. Statistical significance reported next to standard errors: *p<0.1, **p<0.05, ***p<0.01.

One potential concern is that the results in Table 3 may underestimate the effects of individual property rights since the underlying data describes land ownership after these rights had been introduced into control reservations, providing an opportunity for convergence. Appendix B tests the sensitivity of our results to this concern, presenting a similar analysis using land use data from the 1974 Indigenous Agricultural Declaration. Reassuringly, this analysis yields similar results – when predicting ethnicity for families for which ethnicity is not known, we find that the introduction of individual property rights led to a 13 percentage point decline in the share of land used by Mapuche families.

C. Transformations in the allocation of reservations' land and labor

Individual property rights are not only expected to affect the share of reservation land controlled by Mapuche, but also the way in which land and labor is used in reservations. Collective ownership burdened by a traumatic history of colonization might have led to an inefficient allocation of land and labor among and within reservations' families through at least three mechanisms. First, since use-rights were not assigned to specific tracts of land, collective ownership may have restricted land transactions. This friction in land markets is the source of collective ownership's inefficiency modelled in Section I, and is likely to have sustained an excessively atomized productive structure. Second, collective ownership may have led to a "tragedy of the commons" by failing to induce families to internalize the full costs of livestock grazing. Third, use rights under collective ownership may have discouraged farmers from reallocating their labor away from their plots out of fear of losing their land, inefficiently tying labor to land.[18]

We hypothesize that individual property rights would improve allocative efficiency in reservations by creating enforceable deeds over clearly demarcated and trans-

[18] The last two mechanisms were not modelled in Section I, but have been shown to be relevant sources of inefficiencies of collective ownership and are likely relevant given the context of collective ownership in Mapuche reservations. The literature also identifies collateralization as a possible mechanism through which individual rights can improve farmers' livelihoods in the long run. While uptake of formal bank credit was low in reservations, we cannot discard that credit given by local agricultural dealers did not play a role, since the 1931 Decree, article 54, defines that allotted parcels can be used as collateral for credit with the authorization of the Court of Indians (República de Chile, 1931a). Unfortunately, we have no data on local credit to test the importance of this mechanism.

ferable plots. We anticipate that this transition in property rights would facilitate the enclosure of plots to exclude livestock owned by other households, improving the protection of natural capital and providing sufficient tenure security for individuals to disengage from agricultural activities in their plots and join local labor markets. We also expect that these transformations would support higher living standards in the long term.

Consolidation of landholdings

Small, family-owned farms were the primary unit of agricultural production within Mapuche reservations (Bengoa and Valenzuela, 1982). This productive structure may provide one explanation for why yields on reservations were only half as high as was obtained by farms outside reservations in the same region (Apey et al., 2001). Indeed, Bengoa and Valenzuela (1982) describes the typical family in a reservation as having access to use rights over too many small plots scattered throughout numerous reservations. Under these conditions, it is possible for formal individual property rights to have facilitated a process of land consolidation that brought landholdings closer to their optimal scale.

The results reported in Table 4 support the hypothesis that individual property rights facilitated land consolidation, decreasing the number of families in reservations and increasing the size of the average landholding. Columns 1 and 2 present the results for all households (Mapuche, Not-Mapuche, and of unknown ethnicity). The estimates suggest that a consolidation process of landholdings supported by outmigration had taken place by 1999-2018, with a decline of 12.9 ($p<1\%$) in the average number of owners and an increase of 1.7 ($p<5\%$) hectares in the average size of owners' landholdings. Both estimates are large compared to the average number of owners and landholding size in reservations allotted after 1979, 27.2 and 5.3.

Columns 2 and 3 of Table 4 presents the results when selecting only Mapuche owners (columns 3-4). The results closely align with those presented in columns

Table 4—: Land consolidation, 1999-2018

Sample	All		Mapuche		Not-Mapuche	
Dep. var.	# owners	Avg. land	# owners	Avg. land	# owners	Avg. land
	(1)	(2)	(3)	(4)	(5)	(6)
Private	-12.87	1.70	-15.58	0.48	3.12	5.67
	(2.64)***	(0.86)**	(2.50)***	(0.93)	(0.83)***	(2.23)**
$\overline{Y}$ collective	27.16	5.25	26.04	5.27	2.75	4.58
Reservations	1337	1337	1304	1304	684	684

Unit of analysis is a reservation. Private row presents treatment effects estimates of reservations being allotted before 1979 on the dependent variables in the columns' headers, using the baseline Fuzzy Regressions Discontinuity Design (equations 7 and 8) with Conley standard errors (50-km bandwidth) below point estimates. $\overline{Y}$ collective reports average of dependent variable in reservations allotted after 1979. Statistical significance reported next to standard errors: *p<0.1, **p<0.05, ***p<0.01.

1 and 2, although the estimated declines in the number of owners is larger and the estimated increases in average landholdings is smaller. The difference reflects the loss of Mapuche control over reservation land reported in Table 3.

Columns 5 and 6 of Table 4 presents the results when selecting only not-Mapuche owners. In contrast to what is observed among Mapuche, the number of owners increases by 3.1 (p<1%). The gain in the area controlled by the Not-Mapuche community reported in Table 3 more than compensates for their increase in population, leading to increases of 5.7 (p<10%) hectares in the average size of their landholdings.

Note that these effects are reported for 1999-2018, that is, after all reservations had been allotted. Thus, if some convergence occurred, the estimates are likely biased towards zero. The fact that there is no full convergence indicates that it takes time for land markets to adjust to the optimal parcel size following privatization. This delay may be due, in part, to the transaction costs associated with consolidating small landholdings.[19] Appendix B shows that we find similar results in a sample of land users from 558 reservations included in the 1974 Indigenous Agricultural Declaration.

[19]The restriction, in effect since 1993, prohibiting the sale of Mapuche-owned plots to non-Mapuche individuals in former reservations, could contribute to the overall transaction costs by reducing the pool of potential buyers.

The closing of the commons and its impact on grazing and erosion

Considering the historical conditions under which reservations were created, we hypothesize that local institutions could not induce families to internalize the full costs of grazing their livestock in collectively owned reservations. The description in Titiev (1951, p. 20) provides a vivid depiction of the environmental and economic burdens associated with the unchecked increase of livestock in reservations by the 1940s:

> ...the increase of livestock since pacification [forced settlement] has led to serious overgrazing, with the result that the heavy rains of winter wash valuable chemicals out of the denuded earth and erode great tracts of precious soil as the waters cut deeply into the bare ground.

If individual property rights closed an inefficiently governed open access regime for grazing resources, we would expect livestock pressure over reservation land to fall as farmers internalize prior externalities associated with livestock production. Column 1 of Table 5 presents an estimate of the effect on livestock density in 1974. Livestock density fell by 0.34 units ($p<1\%$), a considerable decline considering the average among reservations allotted after 1979, 0.74.

Table 5—: Livestock density in 1974 and land cover in erodible lands in 1999

Dep.var	1974 Livestock Density	1999 Land Cover in Erodible Land (%)			
		Grassland	Cropland	Forest	Shrubland
	(1)	(2)	(3)	(4)	(5)
Private	-0.34	-21.00	2.01	20.45	-1.24
	(0.06)***	(4.52)***	(0.98)**	(4.04)***	(0.62)**
$\overline{Y}$ collective	0.74	60.39	0.94	36.42	1.62
Reservations	558	1,345	1,345	1,345	1,345

Unit of analysis is a reservation. Private row presents treatment effects estimates of reservations being allotted before 1979 on the dependent variables in the columns' headers, using the baseline Fuzzy Regressions Discontinuity Design (equations 7 and 8) with Conley standard errors (50-km bandwidth) below point estimates. $\overline{Y}$ collective reports average of dependent variable in reservations allotted after 1979. Statistical significance reported next to standard errors: *p<0.1, **p<0.05, ***p<0.01.

Erosion and the associated decline in soil fertility caused by overgrazing has been one of the main environmental and economic burdens in reservations since forced settlement (Klubock, 2014). Columns 2-5 present estimates of land cover as of 1999 on erodible land. Consistent with the declining importance of livestock, column 2 reports that the fraction of erodible reservation land devoted to grassland is 21 percentage points lower on average (p<1%) in reservations allotted after 1979. The results for the other land cover classes (cropland, forest, and shrubland) suggest that lands that would have been allocated to grasslands were, instead, primarily covered by forests (by definition all land cover class fractions sum to 1).[20]

Reallocation of labor

Families facing unclear or unenforceable claims to land may allocate additional labor to their farms to maintain usufructuary rights, inefficiently tying labor to land. In doing so, the lack of formal individual property rights may preclude the formation of a fluid labor market, increasing the cost of hired labor for local families and firms.

