Unbundling Property Rights: Evidence from Ecuador's Agrarian Reform

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Abstract

This paper studies how property rights shaped long-run adaptation after Ecuador's agrarian reform. I compare nearby coastal areas under public land transfers (PLT), which gave farmers more freedom over land use, and expropriation, which imposed tighter constraints. A geographic regression discontinuity at the policy boundary shows that rights shaped crop choice more clearly than aggregate productivity. Expropriation sustained narrow specialization through two routes. Decree 1001 tied land access directly to rice production. Expropriation risk may also have discouraged established banana growers from leaving a familiar, profitable crop. PLT instead shifted production away from rice and widened the perennial portfolio, mainly by encouraging farmers to adopt different crops rather than raising productivity in every incumbent crop. High productivity in rice or bananas did not generate broader gains when the institutional regime kept production narrow. The reform's long-run effects depended not only on who received land, but also on the rights attached to it.

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1. Introduction

Property rights shape development through investment incentives, but productivity in one crop is not enough to generate broad development. In agrarian settings, the key long-run question is not only whether farmers invest after gaining access to land, but whether the institutional environment lets productive activity spread beyond a narrow crop structure. A first-order effect concerns whether producers invest at all. A second-order effect concerns the composition of that investment and the equilibrium it sustains. That distinction matters because productivity gains in incumbent crops may remain concentrated and fail to generate broader reallocation, structural change, or local growth. Latin American debates on agrarian reform have often emphasized disappointing aggregate results, distortions, and weak incentives under expropriation-based settings (de Janvry, 1981; Kay, 2002, 2019). Much less is known about public land settlement, internal colonization, or public land transfers[1], even though these policies were also common in several contemporary agrarian reforms in Latin America (Albertus, 2015). Few studies examine that margin directly, and almost no quantitative work compares expropriation and public land transfers within the same reform episode, even though both strategies often coexisted.

This paper studies how different bundles of rights shaped long-run crop allocation during Ecuador's agrarian reform. I compare adjacent coastal areas under two regimes: public land transfers (PLT), which gave farmers more flexibility over subsequent land use, and expropriation in rice-growing zones, where the state imposed stronger production constraints. A geographic regression discontinuity at the border between these regimes compares two institutional arrangements within the same reform (Keele and Titiunik, 2015; Cattaneo et al., 2019). Expropriation sustained narrow crop specialization through two routes. Decree 1001 directly tied access to expropriated land to rice production. Weaker rights also encouraged established banana producers to remain in a familiar, profitable crop instead of diversifying into a broader perennial portfolio. The evidence identifies the rice route more directly than the banana route. PLT widened crop choice and increased the adoption of other perennial crops. Banana productivity remained stronger under expropriation, but high productivity in one incumbent crop did not produce broad diversification or development. The institutional environment determined whether producers kept activity concentrated or spread it through adaptation and reallocation. I also find suggestive evidence of movement out of agricultural employment under PLT. Although PLT often granted larger plots historically, agricultural surface is locally similar across the studied

[1] Throughout the paper, I use the term public land transfers to refer to this land-allocation policy.

border. Different reform laws, rather than a sharp pre-existing difference in farm size, divided nearby places with a common agrarian history.

Ecuador's agrarian reform placed both allocation strategies in a common agrarian landscape. The same history shaped both sides of the border. Large haciendas first organized the cocoa economy. External shocks then brought its collapse. Rice spread across abandoned or weakly controlled estates, and the banana boom created new opportunities for accumulation (Chiriboga, 1980; Arosemena, 1991; Guerrero, 1994; Uggen, 1975; Espinosa, 2014; Larrea, 1987). The Ecuadorian Institute of Agrarian Reform and Colonization (IERAC, its Spanish acronym) later divided neighboring areas into two institutional environments. PLT gave beneficiaries broad freedom over crop choice. Expropriation imposed tighter rules in rice-growing zones, where later interventions sought to preserve rice production.

The empirical strategy compares locations around the digitized outer edge of the PLT footprint in IERAC's 1978 map. The baseline uses a sharp geographic regression discontinuity with robust bias correction. It uses a 40 km bandwidth and geographic controls. It also excludes the two parishes closest to the threshold to reduce uncertainty about the historical border. The 2000 agricultural census provides the main outcomes. Earlier censuses establish the pre-reform context. Evidence on credit, crop structure, and structural transformation helps interpret the results. A broad set of robustness checks tests the design. For interpretation only, I also report a brief back-of-the-envelope adaptation of Kim and Wang (2025), using the reallocation logic in McCaig and Pavcnik (2018). It shows how aggregate productivity measures can obscure diversification and labor-reallocation gains within the same reform.

Both regimes sustained investment, but they directed it toward different crop structures. Decree 1001 required rice production, and the informal-credit pattern is consistent with persistence along that direct route. Weaker rights also made persistence in bananas more attractive to established producers than diversification into other perennials. Because the data identify this second route less directly, I treat it as an interpretation of the crop and cadastre evidence. PLT instead gave producers more freedom to adopt a broader perennial portfolio. This shift operated mainly through adoption rather than uniformly higher productivity within incumbent crops. Property rights determined whether productive activity remained concentrated in inherited crops or spread through diversification and reallocation.

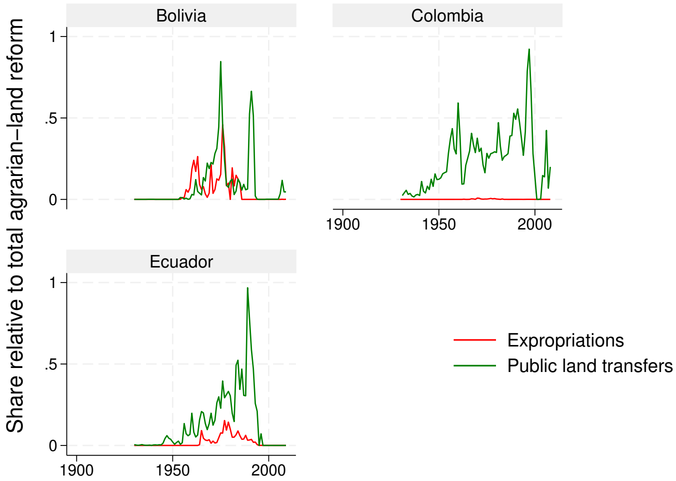
The paper contributes to three literatures. First, it shifts the Latin American agrarian-reform literature from average reform effects toward the allocation strategies within reforms. Most empirical studies examine expropriation and its effects on productivity, inequality, and long-run development (Besley and Burgess, 2000; Do and Iyer, 2008; Galán, 2020; Montero, 2022, 2023; Edwards et al., 2022). A smaller literature studies public land distribution and PLT, often through their political economy or distributive effects (Albertus, 2015; Faguet et al., 2020). I connect these strands by comparing expropriation and PLT within one reform episode. Work on Taiwan likewise shows that distinct phases of one agrarian reform can produce different effects on productivity and structural change (Kim and Wang, 2025). Agrarian reform is not a single policy when its components assign different rights and constraints. Second, the paper shows that agricultural development depends on the bundle of property rights attached to land allocation, not only on whether rights exist (Alchian, 1965; Hornbeck, 2010; Galiani and Schargrodsky, 2010; Bühler, 2021; Smith, 2020). Third, it links local reform design to persistent differences in crop structure, misallocation, and structural transformation (Adamopoulos, 2008; Herrendorf et al., 2014; Kitamura, 2022; Blankespoor et al., 2022).

Section 2 presents the historical and institutional context. Sections 3 and 4 describe the data and empirical strategy. Section 5 reports the results and robustness exercises, Section 6 discusses mechanisms, and Section 7 concludes.

2. Historical and Institutional Context

Latin American agrarian reforms did not apply a single kind of land-allocation policy. Some governments relied mainly on expropriation. Others, including Ecuador, Bolivia, and Colombia, combined expropriation with large public land transfers (PLT) (Albertus, 2015). Figure 1 shows the importance of both channels across the region. These channels transferred land under different rules even within the same national reform. Ecuador therefore permits a comparison of two bundles of rights within one reform episode and regional context.

Figure 1: Public land transfers and expropriation in Latin American agrarian reforms



Note: Public land transfers were quantitatively important in several Latin American agrarian reforms, including Bolivia, Colombia, and Ecuador. Source: Albertus (2015).

2.1. From cocoa to rice and bananas

The cocoa economy created the agrarian landscape that IERAC later divided. During the nineteenth and early twentieth centuries, Ecuador became a major cocoa exporter, and the coastal provinces of Guayas and Los Ríos organized production around large haciendas. A small landed elite controlled much of the land, often from abroad, while workers cultivated it under precarious labor and tenancy arrangements (Chiriboga, 1980; Arosemena, 1991; Guerrero, 1994).

The cocoa system collapsed in the 1920s. Falling world prices and witches' broom disease made many estates unprofitable. Absentee owners abandoned them or lost effective control. Workers remained on the land, divided fields, and entered informal arrangements that the state did not fully recognize. The collapse changed crops and property relations at the same time. Productive communities remained, but estate boundaries and legitimate claims became difficult to establish (Uggen, 1975; Espinosa, 2014; Carrasco, 1994).

Rice spread across parts of this post-cocoa landscape. Unlike cocoa, rice served the domestic market and became increasingly important to food security. Rising imports and balance-of-payments pressure made the crop politically salient, and the government later treated local rice production as a national priority. Small rice plots could coexist with unsettled ownership because former workers continued to cultivate land whose legal status remained disputed (Espinosa, 2014; Redclift, 1976).

The banana boom of the 1950s created a second export economy before agrarian reform. Producers in central and southern Los Ríos and Guayas converted some former cocoa land to bananas, and both large and small landholders entered the sector. Bananas brought commercial opportunities and valuable crop-specific experience, but they did not resolve the region's unequal or uncertain land relations (Larrea, 1987). By the 1960s, the coastal economy therefore combined two established crops: rice as the principal annual staple and bananas as the principal perennial export. Agrarian reform entered this settled, commercially active landscape rather than a blank frontier.

2.2. Agrarian Reform, PLT, and Decree 1001

The 1964 Agrarian Reform and Colonization Law created the Ecuadorian Institute of Agrarian Reform and Colonization (IERAC) and charged it with redistributing land and expanding cultivation. IERAC used two main channels. Through PLT, called colonization in the legislation, the state adjudicated public, abandoned, or underused land to farmers and sought to expand the agricultural frontier (Canelos, 1980; Barsky, 1984). Through expropriation, the state intervened in large estates and transferred land, often to people who already worked it. After an initial slowdown, the government renewed coastal reform in 1970, but IERAC continued to administer the two channels under different legal rules (Barsky, 1984; Redclift, 1976).

