NATIONAL COURTS, PROPERTY RIGHTS, AND THE TRANSFORMATION OF AN INDIGENOUS SOCIETY

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Indigenous lands are increasingly being integrated into national property rights systems, formalizing indigenous families' claims to lands but restricting traditional institutions' authority to enforce property rights. This paper quantifies the long-term impacts that such a reform had on Chile's largest indigenous group, the Mapuche. The early closure of a national court that enforced property rights opened a wedge in access to courts among neighboring reservations that persisted from 1931 to 1979. Better access to courts fueled a dramatic transition from communal to individual ownership of land. Shifts in production practices suggest the security and marketability of property rights improved. Material conditions, schooling, and soil preservation improved; but Mapuche presence fell. Only a small fraction of the results can be attributed to changes in the ethnic composition of reservations. These results suggest that efficiency gains from individual property titles might come at the cost of reduced indigenous presence.

KEYWORDS: Customary tenure, Property rights, Indigenous reservations, Overgrazing.

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1. INTRODUCTION

THE AUTONOMY WITH WHICH TRADITIONAL INSTITUTIONS can allocate and enforce property rights within indigenous reservations has been a contentious issue since the creation of reservation systems across the Americas. While some have praised this autonomy as the last line of defense against dispossession, others have blamed a lack of access to nationally backed individual property titles for persistent poverty in reservations. In many countries, legal reforms have integrated indigenous lands into national property markets and, as a result, have weakened customary tenure institutions. While these reforms constitute a fundamental development in the history of indigenous peoples, our understanding of their long-term impact on indigenous lands and communities remains limited. Have these reforms improved the security and marketability of property rights, boosting material conditions as envisioned by their advocates? Have indigenous people lost control of their ancestral territories as feared by their opponents? Do reform-driven changes in material conditions reflect meaningful improvements for indigenous families, or do they merely emerge from changes in the ethnic composition of local communities? Here, we study these questions by estimating the long-term effects that a quasi-random expansion of access to national property rights courts had on Chile's largest indigenous group, the Mapuche.

The Mapuche were forced to settle in close to 3,000 reservations in the late 19^{th} century. Reservation land was granted to local chiefs on behalf of their people, entitling each settler to an inheritable and transferable share. While traditional institutions were not officially recognized, they were *de-facto* allowed to allocate land among families through the 1920s. In 1931, a network of specialized courts were created to enforce property rights in reservations according to national statutes. Individuals that felt their rights were not being protected by traditional institutions could take their cases to these courts. In addition, courts were empowered to respond to communities' petitions requesting the division of reservation land into nationally-backed property titles held by individual families.

The early closure of one of these courts in 1931 created a disparity in access to court services on either side of a judicial boundary. This difference was maintained until 1979, when a new reform swiftly divided all remaining reservations. We exploit this plausibly ex-

ogenous source of variation with a geographic regression discontinuity estimator to assess the long-term impact of access to national property rights institutions on the economy, environment, and ethnic composition of reservations. The analysis uses novel historical data tabulated from the General Archive of Indigenous Affairs in Temuco, Chile, in combination with census data, property registry data, erosion maps, and land-cover data derived from satellite imagery. Most outcome variables date from the early 1970s to the early 1990s; at least forty years after reservations' differential access to court services had begun.

Greater integration into standardized, national-level institutions can improve the security, marketability, and pledgeability of land titles, increasing the economic efficiency of land use (De Soto, 2003). However, the expansion of national-level property rights institutions has a troubling history, having often been pursued in order to disempower and assimilate indigenous communities (Lipschütz, 1956). Allowing traditional institutions to adjudicate land claims within their traditional territories may facilitate collective action (Henn, 2018), protect against illicit land grabs (Jacoby and Minten, 2007), and provide a valuable safety net for members of indigenous communities (Takasaki, 2011, Mugido and Shackleton, 2017).

The colonization history of Mapuche suggests access to national property rights institutions may have improved economic efficiency in reservations at the expense of greater exposure to spoliation by outsiders. As with other indigenous populations across the Americas, forced settlement had placed traditional institutions under considerable stress. Mapuche lost their political independence and 90% of their territory after their military defeat in 1881, rendering large-scale cattle raising, their primary economic activity, unviable. Heightened scarcity of cropland and grassland, coupled with the expansion of the Chilean State and the mixing of rival families, gradually eroded traditional leadership structures (Guevara, 1913, Bengoa, 2000). Contemporaneous scholars, bureaucrats, and some Mapuche organizations identified customary tenure as the source of unsolvable quarrels that hindered reservations' progress (Almonacid, 2008). However, some of them also warned that "without the protection of the reservation system it is unlikely that Mapuche society could have survived as a culturally and independent social entity" (Faron, 1961, p. 99).

In this paper we show that greater access to national court services improved property rights within Mapuche reservations, fostering more efficient and sustainable use of reservations' labor and land, while at the same time weakening protections for Mapuche ownership of land. By 1952, better access to court services increased the fraction of reservations that had abandoned customary tenure in favor of individual property rights by 70 percentage points. The rapid abandonment of customary tenure could reflect a preference within reservations for individual property rights. However, it is also possible that improved court services undermined the value of local institutions governing customary tenure. Understanding whether the expansion of national-level institutions into reservations improved the security, marketability, and pledgeability of property rights requires a more detailed analysis of the ensuing long-term transformation of Mapuche communities.

As a result of shifts in national-scale politics that halted further divisions of reservations between 1952 and 1978, we are able to document long-term changes in the allocation of labor and land, as well as the accumulation and distribution of material assets. We focus particular attention on how changes in property rights regimes affected grazing practices, a central economic and cultural activity within Mapuche society. While open access to grazing resources was associated with severe overgrazing in reservations under customary tenure (Titiev, 1951, Faron, 1961), we find that families with better access to court services reduced the size of their herds and increased fodder production. This joint effect is consistent with a causal pathway whereby the adoption of individual property rights ended open access to grazing resources and strengthened tenure security over specific tracts of land, forcing families to internalize the negative impact of livestock on grassland productivity and the benefits of fodder production and grassland fallowing. These changes in agricultural practices were associated with substantial improvements in environmental conditions, increasing vegetation coverage and slowing soil erosion, a critical environmental challenge in the region (Klubock, 2014).

Shifts in the allocation of land among families and changes in worker's occupational choices align with findings from previous studies that have linked improvements in property rights security and marketability with market-level efficiency gains in the allocation of

land and labor (De Janvry et al., 2015, Beg, 2020, Chen et al., 2021 in press). The results show that better access to court services decoupled labor from land, increasing the fraction of wage workers and workers in non-agricultural occupations. It also facilitated the redistribution of land among producers, increasing the average size of estates. Thus, better access to court services seems to have triggered a structural transformation of the local economy by moving reservations away from a production based on small, family-owned subsistence-oriented farms.

The documented changes in the allocation of productive factors are a plausible explanation for observed improvements in human capital formation and material conditions in households by 1992. Adults in reservations that had better access to court services between 1931 and 1979 were more likely to have completed their primary education. Furthermore, households in these reservations were more likely to enjoy basic amenities such as improved floors, running water and toilets; as well as non-essential goods such as televisions and radios.

These average improvements may mask an uneven distribution of the benefits and costs of the courts' long-term impacts. Although all households likely benefited from reductions in grazing pressure and associated erosion, declines in livestock holdings were not equally distributed: better access to courts substantially increased the number of families with no livestock. Similarly, while the documented increase in average landholdings plausibly increased overall efficiency, the results suggest that land inequality increased with access to court services, with the impact on the 90^{th} quantile of the distribution being more than an order of magnitude larger that the impact in the 10^{th} quantile. While these results do not prove that families with no livestock or small landholdings were made worse off by better access to court services, they are consistent with the idea that the transition towards national-level property rights institutions accelerated socioeconomic differentiation in reservations, as suggested by Bengoa and Valenzuela (1982).

Given the saliency of the conflict between indigenous and non-indigenous populations over the control of indigenous ancestral territories, an important question is the extent to which changes in property rights institutions affect the amount of reservation land con-

trolled by indigenous inhabitants. In the case of Chile, the conflict between Mapuche and their non-Mapuche neighbors over reservation land that slipped from Mapuche control has escalated in the past decades (Cayul et al., 2021 forthcoming). Our results show that improved access to court services led to a sizable decline in Mapuche presence on former reservation land, both in terms of the number of Mapuche families and the extent of land they control.

A natural concern that emerges from observing a large shift in the ethnic composition of reservations is that the results reported so far might not represent changes within Mapuche families, but rather the replacement of small Mapuche families by wealthier, better educated, less livestock-intensive non-Mapuche families. We propose a novel decomposition of a causal effect to formally assess this concern. For a given outcome variable, the total treatment effect can be split into two within-ethnic components—that is, among non-Mapuche and Mapuche families, respectively—and one between-ethnic component—that is, what can be attributed to shifts in the share of Mapuche vis-à-vis not Mapuche families in reservations. For most outcome variables, we find that the impacts of access to court services can be attributed to changes experienced within the Mapuche population, with shifts in the ethnic composition of reservations playing a minor role.

This paper relates to a growing body of research in economics that studies the historical determinants of long term development in indigenous territories (Dippel, 2014, Akee and Jorgensen, 2014, De Janvry et al., 2015, Aragón, 2015, Akee et al., 2015, Feir, 2016, Feir et al., 2017, Leonard et al., 2020, Baragwanath and Bayi, 2020). While property rights institutions have been widely recognized as a key determinant, only a few studies offer quantitative estimates of the causal, long-term impacts of reforms to 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 and Jorgensen, 2014, Dippel et al., 2020), Mexico's 1992 PROCEDE program (De Janvry et al., 2015), Canada's First Nations' modern treaties (Aragón, 2015), and Brazil's recent formal recognition of indigenous territories (Baragwanath and Bayi, 2020). The setting we study most closely resembles that of Akee and Jorgensen (2014), De Janvry et al. (2015), 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 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. We complement previous studies by providing a detailed depiction of the structural transformations ushered in as a result of improved access to national property rights institutions in this environment. Among the novel results that emerge from our analyses, is the existence of a trade off between economic efficiency and environmental sustainability on the one side and indigenous ownership on the other. Even though this trade off has been at the center of public discussions about development in indigenous territories, previous studies have focused exclusively on economic efficiency without assessing the extent to which reservation land has slipped from the control of the ethnic group to which it was originally granted. We provide such estimates for a case where indigenous ownership carries important political implications, and develop a novel decomposition that is conceptually equivalent to the canonical Oaxaca-Blinder decomposition to assess the extent to which the estimated structural transformations reflect meaningful changes within ethnic groups as opposed to shifts in the ethnic composition of the population.

Our results on livestock production and soil conservation address another gap in the literature. While the deterioration of access to traditional resources has been identified as an important impediment to development among indigenous communities (Feir et al., 2017), there is limited research demonstrating how different property rights regimes shape the way in which indigenous reservations have dealt with this deterioration. We show that, in the absence of a *de-jure* recognition of traditional institutions, greater integration into national property rights systems may alleviate the environmental problems associated with overgrazing, a phenomena that is likely to emerge in a pastoral society whose territory is dramatically reduced while their traditional institutions are undermined. These results also add to a mature literature in economics and political sciences on the management of

Common Pool Resources, particularly those that explore whether individual property rights can mitigate the 'tragedy of the commons' (Ostrom, 1990, Costello et al., 2008, Liscow, 2013, Isaksen and Richter, 2019, Ayres et al., 2021, Bühler, 2021).

This paper also relates to the more general inquiry into the impacts of strengthening property rights on economic development and environmental sustainability. In agricultural landscapes, several empirical studies have used quasi-experimental methods to document the relationship between strengthening 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, 2021), labor mobility and its allocation between agricultural and non-agricultural activities (De Janvry et al., 2015, Chernina et al., 2014, Beg, 2020), the allocation of land among producers (Libecap and Lueck, 2011, Chen et al., 2021 in press, 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). The empirical strategies pursued by most of these studies estimate short term effects that do not fully capture the impact of long-run resource reallocation, and the notable exceptions that estimate steady state differences across individuals miss market-level dynamics. This paper joins the small number of studies that estimates long-term impacts inclusive of market-level dynamics (Liscow, 2013, Christensen et al., 2021), complementing previous findings by analyzing a rich set of outcomes that provide a comprehensive appraisal of the impact of improved, individual property rights on agricultural practices, soil preservation, human capital formation, and indigenous ownership.

2. PROPERTY RIGHTS IN MAPUCHE RESERVATIONS SINCE FORCED SETTLEMENT

Prior to their conquest by Chilean armies in 1881, Mapuche were organized across a flexible network of interconnected but independent kin groups (Guevara, 1916, pp. 189-196; Latcham, 1924, pp. 581-596). The Mapuche's primary economic activities centered upon raising and raiding livestock, and a chief's livestock holdings reflected his prestige and influence (Faron, 1961, pp. 22-23). The constant state of war with the colonial society exerted strong pressures towards 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. This system provided substantial flexibility for individual families, as local chiefs were eager to grow their communities and families were free to move (Bengoa, 2000, pp. 60-63).

After colonization, the 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: the head of each family distributed land among its members, and the local chief mediated conflicts between families in consultation with influential individuals (Faron, 1961, p. 110-116).

Forced settlement reduced Mapuche's territory while simultaneously undermining the social structure above the extended family that could have formed the basis to build effective institutions to sustain collective action. As a result, overgrazing and conflicts among families emerged as prominent problems in reservations. A contemporary observer involved in the process provides a vivid account of the type of quarrels he dealt with:

> ...this office attends to the complaints between indigenous people, specifically those about who has the claim to use a particular piece of the tract of land granted to them. Those complaints are very complicated, and the motives behind them give rise to irritated enmities between them that degenerate into armed battles, witnessing the fields stick fights and, in occasions, even stabbing fights. In rare occasions the parties can be reconciled, and the best solution is to put an end to the community, dividing the land among those listed in the title.[1]

As the last reservations were being established in the late 1920s, ad-hoc courts were created to resolve conflicts over land within the reservations. These courts adjudicated cases brought by individuals claiming that their legal rights were not being fulfilled by local institutions, and verified that transfers of reservations' shares were consensual. In addition, the owners of at least a third of a reservation's shares could petition the court to dissolve the reservation as a legal entity. Upon dissolution, the court would divide the reservation's

[1] Eulojio Robles Rodriguez, quoted in (Guevara, 1913, pp. 197-198). Translated to English by the authors.

land holdings, and allocate to each member of the reservation an individual property title over a parcel. During the twenty years that followed a division, the role of courts was restricted to verify that sales of parcels were consensual, with other issues left to regular civil courts. Hence, the property rights system in undivided reservations can be characterized as a *de-facto* form of customary tenure, with national courts providing an external conflict-resolution mechanism and the only avenue to formally transfer shares and abandon customary tenure in favor of nationally-backed individual titles.

Three Courts of Indians, shown in Figure 1, were established in June 1931 across our study region, located 600 kilometers south of Santiago: Victoria in the North, Nueva Imperial in the Southwest, and Temuco in the Southeast (República de Chile, 1931a).[2] Only a month had passed when a new decree closed the court of Nueva Imperial and appended its jurisdiction to Temuco due to budgetary constraints. Although this merger meant that the Temuco court's jurisdiction spanned more than double the number of reservations of the Victoria court's jurisdiction, the new decree provided similar staffing to each court (República de Chile, 1931b).[3] The workload imbalance between both courts was acknowledged by the Government in a decree published in 1948, where a small part of the jurisdiction of Temuco was transferred to Victoria (República de Chile, 1948).

In 1952 the Corporación Araucana, a Mapuche organization that opposed divisions, supported the candidate Carlos Ibañez del Campo for the presidency of Chile (Almonacid, 2008). Shortly after winning, Carlos Ibañez del Campo closed the court of Victoria and appended its jurisdiction to Temuco's court (República de Chile, 1952). While no new divisions were completed under his government, the imbalance in access to courts across the judicial boundary had already opened a large wedge in the adoption of individual property rights: while 83% of Victoria's reservations in the study region had abandoned customary

[2] A short-living ad-hoc court preceded the Courts of Indians between 1927 and 1931. It was a unique court in Temuco charged with dividing all reservations, and was quickly opposed both by Mapuche organizations, who wanted to have a say in whether to divide reservations, and non-indigenous settlers, who felt that their rights were being threatened (Almonacid, 2008).

[3] 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 an assistant attorney.