Table 6 shows how the characteristics of the labor force were impacted by individual property rights, using data from the 1992 General Population Census. Column 1 shows the impact on the ethnic composition of the labor force in 1992, with the fraction of Mapuche workers declining by 21 percentage points (p<1%). This result aligns with the Mapuche's loss of land and the decline in Mapuche households and owners reported in Tables 3 and 4, confirming that individual property rights reduced Mapuche presence in reservations. Column 2 shows that the fraction of workers engaged in paid labor outside of their farm (wage workers) increased by 15.1 percentage points (p<1%), a large increase when compared to

[20] While these results are consistent with a reduction of livestock pressure and the subsequent regrowth of forests on abandoned grasslands, they also reflect the direct effects of improved tenure security on land cover. For instance, farmers might have felt less pressure to clear forests to secure their claims, or may have responded to enhanced incentives to engage in long-term investments, such as the planting of forests or the maintenance of riparian buffers on erodible riverbanks.

the average among reservations allotted after 1979, 11.3%. This growth in wage workers reflects a shift in the ethnic composition of reservations towards Not-Mapuche households, but also an increase in the share of Mapuche individuals engaged in wage labor (8.9 percentage points, p<1%).

Formal individual property rights may also affect the qualifications of the labor force by enabling families to invest resources in education (Galiani and Schargrodsky, 2010). Columns 3 and 4 present estimates of the impact of individual property rights on average schooling and the fraction of literate individuals. Estimates using the whole population, presented in panel a, show large positive impacts of 0.5 extra years of schooling (p<5%) and a 7.2 percentage point increase in literacy (p<10%). While positive estimates are found for Mapuche in panel b, the impacts are smaller and are not statistically significant. Thus, most of the aggregate results are likely due to the shift in the ethnic composition of reservations towards Not-Mapuche households who had, on average, received more formal education.

D. Changes in socioeconomic conditions

Impacts of allotment on the socioeconomic conditions of reservations' territories and their descendants

The evidence presented so far shows that individual rights did improve the marketability of land, along with efficiency in the use of land and labor. Here, we test whether these transformations led to better socioeconomic conditions in reservations' territories as predicted by the model of Section I, and improvements in socioeconomic conditions among reservations' descendants. The model predicts that descendants' economic conditions will only improve if exposure to dispossession among reservations allotted earlier was low, and that the result can be null or even negative if exposure to dispossession was large.

Columns 1-3 of Table 7 report results of the impacts of individual property rights

Table 6—: Labor market in 1992

Dependent variable	% Mapuche	% Wage workers	Avg. schooling	% Reads
	(1)	(2)	(3)	(4)
Panel a: All households				
Private	-20.90	15.13	0.48	7.18
	(4.15)***	(4.00)***	(0.20)**	(3.09)**
$\overline{Y}$ collective	81.62	11.29	3.97	71.20
Reservations	1,414	1,414	1,414	1,414
Panel b: Mapuche				
Private	—	8.86	0.23	0.87
	—	(2.12)***	(0.18)	(3.48)
$\overline{Y}$ collective	—	9.57	3.77	69.44
Reservations	—	1,371	1,371	1,371
Panel c: Not-Mapuche				
Private	—	9.85	-0.24	13.02
	—	(11.81)	(0.35)	(5.52)**
$\overline{Y}$ collective	—	21.64	5.27	78.80
Reservations	—	1,168	1,168	1,168

Unit of analysis is a reservation. Private row presents treatment effects estimates of reservations being allotted before 1979 on the dependent variables in the columns' headers, using the baseline Fuzzy Regressions Discontinuity Design (equations 7 and 8) with Conley standard errors (50-km bandwidth) below point estimates. $\overline{Y}$ collective reports average of dependent variable in reservations allotted after 1979. Statistical significance reported next to standard errors: *p<0.1, **p<0.05, ***p<0.01.

on reservations' wealth. Column 1 shows a sizable increase of almost half a standard deviation in the wealth index (p<5%), confirming the hypothesis that the transformations produced by individual property rights led to an increase in average socioeconomic conditions in reservations. Columns 2 and 3 recalculate the average index for each reservation, but using only Mapuche and not-Mapuche households as self-reported in the census. While both coefficients are positive, the estimated impact among Mapuche households is half that of not-Mapuche households and not significant at conventional levels. Thus, a large part of the increase in average wealth reported in column 1 is due to the compositional change of reservations' populations, with wealthier not-Mapuche households replacing poorer Mapuche households. Indeed, the average wealth index in reservations allotted after 1979 is considerably lower for Mapuche households, -28 compared to 50 in not-Mapuche households.

Table 7—: Socioeconomic conditions in reservations' territories (1992) and descendants (2021)

Dep. var.	Wealth Score (1992)			Avg. Schooling Head of Households (2021)
	All	Mapuche	Not-Mapuche	
	(1)	(2)	(3)	(4)
Private	44.76	23.77	44.97	-0.48
	(11.88)***	(15.17)	(26.37)*	(0.80)
$\overline{Y}$ collective	-15.29	-27.68	49.92	10.25
Observations	1,414	1,371	1,168	8,763
Reservations	1,414	1,371	1,168	273

Unit of analysis is a reservation in columns 1-3 and a descendant with an uncommon surname (frequency≤150) linked to only one reservation column 4. Private row presents treatment effects estimates of reservations being allotted before 1979 on the dependent variables in the columns' headers, using the baseline Fuzzy Regressions Discontinuity Design (equations 7 and 8) with Conley standard errors (50-km bandwidth) below point estimates. $\overline{Y}$ collective reports average of dependent variable in reservations allotted after 1979. Statistical significance reported next to standard errors: *p<0.1, **p<0.05, ***p<0.01.

The fact that a significant part of the average increase in reservation wealth is due to changes in the ethnic composition of reservations adds to the concern that Mapuche descendants might not have benefited from individual rights. Column 4 tests this hypothesis, using as a proxy of socioeconomic conditions the average schooling of head of households in the census block group where the descendants of reservations live. Over 8,763 reservation descendants with uncommon paternal surnames (frequency below 150) that can be linked to only one of the reservations' historical surnames are selected in the sample. This selection ensures that individuals descend from the reservations they are linked to. The results show an insignificant reduction of 0.5 years of schooling.

These results show that, while the efficiency gains from individual property rights did lead to improvements in living conditions in reservations' territories, reservations' descendants did not benefit from early allotments. Through the lens of Section I's model, this suggests that historical exposure to dispossession might have precluded some reservations' descendants from benefiting from the introduction of individual property rights. The next section tests this explanation.

Impacts of dispossession on Mapuche descendants

Column 1 of Table 8 shows the OLS estimate of exposure to dispossession on socioeconomic conditions among descendants from reservations allotted before 1952. Exposure to dispossession for an individual descending from a reservation is defined as the fraction of her ancestors' reservation's allocated parcels sold in the period where restrictions to buy reservation land were lifted (1943-1946), and socioeconomic conditions are measured as the average schooling of head of households in the block group where each descendant resides. The sample includes descendants with surnames linked to only one reservation's historical surnames, which amounts to 1,596 individuals descending from 48 reservations allotted before 1952. The specification controls for the rich set of predetermined variables in the header of Table 2 and a second-degree polynomial in longitude and latitude. The results show that families descending from reservations that were 100% exposed to dispossession—i.e. where all allotted parcels were sold exposed to dispossession—now live in communities in which the average head of household has 1.5 fewer years of schooling (not significant), as compared to those descending from reservations where no parcel was sold exposed to dispossession.[21] Column 2 displays the results from our preferred OLS specification, which includes allotment year as a control. The point estimate remains stable at -1.5 whereas the standard error decreases by one-third, rendering the point estimate significant at the 5% level.

Column 3 expands the sample to all descendants linked to any reservation, whether or not it was allotted before 1952. This increases the sample to 8,763 individuals descending from 273 reservations. The specification includes a Private dummy, equal to one for reservations allotted before 1979. Early access to individual property rights is associated with an increase of 2.66 years in the schooling of head of households in descendants' block groups (not significant). However, among those

[21] The range of exposure goes from zero to one in the sample.

who gained early access to private property, the descendants from reservations that were 100% exposed to dispossession experienced a reduction of 0.9 years of schooling in their block groups relative to those who were not exposed. While the difference is not significant at conventional levels, the result supports the concern that dispossession played a role in precluding Mapuche descendants from benefiting from individual property rights, as suggested by Section I's model.