The two channels shared some financial features. Beneficiaries generally repaid the state over 20 to 25 years, after a grace period of three to five years, on terms more favorable than private credit (Barsky, 1984). Yet the contracts did not grant the same control over land use. PLT followed a relatively uniform policy and gave beneficiaries more flexible allocation terms, often larger adjudicated plots, and greater freedom over production (Barsky, 1984; Carrasco, 1994). Pilot settlement projects began in Santo Domingo in the 1950s, but the 1964 law turned PLT into a central allocation program.

PLT did more than settle untouched land. Farther north, it extended the agricultural frontier. In Guayas and Los Ríos, however, IERAC also applied PLT to abandoned cocoa haciendas whose former workers already occupied and cultivated the land. The state used the same legal channel to formalize claims in an old agricultural region. Near the policy border, IERAC therefore did not reserve PLT for empty land or places without a crop history (Carrasco, 1994).

Expropriation took a more restrictive form in southern Guayas and Los Ríos. President José María Velasco Ibarra issued Decree 1001 amid concern about precarious labor arrangements, rising rice imports, and falling domestic production. The decree accelerated intervention in rice-growing estates and tied access to expropriated land to continued rice cultivation. Its terms effectively committed beneficiaries to rice for ten years. Beneficiaries received land and favorable repayment terms, but the state directed how they should use it. Decree 1001 therefore supplied a direct route from expropriation to crop specialization: it made rice production part of the bargain rather than leaving crop choice entirely to the farmer (Barsky, 1984; Redclift, 1976).

Bananas reveal an apparent puzzle. Decree 1001 targeted rice, yet the later data show stronger banana productivity on the expropriation side. The decree did not require farmers to grow bananas. Instead, expropriation risk may have made established producers reluctant to leave a familiar, profitable crop and experiment with new perennials. I therefore interpret banana persistence as a possible indirect response to constrained rights, not as another statutory mandate.

The distinction is one of control, not simply ownership. In the sense of Alchian (1965), property consists of a bundle of rights. PLT beneficiaries gained broader authority to redirect land toward another crop. Expropriation beneficiaries gained land under a rule that reserved more control for the state. Both policies redistributed land, but only one explicitly linked the transfer to production of a particular crop.

2.3. IERAC Policy Border

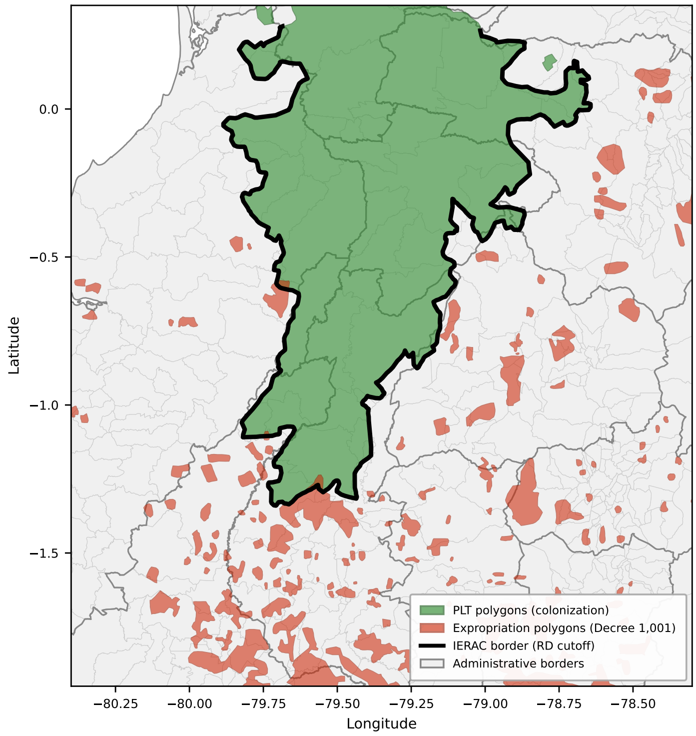
The 1978 IERAC map records the reform's realized spatial footprint. Its green polygon marks the area reached by PLT. I digitize the polygon's outer edge and use it as the policy border. The cutoff therefore comes from the realized expansion of PLT, not from a line jointly drawn to separate PLT from expropriation. Beyond the polygon, especially to the south, IERAC relied more heavily on expropriation after Decree 1001 intensified intervention in the rice economy. Figure 2 shows the reconstructed PLT footprint, the nearby expropriation areas, and the boundary used in the analysis.

The post-cocoa land problem helps explain why PLT could expand through otherwise similar places and stop at this edge. Abandoned haciendas stretched across both sides. Former workers occupied and cultivated land even when estate limits and ownership claims remained unclear. IERAC had discretion to classify these properties as abandoned land eligible for PLT or as estates subject to intervention and expropriation. Near the polygon's edge, the agency applied different legal solutions to communities that shared the same hacienda history (Carrasco, 1994; Guerrero, 1994).

Quevedo, Mocache, Zapotal, and Balzar make the contrast especially clear. These places lay near the edge of the realized PLT footprint and contained land from the former cocoa economy. Farther north, PLT increasingly resembled frontier settlement; close to the border, it instead reached established farms and resident workers. The local comparison therefore does not pit frontier settlers against an old plantation economy. It compares neighboring parts of the same post-cocoa agricultural region.

Historical evidence also ties the northern side to the same cocoa collapse. Contemporary accounts describe the abandonment of Pichilingue, near Quevedo, after crop disease damaged the cocoa economy; agricultural programs later used the area as an important center of experimentation (Leonard, 1947; Cuvi, 2015). The international price decline and plant disease preceded the reform and affected haciendas on both sides of the later IERAC line (Chiriboga, 1980; Guerrero, 1994). This common shock left IERAC to resolve similar land claims under different statutes.

Figure 2: GIS reconstruction of the IERAC policy border and reform regimes



Note: Green polygons show the realized PLT footprint recorded in IERAC's 1978 map, and red polygons mark expropriations associated with Decree 1001. The black line traces the digitized outer edge of the PLT polygon used as the RD cutoff; gray lines show administrative boundaries.

The polygon edge separates legal treatment more clearly than initial agricultural potential. It follows neither the limit of cultivated land nor a sharp break in the pre-reform crop economy. The design therefore compares PLT with expropriation within a common historical landscape. The balance and continuity tests below assess this claim (Keele and Titiunik, 2015).

The two regimes could sustain specialization through different incentives. Decree 1001 directly required rice production on expropriated land. Expropriation may also have made established banana producers less willing to leave a familiar and profitable crop: changing crops required new investment while weaker control over future land use made experimentation riskier. The data identify this banana channel less directly than the rice mandate, so I treat it as an interpretation rather than a legal requirement. PLT gave producers more room to change course. The relevant contrast is therefore not perennial versus annual production in the abstract, but a narrower equilibrium centered on rice and banana persistence versus one that allowed broader perennial diversification.

3. Data

3.1. Agricultural census and historical sources

Ecuador's National Institute of Statistics and Censuses (INEC) collected the 2000 National Agricultural Census. It supplies the core plot-level data (Instituto Nacional de Estadística y Censos, 2002b,a). Its crop questionnaires report production, area, crop age, and land use. The census also records agricultural surface, tenure, workers, and farm credit. I use crop records for the main outcomes and tenure as a baseline control. Credit provides suggestive evidence on rice persistence. Workers provide a post-treatment diagnostic of farm labor scale. Surface enters the landholding checks. The main sample covers the coastal reform corridor. The appendix extends the comparison to Manabi. The census places annual and perennial crops in separate questionnaires. This feature determines the outcome samples described below.

Two earlier national agricultural censuses establish the crop history around the reform. I digitized canton-level records from the 1954 census and parish-level records from the 1974 census. The 1954 census describes agriculture before the 1964 reform and reports production and cultivated area for rice and bananas. The 1974 census records land in annual and perennial crops during the reform's first decade. Together with the 2000 census, these sources trace crop composition from the pre-reform economy to the long run. Their geographic units differ from the plot-level data, so I use them as descriptive evidence rather than as part of the local RD.

IERAC's archival records identify where the state applied each reform channel. Statistical reports record the amount of land assigned through PLT and expropriation by local administrative unit. IERAC's 1978 map records the realized PLT footprint. I digitized and georeferenced its outer edge, overlaid it with current parish boundaries, and calculated each parish's signed distance to that edge. This reconstruction defines treatment status and the running variable in the geographic RD. Appendix Figure A1 reproduces the original 1978 map, and Figure 2 shows the georeferenced reconstruction.

3.2. Outcome construction

I construct perennial revenue per hectare from banana, cacao, sugar cane, oil palm, and plantain. I construct annual revenue per hectare from rice, maize, beans, and potatoes. For these aggregates, I value each crop with the fixed 2013 INEC producer-price schedule implemented in the analysis code. I then divide by the corresponding area.[2] I also study physical yields for rice, cocoa, and banana. A narrower basket contains sugar cane, oil palm, and plantain. I call it the main other-perennial basket.[3] It measures diversification beyond the traditional cocoa-banana structure. The crop groups follow INEC's distinction between permanent (perennial) and transitory (annual) crops and the principal coastal crop patterns in the 2000 census (Instituto Nacional de Estadística y Censos, 2002b,a).

The 2000 census records perennial and annual crops in separate modules. I therefore use the relevant questionnaire for each outcome rather than force every regression onto the overlap sample. Perennial outcomes use the perennial module, and annual outcomes use the annual module. I define perennial-questionnaire membership before applying the crop-age restriction. I retain records with missing crop age and exclude only reported ages of at least 37 years, measured from the reform's start in 1964. I assign zero only when a plot appears in the relevant module but reports no eligible production for the outcome. The overlap sample provides a robustness check.

I construct the perennial revenue denominator conservatively: harvested area first, productive area when harvested area is missing, and planted area as the final fallback. Observations without usable area after these steps remain missing. For cacao and banana yields, I divide total plot production by total usable crop area rather than average crop-record yields. A fixed cross-crop schedule of Ecuadorian 2013 INEC producer prices keeps local price variation from driving the comparisons.

[2] The implemented bean price averages the monthly 2013 tender red-bean series. A broader bean average recorded in the source workbook changes the annual-crop coefficient from -0.524 to -0.511. It changes the aggregate residual-productivity coefficient from -0.573 to -0.570. The conclusions remain unchanged.

[3] Appendix robustness exercises expand this narrower perennial basket to include additional crops such as coffee, passion fruit, lemon, palmito, and pineapple. The positive diversification result remains.