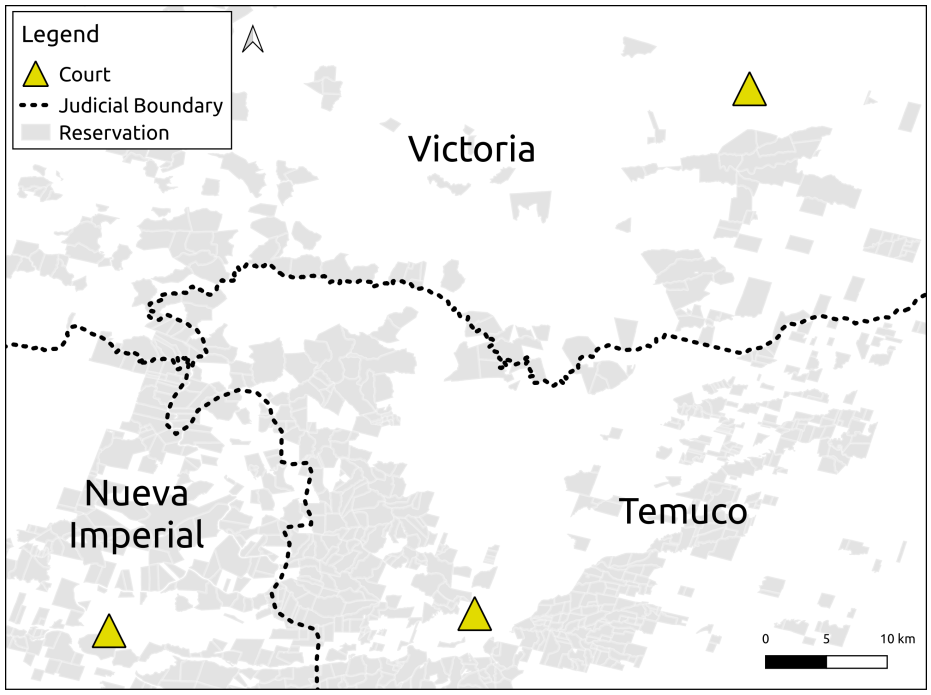

FIGURE 1.—Jurisdictions of Courts of Indians in study region as of June 1931

tenure and adopted individual property rights, only 16% had done the same on the other side of the judicial boundary (Figure 2). A new law adopted in 1961 implemented minor modifications to the process of division and replaced the original Courts of Indians with new courts called Civil Courts of Indians (República de Chile, 1961). Only a few reservations were divided under this law, and the new jurisdictions closely followed those originally created in June 1931. As only a few reservations were left undivided in Victoria by then, access to court services for reservations that remained undivided was plausibly still better in Victoria than in Temuco or Nueva Imperial during this period. Further divisions remained virtually frozen until 1979, when a new Decree was published by Pinochet's dictatorship to divide the remaining reservations (República de Chile, 1979). The law closed the Civil Courts of Indians and placed reservations under the oversight of regular civil courts. By 1989 the fraction of divided reservations across the judicial boundary was equal, and almost all reservations had been divided across the study area. Sales of the individual

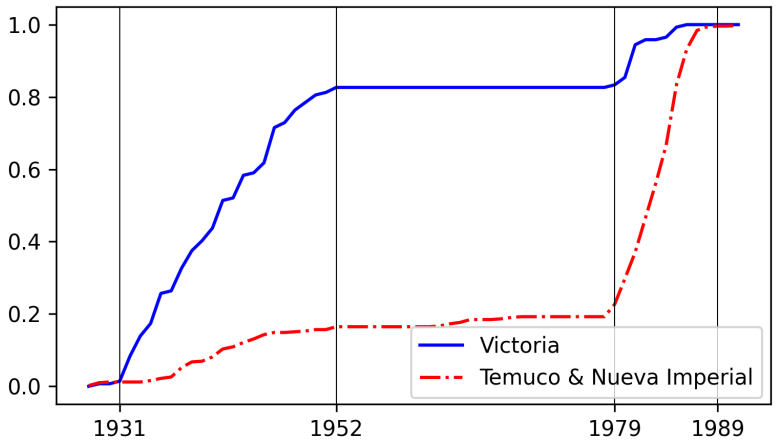

FIGURE 2.—Fraction of reservations divided by jurisdiction

property titles resulting from reservations' divisions after 1979 were banned until twenty years had passed since the titles were granted. [4]

Relatively limited access to court services within the Temuco court's jurisdiction between 1931 and 1979 led to ambiguity in property rights within reservations. A case described in Faron (1961, pp. 86-88) provides a vivid example. Carlos Curiqueo came back to his reservation after 30 years and asked the chief to grant him a parcel of land. Although Carlos had no remaining family in the reservation and there was no land to spare, the chief took the case seriously because Carlos could have taken the case to court. He hosted Carlos for a month while he deliberated with the heads of households. They decided to reject Carlos' request, and he did not take the case to the court. In this case, the combination of unrecognized traditional institutions and poor access to courts gave rise to ambiguity over Carlos' property rights. Had traditional institutions been recognized, Carlos would have known that he had no chance at getting land in the reservation without family to vouch

[4]Two additional laws modified the regulation of reservations' property rights. A law published in 1971 facilitated the expropriation of some large landholding in favor of Mapuche reservations (República de Chile, 1972). No reservation was divided under this law, and reservations lost the land obtained during this period after the 1973 military coup (see Jaimovich and Toledo-Concha (2020) for a study of the consequences of this failed land reform on the contemporaneous conflict between Mapuche and the Chilean State). After the return of democracy in 1990, a new law was published introducing modifications to the process of division (República de Chile, 1993).

for him. If court services were more accessible, Carlos and the chief would have known that Carlos's legal claim could have been enforced. In this scenario, increasing access to national courts is likely to clarify property rights by establishing a single valid authority that enforces legal statutes. Moreover, by facilitating shares transfers, courts could have provided Carlos with a simple alternative to obtain land in the reservation by buying back shares from current occupants.

However, the Courts of Indians were also widely used by non-Mapuche settlers to formalize their claims over reservation land. One common practice employed by these settlers was to convince reservation members to sign a transfer of shares under the false pretext that they were only agreeing to a temporary lease (Almonacid, 2008). Hence, it is likely that access to courts improved the quality of property rights in reservations while at the same time facilitating the spoliation of Mapuche by outsiders.

3. DATA

The tract of land assigned to each reservation in their original property titles were digitized by the Chilean General Archive of Indigenous Affairs (*Archivo General de Asuntos Indígenas*, AGAI) for 2,900 out of the original 3,011 reservations, and are publicly available at their interactive-data web site.[5] Data on the date of division was gathered from different sources provided by AGAI. We reviewed over 250,000 pages of documentation by training a classifier that recognized different types of documents, and recovered the date of division for almost all reservations in the regions of interest.[6]

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

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

[6]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%.

used inside and outside the reservation, the number of hectares planted with different crops (wheat, rye, oat, pulses, beets, 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). We crossed this dataset with the list of Mapuche surnames compiled by the Mapuche Data Project from the work of Amigo and Bustos (2008) and Painemal Morales (2011) to identify which head of households are Mapuche.[7]

Land cover maps for the study region for the austral summers starting in 1973, 1986, 1996, 2006, and 2016 were obtained from Jordán (2021a). The paper proposes a novel CNN-RNN deep learning architecture, tailored to the challenge of combining satellite imagery from different sensors of the Landsat program, to obtain decadal maps with an overall accuracy over 85%. The maps assign every valid 60×60 meter pixel in the study region to one of the following six land cover classes: Native vegetation, Plantation forest, Agricultural land, Bare soil, Water, and Urban.

Socioeconomic data from the early 1990s were obtained by combining the microdata of the 1992 General Population Census, available at the Chilean National Institute of Statistics (*Instituto Nacional de Estadística*), with scanned cartographic maps used by the agency to plan the implementation of the Census. We digitized and georeferenced *Sectores* from the maps, the most disaggregated rural geographical unit that can be linked to the microdata. *Sectores* generally include around 30 households, and a reservation typically overlaps with one or more *Sectores*. We also georeferenced the location of dwellings. Although they cannot be linked to the microdata, they are helpful to impute which observations are considered part of reservations: we define an observation as being part of a reservation if its associated *Sector* contains at least one dwelling that falls within the polygon of a reservation. We

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

select individuals that were at least 18 years old in 1979 for schooling data, for whom it is safe to assume they had finished their formal education when responding to the census questionnaire.

Georeferenced parcel vector data for all rural properties as of the year 2013 were obtained from the Chilean Ministry of Agriculture's Center of Information on Natural Resources (*Centro de Información de Recursos Naturales*, CIREN). This dataset includes the name of the owner of each parcel, which we combine with the list of Mapuche surnames compiled by the Mapuche Data Project to identify which plots were owned by Mapuche.

Historical data on the conditions of forced settlement of each reservation were obtained from Jordán (2021b). The data includes 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 Alesina et al. (2003)'s fractionalization index among reservations' patrilineal localized kinship groups.

Data describing the biophysical characteristics of the region were collected from a variety of sources. Elevation, slope, and aspect were obtained at a 30 meter resolution from Farr et al. (2007), while historic monthly data on temperature and precipitation between 1970 and 2000 at 30 arc second resolution ($\sim$1 km) was obtained from Fick and Hijmans (2017). We explored impacts on erosion using several variables from Centro de Información de Recursos Naturales de Chile (2010). "Erosion potential" measures the relative risk for erosion based on local topography, soil and climatic conditions, while ignoring vegetation coverage. We interact this time invariant measure or erosion potential with our annual land cover maps to measure the risk of erosion at multiple points in time. Finally, "actual erosion" measures the scale of observed erosion, as detected through a model that relies upon year 2009 Landsat imagery.

4. ESTIMATION FRAMEWORK

Reservations on either side of the judicial boundary separating Victoria from Temuco and Nueva Imperial are likely to share similar natural endowments and conditions of settlement. However, the early closure of Nueva Imperial's court in 1931 opened a wedge

between them: families in Victoria's reservations enjoyed better access to the services provided by the national-level ad-hoc courts between 1931 and 1978, including resolution of conflicting claims between members, the authorization to transfer shares, and the possibility of obtaining individual property titles. The impact of this difference is likely to have persisted even after ad-hoc courts were closed in 1979, as it took about ten years for reservations in Temuco and Nueva Imperial to catch up in adopting individual property rights, and sales of those new titles were banned for an additional twenty years. Furthermore, the full effect of improvements in access to national property rights institutions might take a long time to materialize if they include changes resulting from long-term investments. Figure 3 summarizes the most important events in terms of the exogenous variation used in this study.

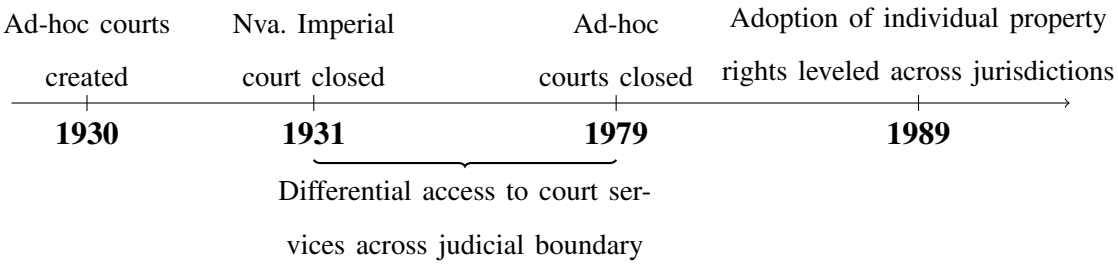

FIGURE 3.—Timing of exogenous variation in access to court services

The quasi-experimental nature of the variation in access to court services between 1931 and 1978 at the judicial boundary motivates a geographic regression discontinuity estimator to study the causal effects of enhanced access to courts. We estimate

$$y_i = \beta_0 + \beta_1 High\ Access_i + f(lon_i, lat_i) + \mathbf{X_i}\Theta + u_i, \tag{1}$$

where y_i is an outcome variable for unit i, $High\ Access_i$ is a dummy equal to one if unit i is located within Victoria's jurisdiction and zero otherwise, $f(lon_i, lat_i)$ is a function of unit i's longitude and latitude, $\mathbf{X_i}$ is a vector of additional controls for unit i, and u_i is a zero-mean disturbance. β_1 captures the causal effect of increasing access to courts under the standard identification assumptions of the geographic regression discontinuity estimator.

We estimate Equation 1 with a local linear regression using distance to the judicial boundary as the running variable, a Epanechnikov kernel, and a 20 km bandwidth for our baseline specification, and check whether the results are robust to using different bandwidths and linear models with first- and second-degree polynomials in longitude and latitude instead (Online Appendix E). All regressions include distance to Temuco and dummies for regions along the judicial boundary in $\mathbf{X_i}$. We exclude a small number of reservations in the Andes mountains and the coast from the sample, as they are too far from the rest of reservations, have different climatic and geographic characteristics, and do not share the same historical background (see Online Appendix A for details on regions along the judicial boundary and sample selection). For inference, we cluster the standard errors at the Census District level, which are meaningful geographic units containing up to fifty reservations.[8]

Our identification strategy requires unobservable variables correlated with the outcome of interest to be continuous at the boundary in order to correctly identify β_1. A plausible concern is that the judicial boundary dividing Victoria from Temuco and Nueva Imperial coincides with the boundary between the Cautín and Malleco provinces as defined in the creation of these provinces in 1887 (República de Chile, 1887). Thus, plausible confounders related to this administrative division can be split into two groups: those that predate the treatment (1887-1930) and those contemporaneous to the treatment (after 1931).

Among the plausible confounders that predate treatment, we must pay special attention to the role of provinces in the process of forced settlement occurring between 1884 and 1929. Forced settlement was implemented by an ad-hoc agency, called the Indigenous Settlement Commission (*Comisión Radicadora de Indígenas*). This agency was located in Temuco and its activities were not organized following the provincial division of the territory. 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

[8]Clustering the standard errors at a relatively high level of aggregation ameliorates the possibility of having effective test sizes above nominal levels due to spatial autocorrelation (Kelly, 2019).

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, as in the region of study over 90% of reservations were settled before 1910. Consistent with the assumption that the process of forced settlement was not influenced by the provincial boundary, we detect no discontinuities across twelve predetermined variables that include topographic and climatic characteristics of reservations and conditions of forced settlement (Online Appendix B). Had access to the services provided by the Protector of Indians differed across this provincial boundary, we would expect to see reservations on one side of the boundary obtaining better conditions of settlement than their neighbors on the other side of the boundary (e.g. larger reservations, earlier settlements, or flatter land). The absence of such evidence suggests that the process of forced settlement was smooth across the judicial boundary.

We also explore the concern that the overlap between provincial and judicial divisions during the treatment (1931 to 1979) may bias our causal estimates. We believe the administrative division is unlikely to bias our results because the 1925 Constitution established a centralized system that left little discretion to provinces and municipalities (Carrasco, 1997). For instance, the provincial administration did not play a significant role in either the provision of education nor agricultural credit to reservations. The former was provided by local public schools and Christian missionaries, which were overseen by the central administration in Santiago (Ponce de León, 2018), while the latter was mainly provided by the private market through small businesses in nearby towns (Titiev, 1951, pp. 53-56). Whenever possible, we check whether there are discontinuities in the dependent variable for units that lie outside reservations (Online Appendix F). Although not strictly a placebo, because the treatment can have spillovers outside reservations—as in Aragón (2015), a null result supports the hypothesis that the provincial level has no effect per-se. This is the case for most variables throughout our analysis. In Section 8 we discuss mechanisms that could explain a spillover of the effect to units outside reservations in the few occasions when this is not the case.

5. ADOPTION OF INDIVIDUAL PROPERTY RIGHTS

Better access to court services enabled a large and rapid shift from customary tenure to individual property rights in reservations. Table I shows estimates of β_1 from Equation 1 in the first row, labeled as "High access", using the baseline specification described in Section 4. Column 1 reveals that the fraction of reservations that transitioned from customary tenure to individual property rights increased by 70 percentage points ($p < 1\%$) by the time the Victoria court was closed in 1952, while column 2 shows this difference was maintained until 1978 and column 3 that by 1989 the gap was completely closed. Column 4 presents an alternative way of looking at the discontinuity in the timing of division at the judicial boundary by showing that reservations exposed to greater access to court services between 1931 and 1979 were divided, on average, 30 years earlier ($p < 1\%$). Overall, the evolution of the treatment effect in terms of the adoption of individual property rights at the judicial boundary conforms with the overall pattern across both jurisdictions presented in Figure 3.

TABLE I

TRANSITION FROM CUSTOMARY TENURE TO INDIVIDUAL PROPERTY RIGHTS[a]

	Dependent variable is:			
	Divided on or before			Year divided
	1952	1978	1989	
	(1)	(2)	(3)	(4)
High access	69.94	69.07	-1.21	-29.98
	(9.01)	(9.59)	(0.81)	(4.21)
Mean low access	19.18	21.74	99.49	1975
Observations	535	535	535	535
Clusters	48	48	48	48

[a]Unit of analysis is a reservation. High access row presents treatment effects estimates from baseline specification (Eq. 1) using the dependent variable in the column, with standard errors clustered at the census district level in parenthesis below. Dependent variables measured as percentage points in columns 1-3 (100 if reservations was divided before or at the year indicated in the head of the column and zero otherwise) and in years in column 4. Mean low access row shows the average of the dependent variable in reservations originally assigned to Temuco and Nueva Imperial courts as a benchmark. Observations and Clusters rows present number of observations and clusters respectively.