Table 8—: Exposure to Dispossession and Descendants' Socioeconomic Status

Dep. var.	Avg. Schooling Head of Households in Census Block Group					
Estimator		OLS			2SLS	
	(1)	(2)	(3)	(4)	(5)	(6)
Exposure	-1.45	-1.48	-0.94	-6.18	-3.63	-1.57
	(0.95)	(0.65)**	(1.02)	(1.81)***	(1.90)*	(4.94)
Allotment Year		0.08			0.08	
		(0.04)**			(0.05)	
Private			2.66			-0.26
			(1.90)			(2.11)
$\overline{Y}$ not exposed	9.77	9.77	10.22	9.77	9.77	10.22
Reservations	48	48	273	48	48	273
Observations	1,596	1,596	8,763	1,596	1,596	8,763
F-stat				14.5	13.4	20.1/193.8

Unit of analysis is an individual with an uncommon surname (frequency≤150) linked to only one reservation. Sample restricted to reservations within 50 km of the judicial boundary within the 1874 prohibition zone. Private row presents treatment effects of descending from reservation allotted before 1979, instrumented with Victoria's jurisdiction dummy in column 6. Exposure equals the fraction of allotted parcels sold between 1943 and 1946, instrumented by the amount of exposure that is attributable to the average pattern of sales after allotment (see Section III.B for a detailed explanation). All specifications include a second-degree polynomial in longitude and latitude and predetermined reservations' controls (the 14 dependent variables of Table 2). Conley standard errors (50-km bandwidth) reported in parenthesis below point estimates. Statistical significance reported next to standard errors: *p<0.1, **p<0.05, ***p<0.01.

Columns 4-6 show estimates of the same regressions as columns 1-3, but use instrumental variables instead of OLS (the detailed identification strategy, including the definition of the instrument, is presented in Section III.B). The results confirm the negative impact of dispossession on reservations' descendants' socioeconomic status. In columns 4 and 5, full exposure is estimated to have reduced the average years of schooling of head of households in descendants' block groups by 6.2 and 3.6 years (significants at the 1 and 10% levels), relative to descendants that also had early access to private property but were not exposed to dispossession. The inclusion of allotment year as an additional control in column 5 reduces the point estimate in relation to column 4, although it remains significant at the 10% level.

Column 6 expands the sample to reservations allotted after 1952 as in column 3, adding the Private dummy to the regression. The Private dummy is instrumented with the Victoria dummy as in Tables 3 through 7. The results suggest that private property reduces the years of schooling of head of households in reservations' descendants' block groups by 0.26, although the estimate is not significant at conventional levels. However, those individuals who descend from reservations that were also fully exposed to dispossession experienced an additional reduction of 1.57 in the years of schooling of the head of households of their block groups. That is, for those exposed to dispossession, early access to private property led to a reduction of 1.83 (0.26+1.47) years of schooling. While the regression is underpowered and the results are not statistically significant, point estimates are consistent with the pattern estimated with OLS in Column 3, and with the finding of a large negative impact of exposure to dispossession among reservations allotted before 1952 in columns 4 and 5. Interestingly, IV estimates suggest that OLS overestimates the positive impact of private property with no exposure to dispossession and underestimates the negative impact of dispossession, consistent with reservations that enjoy better conditions to sustain long-term economic growth being selected into early allotment and high exposure to dispossession.

E. Robustness checks and placebo tests

We estimate several alternative specifications to test the robustness of our results, and run placebo exercises to strengthen our causal claims. Results from tables 3 through 7 are robust to varying the kernel and the running variable of the Fuzzy Geographic Regression Discontinuity Design—the function and the bandwidth of the kernel and using longitude and latitude instead of distance to the judicial boundary as the running variable, the bandwidth of the Conley's standard errors, eliminating observations close to the judicial boundary, and adding province fixed effects. We find mostly null results at the provincial boundary or for units outside reservations. The robustness of the results and the null results found for the placebo test support our causal claims. These robustness and placebo exercise are discussed and presented in Appendix C.C1.

We run a separate set of robustness analyses for the results presented in Table 8, as they use a different identification strategy (equation 9 instead of equations 7-8). The results are discussed and presented in Appendix C.C2. They show that the instrument is relevant across a broader sample and that the results are robust to removing extreme values and varying the threshold used to consider a surname uncommon.

VI. Conclusion

In this paper, we study whether the allotment of reservations into individual properties improved economic conditions for the Mapuche. We find that individual property rights enabled more efficient use of multiple resources—atomized landholdings were consolidated into larger estates, labor was decoupled from land, overgrazing declined, and a greater share of erodible lands were covered with permanent vegetation. However, individual property rights also led to the loss of Mapuche control over a fifth of reservation land. Given contemporaneous accounts of fraudulent dispossession, it is possible that these transfers undermined the potential for Mapuche families to benefit from improved efficiency within former reservations. Consistent with this concern, we find that allotment did not significantly increase wealth among the Mapuche that stayed within former reservations, nor did it improve the economic conditions experienced by the descendants of early-allotted reservations. We provide suggestive evidence that dispossession was one mechanism preventing Mapuche families from benefiting from the introduction of individual property rights.

These results reveal that individual property rights led to conflicting outcomes, improving local economic efficiency, while eroding the territorial base that sustains Mapuche's collective identity. When analyzing the generalizability of our conclusions, it is important to recognize that this trade-off is a direct consequence of the historical conditions underpinning the creation of indigenous reservations in Southern Chile. As was commonly the case for indigenous groups across the Americas, Mapuche lost most of their territory and many of their traditional institutions when forced to settle in reservations. This tragic history is unlikely to have nurtured the creation and maintenance of the kind of institutions that are required to sustain effective collective action under communal ownership. Within this context, there are strong theoretical reasons to expect individual property rights to promote economic efficiency. Understanding the long-term social, economic and environmental effects of individual property rights vis-à-vis traditional forms of tenure enforced by local institutions across a broader diversity of contexts remains an important research topic to inform the designing of land policies that are tailored to the historical context of targeted populations. In addition, we note that our conclusions about the long-term economic effects of dispossession are limited both by lack of statistical power and the challenge inherent in tracking economic outcomes among emigrants from reservations. Although we believe our results provide suggestive evidence that t active protections against dispossession improved economic conditions for the Mapuche, we believe there is a need for more research documenting how indigenous land rights reforms can be implemented to ensure they yield just outcomes. Finally, a major concern about indigenous people's territorial loss is the potential negative impact on indigenous peoples' capacity to reproduce their culture and language. While this paper did not address this fundamental dimension due to data limitations, we acknowledge its importance for future research on indigenous development.

Our results carry important implications for the design of indigenous land reform in Latin America. Most importantly, our analysis demonstrates that the transition from communal to individual rights does not necessarily benefit indigenous communities, even when these reforms facilitate more efficient use of their land.

Policymakers seeking to improve economic conditions for indigenous communities should think carefully about the distributional consequences that may result from the introduction of individual property rights. In addition, the erosion of indigenous control over land is itself a concern, since territorial loss lies at the center of Latin American conflicts between indigenous peoples, European descendants, and the State. Carefully designed restrictions on the inter-ethnic transfer of privately-held indigenous lands may be necessary to ensure continued indigenous control over their ancestral lands. Finally, indigenous communities who face discrimination or are unfamiliar with their legal rights may be exposed to dispossession when communal lands are allotted into individual properties. Legal reviews may be needed to ensure that buyers are not defrauding indigenous property owners of their lands, and that sellers are well-informed of their rights and are entering into property transactions voluntarily.

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"WHO GAINS FROM INDIVIDUAL PROPERTY RIGHTS? EVIDENCE FROM THE ALLOTMENT OF MAPUCHE RESERVATIONS"

ONLINE APPENDICES

A. Regions along the boundary

From west to east, most of Chile has three distinctive landmarks: the coastal mountains (which in the region we study are called the Nahuelbuta mountains), the central valley, and the Andes mountains. Geographically, it is natural to define five regions based on them: the western slope of the coastal mountains, the eastern slope of the coastal mountains, the central valley, the western slope of the Andes, and the high Andes.