3.3. Additional data

Spatial data describe the geography around the IERAC border. WorldClim supplies precipitation and temperature. The Center for Climatic Research at the University of Wisconsin–Madison supplies elevation and general agricultural suitability, and Nunn and Puga (2012) supplies terrain ruggedness. The Food and Agriculture Organization's Global Agro-Ecological Zones database (FAO-GAEZ) supplies agro-climatic potential yields for banana, rice, cacao, and oil palm. I merge these gridded measures with the agricultural and parish data. The preferred RD includes banana potential yield because bananas predated the reform and could otherwise confound the comparison. The balance tests and auxiliary specifications use the broader geographic set.

Harmonized IPUMS International population censuses provide the labor-allocation outcomes (Center, 2020). I merge person and household variables one-to-one by census sample, household serial number, and person number. I use IPUMS person weights. The analysis covers the 1962, 1982, 1990, 2001, and 2010 censuses. It measures agricultural employment, manufacturing employment, and urban residence among the active labor force. I exclude the harmonized 1974 IPUMS file because of data-quality problems. This exclusion does not affect the separately digitized 1974 agricultural census described above. The urban indicator is unavailable in 1982. IPUMS identifies cantons rather than parishes. I therefore aggregate reform exposure to cantons and treat these results as supporting evidence. The productivity-reallocation calibration uses a separate national source. Ecuador's 2000 observations in the GGDC/UNU-WIDER Economic Transformation Database provide the agricultural employment share and the productivity gap between agriculture and non-agriculture (Kruse et al., 2023).

The Ministerio de Agricultura y Ganaderia (MAGAP) supplies two georeferenced sources on later agricultural structure. Its 2021 land-use data classify grid cells by crop duration and by whether observed land use matches local productive potential. I use these data to compare land-use alignment for perennial and other agricultural cells. A later MAGAP banana cadastre records banana producers and cultivated area. I use it descriptively to compare producer size and concentration within 40 and 60 km of the border; its uneven coverage does not support an RD estimate.

Finally, Defense Meteorological Satellite Program night-light rasters distributed by the National Oceanic and Atmospheric Administration's National Centers for Environmental Information provide a proxy for local economic activity. I construct parish-level light measures for 1992, 2001, and 2010 from the raster data and compare them around the reform border with heteroskedasticity-robust inference. The IPUMS, MAGAP, night-light, and ETD exercises help interpret the crop results, but none forms part of the paper's core identification strategy.

4. Empirical Strategy

4.1. Baseline geographic RD

The main design uses a sharp geographic regression discontinuity around the digitized outer edge of the PLT polygon in IERAC's 1978 map. Let d_p denote parish p's signed distance from that edge, with positive values inside the PLT polygon.[4] I estimate:

$$Y_{ipb} = \alpha + \tau\, PLT_p + \beta\, d_p + X_p'\Gamma + f(\mathrm{lat}, \mathrm{lon})_p + \phi_b + \delta_t + \gamma_{\mathrm{prov}} + \varepsilon_{ipb} \qquad (1)$$

Here, Y_{ipb} is an agricultural outcome for plot i in border segment b and parish p. The indicator PLT_p equals one on the PLT side. The variable d_p measures signed distance to the border. The vector X_p contains parish geography and crop-suitability controls. The function $f(\mathrm{lat}, \mathrm{lon})_p$ captures local geography. The terms ϕ_b, δ_t, and γ_{prov} absorb average differences across border segments, tenure categories, and provinces. The coefficient τ measures the jump at the PLT border. I estimate it with robust bias-corrected local-linear RD methods following Calonico et al. (2014, 2017, 2021) and the practical guidance in Cattaneo et al. (2019).

The baseline uses a 40 km bandwidth and clusters standard errors by parish. It excludes the two parishes closest to the threshold. I call this exclusion the doughnut. The historical map does not locate its edge with modern surveying precision. The doughnut therefore reduces boundary ambiguity and treatment misclassification (Barreca et al., 2011). Controls include latitude, longitude, border-segment fixed effects, province fixed effects, land-tenure fixed effects, and banana potential yield. Full tenure occurs more often on the PLT side in the broader sample but shows no equally sharp local break at the cutoff. The controls discipline remaining geographic variation. They do not provide identification.[5]

4.2. Identification

The source of the cutoff anchors identification. The 1978 IERAC map records the realized PLT footprint. I use the outer edge of its green polygon as the RD threshold. The cutoff is a PLT

[4] This specification follows the canonical model in Dell (2010).
[5] Where I report Huber–White standard errors, I use the leverage-adjusted HC3 correction.

boundary, not a line jointly drawn to separate PLT from expropriation. PLT expanded across an already settled post-cocoa region and stopped at this edge. IERAC relied more heavily on expropriation outside the polygon, especially to the south. The sharp RD estimates the effect of assignment to the historical PLT side. It does not estimate the effect of an additional hectare treated through PLT.

IERAC's administrative reports provide a supporting check on the mapped treatment geography. I match the reported PLT hectares to current parish boundaries. When parish borders changed, I use the historical parent jurisdiction. The reports, the 1978 map, and the agricultural census use different geographic units. The reconstruction therefore cannot produce a perfect parish-by-parish match.[6] The administrative share remains noisy, but the fitted probability of lying inside the PLT polygon rises at its edge. Appendix Figure A5 reports both measures.

Appendix Tables A6 and A7 use the administrative PLT share as treatment intensity. This is the fuzzy RD exercise. The share varies only at the parish level. The full sample contains 28 parishes, and the doughnut sample contains 26. The boundary also separates PLT from expropriation, not treatment from no treatment. I therefore treat the fuzzy estimates as robustness evidence. The sharp RD remains the preferred comparison between the two regimes.

The map records realized treatment geography. It does not prove random placement. Identification requires nearby locations to have followed smooth trends at the border without the two reform regimes. Near the cutoff, the polygon divided neighboring parts of the same post-cocoa economy. It did not divide cultivated land from an empty frontier. Nor did it follow one natural boundary or a sharp ecological break. The 1954 crop comparisons and the balance tests support this continuity assumption. A separate test finds no detectable break in agricultural surface in 2000. The doughnut removes the two parishes where the historical border is least certain. It loses the closest observations but reduces treatment misclassification.

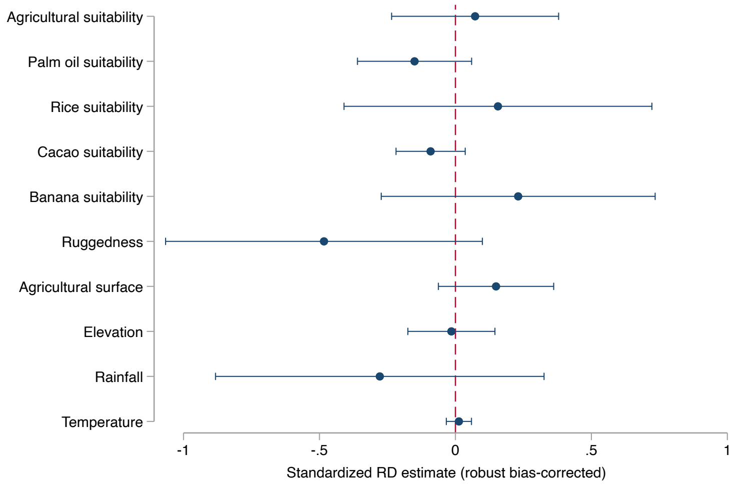
4.2.1. Balance and pre-reform evidence

Predetermined geography shows no statistically detectable discontinuity at the cutoff. Figure 3 reports sharp parish-level local-linear estimates for climate, terrain, and crop suitability using the preferred 40 km doughnut sample. The test has limited power with 26 parishes, so the absence of significant jumps supports local continuity without proving exact equivalence. Full

[6] The crosswalk treats San Carlos in Los Rios as a PLT parish. The former paper reconstruction classified it as PLT, and the digitized 1978 polygon covers 94.9 percent of its current area. I also classify Manga del Cura as PLT. Its nondelimited status concerns its later provincial assignment, while the historical map places it in the colonization area.

tenure occurs more often on the PLT side in the broader sample but shows no comparable local break at the cutoff. The figure also reports mean agricultural surface from the 2000 census as a separate comparability check. Surface is post-treatment rather than predetermined, but the estimate reveals no statistically detectable difference in the scale of agricultural units at the border. The design therefore compares neighboring places with a common agrarian background and no evident local break in observed farm scale, but different legal regimes.

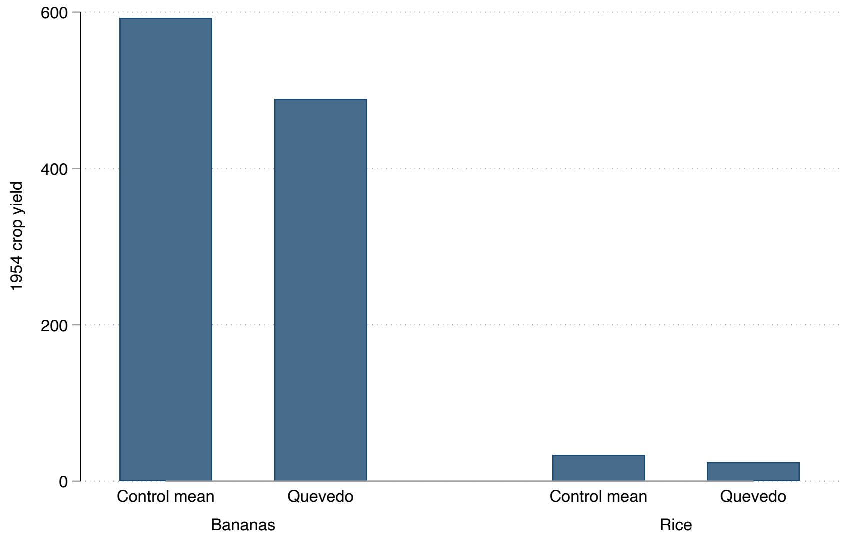
Figure 3: Continuity in geography and agricultural surface



Note: The figure reports robust bias-corrected local-linear sharp RD estimates in standard-deviation units. The sample contains 26 parishes within 40 km of the IERAC border after excluding the two parishes closest to the cutoff. Bars show 95 percent confidence intervals based on Huber–White standard errors. Climate, terrain, and crop-suitability measures describe predetermined geography. Agricultural surface is mean reported agricultural-unit area in the 2000 agricultural census; it is post-treatment and serves only as a comparability diagnostic.