6. ALLOCATION OF FACTORS OF PRODUCTION

The documented shift from customary tenure to individual property titles is consistent with reservations' families finding the latter form of property rights more advantageous as access to court services increased. However, this does not imply that property rights in reservations improved in terms of their security, marketability, and pledgeability. It is plausible that greater access to courts undermined the capacity of local institutions to enforce property rights, thus rendering their alternative, individual property rights, preferable. This section takes advantage of the extended period through which reservations had differential access to court services across the judicial boundary to study the impacts of this difference on the allocation of productive factors within reservations.

6.1. *Grazing resources, the 'tragedy of the commons', and natural capital*

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. 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 the adoption of individual property rights closed an inefficiently governed open access regime for grazing resources, we would expect access to court services to have helped curtail overgrazing and associated erosion by encouraging farmers to internalize prior externalities associated with cattle production. Indeed, Table II shows that improved access to court services led to a reduction in livestock stocking rates and an increase in fodder production. The columns of the table present estimates of β_1 of Equation 1 using as the dependent variable different types of animals owned per household (columns 1-5), whether households had no livestock (column 6), and hectares sowed with fodder—oats—per household (column 7). Only small animals raised for the market and households' consumption—as opposed to large animals raised as a source of power in crop production—experienced a

statistically significant reduction at conventional levels. These reductions are sizable, equivalent to 53%, 25%, and 48% of the average in control reservations for Sheep & Goats, Pigs, and Poultry.

Column 6 reports an increase of nine percentage points ($p < 1\%$) in the number of families that have no livestock, equivalent to 200% of the average level in control reservations. Households with no livestock in control reservations have fewer hectares (5.6 vs. 9.1, $p < 1\%$), fewer family members (4.1 vs. 5.8, $p < 1\%$), and sowed fewer hectares with wheat, the main crop planted in reservations (1.38 vs. 2.6, $p < 1\%$). These results suggest that the burden of reducing livestock was not equally shared among households; the closure of communal pastures seems to have pushed smaller productive units out of livestock production. This result is consistent with Weitzman (1974)'s argument that the closure of the commons may negatively affect those that do not obtain a piece of the hitherto communal land. Those families are likely to belong to already marginalized groups (Vinez, 2017), and their exclusion from livestock production carries particular significance in this context given the symbolic importance of livestock in Mapuche society.

Column 7 shows that access to court services increased fodder production: the increase in the number of hectares sown with fodder more than doubles the average level of control reservations. We consider fodder production alongside livestock holdings because grassland degradation is a function of both the intensity of livestock pressure as well as investments that have been made to upgrade pastures. (Lyne et al., 1990, Bühler, 2021). Fodder production can support this investment, as it reduces livestock reliance of grassland. Online Appendix C formalizes this intuition with a simple model. Columns 5 and 6 of Table G.1 of Online Appendix G show that we detected no change at conventional significance levels in the number of hectares sown with wheat and other minor crops (including pulses, ryes, beets, and potatoes), providing support to the hypothesis that the impact on oats is due to its use as fodder on the region of study.

The decline in livestock pressure on grasslands is expected to have improved natural capital within reservations. We measured the impact of court services on native vegetation and soil, two forms of natural capital that are of critical importance to the agricultural economy

TABLE II

LIVESTOCK AND FODDER PRODUCTION[a]

	Dependent variable is:						
	Cows & Oxen	Horses	Sheep & Goats	Pigs	Poultry	No Livestock	Fodder (Oats)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
High access	-0.15	0.05	-2.86	-1.05	-10.63	0.09	0.35
	(0.38)	(0.08)	(0.78)	(0.37)	(2.00)	(0.02)	(0.05)
Mean low access	3.64	0.24	5.30	4.21	22.28	0.04	0.17
Observations	4,427	4,427	4,427	4,427	4,427	4,427	4,365
Clusters	37	37	37	37	37	37	37

[a]Unit of analysis is a household using land in a reservation. High access row presents treatment effects estimates from baseline specification (Eq. 1) using the dependent variable in the column, with standard errors clustered at the census district level in parenthesis below. Dependent variable in Columns 1-5 is measured in number of animals. Dependent variable in Column 6 is the Livestock Unit, a weighted sum of animals with weights equal to the ratio between the grazing need of each animal to the grazing need of an average dairy cow producing 3,000 liters of milk per year. Column 7 presents hectares sowed with oat, the main fodder in the region of study. Mean low access row shows the average of the dependent variable in reservations originally assigned to Temuco and Nueva Imperial courts as a benchmark. Observations and Clusters rows present number of observations and clusters respectively.

of reservations. Access to native vegetation has played an important role in reservations, providing firewood, game, and herbs to families (Catalán and Ramos, 1999). Furthermore, even small patches of vegetation in agricultural landscapes can prevent erosion, stop soil degradation, and improve water quality (Decocq et al., 2016).

Column 1 of Table III shows that, by 1973, the area covered by native vegetation was 3.2 percentage points higher ($p < 5\%$) in reservations that had enjoyed better access to court services, a 29% increase over the average level in control reservations. Columns 2-5 present evidence that this difference persisted even after ad-hoc courts were closed in 1979 and most reservations transitioned to individual property rights during the 1980s.

One important benefit that emerged from increases in vegetation cover is a reduction in soil erosion (Table IV), one of the most salient environmental and economic challenges in reservations throughout the 20$^{\text{th}}$ century (Klubock, 2014, p. 67-69). When comparing

TABLE III

NATIVE VEGETATION COVERAGE[a]

Dependent variable is native vegetation coverage in:					
	1973	1986	1996	2006	2016
	(1)	(2)	(3)	(4)	(5)
High access	3.19	3.53	2.73	3.14	2.91
	(1.30)	(1.59)	(1.43)	(1.48)	(1.35)
Mean low access	11.19	14.41	11.94	12.06	9.70
Observations	339,103	339,443	339,443	339,281	339,442
Clusters	77	77	77	77	77

[a]Unit of analysis is a 60×60 meter pixel within a reservation. High access row presents treatment effects estimates from baseline specification (Eq. 1) with the addition of slope and north orientation of each pixel as controls, using the dependent variable in the column. Standard errors are clustered at the census district level and shown in parenthesis below point estimates. Dependent variables are measured in percentage points (100 if land cover in the pixel is native vegetation in the year indicated in the column and zero otherwise). Mean low access row shows the average of the dependent variable in reservations originally assigned to Temuco and Nueva Imperial courts as a benchmark. Observations and Clusters rows present number of observations and clusters respectively. Pixels that are covered by a cloud in a given year are dropped from the sample of say year.

across the jurisdictional boundary, reservations with improved access to court services were exposed to a similar erosion potential, a measure that integrates soil type, topography and climate (column 1). However, improved access to court services increased permanent vegetation cover on land with a high erosion potential (columns 2-5). Vegetation cover in locations with a high potential for erosion can be an important protection against soil loss. As a result, it is unsurprising that improved access to court services decreased the share of land with evidence of past erosion, as observed by a 2009 survey (column 6). When looking across the jurisdictional boundary, we estimate a 16 percentage point decline ($p < 10\%$) in the share of pixels that had experienced moderate, severe or very severe erosion, a marked 56% decline when compared to the share of eroded pixels in control reservations (29%).

TABLE IV

EROSION[a]

	Dependent variable is:					
	Erosion potential	Share of erodable lands with tree cover in:				Actual erosion in 2009
		1974	1987	1997	2007	
	(1)	(2)	(3)	(4)	(5)	(6)
High access	-3.11	5.87	7.72	7.04	7.80	-16.26
	(4.33)	(3.13)	(3.22)	(3.25)	(4.01)	(9.22)
Mean low access	10.48	25.46	31.88	30.53	33.37	29.01
Observations	332,448	53,125	53,125	53,125	53,125	336,656
Clusters	77	71	71	71	71	77

[a]Unit of analysis is a 60×60 meter pixel within a reservation. High access row presents treatment effects estimates from baseline specification (Eq. 1) with the addition of slope and north orientation of each pixel as controls, using the dependent variable in the column. Standard errors are clustered at the census district level and shown in parenthesis below point estimates. Dependent variables are measured in percentage points (e.g. for column 1, 100 if land is highly erodable and 0 if not). Mean low access row shows the average of the dependent variable in reservations originally assigned to Temuco and Nueva Imperial courts as a benchmark. Observations and Clusters rows present number of observations and clusters respectively.

6.2. *Allocation of land and labor*

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). Customary tenure might have exacerbated inefficient allocation of productive factors within small farms through two mechanisms. First, insecure property rights under customary tenure may have led reservation members to fear that the reallocation of their labor away from agriculture might result in the expropriation of their land. Second, customary tenure may have hindered land transactions, as use-rights did not map to specific tracts of land. Indeed, Bengoa and Valenzuela (1982) describes reservations members as having "too few land", by which they mean the

typical reservation family had access to use rights over too many small plots scattered throughout numerous reservations. We hypothesize that access to court services improved the allocation of labor and land, by providing enough tenure security for individuals to disengage from agricultural activities if deemed convenient, and by creating deeds over clearly demarcated plots of land that could be traded in the market when reservations were divided.

The results presented in columns 1-3 of Table V show that improved access to court services allowed some workers to reallocate labor away from their own fields and other agricultural activities, similar to what was oberved by De Janvry et al. (2015) in Mexican Ejidos. Column 1 shows that the fraction of wage workers increased by 6.5 percentage points ($p < 1\%$), more than 61% of the average level in control reservations with low access to court services, while column 2 shows an increase of 12 percentage points ($p < 5\%$) in the fraction of workers engaged in non-agricultural occupations, which amounts to 59% of the average level in control reservations. Column 3 shows that the number of migrants (defined as those whose mother was living in another municipality when they were born) increased by 4.2 percentage points ($p < 5\%$), 38% of the average fraction in control reservations. As the number of migrants is a stock variable, the result is consistent with either old inhabitants leaving reservations, new individuals arriving, or both. In either case, the result provides further support to the hypothesis that access to court services made labor more mobile.

The results presented in columns 4-9 of Table V suggests that improved access to court services facilitated transactions of land, plausibly allowing the consolidation of small parcels into larger estates that are better positioned to exploit economies of scale. Column 4 shows that the average number of hectares used by a family increased by four ($p < 5\%$) as of 1974, a 45% increase over the average number in control reservations. However, this growth in farm size may mask increasing inequality in the distribution of land. Quantile regressions in columns 5-6 suggest the first decile was almost identical at both sides of the judicial boundary, whereas the ninth decile was 4.8 hectares larger in the jurisdiction with higher access to court services. In columns 7-9 we repeat the same regressions using property registry data as of 2013 and obtain a similar pattern: a significant increase in the average size of parcels of 1.76 hectares ($p < 5\%$) in column 7—equivalent to 41% of the

TABLE V

ALLOCATION OF LABOR AND LAND[a]

	Dependent variable is:								
	Labor (1992)			Land holdings (1974)			Land holdings (2013)		
	Wage Worker	Non-Ag.	Migrant	Mean	Q10	Q90	Mean	Q10	Q90
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
High access	6.58	11.98	4.16	3.95	0.03	4.83	1.76	0.30	2.48
	(2.16)	(4.59)	(1.64)	(1.84)	(8.67)	(14.5)	(0.70)	(0.99)	(2.10)
Mean low access	10.84	20.16	10.98	8.76			4.35		
Observations	25,313	9,569	37,716	4,427			21,211		
Clusters	50	50	50	37			58		
Source	CS	CS	CS	AD			PR		
Year	1992	1992	1992	1974			2013		

[a]Unit of analysis is an individual within a reservation in columns 1-3, a household using land in a reservation in columns 4-6, and a parcel within a reservation in columns 7-9. High access row in columns 1-4 and 7 show the estimate of the locale average treatment effect for the dependent variable in the column from the baseline specification (Eq. 1), while columns 5-6 and 8-9 show the estimate of the local quantile treatment effect for the quantile of land holdings indicated in the column (Qx=xth quantile) from a linear specification that controls for longitude and latitude. Clustered standard errors at the census district level in parenthesis below point estimates, with estimates of the covariance matrix in quantile regressions following Parente and Silva (2016) and Machado et al. (2011). Dependent variable in Columns 1-3 is measured in percentage points (100 if individual works for a wage, has a non-agricultural occupation, or is a migrant respectively, and zero otherwise), while in Columns 4-9 is measured in hectares of land. An individual is defined as migrant if he reports that, when he was born, his mother was living in a Municipality that differs from the one where he currently lives. Mean low access row shows the average of the dependent variable in reservations originally assigned to Temuco and Nueva Imperial courts as a benchmark. Observations and Clusters rows present number of observations and clusters respectively. Last two rows (Source and Year) show the data source of the dependent variable and the year it was collected respectively. Acronyms for data source are: CS=Individual-level responses to the 1992 General Population Census; AD=Family-level responses to 1974 Indigenous Agricultural Declaration; PR=Property registry as of 2013.

average in control reservations, a not-significant estimate close to zero for the first decile, and a considerably larger not-significant estimate for the ninth decile. It is remarkable that, even though the outcome variables in columns 5-6 and 7-9 are conceptually different (land use vs. land ownership) and are separated by almost forty years, they reveal the same overall pattern. Although the quantile regressions are underpowered, the consistency of this pattern through time strongly suggests that access to court services facillitated a process of

consolidation of small parcels into larger estates that increased inequality in land use and land ownership within reservations.

7. IMPACT ON HUMAN CAPITAL AND MATERIAL CONDITIONS

The previous sections show that better access to courts services led to an *en masse* adoption of individual property rights, improving natural capital and the allocation of grazing resources, land, and labor in reservations. This section leverages georeferenced individual-, household-, and dwelling-level data from the 1992 General Population Census to explore whether these transformations were accompanied by improvements in human capital and material conditions.

7.1. *Human capital formation*

Table VI shows that access to court services led to a sizable increase in formal schooling. It displays the results of estimating Equation 1 using literacy (column 1); the probability of an individual having completed the 6^{th}, 8^{th}, and 12^{th} grades (columns 2-4); and total years of formal instruction (column 5) as the dependent variable.[9] We find positive estimates in all columns, although they are statistically significant at conventional levels only in the completion of the 6^{th} and 8^{th} grades (columns 2-3), and in the total years of formal instruction (column 5). The statistically significant effects are quantitatively large, representing 35%, 54% and 13% of the average levels of control reservations with low access to court services, respectively.

To the best of our knowledge, only Galiani and Schargrodsky (2010) have estimated the relationship between improvements in the quality of property rights and education. They document that this relation is likely to be channeled through a reduction of households' size—both through lower levels of fertility and fewer members of the extended family living in the household—which would free resources to invest in children's education. We

[9]The included grades represent milestones in the Chilean educational system. The sixth grade was the end of the first cycle until the 1960s, when a reform extended the first cycle to the 8^{th}. The 12^{th} grade is the end of the second cycle.

TABLE VI

HUMAN CAPITAL[a]

Dependent variable is:					
	Literacy	Max Grade Completed $\geq$			Schooling
		6^{th}	8^{th}	12^{th}	
	(1)	(2)	(3)	(4)	(5)
High access	5.00	8.35	6.36	1.20	0.44
	(3.22)	(2.72)	(1.24)	(0.97)	(0.20)
Mean low access	61.66	23.59	11.68	3.16	3.39
Observations	15,421	15,421	15,421	15,421	15,421
Clusters	50	50	50	50	50

[a]Unit of analysis is an individual within a reservation. High access row presents treatment effects estimates from baseline specification (Eq. 1) using the dependent variable in the column, with standard errors clustered at the census district level in parenthesis below. Mean low access row shows the average of the dependent variable in reservations originally assigned to Temuco and Nueva Imperial courts as a benchmark. Observations and Clusters rows present number of observations and clusters respectively. Dependent variable in Columns 1-4 is measured in percentage points (100 if individual meets criteria stated in the header and zero otherwise), while in Columns 5 is measured in years of education. All regressions include only individuals that were at least 18 years old in 1979.

find that the role of this channel in the case of reservations is likely to be limited. While we find a statistically significant decrease in the number of persons per household of 0.2 ($p < 5\%$), this estimate is small when compared to the average in control reservations (4.32 persons per household). In addition, we find no effect on the total number of children having been born alive to women that are at least 45 years old, or the fraction of individuals that are not part of the nuclear family of their households, suggesting that individual property rights had no impact on fertility or the presence of individuals that are not part of the nuclear family of their households. [10]

Another plausible channel, similar to the mechanism that links individual property rights to an increase in female labor supply in Field (2007), is that tenure security freed children from guarding families' possessions, allowing them to reach higher levels of formal educa-

[10]These results are presented in columns 2-4 of Table G.1 of Online Appendix G.

tion. It is plausible that this mechanism played a role in the case of Mapuche reservations, as ethnographic studies described herding as a traditional chore delegated to children (Titiev, 1951, pp. 91-93, Faron, 1961, p. 141): if families penned their animals after gaining access to individual property rights, they would have freed their children from herding the livestock and facilitated their attendance to school. The reduction of livestock reported in Section 6.1 is consistent with this channel.