The region we study has an atypical central mountain range that divides the central valley in two: the Humpilñielol mountains. This division also carries historical importance, as the two sides of the mountain range were inhabited by two rival groups that played an important role in Mapuche history before forced settlement: the Abajino Mapuche confederation on the western side and the Arribano Mapuche confederation on the eastern side (Bengoa, 2000). Therefore, we define six regions: the western slope of the Nahuelbuta mountains, which goes from the Pacific ocean to the highest peaks of the Nahuelbuta mountains; the eastern slope of the Nahuelbuta mountains, which goes from the latter point to the line formed, from north to south, by the Puren, Lumaco, and Cholchol rivers, and a straight line south on its confluence with the Imperial river; the western central valley, which goes from the latter line to the highest peaks of the central mountain range in the center; the eastern central valley, which goes from the latter line to the beginning of the western slope of the Andes mountains; the western slope of the Andres, which goes from the latter point to the high picks of the Andres; and the Andes, that goes from there to the border with Argentina.

For the empirical results of this paper, we drop the western slope of the Andes and the Andes from the sample, as there are only a few isolated reservations in these regions. Figure A1 shows all reservations located within fifty kilometers of the judicial boundary, along with the regions described above and a hillshade gray background representing elevation.

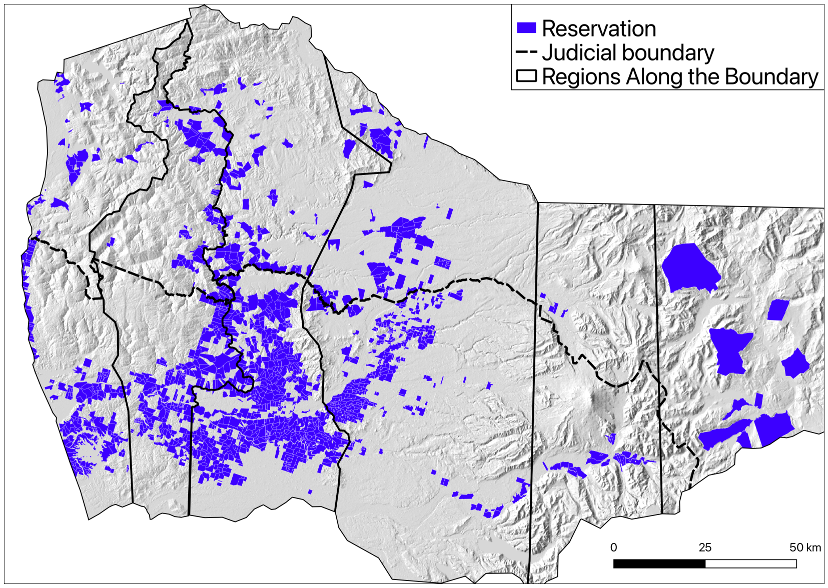

Figure A1. : Regions along the judicial boundary

B. Control and consolidation of reservation land, 1974

Table B1 shows the impact of individual property rights on the share of land used by families by ethnicity. Data is drawn from the 1974 Indigenous Agricultural Declaration, available for 558 reservations within the study area. Column 1 shows that, while 35% of reservation area is not accounted for in the data, we detect no significant impact on the share of land that is part of the survey. Column 2 shows that the fraction of land used by Mapuche families falls by 17.1 percentage points ($p<1\%$). Columns 3 and 4 show that this reduction had, as a counterpart, an increase of 10.6 and 6.5 in land controlled by not-Mapuche families and families with unknown ethnicity, both significant at the 1% level.

In column 5, the ethnicity of families with unknown ethnicity is predicted with a Random Forest model that uses reservation-level predetermined controls (variables in the header of Table 2) and characteristics of the household (age and sex of head of households, number of members younger and older than 15 years old, and hectares used in reservation). We estimate a reduction of 12.8 percentage points in the share of Mapuche land used.[22]

Table B1—: Control of land, 1974

Dep. var. % land	Surveyed	Mapuche	Not-Mapuche	Unknown	Pred. Mapuche
	(1)	(2)	(3)	(4)	(5)
Private	-4.97	-17.15	10.59	6.57	-12.80
	(4.54)	(2.94)***	(3.02)***	(2.16)***	(3.16)***
$\overline{Y}$ collective	64.67	88.26	7.05	4.69	91.82
Reservations	558	558	558	558	558

Unit of analysis is a reservation. Private row presents treatment effects estimates of reservations being allotted before 1979 on the dependent variables in the columns' headers, using the baseline Fuzzy Regressions Discontinuity Design (equations 7 and 8) with Conley standard errors (50-km bandwidth) below point estimates. $\overline{Y}$ collective reports average of dependent variable in reservations allotted after 1979. The dependent variables in column 1 is the total used area reported in the 1974 Indigenous Agricultural Declaration over the total area of the reservations considering the historical limits. Columns 2-4 represent the share of reservation land under the type of user described in the header. The dependent variable in column 5 is the share of Mapuche land estimated after imputing the ethnicity of owners of parcels with unkown ethnicity. Statistical significance reported next to standard errors: *p<0.1, **p<0.05, ***p<0.01.

Table B2 replicates the results reported in Table 4, but using data from households that reported using reservation land in the 1974 Indigenous Agricultural Declaration. The results are consistent, showing a reduction of households accompanied by an increase in the average landholding size in columns 1 and 2, a larger reduction in the number of Mapuche households accompanied by a smaller increase in average Mapuche landholding size in columns 3 and 4, and an increase of both the number of households and average landholding size for Not-Mapuche households, in columns 5 and 6.

[22]The model has an out-of-sample accuracy of 92.7%. Precision and recall are 94% and 48% and 98% and 22% for Mapuche and not-Mapuche users.

Table B2—: Land consolidation, 1974

Sample	All		Mapuche		Not-Mapuche	
Dep. var.	# households	Avg. land	#households	Avg. land	#households	Avg. land
	(1)	(2)	(3)	(4)	(5)	(6)
Private	-5.00	3.08	-8.25	1.55	1.79	7.69
	(2.69)*	(2.22)	(2.94)***	(1.60)	(0.54)***	(6.22)
$\overline{Y}$ collective	14.46	8.21	13.36	8.23	2.05	8.55
Reservations	558	558	539	539	230	230

Unit of analysis is a reservation. Private row presents treatment effects estimates of reservations being allotted before 1979 on the dependent variables in the columns' headers, using the baseline Fuzzy Regressions Discontinuity Design (equations 7 and 8) with Conley standard errors (50-km bandwidth) below point estimates. $\overline{Y}$ collective reports average of dependent variable in reservations allotted after 1979. Statistical significance reported next to standard errors: *p<0.1, **p<0.05, ***p<0.01.

C. Robustness checks and placebo tests

C1. Tables 3-7

We estimate several alternative specifications to test the robustness of our results, and run placebo exercises to strengthen our causal claims. Here, we explain the alternative regressions we run and provide an overview of the results. Plots showing robustness and placebo checks for the results of tables 3 through 7 are presented in C.

Each figure depicts estimates from at least ten alternative specifications for each of the dependent variables. Each figure's first bar corresponds to the benchmark specification; the same estimate presented in the respective table. The second bar is the OLS estimate of allotment before 1979 on the dependent variable, presented to assess the bias induced by the endogeneity of allotment.

The third and fourth bars show the results when reducing the bandwidth to 35 and 20 kilometers. The fifth bar reduces the bandwidth of the triangular kernel for the Conley standard errors from 50 to 10 kilometers. The sixth bar uses a Epanechnikov instead of a triangular kernel in the running variable (distance to judicial boundary). The seventh bar replaces the running variable with longitude and latitude. These five alternative specifications are displayed to show that the results are robust to changes in the key parameters of the geographic regression discontinuity design (bandwidth, kernels, running variable). The results are stable across these alternative specifications.

The eight bar presents the results when removing observations that lie within 1 kilometer of the judicial boundary, i.e. running the geographic regression discontinuity with a 2 kilometer 'donut hole'. This design allows us to address possible violations of the Stable Unit Treatment Values Assumption (SUTVA). This violation is possible in our context: it was common for Mapuche to have plots in several reservations, so individuals living in Victoria's reservations could have benefited from individual property rights in Temuco's reservations where they had land. In that case, our benchmark results would underestimate the true treatment effects. However, alternate scenarios in which farmers reallocate their efforts towards parcels with individual property rights might bias our results in the other direction. In either case, these spillovers are expected to be stronger for reservations closer to other reservations with a contrasting property rights regime, that is, at the judicial boundary. Reassuringly, the results when dropping reservations that lie within 1 kilometer of the judicial boundary are similar to the benchmark results, suggesting that possible violations to SUTVA have limited effects on the reported results.