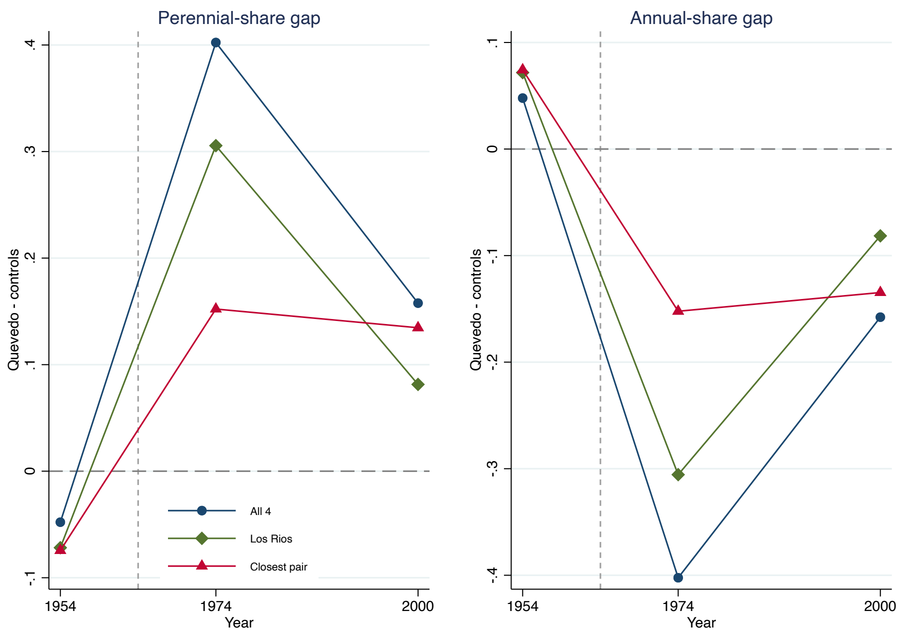
Historical censuses also place both sides on a common pre-reform trajectory. Figure 4 compares Quevedo with the 1954 control mean for rice and bananas, the coast's central crops. The areas need not match on every margin; the relevant fact is that the later boundary did not divide clearly different crop economies. Both belonged to the same post-cocoa landscape. Figure 5 tracks Quevedo-minus-control gaps in annual and perennial land shares across available censuses. Quevedo shows no clear perennial advantage in 1954; the gap widens in 1974 and narrows again by 2000. Because different censuses and mixed control groups produce these canton-level aggregates, I treat them as descriptive context rather than a preview of the local RD estimates.

Figure 4: Pre-reform rice and banana yields in 1954



Note: Descriptive evidence from the 1954 agricultural census. The figure compares crop yields in Quevedo with the corresponding control mean for rice and bananas, the two historically central coastal crops highlighted in the paper's background discussion.

Figure 5: Historical annual and perennial land-share gaps over time



Note: Descriptive comparison across the historical agricultural censuses available for this project. The figure tracks Quevedo-minus-control gaps in the annual and perennial land shares over time for alternative control groups. These are canton-level historical aggregates rather than local RD objects.

5. Results

5.1. Main results

More flexible rights changed crop composition more clearly than aggregate perennial investment. Table 1 and Figure 6 show a small, imprecise aggregate perennial-revenue effect but sharp differences across crops.

PLT areas produce less rice and more main other perennials than nearby expropriation areas. Higher rice yields alone do not make a reform regime development-enhancing. Work on Taiwan reaches a related conclusion. Some reform phases raised rice yields through narrow channels, not through the broad forces implied by the classic miracle narrative (Kim and Wang, 2025). In Ecuador, expropriation combined rice mandates, constrained rights, and crop persistence. The baseline coefficient is -0.661 for rice yield and 1.239 for main other-perennial revenue. Both outcomes use transformations that retain zeros. The coefficients therefore do not measure literal percentage changes. PLT also lowers aggregate annual-crop revenue and banana productivity.[7] These results describe reallocation, not simple expansion. Policy sustained rice under expropriation. Weaker incentives to diversify sustained banana specialization. PLT instead enabled experimentation beyond the historical crop bundle. The question is not which regime maximized every crop's productivity. It is which regime allowed productive activity to support broader development.

The bundle of rights changed the composition of investment more clearly than its aggregate level. Property rights shaped both whether land remained productive and how producers adapted.

The crop coefficients also explain why the aggregate perennial estimate alone gives an incomplete account of reform performance. That aggregate combines a large negative banana margin, a negative cacao margin, and a large positive shift toward other perennials. These forces offset one another by construction. The near-zero aggregate result therefore does not show that property-rights design had little effect. It shows that the two regimes supported different productive margins: expropriation preserved performance in established crops, whereas PLT redi-

[7] The perennial-crop census records crop age incompletely. Many raw banana observations lack age, plausibly because respondents struggle to date ratoon and continuously renewed plants. I define perennial-questionnaire membership before applying the age restriction. I retain records with missing age and exclude only reported ages of at least 37 years. Plots therefore remain in the perennial-questionnaire sample even when no crop record survives the age screen. The remaining age evidence is suggestive. Among banana observations with reported age in the final local sample, bananas are slightly older on average under expropriation. The local RD points in the same direction. In the raw perennial file, older banana observations linked to treated parishes also tilt toward expropriation (34 versus 12 under PLT). I treat banana age as supportive rather than decisive evidence of persistence.

rected activity toward a broader set of perennial opportunities. The comparison turns on the direction of adaptation, not on a uniform gain in every agricultural outcome.

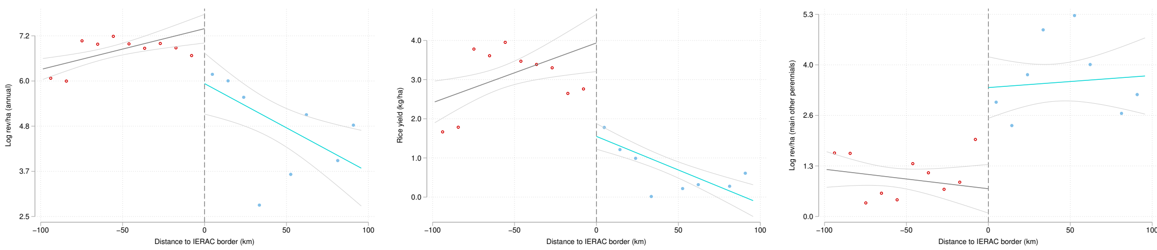
Table 1: Main RD results

	Perennial	Annual	Rice	Cocoa	Banana	Main other perennials
PLT-side jump	-0.172	-0.524***	-0.661***	-0.047***	-1.645***	1.239***
	(0.299)	(0.165)	(0.210)	(0.012)	(0.539)	(0.189)
	[0.317]	[0.168]	[0.226]	[0.012]	[1.310]	[0.316]
Observations	5590	4364	4364	5590	5590	5590
Parishes	26	26	26	26	26	26
Bandwidth (km)	40	40	40	40	40	40
Mean dep. var.	3.910	6.432	2.238	0.064	2.106	2.316
Coefficient/mean ($\times$100)	-4.4	-8.1	-29.5	-73.9	-78.1	53.5

Every specification controls for latitude, longitude, border-segment fixed effects, province fixed effects, land-tenure fixed effects, and banana potential yield.
The main specification uses the questionnaire relevant to each outcome: perennial outcomes use plots observed in the perennial-crop questionnaire, while annual and rice outcomes use plots observed in the annual-crop questionnaire. I assign zeros only within the relevant questionnaire. Perennial-questionnaire membership is defined before the crop-age restriction; missing ages remain, and only reported ages of 37 years or more are excluded. Revenue outcomes use fixed Ecuador 2013 producer prices. Cacao and banana yields divide plot-level total production by total usable crop area.
Coefficient/mean multiplies the displayed coefficient-to-mean ratio by 100. It is not a percentage change in the untransformed outcome.
Robust bias-corrected estimates following Calonico et al. (2014). Parentheses show parish-clustered standard errors; brackets show Huber–White standard errors. Stars use parish-clustered inference.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Figure 6: Main RD evidence

(a) Annual revenue | (b) Rice yield | (c) Main other perennials



Note: The panels plot unadjusted parish-level means for three outcomes from the preferred sharp geographic RD sample. The corresponding estimates use a 40 km bandwidth, exclude the two parishes closest to the cutoff, and control for latitude, longitude, border-segment fixed effects, province fixed effects, land-tenure fixed effects, and banana potential yield. The clearest negative margins on the PLT side remain annual revenue and rice, while the clearest positive revenue margin is in the main other-perennial basket.

5.2. Portfolio shift and alternative measures of diversification

Three outcomes clarify the portfolio shift. Table 2 reports the main other-perennial land share, its revenue share, and the number of distinct perennial crops. PLT farms devote more land and revenue to the broader basket. The crop-count estimate is positive but imprecise. Diversification appears most clearly in land and revenue allocation. The data do not precisely establish an increase in the total number of crops. Appendix Figures A6, A7, and A8 show the corresponding

RD graphs.

The magnitudes reinforce this interpretation. The PLT-side discontinuity equals 0.143 for the land share and 0.224 for the revenue share, while the crop-count coefficient equals 0.376. The share outcomes measure economically meaningful reallocation even if a farm adds only one crop or changes the weight assigned to crops it already grows. The count outcome, by contrast, gives the same weight to a minor crop and a crop that occupies much of the farm. Its positive but imprecise estimate cannot establish a rise in crop variety on its own. Together, the three measures point more strongly to portfolio reweighting than to a mechanical proliferation of crop names.

Table 2: Alternative measures of the portfolio shift

	Main other perennial land	Main other perennial rev. share	No. perm. crops
PLT-side jump	0.143***	0.224***	0.376
	(0.033)	(0.027)	(0.334)
Observations	5590	5590	5590
Parishes	26	26	26
Bandwidth (km)	40	40	40
Mean dep. var.	0.190	0.407	4.054
Coefficient/mean ($\times 100$)	74.9	55.1	9.3

The sharp geographic RD uses the preferred 40 km doughnut sample and plots observed in the perennial-crop questionnaire. Questionnaire membership is defined before the crop-age restriction; records with missing ages remain, and only reported ages of 37 years or more are excluded. The revenue-share outcome uses fixed Ecuador 2013 producer prices. Every specification controls for latitude, longitude, border-segment fixed effects, province fixed effects, land-tenure fixed effects, and banana potential yield, and clusters standard errors by parish.
Coefficient/mean multiplies the displayed coefficient-to-mean ratio by 100. It is not a percentage change in an untransformed outcome.
Robust bias-corrected estimates following Calonico et al. (2014). * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

5.3. Intensive and extensive margins

The main outcomes combine crop adoption with production conditional on adoption. I separate these margins by estimating an extensive-margin RD for positive production within the relevant module and an intensive-margin RD for the original outcome among positive producers. For aggregate perennial and annual outcomes, the intensive margin conditions on positive price-weighted revenue per hectare. For rice, cacao, and banana, it conditions on positive physical yield. These components do not mechanically sum to the logged combined outcome, but they locate the main discontinuities.