7.2. *Dwelling quality and durable goods*

Access to court services led to considerable improvements in the characteristics of reservations' dwellings, decreasing crowding and increasing the presence of basic amenities such as improved floors, toilets, running water, and tubs or showers. Table VII present the results. Column 1 reports a positive impact of 0.22 ($p < 1\%$) in the number of common rooms—i.e. excluding restrooms and bedrooms. This effect is large when compared to the average number of common rooms in control reservations, 1.6. Column 2 shows that the number of bedrooms per person increased by 0.05 on average ($p < 10\%$), equivalent to 10% of the average found in control reservations. We cannot detect an effect at conventional levels on the presence of electricity in Column 3, which is not surprising considering that the electric grid had not reached most reservations in the early 1990s. Column 4 reports an increase of nine percentage points ($p < 10\%$) in the fraction of households with running water, a large increase when compared with the average of 10.5 percentage points on control reservations. Consistently, an increase of 2.9 percentage points ($p < 10\%$) in the presence of tubs or showers is reported in Column 5, a large increase when compared with an average of 3.7 percentage points in control reservations. Column 6 shows an estimated increase of 3.5 percentage points ($p < 10\%$) in the presence of toilets (wc or latrine), an impact that represents a sizable decrease in the fraction of dwellings without access to toilets when compared to the percentage of dwellings with no toilet in control reservations (8.2%). Column 7 reports an increase of 9.3 percentage points ($p < 5\%$) in the number of dwellings with an improved floor—i.e not dirt floor. This effect represents a large decline in the number of dwellings with dirt floors when compared to the level in control

reservations (25.9%). We cannot detect an effect at conventional levels on the use of solid materials (no straw, mud, refuses, or cardboard) in walls and roofs in columns 8 and 9. Finally, column 10 uses as the dependent variable a Dwelling Index, which is equal to the first component of a Principal Component Analysis of the standardized dependent variables used in columns 1 to 9 on the sample of reservations' dwellings. The index assigns positive weights to all variables, ranging from 0.44 (Improved floors) to 0.25 (Dorms per person), and is standarized to have a mean of zero and a standard deviation of 100 (refer to Figure G.1 in Online Appendix G for a plot displaying all weights). Overall, dwelling quality as measured by this index improved by more than a quarter of a standard deviation ($p < 5\%$) in reservations that enjoyed better access to courts.

These improvements in dwelling conditions are consistent with court services having increased income and the security of property rights within reservations, securing households the return from investing in their dwellings (Galiani and Schargrodsky, 2010). Past studies suggest that the impact of the documented upgrades on living conditions within reservations are likely to be substantial. Household crowding has been associated with poor health and low academic performance in children (Solari and Mare, 2012, Contreras et al., 2019). The substitution of dirt floors with hard floors has been linked to improvements in childrens' health (decreasing the incidence of parasite infections, diarrhea, and anemia) and cognitive development, along with improvements in adults' mental health (Woldemicael, 2001, Cattaneo et al., 2009). Access to running water—even if untreated—has been identified as an important determinant of children's health, decreasing the incidence of diarrhea and increasing height-per-age (Jalan and Ravallion, 2003, Mangyo, 2008). Furthermore, having running water within dwellings' plots increases households' available time and reduces the hassles associated with fetching water, a chore disproportionately carried out by women and children (Devoto et al., 2012, Graham et al., 2016). Access to a toilet where human waste can be safely disposed constitutes one of the most basic steps required to secure a population's health (Roma and Pugh, 2012).

To study households' ownership of durables, we select goods that are relevant for the population under study by excluding those that are owned by more than 99% or less than

TABLE VII

DWELLING QUALITY[a]

	Dependent variable is:				
	Common rooms	Dorms per person	Electricity	Running water	Tub/Shower
	(1)	(2)	(3)	(4)	(5)
High access	0.22	0.05	2.05	9.07	2.92
	(0.07)	(0.03)	(2.75)	(5.29)	(1.63)
Mean low access	1.60	0.51	5.14	10.54	3.65
Observations	8,275	8,275	8,275	8,275	8,275
Clusters	50	50	50	50	50

	Toilet	Improved floor	Solid walls	Solid roof	Dwelling Index
	(6)	(7)	(8)	(9)	(10)
High access	3.47	9.26	-0.97	-0.89	26.73
	(1.91)	(3.93)	(1.39)	(3.09)	(10.63)
Mean low access	91.87	74.09	94.21	89.16	-4.03
Observations	8,275	8,275	8,275	8,275	8,275
Clusters	50	50	50	50	50

[a]Unit of analysis is a dwelling in a reservation. High access row presents treatment effects estimates from baseline specification (Eq. 1) using the dependent variable in the column, with standard errors clustered at the census district level in parenthesis below. Dependent variable is the number of rooms excluding bedrooms or bathrooms in column 1, the number of bedrooms per person in column 2, 100 if the dwelling has electricity and zero otherwise in column 3, 100 if the dwelling has running water by pipe and zero otherwise in column 4, 100 if there is a tub or a shower in the dwelling and zero otherwise in column 5, 100 if there is a toilet (WC or latrine) in or near the dwelling and zero otherwise in column 6, 100 if the dwelling has a not dirt floor and zero otherwise in column 7, 100 if the dwelling has solid walls (not refuse or mud) and zero otherwise in column 8, 100 if the dwelling has a solid roof (not straw or impermeabilized cardboard) and zero otherwise in column 9, and the first component of a principal component analysis of the variables of the other columns in column 10 (standardized to have a mean of zero and a standard deviation of 100). Mean low access row shows the average of the dependent variable in reservations originally assigned to Temuco and Nueva Imperial courts as a benchmark. Observations and Clusters rows present number of observations and clusters respectively.

1% of households. This criteria restricts the analysis to two groups of durable: four related

to transportation (Carts, Bicycles, Pickups, and Cars) and two related to media (Televisions and Radios).

We find that access to court services led to an increase in the fraction of households that owned televisions and radios, and no effects regarding the ownership of means of transportation. Table VIII present the results. Note that the sample size is slightly larger than in Table VII, as in rare occasions two or more households share a dwelling. Columns 1 to 4 show point estimates when the dependent variable is equal to 100 if a household owns one or more carts, bicycles, pickups, or cars respectively, and zero otherwise. While we cannot detect a statistically significant effect in any of these columns, all point estimates are positive and economically relevant when compared to the average percentage of households that own these goods in control reservation with low access to court services. Column 5 reports an estimated increase of 11 percentage points ($p < 5\%$) in the fraction of households that own a television. This estimate equals 65% of the average level in control reservations. Column 6 shows an estimated increase of 7.5 percentage points ($p < 1\%$) in the fraction of households that own a radio. This result represents a large decline in the number of households with no radio when compared to the average level in control reservations, 24.6%. Finally, column 7 uses as the dependent variable a Durables Index, which is equal to the first component of a Principal Component Analysis of the standardized dependent variables used in columns 1 to 6 on the sample of reservations' households. The index assigns positive weights to all variables, ranging from 0.61 (TV) to 0.23 (Carts), and is standarized to have a mean of zero and a standard deviation of 100 (refer to Figure G.2 in Online Appendix G for a plot displaying all weights). Overall, ownership of durable goods as measured by this index improved by more than a quarter of a standard deviation ($p < 1\%$) in reservations that enjoyed better access to courts.

The detected increase in access to radio and television may be a consequence of higher income in reservations with better access to court services, although it might also be part of a broader cultural change ushered in by the individualization of property rights supported by courts. Individual property rights have been shown to influence individuals' beliefs and political preferences (Di Tella et al., 2007, De Janvry et al., 2014), raising the interesting

TABLE VIII

DURABLE GOODS[a]

	Dependent variable is:						
	Transportation				Media		Durables
	Cart	Bicycle	Pickup	Car	TV	Radio	Index
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
High access	5.86	0.58	0.33	0.81	11.00	7.51	25.80
	(3.81)	(2.29)	(0.92)	(0.85)	(4.29)	(2.24)	(8.87)
Mean low access	34.23	8.85	1.92	1.05	16.87	75.44	-5.94
Observations	8,319	8,319	8,319	8,319	8,319	8,319	8,319
Clusters	50	50	50	50	50	50	50

[a]Unit of analysis is a household in a reservation. High access row presents treatment effects estimates from baseline specification (Eq. 1) using the dependent variable in the column, with standard errors clustered at the census district level in parenthesis below. Dependent variable is 100 if the household has the durable good at the header of the column and zero otherwise in columns 1-6, and the first component of a principal component analysis of the variables of the other columns in column 7. Mean low access row shows the average of the dependent variable in reservations originally assigned to Temuco and Nueva Imperial courts as a benchmark. Observations and Clusters rows present number of observations and clusters respectively.

possibility that greater access to national media through television and radio may reflect the growing importance of national identity within reservations. At the same time, access to national media may also shape indigenous people's culture, challenging the preservation of aboriginal ways of life and language (Barry, 1998). Disentangling the relationship between property rights, access to national media, and indigenous culture constitute an interesting topic for future research.

7.3. *Mapuche presence and decomposition of estimated impacts across ethnic groups*

Access to national-level property rights institutions may also accelerate changes in the ethnic composition of reservations. These changes in ethnic composition are important to consider for two reasons. First, a relative decline in the concentration of indigenous peoples within reservations may represent one step in a process of broader assimilation. Ensuing changes in cultural identity and political power may be of particular interest in the case

of Mapuche reservations given the long standing self-determination conflict between Mapuche and the Chilean state (Cayul et al., 2021 forthcoming). Second, changes in the communities' ethnic composition may affect the interpretation of our previous results – even if access to national-level property rights institutions fostered economic development in our study region, it is not guaranteed that this transformation improved economic conditions for Mapuche inhabitants specifically.

We impute the ethnic group of households using the surnames provided in the 1974 Agricultural Declaration and the 2013 Property Registry—defining an individual as Mapuche if either her paternal or maternal surname is part of the list of Mapuche surnames compiled by the Mapuche Data Project, and the self-declared ethnicity available in the individual-level microdata of the 1992 General Population Census. The resulting measures of reservations' ethnic composition allow us to analyze both the impact of court services on the presence of Mapuche as well as the extent to which shifts in the ethnic composition of reservations account for the results from previous sections.

Table IX documents a sizable decline in the presence of Mapuche in reservations across several dimensions. Columns 1 and 2 show that, by 2013, access to court services had led to a 25 and 27 percentage point decline in the number of plots and hectares owned by Mapuche, both significant at the 1% level. Columns 3 and 4 present estimates of the effect of access to court services on the number of Mapuche households in 1974 and Mapuche persons in 1992, respectively. Both experienced an approximately 15 percentage point reduction, significant at the 1% level.

To obtain a formal assessment of the extent to which the documented shift in the ethnic composition of reservations explains the results from previous sections, we develop a simple decomposition that is conceptually equivalent to the canonical decomposition proposed by Oaxaca (1973) and Blinder (1973) (Online Appendix D formally shows the equivalence). In what follows, we first formally derive the proposed decomposition, and then apply it to decompose the total effect of access to court services on an outcome variable in a between-ethnic component that captures the fraction of the effect attributed to a shift in

TABLE IX

ETHNIC COMPOSITION OF RESERVATIONS[a]

	Dependent variable is:			
	Mapuche (Land, 2013)		Mapuche (People)	
	Owner	Hectares	1974	1992
	(1)	(2)	(3)	(4)
High access	-25.29	-27.34	-14.80	-16.13
	(3.94)	(4.73)	(4.99)	(4.49)
Mean low access	84.33	66.88	87.66	82.68
Observations	21,200	534	4,427	25,227
Clusters	58	48	37	50
Source	PR	PR	AD	CS
Year	2013	2013	1974	1992

[a]Unit of analysis is a parcel within a reservation in columns 1, a reservation in column 2, a head of a household within a reservation in columns 3, and an individual within a reservations in column 4. High access row presents treatment effects estimates from baseline specification (Eq. 1) using the dependent variable in the column, with standard errors clustered at the census district level in parenthesis below. Dependent variable in Column 1 is measured in percentage points (100 if owner of plot has at least one Mapuche surname and zero otherwise), while in Column 2 is equal to the share of hectares in a reservation owned by Mapuche owners (reservations are weighted by their total number of hectares in the regression). In column 3 and 4 the dependent variable is measured in percentage points (100 if the surveyed head of household has at least one Mapuche surname and zero otherwise in column 3, 100 if the respondent of the census self identifies as Mapuche and zero otherwise in column 4). Mean low access row shows the average of the dependent variable in reservations originally assigned to Temuco and Nueva Imperial courts as a benchmark. Observations and Clusters rows present number of observations and clusters respectively. Last two rows (Source and Year) show the data source of dependent variable and the year it was collected respectively. Acronyms for data source are: CS=Individual-level responses to the 1992 General Population Census; AD=Family-level responses to 1974 Indigenous Agricultural Declaration; PR=Property registry as of 2013.

the ethnic composition of reservations, and two within-ethnic components that capture the share of the effect that can be attributed to the treatment effect within each ethnic group.

Let y_t^j be the potential outcome for group $j = \{M, C\}$ and treatment status $t = \{0, 1\}$, defined as the expected value of the outcome variable for group j under treatment t, where M refers to Mapuche and C to Not-Mapuche Chileans (Chileans hereafter), and let α_1 and α_0 be the expected share of Mapuche and Chileans in a reservation when treated and not treated respectively. Then, the aggregate expected potential outcomes y_1 and y_0 can be

written as:

$$y_1 = \alpha_1 y_1^M + (1-\alpha_1) y_1^C, \tag{2}$$

$$y_0 = \alpha_0 y_0^M + (1-\alpha_0) y_0^C. \tag{3}$$

After subtracting 3 from 2 and adding and subtracting $\alpha_1 y_0^M + (1-\alpha_1) y_0^C$:

$$y_1 - y_0 = \underbrace{\alpha_1 (y_1^M - y_0^M)}_{\text{Within Mapuche}} + \underbrace{(1-\alpha_1)(y_1^C - y_0^C)}_{\text{Within Chilean}} + \underbrace{(\alpha_1 - \alpha_0)(y_0^M - y_0^C)}_{\text{Composition}}. \tag{4}$$

The first term shows the part of the total treatment effect that can be attributed to the causal effect of the treatment on the expected value of the outcome for Mapuche individuals. Note that this effect includes both behavioral changes of Mapuche that stayed in reservations and changes in the composition of Mapuche inhabitants. We call this effect the 'Within Mapuche Effect'. The second term captures the analogous effect for Chileans living within reservation boundaries. We call this the 'Within Chilean Effect'. Finally, the last term shows the part of the overall effect that can be attributed to changes in the ethnic composition of reservations, which is equal to the change in the share of Mapuche dwellers times the expected value of the difference in the outcome variable between Mapuche and Chileans in the absence of the treatment. We call this effect the 'Composition Effect'. The decomposition can be thought of in the following way: first, the 'Composition Effect' factors in the change in the ethnic composition, keeping constant the effect of the treatment within each ethnic group. Then, the two Within Effects add the treatment effect within ethnic groups, weighting them by their shares when treated.

We are interested in the relative importance of each component, hence we express them as percentages of the total effect $(y_1 - y_0)$. A positive number indicates that the sign of the component aligns with that of the total effect, and a negative number that it goes in the opposite direction. To provide a quantification of uncertainty from sampling fluctuations, we calculate a p-value for each component that represents the probability that the component is at least as large as the obtained point estimate under the null hypothesis that the component in question is not the largest component. As the estimation procedure involves

nonlinear combinations of estimates from separate regressions, we calculate these p-values using a 500 repetition block bootstrap where clusters are given by census districts.

Figure 4 summarizes the result of the decomposition for outcome variables from previous sections for which we detected robust total treatment effects and where ethnicity can be identified at the individual or household level (see Table G.2 in Online Appendix G for detailed results). From the 23 outcome variables that meet these criteria, the null can be rejected for 14 and 11 variables in the case of the Within Mapuche Effect at the 10% and 5% levels respectively, and for no variable at the 10% level in the case of the other components. These results suggest that the bulk of the economic benefits derived from improved access to national-level property right institutions in reservations were received by the ethnic-group that had an historical claim over reservations' land. While this study shares the limitation of most studies in the related literature that follow a region rather than individuals, we believe the proposed decomposition helps ameliorate this limitation by offering new insights into how the impacts of a policy are distributed across ethnic groups.