The ninth bar shows the results when adding fixed effects for each province. As mentioned in Section III, a sizable portion of the provincial boundary between the Cautín and Malleco was moved about 10 kilometers north in 1938. By including province fixed effects, we restrict our estimation of the treatment effect to rely only upon variation from the segment of the judicial boundary that has not coincided with the provincial boundary since 1938. Reassuringly, the results are similar to those of the benchmark specification.

The tenth bar shows the results of a placebo exercise that exploits the modification of the provincial boundary. It runs the reduced form specification on the provincial instead of the judicial boundary, controlling for the Victoria jurisdiction dummy. Estimates of the placebo effect—i.e. the discontinuity at the segment of the provincial boundary that does not overlap with the judicial boundary—are, in most cases, small and not significant. They even have the opposite sign than the benchmark treatment effect in some cases. This placebo exercise strongly suggests that provinces have had no lasting impacts on reservations, strengthening our argument that the discontinuity at the judicial boundary captures the impact of the divergent trajectories of property rights on either side of the judicial boundary.

When data for units outside of reservations are available (all dependent variables except those derived from the Indigenous Agricultural Declaration and the 2021 Electoral Registry), we add an eleventh bar that depicts the results of the benchmark specification when estimated on Chilean census entities (*entidades*) that do not overlap with reservations. We focus upon Chile's census entities since this is the scale at which reservations are represented in the census. The census' cartographic maps include approximate boundaries for each entity, which we use to aggregate 1999-2018 parcel data and land cover data for entities outside reservations. This procedure is analogous to how we computed these outcome variables for reservations. It is important to note that this exercise is not a strict placebo because the treatment can have spillovers outside reservations, as in Aragón (2015). Nonetheless, null result for areas falling outside of reservations would provide further support to our argument that our regression discontinuity identifies the causal effect of the changes to indigenous property rights, rather than the effect of any other discontinuous difference across the jurisdictional boundary. This is mostly the case: we find few statistically significant impacts for units located outside reservations.

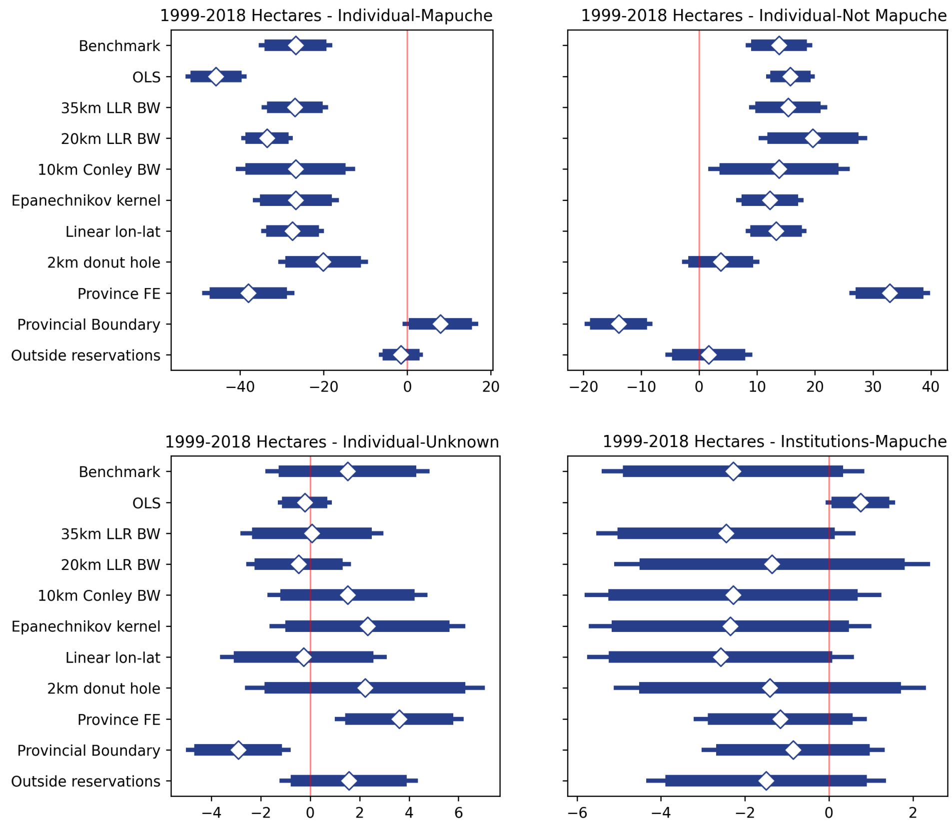

Figure C1. : Robustness check Table 3—The first bar shows the 2SLS result presented in Table 3, in the column with the header of the title of the plot. The second bar presents the result estimated with OLS. Bars 3 through 9 run robustness checks. The third and forth bars reduce the Fuzzy Geographic Regression Discontinuity (FGRD)'s bandwidth to 35 and 25 km. The fifth bar reduces the bandwidth of Conley's standard errors' kernel to 10 km. The sixth bar uses an Epanechnikov instead of a triangular kernel for the FGRD. The seventh bar uses a first-degree polynomial in longitude and latitude instead of distance to the judicial boundary as the running variable. The eigth bar drops observations within 1 km of the judicial boundary. The ninth bar adds province FE. The following bars run placebo tests. The tenth bar runs the reduced form Regression Discontinuity Design on the provincial boundary, controlling for historical jurisdictions. The eleventh bar runs the FGRD for census entidades located outside reservations.

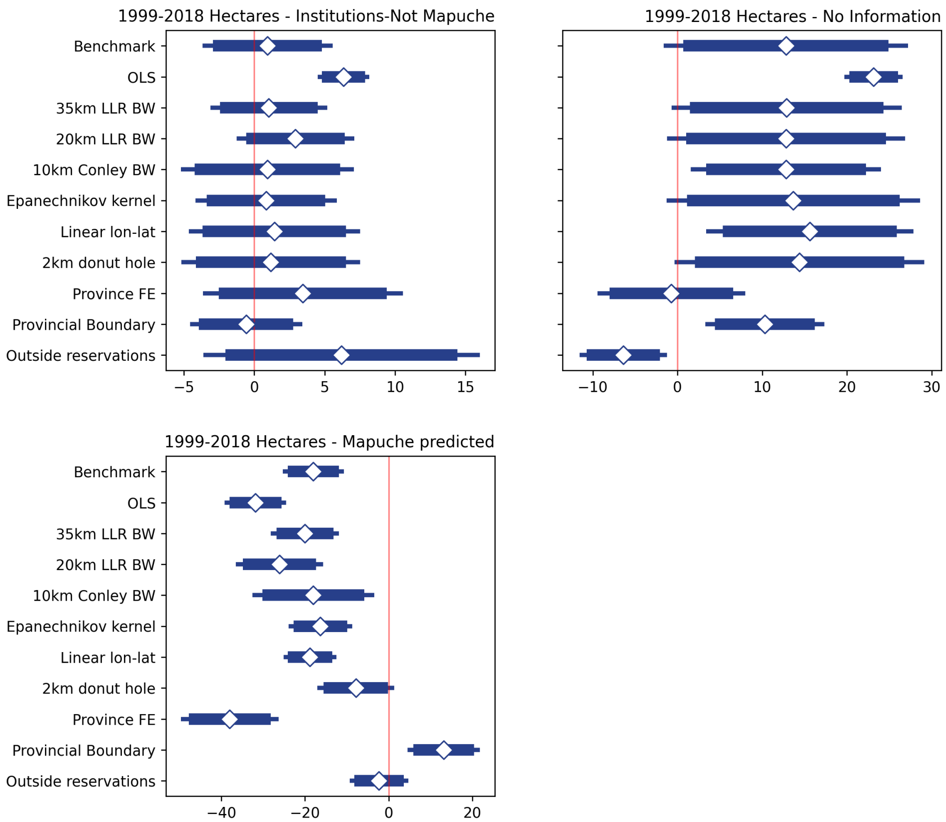

Figure C1. : Robustness check Table 3 (continued)