Table 3 shows that adoption drives most crop differences. PLT plots more often produce sugar cane, oil palm, or plantain, while revenue among positive producers is statistically similar across regimes. Expropriation plots more often remain in annual crops and rice. Bananas differ: PLT has a slightly positive extensive margin but a strongly negative intensive margin, so lower productivity among banana producers drives the combined result. Cacao moves on both margins. PLT therefore changed crop choice rather than raising productivity across the board, while incumbent banana productivity remained stronger under expropriation.

The margin split clarifies the development argument. Flexible rights widened the perennial activities that producers entered, while expropriation sustained adoption of rice and annual crops. Banana instead captures productivity among incumbent producers. PLT changed the direction of adaptation more clearly than productivity within every inherited crop. These new choices offer the most plausible link to better land use, local growth, and movement out of agriculture. Productivity could remain concentrated in one crop or spread through diversification and reallocation.

I treat the extensive and intensive estimates as diagnostic margins rather than as an exact decomposition. The intensive regressions condition on positive production. Producer composition can therefore differ across the border. The two columns also need not add to the combined coefficient. Even with that limitation, the pattern is informative. Rice and the broader perennial basket move mainly through entry. Bananas move mainly through output per hectare among producers. This contrast matches the institutional setting. Direct incentives affected whether producers planted rice. Flexible rights affected which alternatives they adopted. Accumulated crop-specific knowledge protected productivity among established banana growers.

Table 3: Main RD results by combined, extensive, and intensive margins

Outcome	Combined	Extensive	Intensive
Perennial revenue per hectare	-0.172	-0.018	-0.289^{*}
	(0.299)	(0.040)	(0.156)
Annual revenue per hectare	-0.524^{***}	-0.078^{***}	-0.046
	(0.165)	(0.018)	(0.080)
Rice yield	-0.661^{***}	-0.146^{***}	-0.124
	(0.210)	(0.038)	(0.212)
Cacao yield	-0.047^{***}	-0.256^{***}	-0.044^{***}
	(0.012)	(0.073)	(0.015)
Banana yield	-1.645^{***}	0.054^{***}	-28.343^{***}
	(0.539)	(0.020)	(2.622)
Main other perennials	1.239^{***}	0.204^{***}	0.069
	(0.189)	(0.029)	(0.118)

Note: The combined column reports the baseline outcome construction, which assigns zeros only to plots observed in the relevant crop questionnaire. I define perennial-questionnaire membership before applying the crop-age restriction, retain missing ages, and exclude only reported ages of 37 years or more. The extensive column indicates positive outcomes within that questionnaire. The intensive column reports the original outcome among positive producers. Aggregate perennial and annual outcomes use price-weighted revenue per hectare; rice, cacao, and banana use physical yields. Cacao and banana yields divide plot-level total production by total usable crop area. Parentheses report parish-clustered standard errors. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

5.4. Further evidence

PLT shifted production toward broader perennial diversification without clearly raising aggregate perennial investment. Supporting exercises connect this compositional difference to labor allocation, land-use quality, and local economic activity. None matches the core RD's identifying strength.

The supporting models differ because the data answer different questions. The IPUMS analysis pools canton-year observations within 50 km. It uses ordinary least squares with census-year fixed effects. The MAGAP analysis uses a linear probability model with grid-cell fixed effects. It asks whether PLT areas align perennial land more closely with productive potential. The night-light analysis returns to a local geographic RD. It uses parish-level light measures and several wider bandwidths. These models do not estimate one chain of causation. They ask whether the main crop results appear alongside broader patterns in labor, land use, and local growth.

5.4.1. Structural transformation

IPUMS identifies locations only at the canton level. I therefore aggregate reform exposure from parishes to cantons. I pool the 1962, 1982, 1990, 2001, and 2010 censuses. I restrict the comparison to cantons within 50 km and include census-year fixed effects. This is a near-border ordinary least-squares comparison, not a parish-level RD. Treatment varies across only 21 cantons, so I cluster inference at that level. The coarse geography and small number of clusters make the estimates suggestive.

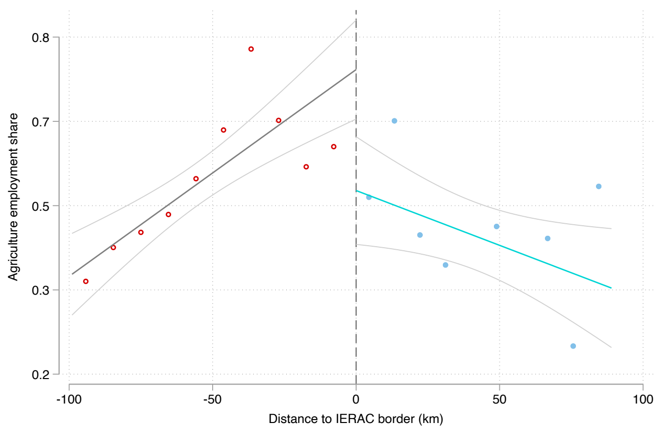
The PLT coefficient for agricultural employment is -0.136. Its canton-clustered standard error is 0.072. A bootstrap test designed for the small number of cantons gives a p-value of 0.098. The manufacturing estimate is positive but imprecise. The urban estimate is close to zero. Table 4 and Figure 7 therefore point to movement out of agriculture without showing where workers moved. This pattern fits the diversification account. A broader crop portfolio can release labor even when aggregate agricultural productivity looks weak. The exercise does not show that diversification caused structural transformation.

Table 4: Supporting labor-allocation indicators

	Ag. share	Mfg. share	Urban
PLT indicator	-0.136*	0.026	-0.027
	(0.072)	(0.018)	(0.095)
Observations	64	64	53
Cantons	21	21	21
Mean dep. var.	0.593	0.053	0.442
Coefficient/mean ($\times$100)	-22.9	49.9	-6.2
Bandwidth (km)		50	

Outcome columns are the agricultural employment share, manufacturing employment share, and urban-residence share among the active labor force. The coefficient is the PLT indicator from pooled canton-level ordinary least squares. The construction merges the harmonized person and household extracts one-to-one on IPUMS sample, household serial, and person number and uses person weights.
Coefficient/mean multiplies the displayed coefficient-to-mean ratio by 100; it is not a percentage-point effect.
Every specification includes census-year fixed effects, restricts cantons to 50 km from the border, and clusters standard errors by canton. The sample uses the 1962, 1982, 1990, 2001, and 2010 censuses and excludes 1974. The urban indicator is unavailable in 1982. A null-imposed wild-cluster bootstrap with 9,999 Rademacher replications gives p=0.098 for the agricultural-employment coefficient. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Figure 7: Agricultural employment near the IERAC border



Note: The figure plots the agricultural employment share against canton distance to the IERAC border using the corrected one-to-one IPUMS merge. Positive distances denote the PLT side. The graph pools the 1962, 1982, 1990, 2001, and 2010 censuses within 100 km. I treat it as supportive because treatment varies across only 21 cantons; Table 4 reports the 50 km pooled estimates with year fixed effects and canton-clustered inference.

5.4.2. Pixel-level land-use conflict and alignment

The 2021 MAGAP data connect crop choice to land-use quality. The outcome equals one when observed land use fits local productive potential. I estimate a linear probability model and interact the PLT side with perennial-crop status. Grid-cell fixed effects absorb permanent differences across cells. Parish-clustered standard errors allow observations in the same parish to move together. The first column uses all available agricultural records after the doughnut exclusion. The second keeps records within 50 km. This is not the baseline RD. The interaction measures whether PLT changes the alignment advantage of perennial land relative to other agricultural land.

The PLT-perennial interaction equals 0.203 in the full doughnut sample and 0.141 within 50 km. Both estimates differ statistically from zero. The data, unit of observation, and model differ from the agricultural-census RD. Even so, the result extends the crop-choice evidence. The regimes differ in what producers plant and in how well perennial land fits local potential. Table 5 thus links flexible rights to better adaptation. The outcome comes from 2021, and the model compares crop types within cells. I therefore treat it as a long-run land-use diagnostic, not a second estimate of the main treatment effect.

Table 5: Pixel-level land-use alignment in MAGAP 2021

	Whole sample	Within 50 km
PLT side $\times$ perennial crop	0.203***	0.141**
	(0.050)	(0.060)
Observations	74431	38417
Parishes	116	32
Grid cells	421	151
Mean dep. var.	0.245	0.211
Coefficient/mean ($\times$100)	82.9	66.8
Grid-cell fixed effects	Yes	Yes

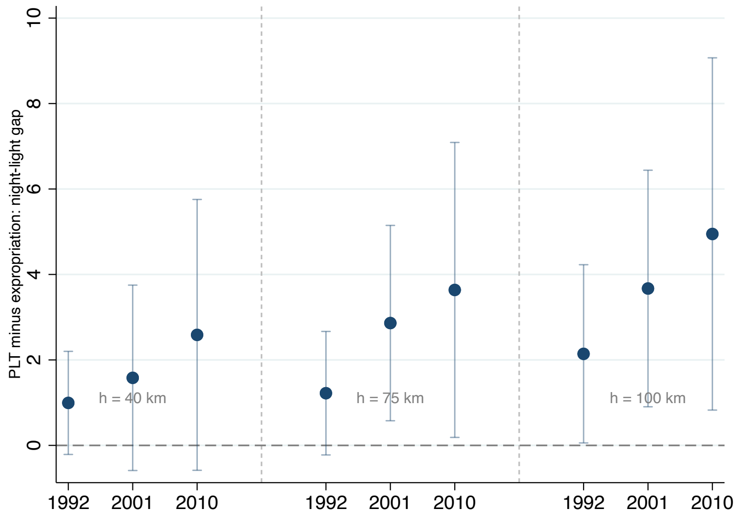
The outcome indicates good land use in the 2021 Ministry of Agriculture and Livestock data. Each column reports the interaction between the PLT side and a perennial-crop cell.
Coefficient/mean multiplies the displayed ratio by 100; it is not a percentage-point effect. The linear probability model includes grid-cell fixed effects, excludes the two parishes closest to the cutoff, and clusters standard errors by parish.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

5.4.3. Economic growth

NOAA night-light rasters provide a suggestive measure of local economic activity. I construct one light measure per parish and exclude the same two near-cutoff parishes. I estimate local-linear RDs at 40, 75, and 100 km. Each regression controls for latitude, longitude, agricultural suitability, elevation, and precipitation. It also uses heteroskedasticity-robust inference. Unlike the MAGAP model, this exercise keeps the border-distance RD structure. Unlike the main agricultural regressions, it studies a later parish-level outcome and explores wider windows.