8. ROBUSTNESS CHECKS AND RESULTS FOR UNITS OUTSIDE RESERVATIONS

Online Appendix E presents figures that check the robustness of the results presented in Tables I to IX. Most results are robust across different bandwidth (10 to 20 km) and different specifications (Local Linear Regression with distance to the boundary as running variable and first- and second-degree polynomials in longitude and latitude). However, we note that in Tables III, IV, and VII most results are sensitive to reductions in the bandwidth, with point estimates becoming insignificant and in some cases switching their signs. While results for specific variables from these tables should be read with some caution, we think the overall pattern revealed by these results when considered together provides a consistent picture of the long-term transformations resulting from reservations' access to court services.

Online Appendix F presents similar figures using units located outside reservations when the information is available. In all but two cases, we find consistently null effects across different bandwidths and specifications, strengthening the causal interpretation of our results.

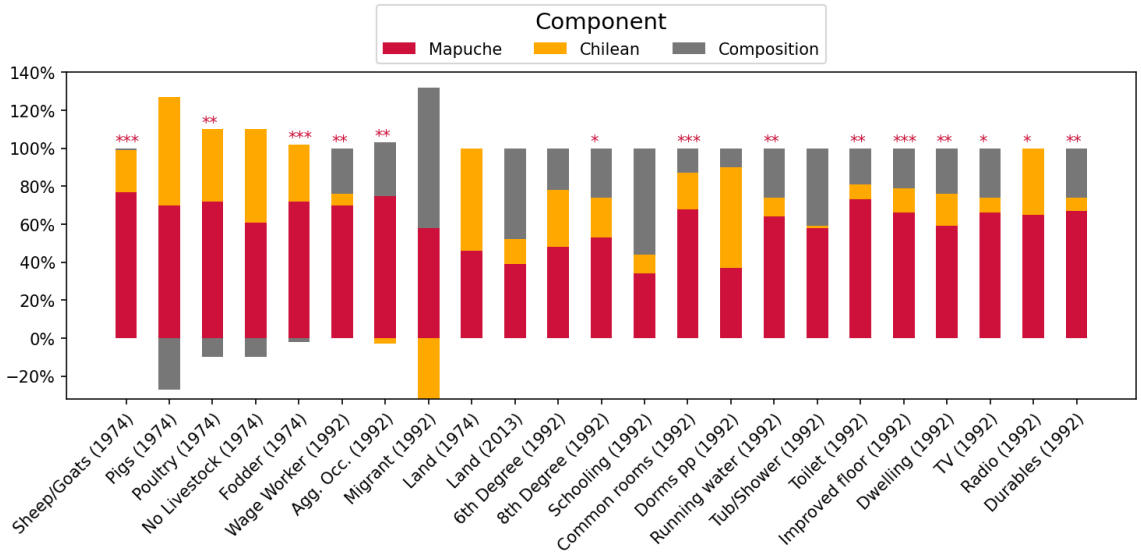

FIGURE 4.—Ethnic decomposition of treatment effects: For each variable in Tables I to IX for which we detect robust treatment effects and are able to impute the ethnicity of each observation, the bar depicts in different colors the fraction of the total treatment effect attributable to each component of the decomposition presented in Equation 4. The colored stars on top of the bars show p-values for the null hypothesis that the competent with the corresponding color is not the largest among the three components (*p<.1, **p<.05, ***p<.01).

In the two cases where we do find evidence of an impact outside reservations, there are sensible mechanisms through which treatment effects in reservations might have spilled over to units outside reservations, as in Aragón (2015). In the first case, we find negative effects on human capital formation for units outside reservations (the opposite to what we find within reservations). A plausible explanation is that court services may have affected the location of new schools. By settling conflicting claims on land ownership, courts may have facilitated the establishment of new schools within reservations. Coupled with a restricted supply of new schools, this would imply longer distances to schools outside reservations, which could explain why point estimates are negative when using the sample of individuals outside reservations. Testing this hypothesis requires the collection of new data on the historical location of schools, which goes beyond the scope of this paper, although we note this constitutes an interesting topic for future research.

In the second case, we detect a robust increase of ten percentage points in the ownership of bicycles for units outside reservations. A plausible explanation for this effect is that more secure property rights allowed some households to move their residence outside the reservation while maintaining agricultural land in the reservations, prompting them to acquire a bicycle to facilitate the transportation between their residence and the reservation. This hypothetical mechanism is supported by evidence from the 1974 Indigenous Agricultural Declaration. The Declaration reports, for all surveyed households that use land in a reservation, whether their residence is located within the reservation. Using the baseline specification, column 1 of Table G.1 of Online Appendix G shows that access to court services increased the fraction of households whose residence is located outside their reservation by 5.9 percentage points ($p < 5\%$), a large increment when compared to the average level in control reservations, 4.32%.

9. CONCLUSION

This paper studies the long term effect of access to national-level property rights institutions on the economy and environment of indigenous reservations in Chile. Using a comprehensive dataset containing numerous original sources collected for this study, we assess the effects of more than forty years of differential access to national ad-hoc courts entrusted with the registration, transformation, and enforcement of property rights within reservations. We find that better access to court services led to widespread abandonment of customary tenure in favor of individual property rights, as well as an increase in access to household amenities such as improved floors and running water, and a greater accumulation of natural and human capital. One explanation for these outcomes is that improved security and marketability of property rights enabled communities to resolve two inefficiencies that had inhibited economic development in Mapuche reservations in the 20$^{\text{th}}$ century. We provide two lines of evidence to support this explanation. First, these communities resolved persistent overgrazing that had led to soil erosion and degradation. Second, these communities reallocated land and labor through the consolidation of small, family-owned farms. Together, the more sustainable use of grazing resources and the more efficient allocation

of land and labor gave rise to higher levels of human and natural capital in the long term, supporting better material conditions in reservations.

An important concern raised about the integration of indigenous territories into national-level property rights institutions is that these reforms may undermine the social fabric of indigenous communities, accelerating land dispossession, outmigration, and the loss of cultural resources and political power. We find that reservations with improved access to national-level property rights institutions did experience a persistent decline in the fraction of Mapuche families and the proportion of land controlled by Mapuche families. Nevertheless, observed improvements in material conditions are primarily attributable to changes within the indigenous population, as opposed to shifts in the ethnic composition of reservations. Understanding how changes in the spatial distribution of indigenous populations and the accumulation of wealth among indigenous families have affected the culture and political influence of the Mapuche is an important topic for future research.

In addition, it is important to recognize that the positive outcomes emerging from the expansion of national-level property rights institutions to Mapuche reservations is a direct consequence of the historical conditions underpinning the creation of indigenous reservations in Southern Chile. As with other indigenous groups across the Americas, the Mapuche lost most of their territory and 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 customary tenure. Within this specific context, it is unsurprising that access to national-level property rights institutions—which included the possibility of abandoning customary tenure in favor of individual property rights—promoted economic efficiency and environmental sustainability. Understanding the long-term social, economic and environmental effects of modern national-level and traditional local-level property rights institutions across a broader diversity of contexts remains an important topic for future research.

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“NATIONAL COURTS, PROPERTY RIGHTS, AND THE TRANSFORMATION OF AN INDIGENOUS SOCIETY”

ONLINE APPENDICES

ONLINE APPENDIX 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 four regions based on them: the western slope of the coastal mountains, the eastern slope of the coastal mountains, the central valley, and the 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 both 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 in the western side and the Arribano Mapuche confederation in the eastern side (Bengoa, 2000). Therefore, we define five 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 later point to the line form, from north to south, by the Puren, Lumaco, and Cholchol rivers; the western central valley, which goes from the later line to the highest peaks of the central mountain range in the south and a straight line that connects the northern tip of this range with the pick of the Adencul hill; the eastern central valley, which goes from the later line to the western slope of the Andes mountains; and the Andes, that goes from there to the frontier with Argentina.

For the empirical results of this paper, we drop the western slope of the Nahuelbuta mountains and the Andes regions from the sample, as there are only a few isolated reservations in these regions. We also drop two isolated reservations from the eastern slope of the Nahuelbuta mountains. Figure A.1 shows all reservations located within twenty kilometers of the judicial boundary colored by their respective regions, along with the landmarks described above and a hillshade gray background representing elevation. A black frame encapsulates the reservations included in the study, densely packed at the center of the map.

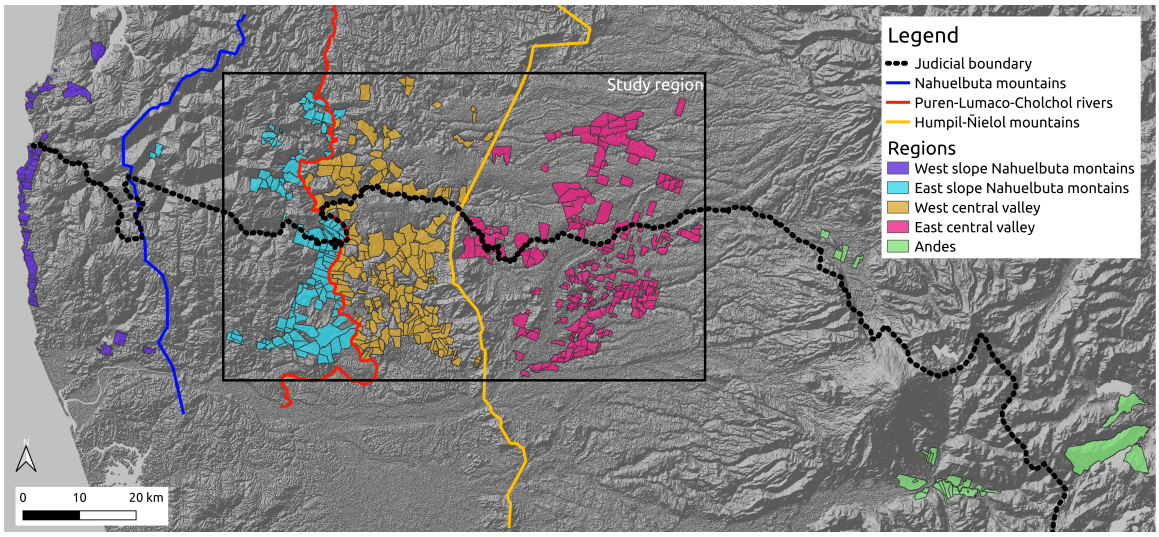

FIGURE A.1.—Regions along the judicial boundary

ONLINE APPENDIX B: CONTINUITY OF PREDETERMINED VARIABLES ACROSS JUDICIAL BOUNDARY

To explore whether cross-jurisdiction differences existed prior to 1931 at the boundary, we run our baseline specification of Equation 1 using twelve predetermined variables as the dependent variable (Table B.1). We do not detect any robust discontinuities at the judicial boundary with regards to the topography of reservations (elevation, mean slope, and standard deviation of the slope in columns 1-3), climate (average temperature and precipitation in columns 4-5), or conditions of forced settlement (year settled, area allocated, number of persons settled, population density at the time of forced settlement, fractionalization between localized patrilineal kinship groups, partitions, and amendments in columns 6-12). Had access to the services provided by the Protector of Indians in Malleco differed from Cautín at the judicial boundary, we would expect to see an effect consistent with reservations at one side of the boundary obtaining better conditions of settlement than at the other side (e.g. larger reservations, earlier settlements, less fractionalized reservations, or flatter land). The absence of such evidence suggests the process of forced settlement was smooth across the judicial boundary.

TABLE B.1

CONTINUITY OF PREDETERMINED VARIABLES ACROSS THE BOUNDARY[a]

	Elevation	Slope (avg)	Slope (std)	Temp	Precipitation	Year settled
	(1)	(2)	(3)	(4)	(5)	(6)
High access	5.97	0.82	0.74	-0.05	-1.15	-2.47
	(26.62)	(0.66)	(0.40)	(0.13)	(3.47)	(3.46)
Mean low access	182	6.18	3.63	11.77	102	1900
Observations	539	539	539	539	539	539
Clusters	48	48	48	48	48	48

	Area	Persons settled	Pop. Density	Fractionalization	Partition	Amendment
	(7)	(8)	(9)	(10)	(11)	(12)
High access	0.42	7.47	-3.09	-0.06	0.12	0.05
	(0.29)	(5.68)	(2.95)	(0.08)	(0.08)	(0.07)
Mean low access	4.63	31.75	22.43	0.43	0.16	0.15
Observations	539	539	539	511	511	511
Clusters	48	48	48	46	46	46

[a]Unit of analysis is a reservation. High access row presents treatment effects estimates from baseline specification (Eq. 1) using the dependent variable in the column, with standard errors clustered at the census district level in parenthesis below. Columns 1-3 have dependent varibles derived from a digital elevation model: elevation in meters in column 1, average slope in reservations measured in minutes in column 2, and the standard deviation of the slope as a measure of roughness in column 3. Columns 4 and 5 use average temperature and precipitation between 1970 and 2000 as dependent variables, respectively. Columns 6 to 12 use data from the forced settlement process as the dependent variable: the year of forced settlement in column 6, the total number of hectares allocated to a reservation in column 7, the number of persons settled in column 8, population density at the time of forced settlement in column 9, the level of fractionalization (as measured Alesina et al. (2003)) between localized patrilineal kinship groups in Column 10, whether a reservations filed a petition for a partition before 1929 in column 11, and whether a reservation had asked for an amendment to its settlement conditions in column 12. Mean low access row shows the average of the dependent variable in reservations originally assigned to Temuco and Nueva Imperial courts as a benchmark. Observations and Clusters rows present number of observations and clusters respectively.

Especially telling is the absence of discontinuities in the last two columns, as they represent procedures that required the intervention of the Protector of Indians. Column 11 refers

to whether a reservation obtained a partition. In this procedure, a clerk from the Indigenous Settlement Commission visited a reservation and drew a map with a suggested division of the reservation among different groups. Although the procedure had no legal validity, it was highly valued by reservations with high levels of internal conflict (República de Chile, 1912, p. 146). Column 12 refers to requests to modify a reservation's settlement conditions after the title was granted, with most of the cases involving petitions to increase the amount of land allocated to the reservation. We find no cross-jurisdiction discontinuities in either of these variables. Figure E.10 in Online Appendix E shows these null results are found across different bandwidths and specifications.

ONLINE APPENDIX C: A SIMPLE MODEL OF THE TRAGEDY OF THE COMMONS WITH FODDER PRODUCTION

Consider a reservation with $M >> 0$ farmers indexed by i. Each farmer decides simultaneously how much livestock per hectare of grassland she has, n_i, and how much fodder per livestock per hectare of grassland she uses, f_i, to maximize her income per hectare of grassland

$$y_i(n_i, f_i) = p \log\left(a - b(n - \delta f) + \lambda f_i\right) n_i - c n_i f_i - d n_i. \tag{5}$$

We assume the total amount of grassland is given, and in what follows we refer to n_i and f_i as livestock and fodder density to simplify the exposition. n and f are total livestock density and average fodder density in the grassland farmers have access to. Without loss of generality, we impose the normalizations $\lambda = p = 1$ and assume $d = 0$.

The average value per unit of livestock density is decreasing in n, reflecting that grassland productivity falls as total livestock density increases. We expand the standard model of the tragedy of the commons by adding fodder as an alternative source of feeding, with aggregate- and individual-level effects in productivity. At the aggregate level, f increases grassland productivity by releasing some of the animals' pressure on the resource. In addition, at the individual level, f_i increases the average value of farmer i's livestock directly by increasing caloric intake. Note that δ captures the relative importance of these two effects,

with larger values of δ associated to a larger impact of fodder on grassland productivity vis-à-vis its direct impact on the average value of livestock.

Under open access to grazing land, farmers maximize Equation 5 taking n and f as given. From the FOC and imposing a symmetrical Nash Equilibrium ($n = Mn_i, f = f_i$), we obtain two equations that define the equilibrium:

$$cf = \log\left(\frac{1}{c}\right), \tag{6}$$

$$-bn + (1 + b\delta)\, f = \frac{1}{c} - a. \tag{7}$$

Under individual property rights each farmer receives individual property rights over $1/M$ of the grassland. As she commands exclusive use of its grassland, she maximizes Equation 5 with $n = n_i$ and $f = f_i$, leading to the following equations that define the equilibrium:

$$\frac{cb}{1 + \delta b} n + cf = log\left(\frac{1 + \delta b}{c}\right), \tag{8}$$

$$-bn + (1 + b\delta) f = \frac{1}{c} - a + \frac{\delta b}{c}. \tag{9}$$

Note that, as n and f have been defined as the total number of animals per hectare and the average use of fodder per animal per hectare respectively, both quantities are comparable across both regimes. The following result characterizes the comparative static of both equilibriums:

Result 1: Production under individual property rights vs. open access

Let (n^{OA}, f^{OA}) and (n^P, f^P) be the symmetrical interior Nash Equilibriums of livestock and fodder density under open access and individual property rights respectively. Then, there exist δ_1 and δ_2, with $\delta_1 < \delta_2$, such that, if $\delta < \delta_1$, then $n^P < n^{OA}$ and $f^P < f^{OA}$; if $\delta_1 < \delta < \delta_2$, then $n^P < n^{OA}$ and $f^P > f^{OA}$; and if $\delta > \delta_2$, then $n^P > n^{OA}$ and $f^P > f^{OA}$.