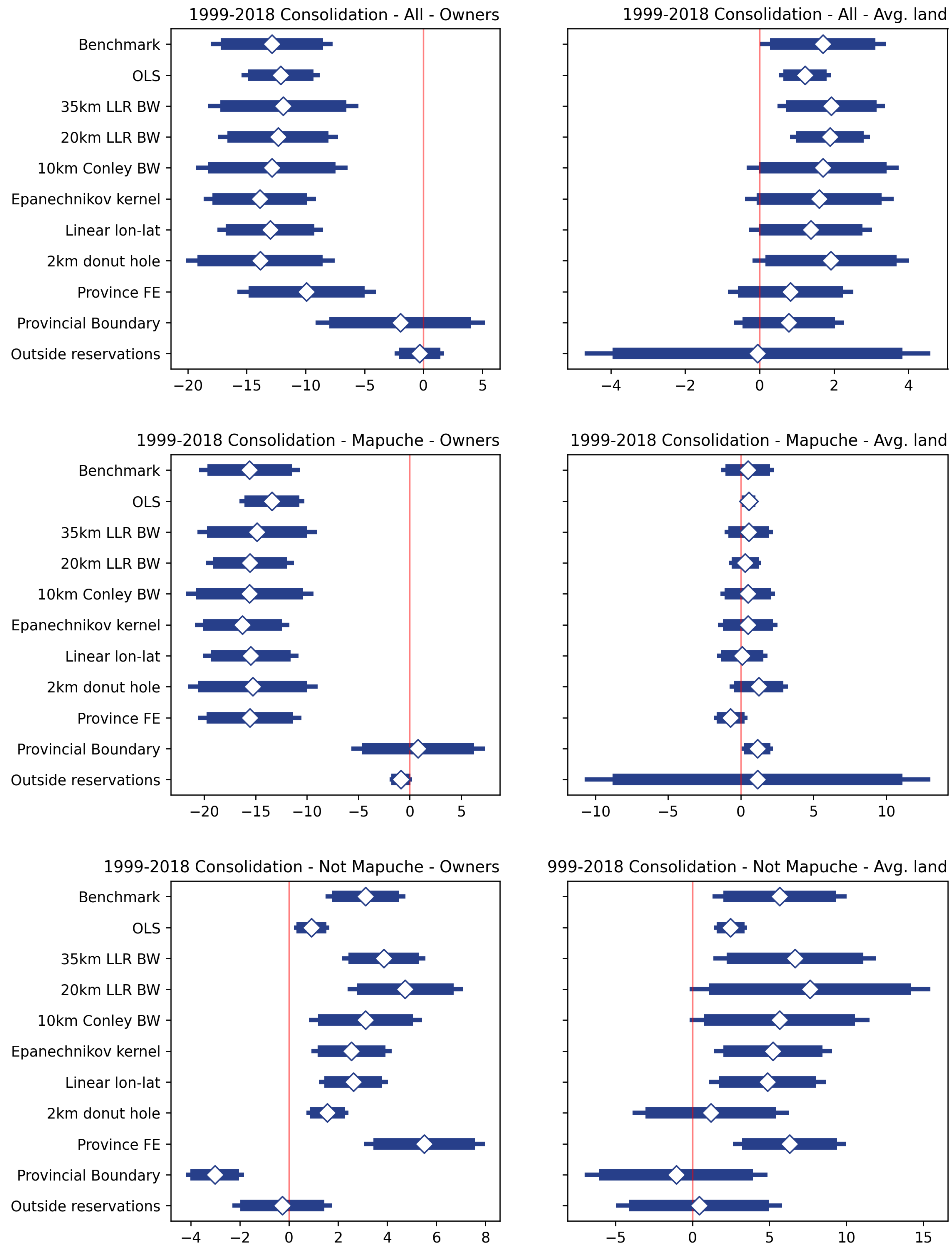

Figure C2. : Robustness check Table 4—The first bar shows the 2SLS result presented in panel a of Table 4, in the column with the header of the title of the plot. The second bar presents the result estimated with OLS. Bars 3 through 9 run robustness checks. The third and forth bars reduce the Fuzzy Geographic Regression Discontinuity (FGRD)'s bandwidth to 35 and 25 km. The fifth bar reduces the bandwidth of Conley's standard errors' kernel to 10 km. The sixth bar uses an Epanechnikov instead of a triangular kernel for the FGRD. The seventh bar uses a first-degree polynomial in longitude and latitude instead of distance to the judicial boundary as the running variable. The eigth bar drops observations within 1 km of the judicial boundary. The ninth bar adds province FE. The following bars run placebo tests. The tenth bar runs the reduced form Regression Discontinuity Design on the provincial boundary, controlling for historical jurisdictions. The eleventh bar runs the FGRD for census entidades located outside reservations.

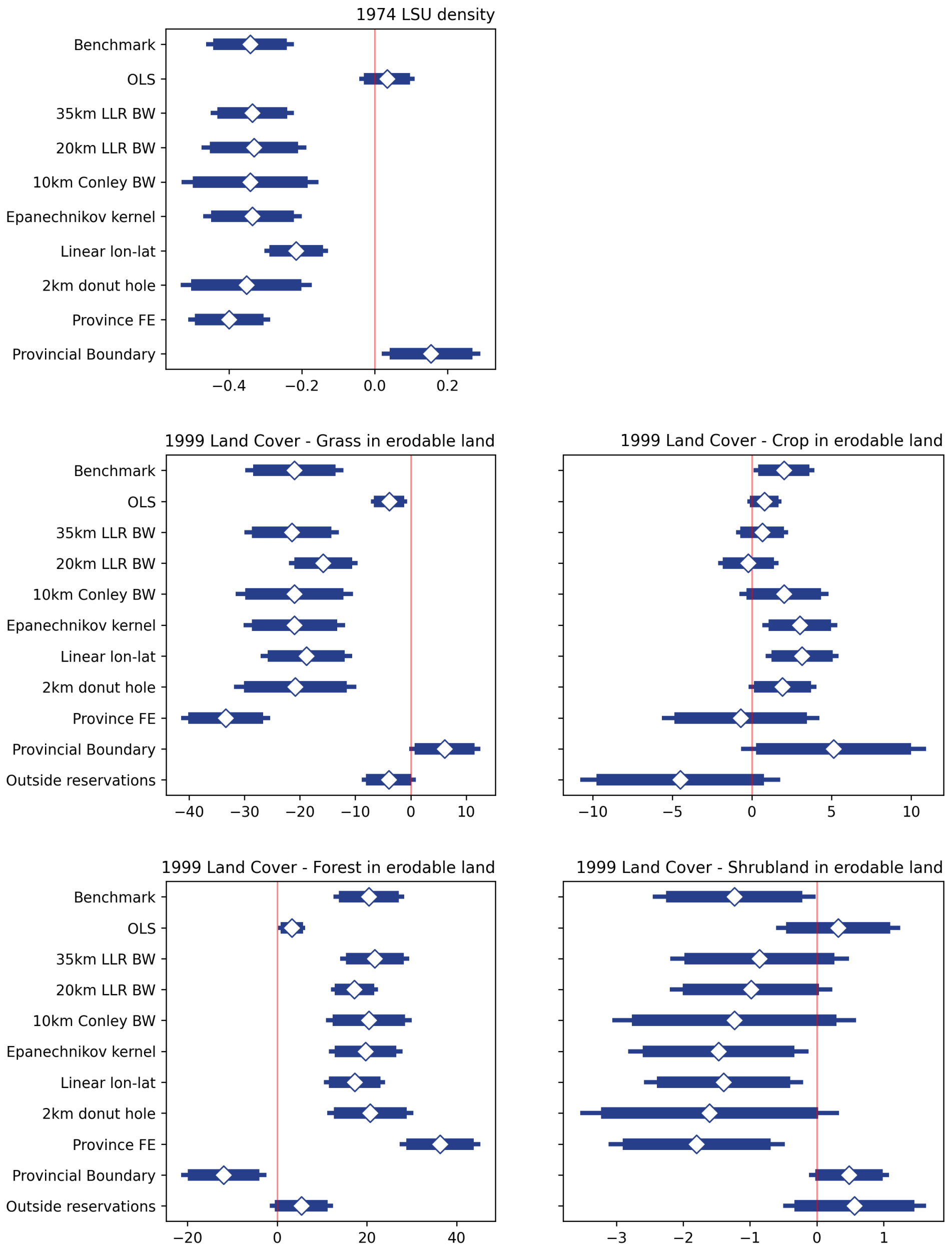

Figure C3. : Robustness check Table 5—The first bar shows the 2SLS result presented in panel a of Table 4, in the column with the header of the title of the plot. The second bar presents the result estimated with OLS. Bars 3 through 9 run robustness checks. The third and forth bars reduce the Fuzzy Geographic Regression Discontinuity (FGRD)'s bandwidth to 35 and 25 km. The fifth bar reduces the bandwidth of Conley's standard errors' kernel to 10 km. The sixth bar uses an Epanechnikov instead of a triangular kernel for the FGRD. The seventh bar uses a first-degree polynomial in longitude and latitude instead of distance to the judicial boundary as the running variable. The eigth bar drops observations within 1 km of the judicial boundary. The ninth bar adds province FE. The following bars run placebo tests. The tenth bar runs the reduced form Regression Discontinuity Design on the provincial boundary, controlling for historical jurisdictions. The eleventh bar runs the FGRD for census entidades located outside reservations.