All nine point estimates for 1992, 2001, and 2010 favor the PLT side, but precision varies across years and bandwidths. The 90 percent intervals exclude zero for 1992 at 40 km and for 2001 and 2010 at 100 km; the remaining intervals include zero. The consistent direction matters more than any single significance threshold. Because night lights appear decades after the reform and summarize many channels of local activity, they cannot provide a standalone development result or identify diversification as the mechanism. Figure 8 instead supports the possibility that flexible rights changed crop composition and placed some locations on a more dynamic long-run path.

Figure 8: Night-light evidence



Note: The figure reports bias-corrected local-linear RD estimates for parish-level night-light measures in 1992, 2001, and 2010, using bandwidths of 40, 75, and 100 km and excluding the two parishes closest to the cutoff. Every estimate controls for latitude, longitude, general agricultural suitability, elevation, and precipitation. The intervals cover 90 percent and use heteroskedasticity-robust standard errors.

5.4.4. A simple productivity-reallocation calibration

Agrarian reform can produce a weak or negative aggregate agricultural-productivity estimate even when it creates gains on specific margins. The agricultural measure averages across crops. It can therefore hide a positive diversification margin when negative results in incumbent crops dominate the average. It also misses gains that arise when labor leaves agriculture for more productive sectors. This is the puzzle that the calibration addresses.

This back-of-the-envelope adaptation of Kim and Wang (2025) adds these two margins. First, I scale the within-agriculture productivity proxy by agriculture's share of employment. Second, I add the potential gain from PLT's lower agricultural employment share using the reallocation logic in McCaig and Pavcnik (2018). The latter depends on the productivity gap between agriculture and the rest of the economy. I use Ecuador's 2000 GGDC/UNU-WIDER Economic Transformation Database for the national employment share and productivity gap (Kruse et al., 2023). I construct the residual-productivity proxy following Montero (2022) and Aragon et al. (2020).

The arithmetic makes the offset clear. The scaled within-agriculture term is -0.181. Labor reallocation contributes 0.099. The combined index remains negative at -0.082, but reallocation offsets more than half of the negative agricultural term. The calculation does not overturn the aggregate result. It shows that the aggregate result combines a negative within-agriculture margin with a sizable positive reallocation margin.

The crop scenarios sharpen the diversification point. The main other-perennial coefficient produces a positive combined index. The rice and banana coefficients produce negative indices. Thus, reform can generate gains through new crop choices and labor reallocation even when incumbent crops pull aggregate productivity downward. These scenarios are illustrative. The crop coefficients do not measure percentage changes in aggregate labor productivity, and the exercise does not identify a causal chain from diversification to labor movement. It shows why a negative aggregate headline need not imply that every part of the reform failed. Appendix C.7 reports the equations and arithmetic.

5.5. Robustness

The central compositional pattern keeps its direction across alternative samples and conventional RD specifications. Statistical precision varies. Rice and banana remain negative in the overlap sample and across bandwidths, polynomial choices, and doughnut choices. Main other perennials remain positive. Alternative definitions of that basket also preserve the positive sign. The aggregate perennial estimate changes sign and remains imprecise. This instability matches the opposing crop-specific margins. A parish-level density test examines sorting around the border. The 2000 agricultural-worker outcome checks for post-treatment differences in local farm-labor scale.

The central directions also survive alternative corrections for spatial dependence. These corrections allow regression errors to remain related across nearby locations. The main bias-corrected estimator does not permit a Conley correction. I therefore approximate the preferred 40 km design with triangular-weighted ordinary least squares and the main controls. I allow spatial correlation within 25 km. This is the largest common radius that produces a covariance estimate for every outcome. The boundary-discontinuity estimator of Cattaneo et al. (2026) also preserves the central signs within 40 km. This holds with and without the doughnut. That estimator uses distance along the boundary and estimates a different parameter from the preferred RD. Table A9 reports both samples.

Randomization inference provides less precise and less uniform support. The plot-level exercise yields negative rice and banana differences. It yields a positive main other-perennial difference. The parish-level exercise asks whether this crop ranking survives when each parish, rather than each plot, contributes one observation. At the parish level, rice remains negative and main other perennials remain positive across all fixed windows. Precision depends on the window. Banana also remains negative but becomes imprecise. Annual crops and cacao do not show the same stability. These exercises first remove the variation explained by the controls and then compare means. They report finite-sample p-values. They complement rather than replace the preferred local-linear RD.[8]

Taken together, this battery preserves the paper's main qualitative conclusion: PLT reduced rice specialization and banana productivity while expanding production in other perennial crops. The exact magnitudes and significance levels vary. Results for aggregate perennials, annual crops, and cacao also vary more across procedures. I therefore do not claim that every outcome responds in the same way. This distinction preserves the comparative pattern without treating every appendix coefficient as a separate confirmation.

The appendix reports the overlap sample in Table A1 and Figure A2. Tables A2 and A3 vary the bandwidth and polynomial. Figure A5 and Tables A6 and A7 compare the mapped polygon with administrative PLT exposure. Figure A3 and Table A4 report the density test. Figure A4 and Table A5 report the worker diagnostic. Tables A8 and A9 address spatial correlation and distance along the border.

The appendix also reports the calibration in Table A17 and Appendix C.7. Table A16 contains the Manabi benchmark. Tables A10 and A11 report randomization inference. It also contains the annual-crop credit check, no-doughnut estimates, the diversification decomposition, and the portfolio graphs. Tables A12, A13, and A14 report those results. Figures A6–A8 show the portfolio outcomes. The calibration and Manabi comparison remain supportive rather than part of the core identification.

6. Mechanisms

The two regimes directed adaptation toward different crops. PLT produced broader perennial reallocation. Expropriation sustained narrow specialization through two routes. Decree 1001 tied land access directly to rice production. The informal-credit pattern is consistent with continued rice persistence among constrained producers. Weaker rights also encouraged established banana producers to remain in a familiar, profitable crop. The margin split matches these routes.

[8] The randomization-inference tables do not reproduce the main local-linear RD coefficient exactly. They compare adjusted differences in means within fixed windows and then calculate finite-sample randomization p-values.

Adoption drives rice and main other perennials, while productivity among incumbent producers drives bananas. The evidence identifies the rice mandate clearly. The credit and banana channels remain suggestive. The later cadastre reveals banana concentration that the agricultural census cannot show.

6.1. Mandated rice specialization

Decree 1001 created the direct route to specialization by tying access to expropriated land to rice production. Credit markets may then have helped producers sustain that choice. Whereas much of the property-rights literature asks whether stronger rights expand formal finance and investment, producers under expropriation report more informal credit use.

Informal credit favors short production horizons. It requires faster repayment and offers fewer opportunities to renegotiate than formal bank credit. Those features suit rice better than experimentation with a perennial portfolio. In the full sample of agricultural units, PLT lowers reported borrowing from informal moneylenders by 5.6 percentage points, while formal borrowing does not change. Parish-clustered inference rejects zero at the 1 percent level, and Huber–White inference rejects zero at the 10 percent level. The estimate attenuates when I restore the two boundary-adjacent parishes, so I treat it as suggestive.

Annual-crop producers sharpen the pattern. Among agricultural units observed in the annual-crop questionnaire, PLT lowers informal credit use by 5.3 percentage points, and parish-clustered inference rejects zero at the 5 percent level. Annual crops turn over quickly, so short-horizon informal credit fits them more readily than perennials. The estimate therefore strengthens the credit interpretation, but it does not show that informal credit caused rice persistence. Table 6 reports the main credit estimates, and Figure 9 plots the annual-revenue and informal-credit discontinuities. Appendix Table A12 reports the annual-crop credit estimates. The extensive-margin results provide clearer evidence that expropriation sustained participation in rice rather than productivity among rice producers.

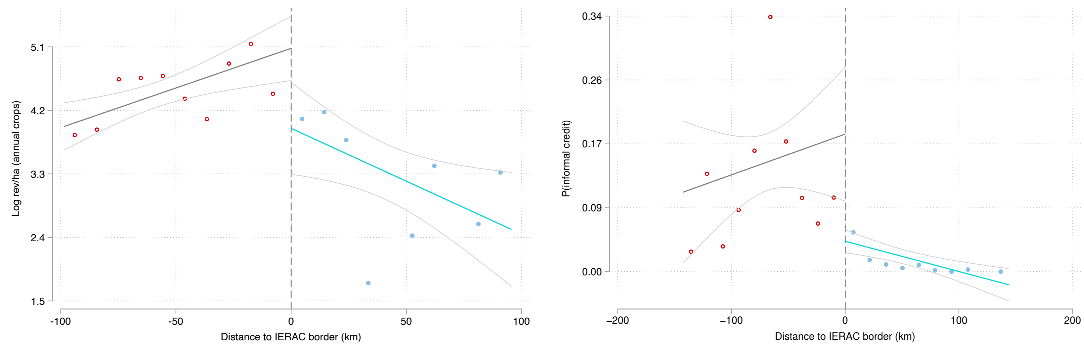
Table 6: Credit-market evidence

	Informal credit	Formal credit
PLT-side jump	-0.056***	0.002
	(0.017)	(0.013)
	[0.031]	[0.034]
Observations	6560	6560
Parishes	26	26
Mean dep. var.	0.061	0.080
Coefficient/mean ($\times$100)	-91.8	2.0
Bandwidth (km)	40	40

The sample includes all agricultural units. Informal credit identifies loans from informal moneylenders (*chulqueros*); formal credit includes the Banco Nacional de Fomento, private banks, and credit cooperatives. Entries report the PLT-side jump from the preferred robust bias-corrected sharp RD following Calonico et al. (2014), with the two closest parishes excluded and a 40 km bandwidth.
Coefficient/mean multiplies the displayed coefficient-to-mean ratio by 100; it is not a percentage-point effect. The informal-credit estimate remains statistically distinguishable from zero at the 10 percent level with Huber–White standard errors but attenuates when the two closest parishes return. I therefore interpret it as suggestive.
Every specification controls for latitude, longitude, border-segment fixed effects, province fixed effects, land-tenure fixed effects, and banana potential yield. Parentheses show parish-clustered standard errors; brackets show Huber–White standard errors. Stars use parish-clustered inference. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Figure 9: Annual-crop and informal-credit evidence

(a) Annual revenue　　(b) Informal credit



Note: Both graphs use parish-level means, so the visual discontinuities are intentionally conservative. The informal-credit panel uses all agricultural units and excludes the two parishes closest to the border, matching the preferred credit specification. The annual-crop margin remains clear, and the informal-credit pattern is consistent with a more persistent rice-oriented equilibrium on the expropriation side.