Demonstration: Solving the linear systems in equations 8 and 9 and equations 6 and 7 we obtain (n^{OA}, f^{OA}) and (n^P, f^P) respectively. Subtracting the former from the later:

$$f^P - f^{OA} = \log(1 + \delta b) + log(c) + 1 - ac, \tag{10}$$

$$n^P - n^{OA} = \frac{1}{2}(1+\delta b)\left(\log(1+\delta b) + 2log(c) + (1+a)c^2\right) + 1 - ac. \quad (11)$$

As the right hand side of equations 10 and 11 are increasing in δ, there exists δ_1 and δ_2 such that $f^P \geq f^{OA}$ if and only if $\delta \geq \delta_1$ and $n^P \geq n^{OA}$ if $\delta \geq \delta_2$, respectively.

It is left to show that $\delta_1 < \delta_2$. Assume $\delta_1 > \delta_2$. Then, it would follow that when $\delta_2 < \delta < \delta_1$, $n^P > n^{OA}$ and $f^P < f^{OA}$. However, as Equation 9 is an upward parallel shift of Equation 7 in the (n, f) cartesian plane, that is not possible. Hence, $\delta_1 < \delta_2$.

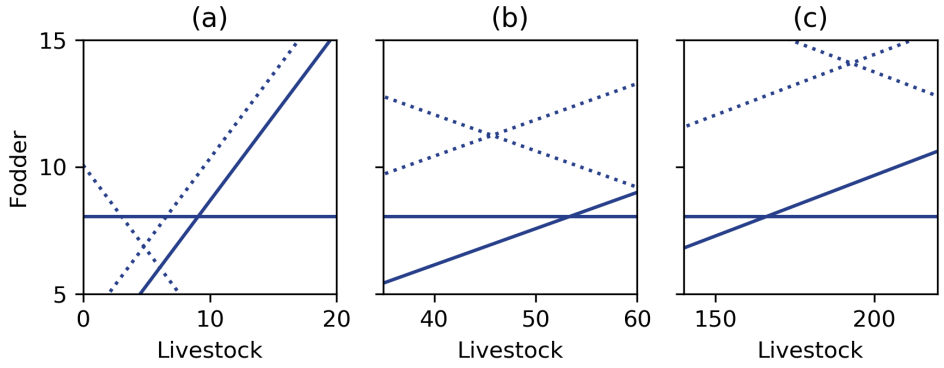

FIGURE C.1.—Model predictions: Solid lines represent equations 6 and 7, with the intersection yielding (n^{OA}, f^{OA}), while dotted lines represent equations 8 and 9, with their intersection yielding (n^P, f^P). Panel a shows the case where $\delta < \delta_1$, whereas panels b and c show the cases where $\delta_1 < \delta < \delta_2$ and $\delta_2 < \delta$ respectively.

When fodder use has a small impact on grassland productivity, the main effect of individual property rights is to internalize the externalities of grazing livestock, which decreases the number of animals and the use of fodder, as the direct impact of fodder on livestock average value falls when grazing productivity recovers (Figure C.1, panel a). For intermediate values of δ, farmers internalize both the fact that they have too many animals and use too little fodder when property rights are introduced, hence increasing the use of fodder and decreasing the number of animals (Figure C.1, panel b). This is the case that rationalizes the empirical findings of this paper. In the third case, which corresponds to what is documented by Bühler (2021), the use of fodder has such a large impact on the productivity

of grassland that farmers end up increasing their number of animals after internalizing the positive externalities of fodder use on grassland production (Figure C.1, panel c). The theoretical explanation for the difference between the results of this paper and Bühler (2021) seems sensible, as investment in grassland productivity are probably more effective in the great plains studied by Bühler (2021) than in the marginal lands where animals grass in the region of study of this paper.

ONLINE APPENDIX D: EQUIVALENCE BETWEEN ETHNIC DECOMPOSITION AND OAXACA-BLINDER DECOMPOSITION

Consider the decomposition of the treatment effect in Equation 4 of Section 7.3. Let

$$y_1 = \gamma_0 + \gamma_1 M_1, \tag{12}$$

$$y_0 = \delta_0 + \delta_1 M_0, \tag{13}$$

where $\gamma_0 = y_1^C$, $\gamma_1 = y_1^M - y_1^C$, $\delta_0 = y_0^C$, $\delta_1 = y_0^M - y_0^C$, $M_1 = \alpha_1$, and $M_0 = \alpha_0$.

Equations 12 and 13 are the standard regressions used in a Oaxaca-Blinder decomposition, with potential outcomes as groups and ethnicity as the attribute. Even though we cannot run these regressions as presented, due to the fundamental problem of causal inference, all its components are identified in an experimental or a regression discontinuity design.

ONLINE APPENDIX E: ROBUSTNESS CHECKS

The following figures present robustness check for Tables B.1 to IX. In each Figure, each plot shows the estimate of β_1 in Equation 1 for the dependent variable displayed at the left, using the specification shown on top (Local Linear Regression (LLR), 1° polynomial in longitude and latitude, and 2° polynomial in longitude and latitude). Each plot presents estimates for 21 bandwidths shown at the bottom in kilometers, with white diamonds representing point estimates and wide and narrow blue bars representing 90% and 95% confidence intervals.

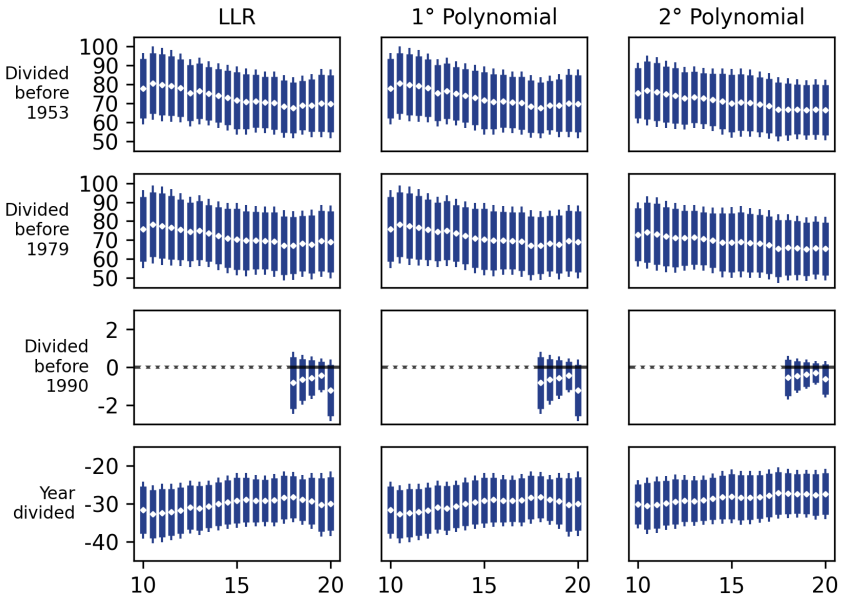

FIGURE E.1.—Robustness Table I

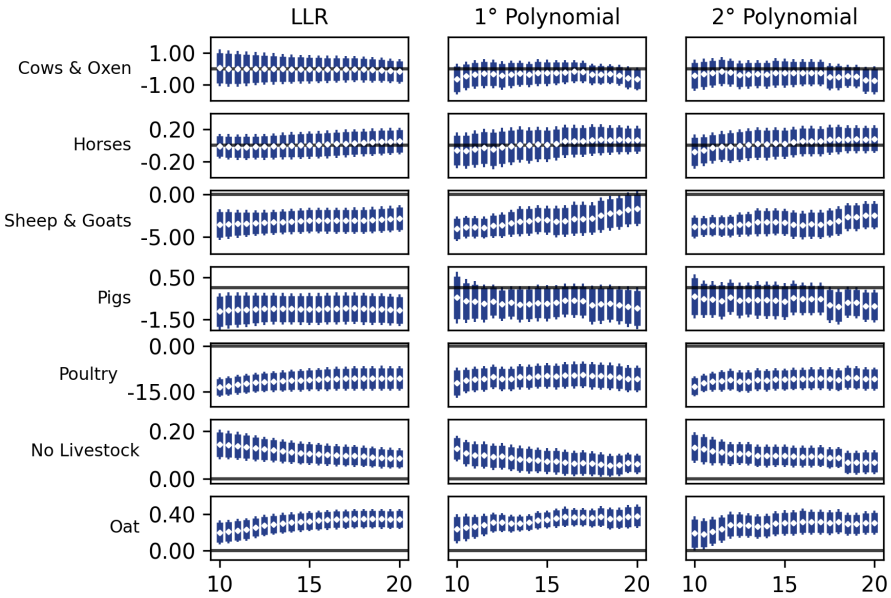

FIGURE E.2.—Robustness check for Table II

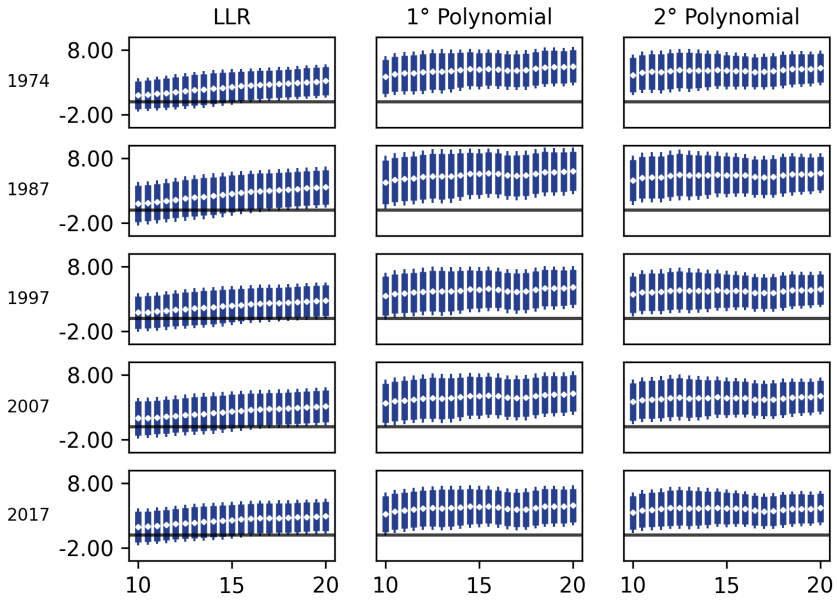

FIGURE E.3.—Robustness check for Table III

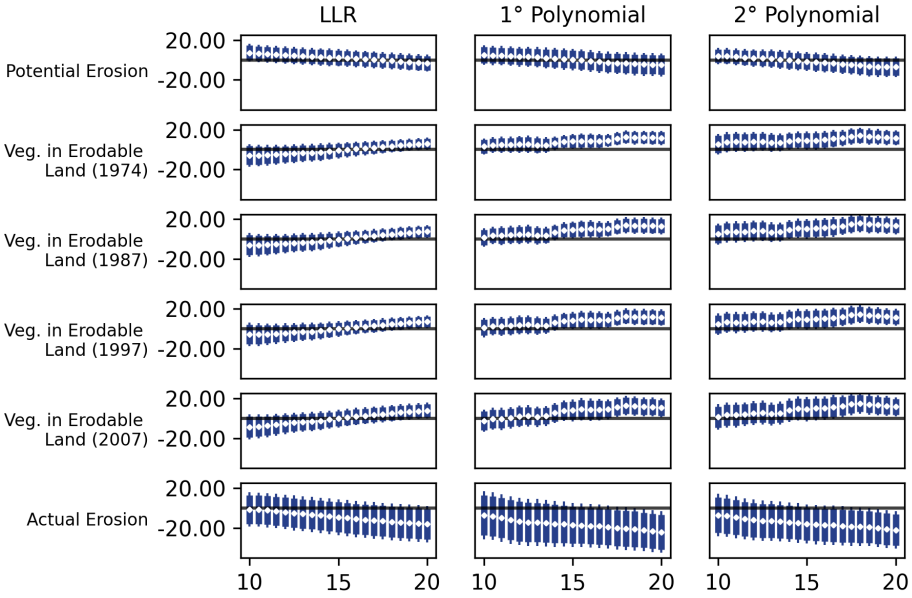

FIGURE E.4.—Robustness check for Table IV

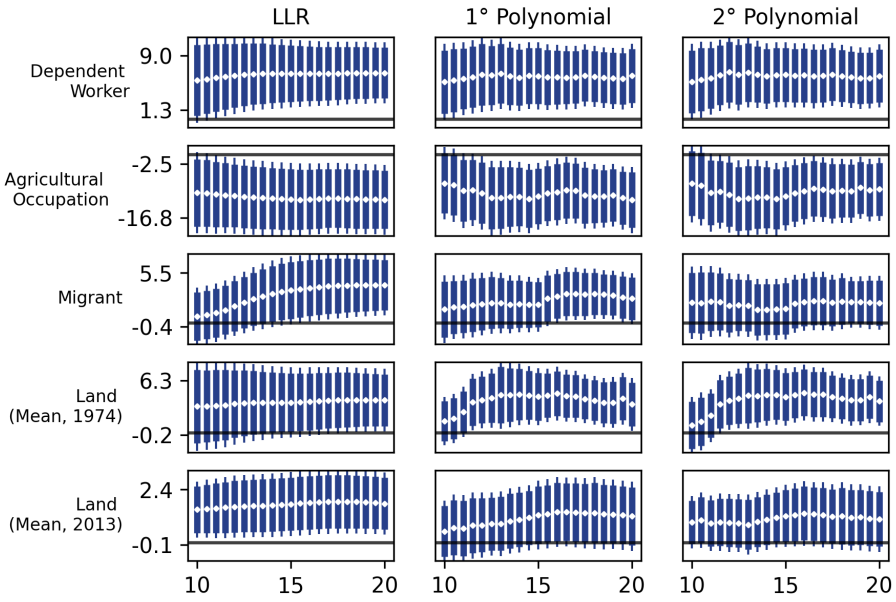

FIGURE E.5.—Robustness check for Table V

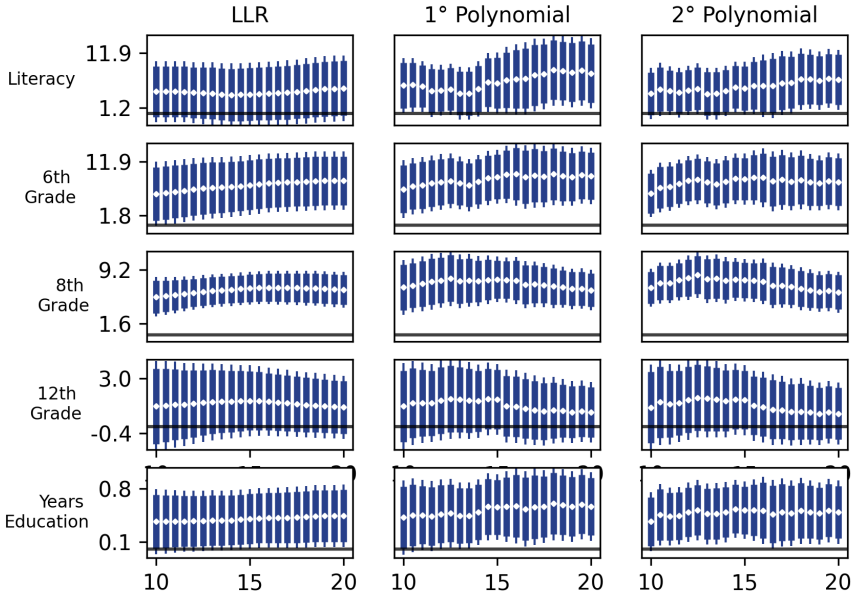

FIGURE E.6.—Robustness check for Table VI

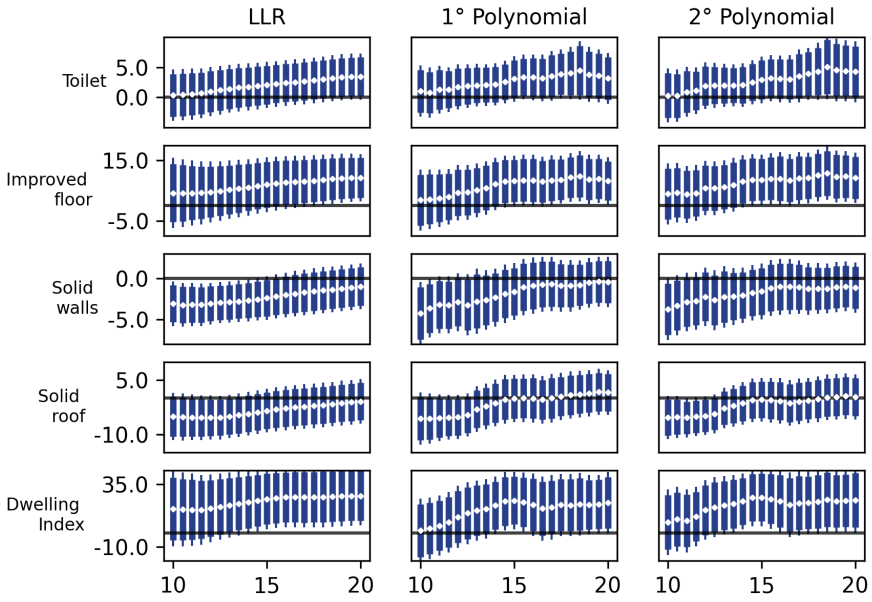

FIGURE E.7.—Robustness check for Table VII (continuation)