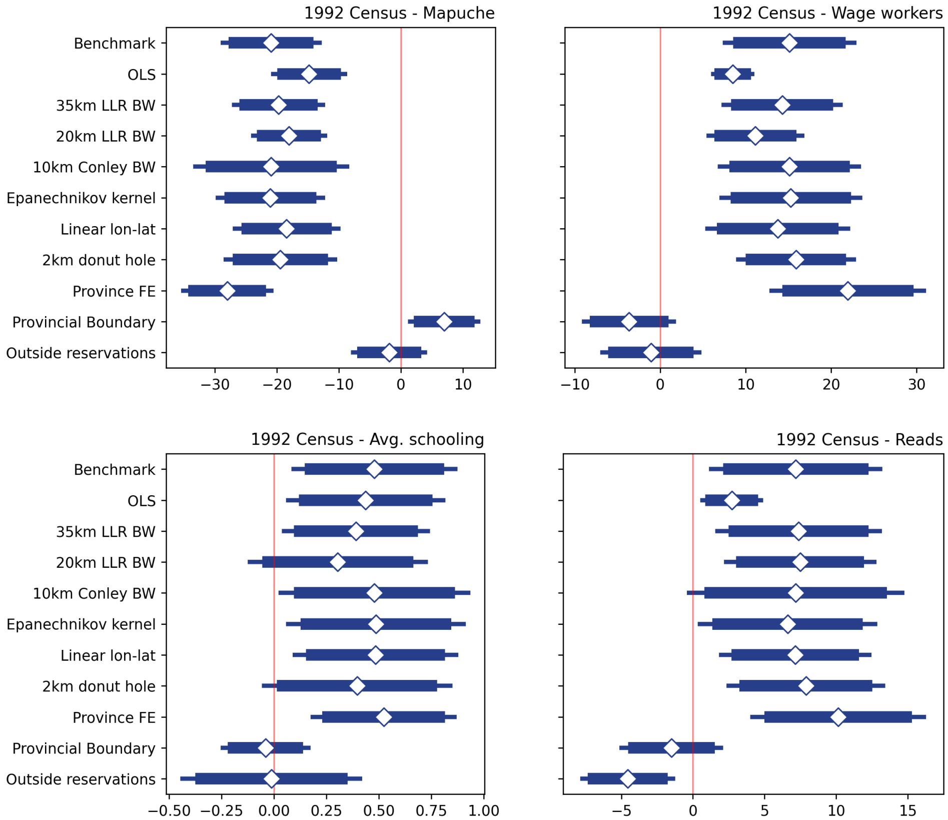

Figure C4. : Robustness check Table 6 Panel a (All households)—The first bar shows the 2SLS result presented in panel a of Table 4, in the column with the header of the title of the plot. The second bar presents the result estimated with OLS. Bars 3 through 9 run robustness checks. The third and forth bars reduce the Fuzzy Geographic Regression Discontinuity (FGRD)'s bandwidth to 35 and 25 km. The fifth bar reduces the bandwidth of Conley's standard errors' kernel to 10 km. The sixth bar uses an Epanechnikov instead of a triangular kernel for the FGRD. The seventh bar uses a first-degree polynomial in longitude and latitude instead of distance to the judicial boundary as the running variable. The eigth bar drops observations within 1 km of the judicial boundary. The ninth bar adds province FE. The following bars run placebo tests. The tenth bar runs the reduced form Regression Discontinuity Design on the provincial boundary, controlling for historical jurisdictions. The eleventh bar runs the FGRD for census entidades located outside reservations.

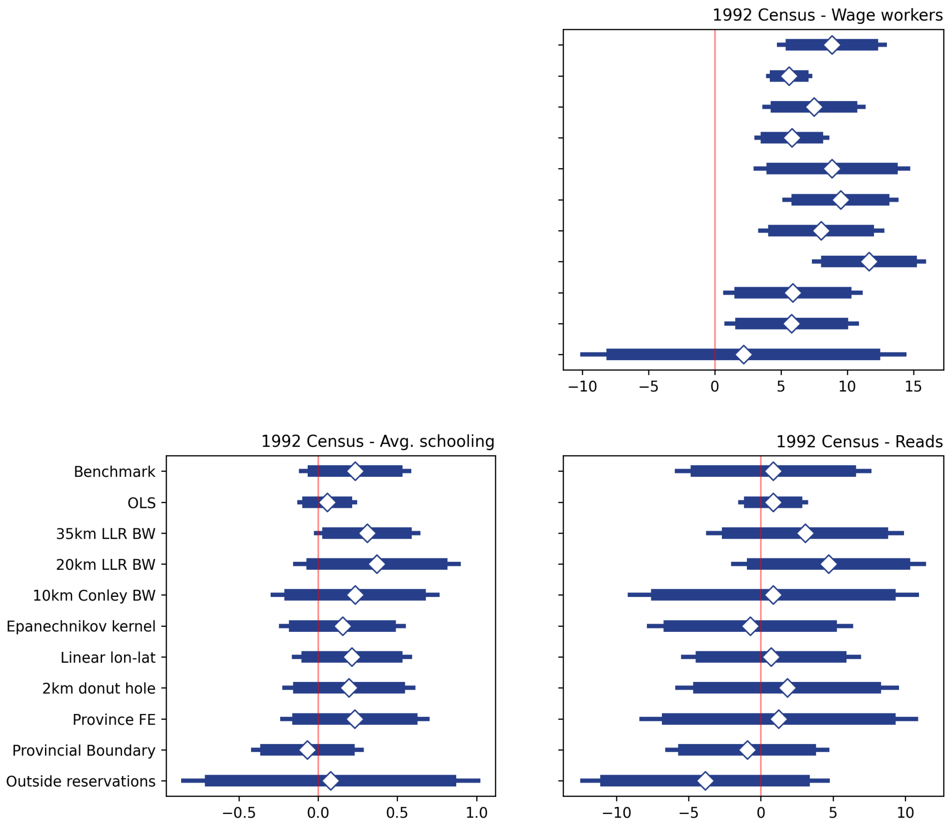

Figure C5. : Robustness check Table 6 Panel b (Mapuche households)—The first bar shows the 2SLS result presented in panel a of Table 4, in the column with the header of the title of the plot. The second bar presents the result estimated with OLS. Bars 3 through 9 run robustness checks. The third and forth bars reduce the Fuzzy Geographic Regression Discontinuity (FGRD)'s bandwidth to 35 and 25 km. The fifth bar reduces the bandwidth of Conley's standard errors' kernel to 10 km. The sixth bar uses an Epanechnikov instead of a triangular kernel for the FGRD. The seventh bar uses a first-degree polynomial in longitude and latitude instead of distance to the judicial boundary as the running variable. The eigth bar drops observations within 1 km of the judicial boundary. The ninth bar adds province FE. The following bars run placebo tests. The tenth bar runs the reduced form Regression Discontinuity Design on the provincial boundary, controlling for historical jurisdictions. The eleventh bar runs the FGRD for census entidades located outside reservations.