6.2. Defensive banana persistence

Established banana producers faced an indirect incentive to specialize. Unlike rice growers, they did not necessarily face the same short-horizon credit constraint. They chose whether to move beyond a familiar, profitable crop. Weaker rights made diversification less attractive. Bananas protected an established activity, while new crops exposed producers to new risks. The margin split supports this interpretation. Lower productivity among PLT banana producers, not fewer producers, drives the negative PLT result.

I interpret this pattern as defensive persistence under weaker rights. The design identifies this channel less cleanly than the direct rice mandate, but the historical sequence, crop estimates, and later banana cadastre point in the same direction. Weak rights preserved profitable perennial activity while reducing incentives to move beyond bananas. Table 7 shows a narrow, concentrated banana margin rather than a uniformly larger sector. PLT has larger banana producers on average, but expropriation has more concentrated banana land in both the 40 km and 60 km windows. This structure fits defensive persistence: expropriation exposure encouraged producers to protect a familiar, profitable crop rather than pursue broader adaptation. High banana productivity could therefore coexist with local concentration and weak diversification.

Expropriation risk may also have shaped how producers used banana wealth after the boom. Protecting an established plantation could take priority over financing broader agricultural diversification. This mechanism would explain why bananas remained important under expropriation without producing a wider perennial transition. Because the design does not identify this channel directly, I treat it as a plausible interpretation rather than a separate claim. The cadastre's greater concentration and inequality under expropriation fit a defensive use of banana wealth under weaker rights.

Table 7: Banana-sector concentration in the banana cadastre

	40 km		60 km	
	Expro	PLT	Expro	PLT
Banana producers	94	383	118	383
Mean banana area	26.588	50.190	34.269	50.190
Median banana area	10.564	32.648	14.155	32.648
Banana-area Gini	0.644	0.551	0.616	0.551

The rows summarize the later banana cadastre from Ecuador's Ministry of Agriculture and Livestock: number of producers, mean banana area, median banana area, and the Gini coefficient of banana area. Columns compare the expropriation and PLT sides within 40 km and 60 km of the policy boundary. The table is descriptive rather than RD-based because the cadastre sample is highly imbalanced near the cutoff.

Together, these routes sustained a narrow, low-diversification equilibrium without suppressing investment. Decree 1001 mandated rice, and the suggestive credit evidence is consistent with continued rice specialization among constrained producers. Weaker rights encouraged established banana producers to defend an incumbent activity. PLT widened long-horizon choices and opened room for a broader perennial portfolio. Property rights shaped both how much producers invested and whether they concentrated that investment in inherited crops or diversified.

7. Conclusion

The rights attached to land redistribution shaped agrarian reform's long-run effects. In coastal Ecuador, PLT and expropriation assigned different rights to adjacent areas. Those rights shaped agricultural specialization beyond the standard choice between investment and no investment.

Expropriation sustained narrow specialization through a direct rice mandate and defensive persistence among established banana producers. PLT gave producers more freedom to adopt a broader perennial portfolio. Adoption of other perennial crops, rather than higher productivity within every incumbent crop, drives the PLT result. Supporting evidence links these crop structures to labor reallocation, land-use quality, and local economic activity.

Land reform assigns rights and constraints as well as land. PLT changed crop choice more clearly than productivity within every inherited crop. Specialization, not a uniform productivity gain, became the central margin. Flexible rights widened the rural portfolio. They also appear to have supported better land use, local growth, and movement out of agriculture. High productivity in rice or bananas did not produce those gains when institutions kept production narrow.

The local design isolates this contrast. Public land transfers often granted larger plots in other settings. Yet plots have similar agricultural surface across the IERAC boundary. The comparison therefore separates legal regimes within a common agrarian landscape. It does not compare large and small farms. Once we distinguish reform designs, the claim that agrarian reform was generally distortionary becomes harder to sustain. Some findings attributed to agrarian reform may instead reflect the restrictive rights attached to expropriation.

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This is a solo-authored paper. I conducted every stage of the research, including writing, data analysis, data curation, methodology, and editing.

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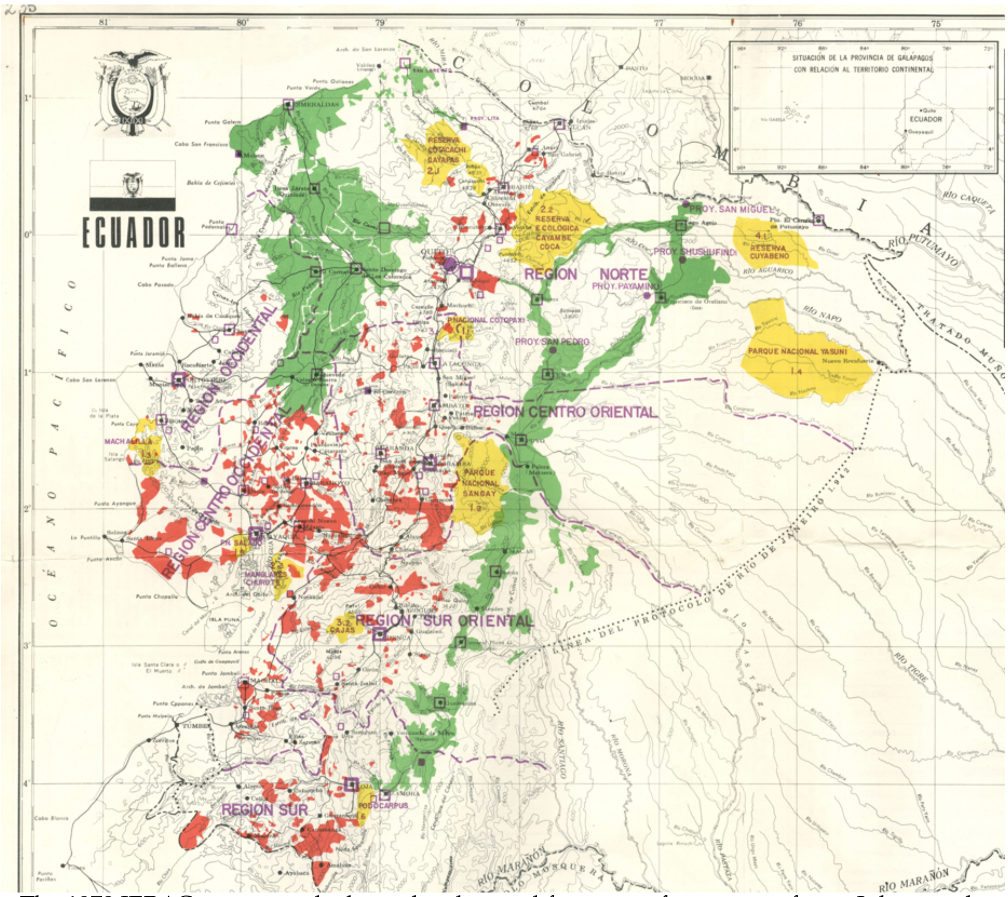
A. Appendix Roadmap

The appendix presents the shared pre-reform history, outcome-construction details, robustness tests, and auxiliary identification and interpretation checks.

B. Historical Appendix

The historical figures and tables document the shared post-cocoa context across the border and provide the chronology, map evidence, and archival detail behind the shorter main-text discussion.

Figure A1: Original 1978 IERAC archival map



Note: The 1978 IERAC map records the realized spatial footprint of agrarian reform. I digitize the outer edge of its PLT polygon to construct the RD cutoff used in the main text.

C. Empirical Appendix

The empirical appendix reports alternative samples and outcome rules, bandwidth and polynomial checks, parish-level density tests, the no-doughnut RD, segment fixed effects, and diversification decompositions. Auxiliary within-expropriation exercises help interpret the rice and banana margins but do not belong to the core design.

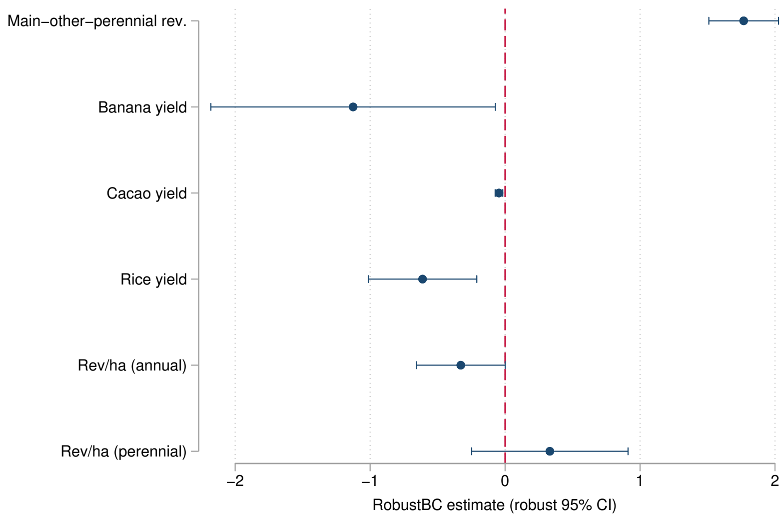
C.1. Overlap-sample robustness

Table A1: Overlap-sample robustness estimates

	Perennial	Annual	Rice	Cocoa	Banana	Main other perennials
PLT-side jump	0.332	-0.328*	-0.611***	-0.045***	-1.126**	1.768***
	(0.296)	(0.168)	(0.205)	(0.014)	(0.538)	(0.132)
	[0.371]	[0.174]	[0.242]	[0.015]	[1.277]	[0.388]
Observations	3632	3632	3632	3632	3632	3632
Parishes	26	26	26	26	26	26
Bandwidth (km)	40	40	40	40	40	40
Mean dep. var.	3.655	6.388	2.178	0.073	1.510	2.123
Coefficient/mean ($\times$100)	9.1	-5.1	-28.1	-62.1	-74.6	83.3

Every specification controls for latitude, longitude, border-segment fixed effects, province fixed effects, land-tenure fixed effects, and banana potential yield.
This robustness check restricts every outcome to plots observed in both the annual- and perennial-crop questionnaires and assigns zeros only within that common sample. Perennial records retain missing crop ages and exclude only reported ages of 37 years or more. Revenue outcomes use fixed Ecuador 2013 producer prices; cacao and banana yields use plot-level production divided by usable crop area.
Coefficient/mean multiplies the displayed coefficient-to-mean ratio by 100. It is not a percentage change in the untransformed outcome.
Robust bias-corrected estimates following Calonico et al. (2014). Parentheses show parish-clustered standard errors; brackets show Huber–White standard errors. Stars use parish-clustered inference.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Figure A2: Overlap-sample robustness summary



Note: These estimates force all outcomes onto the older overlap sample of plots observed in both crop questionnaires.