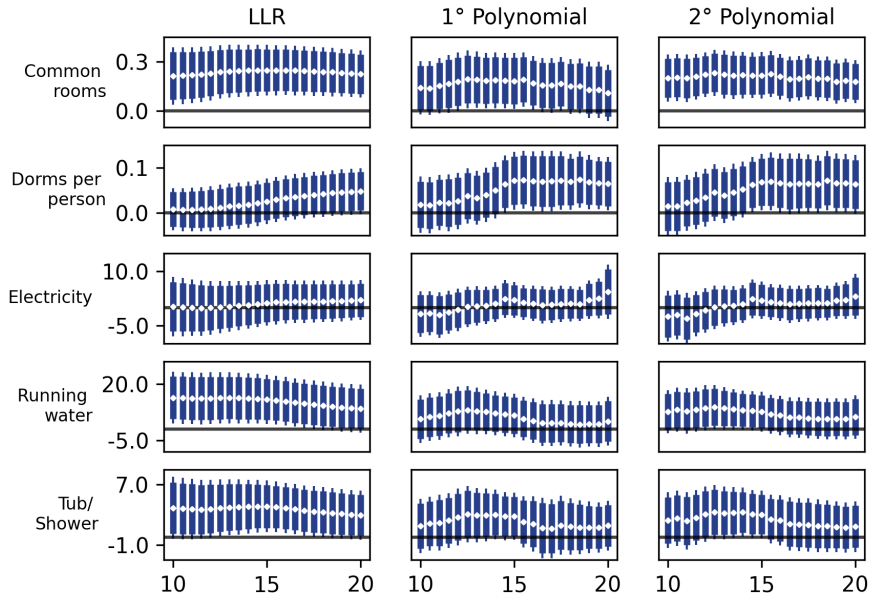

FIGURE E.7.—Robustness check for Table VII

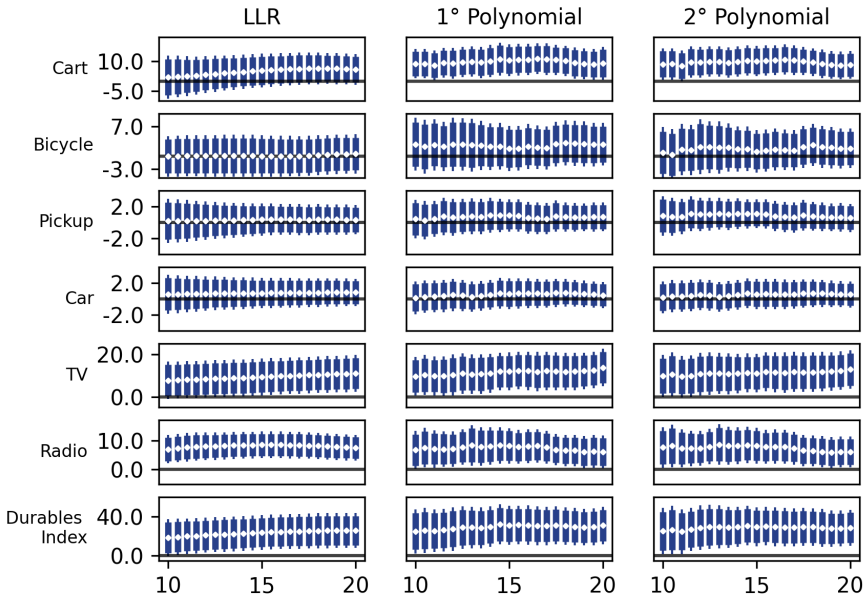

FIGURE E.8.—Robustness check for Table VIII

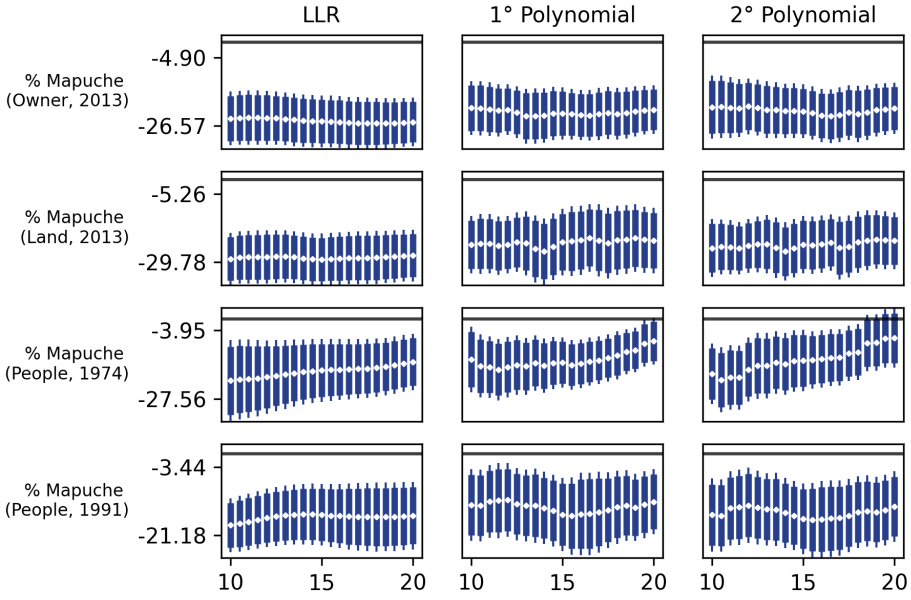

FIGURE E.9.—Robustness check for Table IX

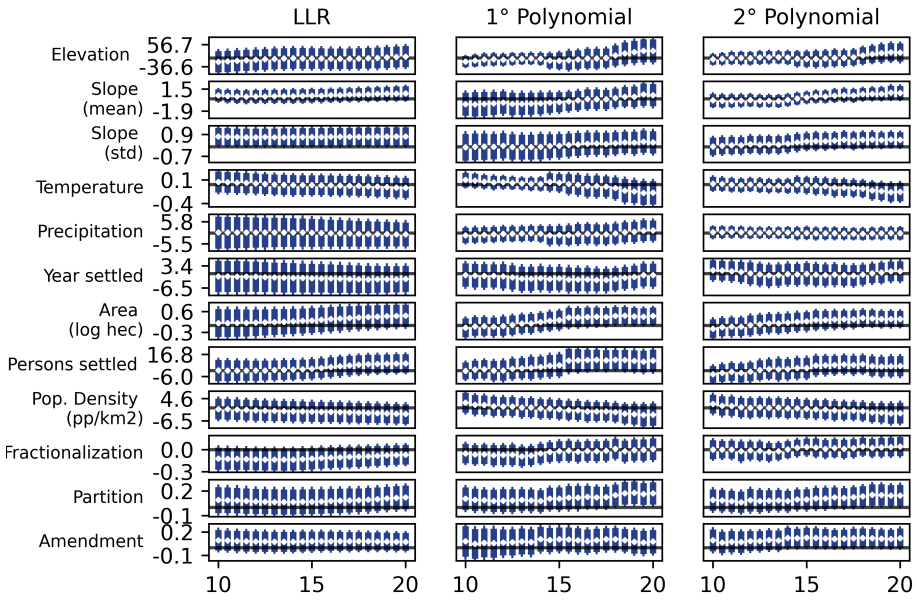

FIGURE E.10.—Robustness Table B.1

ONLINE APPENDIX F: EFFECTS OUTSIDE RESERVATIONS

The following figures present estimates of the treatment effect for units outside reservations when the information is available. In each Figure, Each plot shows the estimate of β_1 in Equation 1 for the dependent variable displayed at the left, using the specification shown on top (Local Linear Regression (LLR), 1° polynomial in longitude and latitude, and 2° polynomial in longitude and latitude). Each plot presents estimates for 21 bandwidths shown at the bottom in kilometers, with white diamonds representing point estimates and wide and narrow blue bars representing 90% and 95% confidence intervals.

In Figures F.1 and F.2, the sample consists of pixels from 'placebo reservations'. These were defined by first creating a 1×1 kilometer grid that covers the study region, to which we subtracted the area covered by reservations. A random sample of the resulting polygons, of size equal to the number of reservations in the study regions, was selected among polygons with at least 100 pixels and 70% of its land covered by agriculture. These restrictions ensure that placebo reservations are comparable to reservations in terms of size and land-cover.