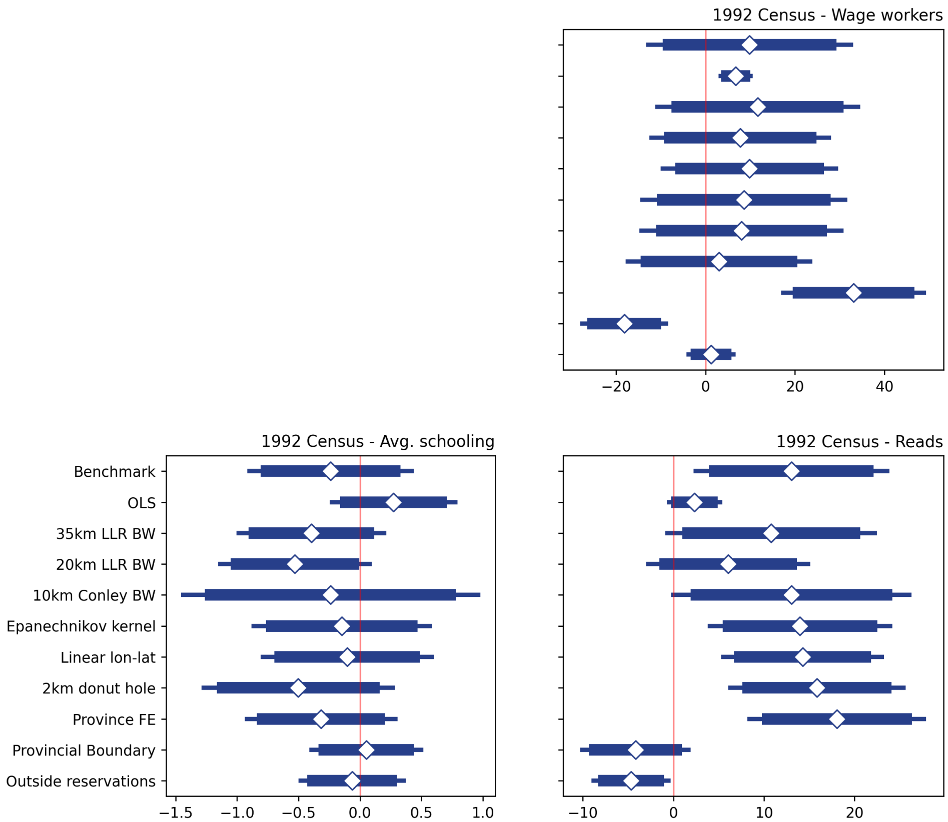

Figure C6. : Robustness check Table 6 Panel c (Not Mapuche households)—The first bar shows the 2SLS result presented in panel a of Table 4, in the column with the header of the title of the plot. The second bar presents the result estimated with OLS. Bars 3 through 9 run robustness checks. The third and forth bars reduce the Fuzzy Geographic Regression Discontinuity (FGRD)'s bandwidth to 35 and 25 km. The fifth bar reduces the bandwidth of Conley's standard errors' kernel to 10 km. The sixth bar uses an Epanechnikov instead of a triangular kernel for the FGRD. The seventh bar uses a first-degree polynomial in longitude and latitude instead of distance to the judicial boundary as the running variable. The eigth bar drops observations within 1 km of the judicial boundary. The ninth bar adds province FE. The following bars run placebo tests. The tenth bar runs the reduced form Regression Discontinuity Design on the provincial boundary, controlling for historical jurisdictions. The eleventh bar runs the FGRD for census entidades located outside reservations.

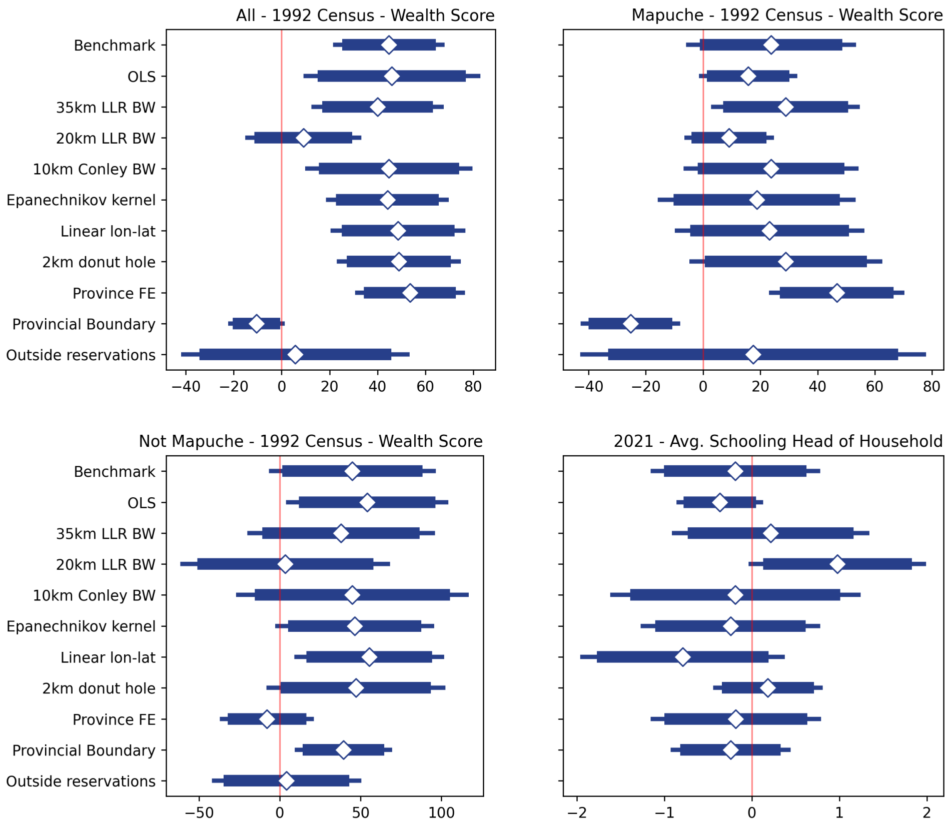

Figure C7. : Robustness check Table 7—The first bar shows the 2SLS result presented in panel a of Table 4, in the column with the header of the title of the plot. The second bar presents the result estimated with OLS. Bars 3 through 9 run robustness checks. The third and forth bars reduce the Fuzzy Geographic Regression Discontinuity (FGRD)'s bandwidth to 35 and 25 km. The fifth bar reduces the bandwidth of Conley's standard errors' kernel to 10 km. The sixth bar uses an Epanechnikov instead of a triangular kernel for the FGRD. The seventh bar uses a first-degree polynomial in longitude and latitude instead of distance to the judicial boundary as the running variable. The eigth bar drops observations within 1 km of the judicial boundary. The ninth bar adds province FE. The following bars run placebo tests. The tenth bar runs the reduced form Regression Discontinuity Design on the provincial boundary, controlling for historical jurisdictions. The eleventh bar runs the FGRD for census entidades located outside reservations.

C2. Table 8

Table C1 presents the results from robustness analysis for regressions of columns 2 and 4 of Table 8. Column 1, panel a, shows that the first stage is not only strong in the selected sample of 45 reservations that had individuals with uncommon surnames, but rather the full sample of reservations divided before 1952. Thus, the instrument's relevance is not unique to our selected sample. Columns 2 through 4 run different variations of the specifications in columns 2 (OLS) and 5 (IV) of Table 8, presenting the results in panels a and b. Column 2 drops from the sample descendants from the reservation with the highest and lowest average value of descendants' neighborhood schooling. The results are very similar, suggesting that outliers are not driving the results. Columns 3 and 4 change the threshold for considering a surname uncommon from a frequency of 150 to 50 and 250, respectively. The results have the same sign, are statistically significant, and are within the same order of magnitude, showing that the point estimates reported in Table 8 are robust to the threshold selection.

Table C1—: Robustness Table 8

Dependent variable	Exposure	Avg. Schooling HH in Census Block		
	(1)	(2)	(3)	(4)
Panel a: OLS				
Instrument	1.47	—	—	—
	(0.25)***	—	—	—
Exposed	—	-1.39	-1.66	-1.99
	—	(0.71)**	(0.76)**	(0.79)**
$\overline{Y}$	0.13	9.74	9.82	10.57
Reservations	350	46	37	49
Observations	350	1,579	685	2,021
Panel b: 2SLS				
Exposed	—	-3.53	-3.46	-5.23
	—	(1.85)*	(1.29)***	(2.47)**
$\overline{Y}$ collective	—	9.69	9.82	9.77
Reservations	350	46	37	49
Observations	350	1,579	685	2,021
F-stat	—	13.42	51.1	11.4

Unit of analysis is a reservation allotted before 1960 in column 1 and an individual with an uncommon surname linked to only one reservation divided before 1960 in columns 2-5. Sample restricted to reservations within 50 km of the judicial boundary within the 1874 prohibition zone. Exposure is the fraction of allotted parcels sold between 1943 and 1947. Instrument is the exposure that is attributable to the timing of allotment given the typical pattern of sales after allotment, as described in Section III.B. All specifications include a second-degree polynomial in longitude and latitude and predetermined reservations' controls (the 14 dependent variables of Table 2). Column 1 estimates the first stage (Instrument on Exposure) for all reservations allotted before 1960 in the study region. Columns 2-5 estimate the impact of Exposure on the average years of schooling of households in the census block groups of descended, with OLS on panel a and 2SLS on panel b. Column 2 restricts the sample to descendants from reservations with average schooling of their descendants' block groups' head of households within the 5^{th} and 95^{th} percentile. Columns 3 and 4 change the threshold to consider a surname uncommon from 150 to 50 and 250, respectively. Conley standard errors (50-km bandwidth) reported in parenthesis below point estimates. Statistical significance reported next to standard errors: *p<0.1, **p<0.05, ***p<0.01.