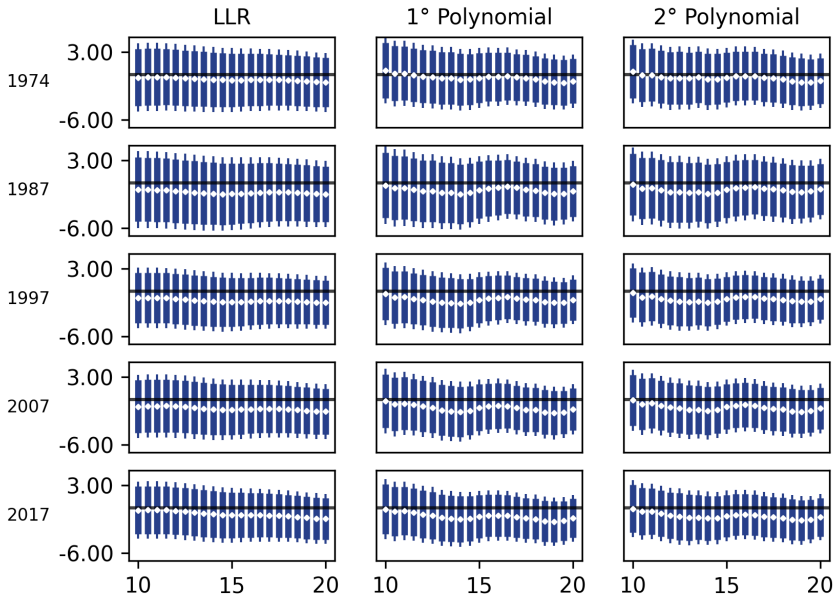

FIGURE F.1.—Effects outside reservations for Table III

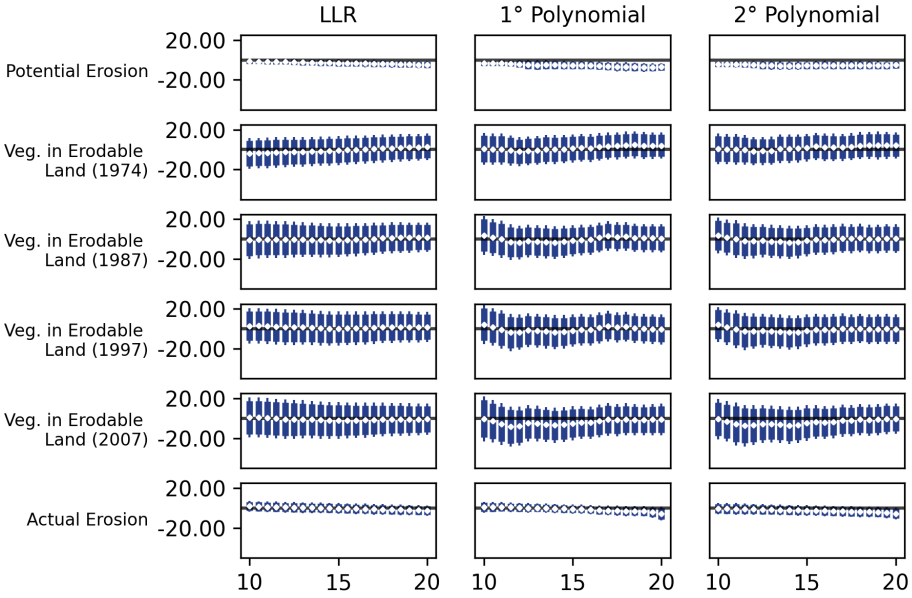

FIGURE F.2.—Effects outside reservations for Table IV

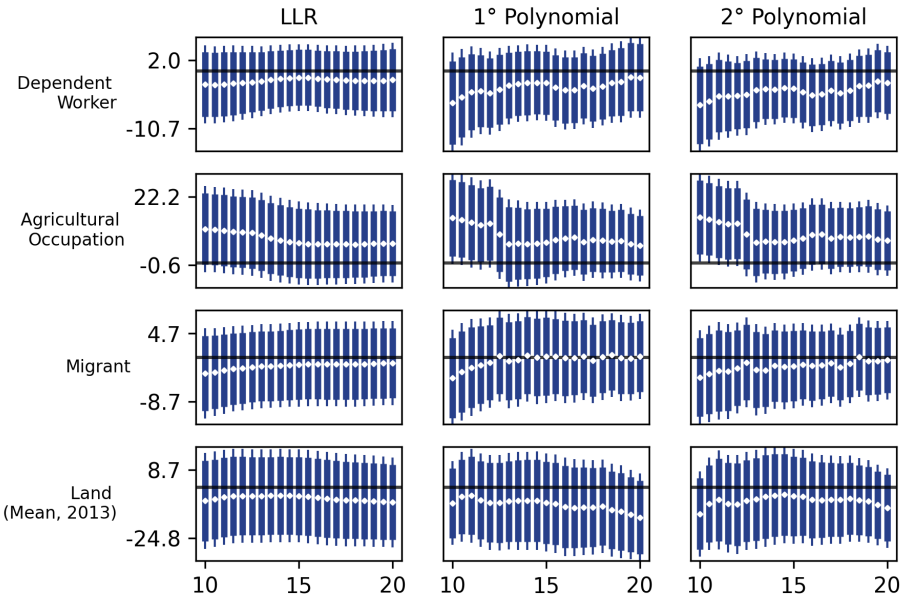

FIGURE F.3.—Effects outside reservations for Table V

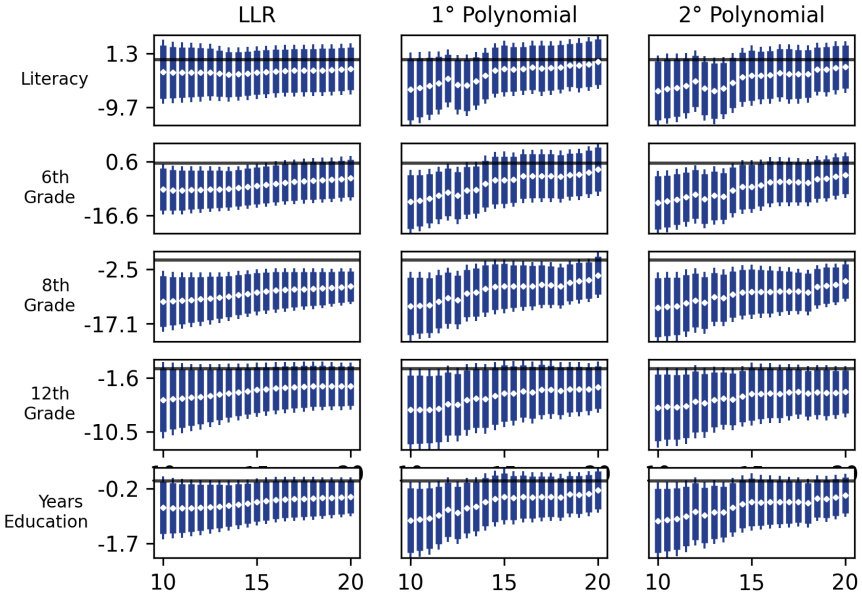

FIGURE F.4.—Effects outside reservations for Table VI

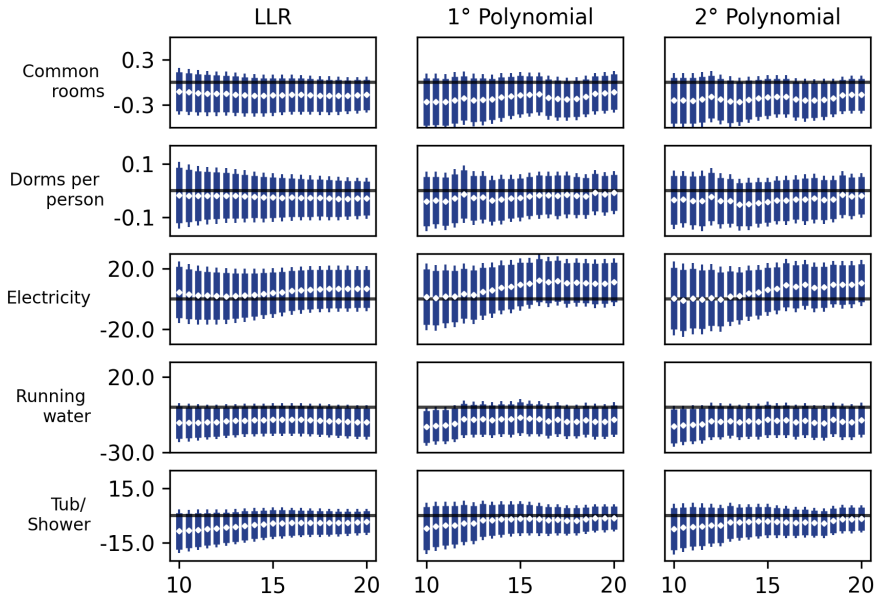

FIGURE F.5.—Effects outside reservations for Table VII

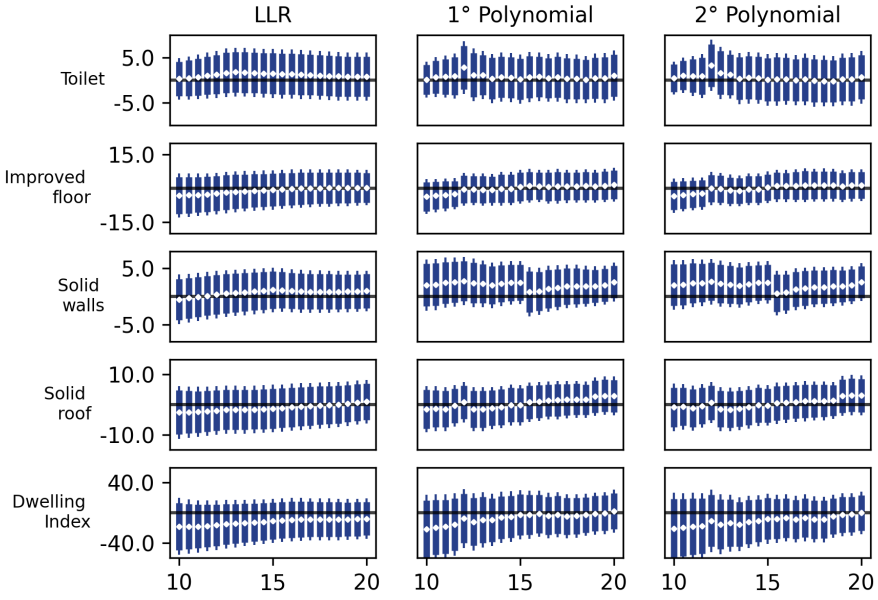

FIGURE F.5.—Effects outside reservations for Table VII (continuation)

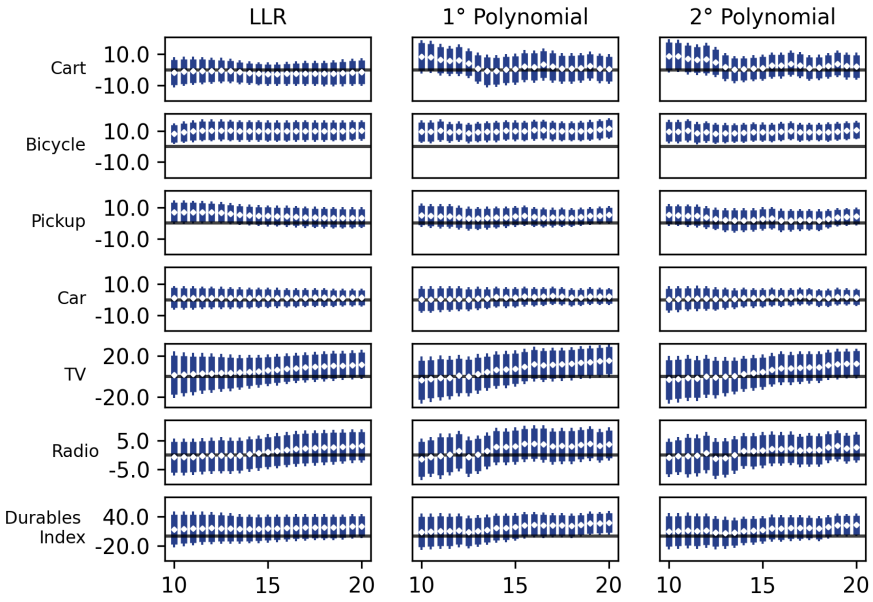

FIGURE F.6.—Effects outside reservations for Table VIII

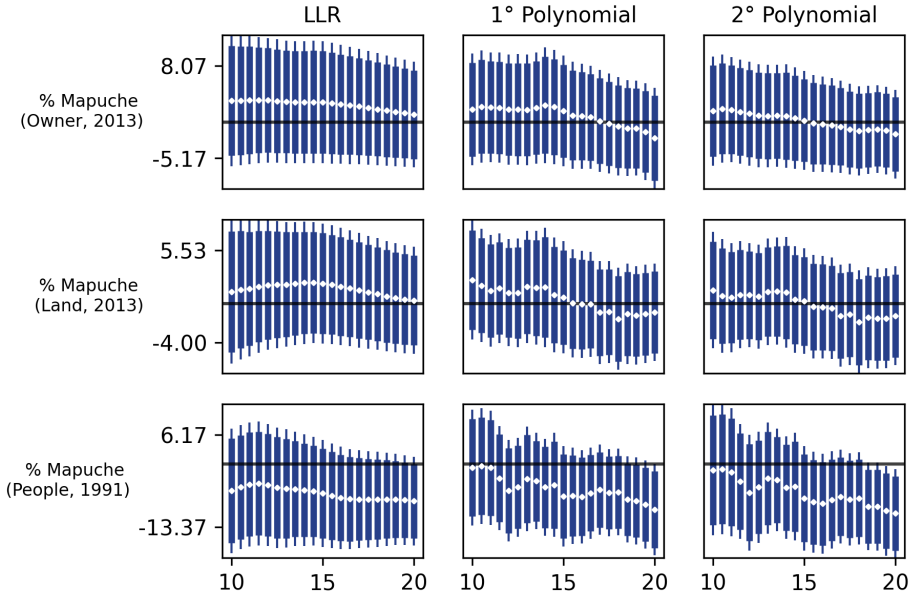

FIGURE F.7.—Effects outside reservations for Table IX

ONLINE APPENDIX G: SUPPLEMENTARY TABLES AND FIGURES

FIGURE G.1.—Weights of variables included in Dwelling Index

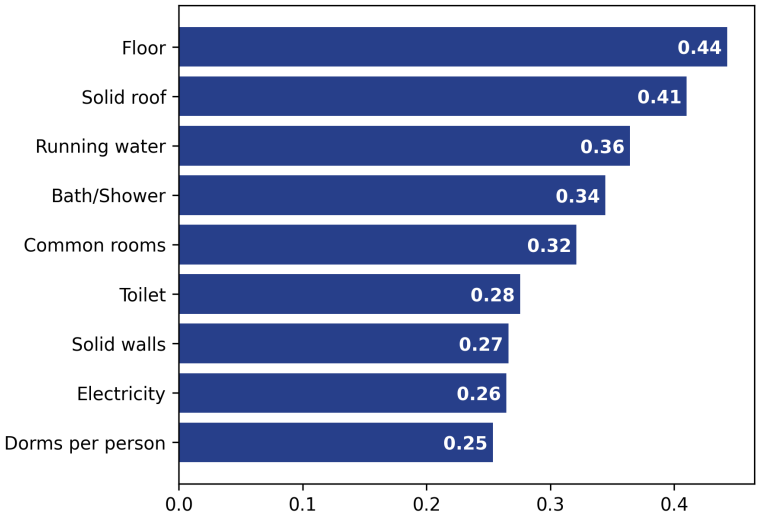

FIGURE G.2.—Weights of variables included in Durables Index

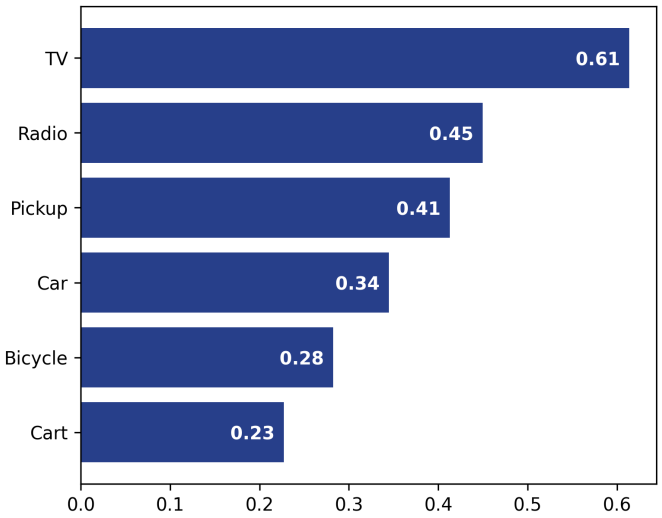

TABLE G.1

SUPPLEMENTARY RESULTS[a]

	Dependent variable is:					
	Lives outside	Persons per Household	Fertility	Not nuclear	Wheat	Other crops
	(1)	(2)	(3)	(4)	(5)	(6)
High access	5.89	-0.20	-0.12	0.45	0.62	-0.23
	(2.33)	(0.08)	(0.11)	(0.59)	(0.43)	(0.15)
Mean low access	4.32	4.50	5.91	9.46	2.55	0.41
Observations	4,427	4,906	2,606	22,327	4,320	4,263
Clusters	37	46	46	46	37	37
Source	AD	CS	CS	CS	AD	AD
Year	1974	1992	1992	1992	1974	1974

[a]Unit of analysis is a household within a reservation columns 1 and 2, and a women 45 years or older in a reservation in column 3, and a person within a reservation that does not work as a servant of a reservation's household in column 4. High access row presents treatment effects estimates from baseline specification (Eq. 1) using the dependent variable in the column, with standard errors clustered at the census district level in parenthesis below. Dependent variable is 100 if a household reports that their residence lies outside a reservation and zero otherwise in column 1, the number of persons in the household in column 2, the number of children born alive that a woman has given birth to in column 3, 100 if a person is not part of the nuclear family of the head of the household in column 4 (the nuclear family includes the partner of the head of the household, children from the head of the household or its partner, and children of these children); and the number of hectares sowed with wheat an other minor crops in columns 5 and 6, respectively. Observations and Clusters rows present number of observations and clusters respectively. Last two rows (Source and Year) show the data source of the dependent variable and the year it was collected respectively. Acronyms for data source are: CS=Individual-level responses to the 1992 General Population Census; AD=Family-level responses to 1974 Indigenous Agricultural Declaration.

TABLE G.2

ETHNIC DECOMPOSITION OF THE TREATMENT EFFECT FOR OUTCOME VARIABLES FOR WHICH THE ETHNICITY OF EACH OBSERVATION CAN BE DETERMINE AND WHERE ROBUST EFFECTS ARE DETECTED

	α_0, α_1	y_0^M, y_1^M	y_0^C, y_1^C	Decomposition		
				Ma-puche	Chilean	Comp.
	(1)	(2)	(3)	(4)	(5)	(6)
Agricultural production (Table II):						
Sheep & Goats (1974)	0.91, 0.76	5.17, 2.31	4.96, 2.32	77%	22%	1%
				[0.000]	[0.980]	[0.980]
Pigs (1974)	0.91, 0.76	4.04 ,3.09	5.92, 3.45	70%	57%	-27%
				[0.432]	[0.552]	[0.902]
Poultry (1974)	0.91, 0.76	25.72, 15.69	32.87, 16.06	72%	38%	-10%
				[0.034]	[0.966]	[0.992]
No Livestock (1974)	0.91, 0.76	0.06, 0.12	0.00, 0.17	61%	49%	-10%
				[0.900]	[0.692]	[0.948]
Fodder (1974)	0.91, 0.76	0.10, 0.43	0.04, 0.47	72%	30%	-2%
				[0.008]	[0.990]	[1.000]
Factors of production (Table V):						
Wage Worker (1992)	0.84, 0.68	10.44, 17.07	19.90, 21.06	70%	6%	24%
				[0.026]	[0.912]	[0.968]
Agg. Occ. (1992)	0.84, 0.68	83.36, 70.30	62.08, 63.17	75%	-3%	28%
				[0.028]	[0.894]	[0.960]
Migrant (1992)	0.84, 0.68	7.33, 11.16	27.92, 23.43	58%	-32%	74%
				[0.590]	[0.706]	[0.404]
Land (1974)	0.91, 0.76	9.99, 12.40	9.87, 18.96	46%	54%	0%
				[0.628]	[0.352]	[0.824]
Land (2013)	0.84, 0.59	3.59, 4.72	6.91, 7.44	39%	13%	48%
				[0.548]	[0.578]	[0.390]

TABLE G.2

ETHNIC DECOMPOSITION OF THE TREATMENT EFFECT FOR OUTCOME VARIABLES FOR WHICH THE ETHNICITY OF EACH OBSERVATION CAN BE DETERMINE AND WHERE ROBUST EFFECTS ARE DETECTED (CONTINUATION)

	α_0, α_1	y_0^M, y_1^M	y_0^C, y_1^C	Decomposition		
				Ma-puche	Chilean	Comp.
	(1)	(2)	(3)	(4)	(5)	(6)
Education (Table VI):						
6th Degree (1992)	0.84, 0.69	18.65, 24.37	30.77, 38.86	48%	30%	22%
				[0.198]	[0.754]	[0.834]
8th Degree (1992)	0.84, 0.69	8.34, 13.19	19.31, 23.53	53%	21%	26%
				[0.090]	[0.852]	[0.878]
Schooling (1992)	0.84, 0.69	2.90, 3.11	4.56, 4.71	34%	10%	56%
				[0.618]	[0.418]	[0.276]
Dwelling conditions (Table VII):						
Common rooms (1992)	0.90, 0.76	1.57, 1.78	1.79, 1.96	68%	19%	13%
				[0.006]	[0.936]	[0.990]
Dorms pp (1992)	0.90, 0.76	0.48, 0.50	0.51, 0.62	37%	53%	10%
				[0.620]	[0.366]	[0.778]
Running water (1992)	0.90, 0.76	9.48, 16.94	26.16, 30.00	64%	10%	26%
				[0.032]	[0.884]	[0.860]
Tub/Shower (1992)	0.90, 0.76	1.36, 3.45	9.56, 9.70	58%	1%	41%
				[0.124]	[0.746]	[0.692]
Toilet (1992)	0.90, 0.76	89.33, 92.64	94.22, 95.44	73%	8%	19%
				[0.026]	[0.940]	[0.954]

TABLE G.2

ETHNIC DECOMPOSITION OF THE TREATMENT EFFECT FOR OUTCOME VARIABLES FOR WHICH THE ETHNICITY OF EACH OBSERVATION CAN BE DETERMINE AND WHERE ROBUST EFFECTS ARE DETECTED (CONTINUATION)[a]

	α_0, α_1	y_0^M, y_1^M	y_0^C, y_1^C	Decomposition		
				Ma-puche	Chilean	Comp.
	(1)	(2)	(3)	(4)	(5)	(6)
Improved floor (1992)	0.90, 0.76	67.65, 75.84	82.32, 87.19	66%	13%	21%
				[0.010]	[0.994]	[0.978]
Dwelling Index (1992)	0.90, 0.76	-39.35, -21.79	0.82, 16.27	59%	17%	24%
				[0.034]	[0.888]	[0.956]
Durable goods (Table VIII):						
TV (1992)	0.90, 0.76	13.78, 23.22	33.91, 37.61	66%	8%	26%
				[0.054]	[0.874]	[0.940]
Radio (1992)	0.90, 0.76	73.31, 79.81	73.16, 83.93	65%	35%	0%
				[0.094]	[0.858]	[0.962]
Durables Index (1992)	0.90, 0.76	-29.67, -12.95	5.01, 10.18	67%	7%	26%
				[0.032]	[0.892]	[0.960]

[a]For each dependent variable presented in the rows, columns 1-3 present the causal estimates of the parameters required to derived the decomposition of Equation 4, while columns 4-6 show the three components of the decomposition: the Intraethnic Mapuche, Intraethnic Chilean, and Ethnic Composition Effects. The dwelling and asset index are standarized to have a mean of zero and a standard deviation of 100 across the full sample (within and outside reservations). P-values in square brackets below decomposition's components, obtained from a 500 repetition block bootstrap where clusters are given by census district and using as the null hypothesis that the component in question is not the largest one among the three components.