C.2. Specification robustness

Table A2: Bandwidth robustness

	Perennial	Annual	Rice	Cocoa	Banana	Main other perennials
(1) $h = 35$ km, parish-clustered standard errors						
PLT-side jump	0.527**	-0.283**	-0.627***	-0.030***	-1.212**	1.727***
	(0.215)	(0.130)	(0.226)	(0.010)	(0.590)	(0.109)
Observations	4760	3863	3863	4760	4760	4760
(2) $h = 40$ km, parish-clustered standard errors						
PLT-side jump	-0.172	-0.524***	-0.661***	-0.047***	-1.645***	1.239***
	(0.299)	(0.165)	(0.210)	(0.012)	(0.539)	(0.189)
Observations	5590	4364	4364	5590	5590	5590
(3) $h = 50$ km, parish-clustered standard errors						
PLT-side jump	0.138	-0.455**	-0.607**	-0.039***	-1.658***	1.373***
	(0.390)	(0.208)	(0.268)	(0.012)	(0.630)	(0.229)
Observations	6967	5675	5675	6967	6967	6967

Columns report estimates at fixed 35, 40, and 50 km bandwidths. Each outcome uses its relevant crop questionnaire, and zeros are assigned only to plots observed in that questionnaire. Perennial-questionnaire membership is defined before the crop-age restriction; missing ages remain, and only reported ages of 37 years or more are excluded. Cacao and banana yields divide plot-level total production by total usable crop area.

Every sharp geographic RD uses robust bias-corrected inference following Calonico et al. (2014), excludes the two parishes closest to the cutoff, and controls for latitude, longitude, border-segment fixed effects, province fixed effects, land-tenure fixed effects, and banana potential yield. Parentheses report parish-clustered standard errors. Fixed bandwidths provide a transparent comparison because automatic selection can be unstable with parish-level mass points. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A3: Local-quadratic robustness

	Perennial	Annual	Rice	Cocoa	Banana	Main other perennials
PLT-side jump	-0.214	-0.752***	-1.156***	-0.060***	-1.001	1.125***
	(0.504)	(0.187)	(0.346)	(0.015)	(1.014)	(0.291)
	[0.433]	[0.222]	[0.300]	[0.016]	[1.750]	[0.424]
Observations	5590	4364	4364	5590	5590	5590
Parishes	26	26	26	26	26	26
Bandwidth (km)	40	40	40	40	40	40
Mean dep. var.	3.910	6.432	2.238	0.064	2.106	2.316
Coefficient/mean ($\times$100)	-5.5	-11.7	-51.6	-93.4	-47.5	48.6

Every specification controls for latitude, longitude, border-segment fixed effects, province fixed effects, land-tenure fixed effects, and banana potential yield.
This robustness check uses the questionnaire relevant to each outcome, excludes the two closest parishes, and uses a 40 km bandwidth. It replaces the baseline local-linear fit with a local-quadratic fit. Zeros are assigned only to plots observed in the relevant questionnaire.
Coefficient/mean multiplies the displayed coefficient-to-mean ratio by 100. It is not a percentage change in the untransformed outcome.
Robust bias-corrected estimates follow Calonico et al. (2014) and the bandwidth refinements in Calonico et al. (2020). Parentheses show parish-clustered standard errors; brackets show Huber–White standard errors. Stars use parish-clustered inference.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Figure A3: Parish-level running-variable density around the cutoff

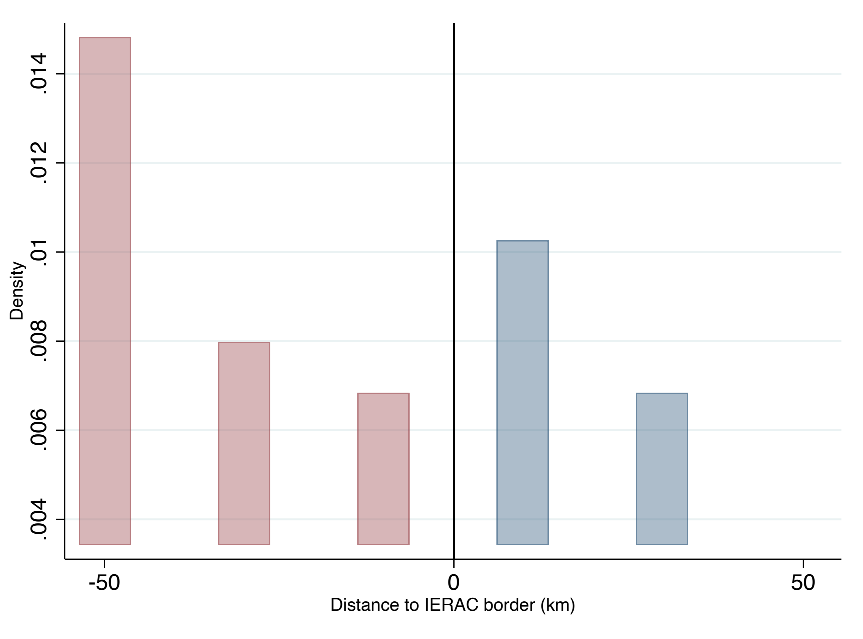
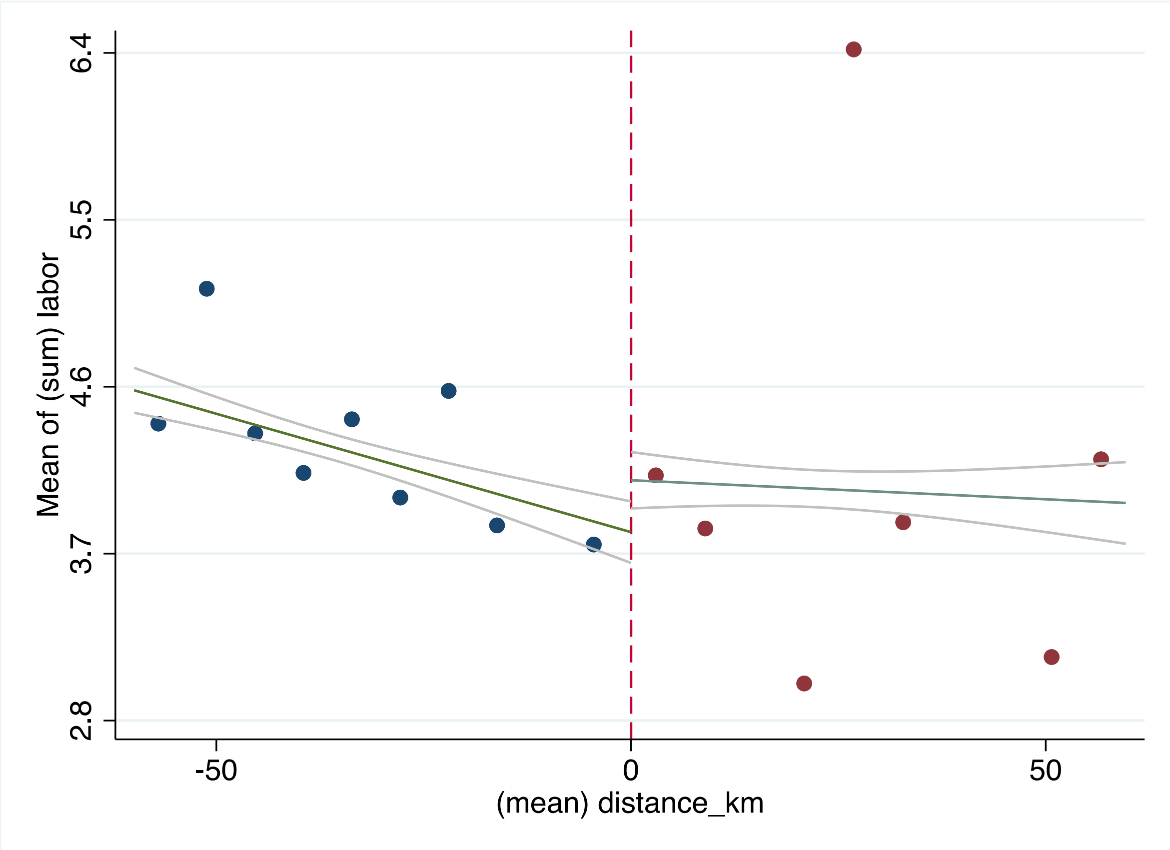


Table A4: Parish-level running-variable density around the cutoff statistics

Statistic	Conventional	Robust
Test statistic	-0.432	1.108
p-value	0.665	0.268
Obs. left / right	26 / 18	
Eff. obs. left / right	25 / 18	
Bandwidth	59.657 km	

The density test uses one observation per parish centroid within 60 km of the IERAC boundary. Figure A3 plots the same parish-level running variable.
The conventional and robust columns report the uncorrected and bias-corrected versions of the local-polynomial density-discontinuity test. This sorting diagnostic complements the paper's robust bias-corrected outcome RD following Calonico et al. (2014).

Figure A4: Post-treatment farm-labor-scale diagnostic



Note: The binned RD plot uses the number of workers reported in the 2000 agricultural census. Because the outcome is post-treatment, it cannot test pre-reform sorting; it only shows whether observed farm-labor scale differs locally at the policy boundary in 2000.

Table A5: Post-treatment agricultural-worker diagnostic

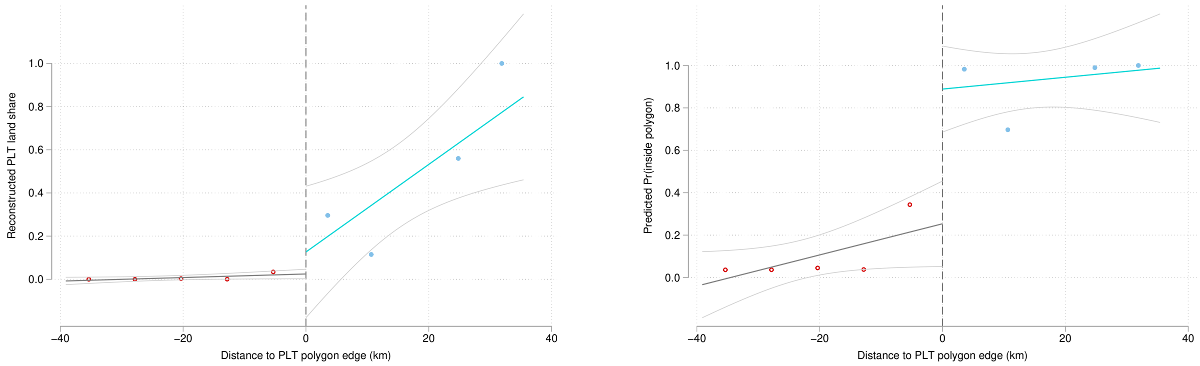
	Number of workers
PLT-side jump	0.245
	(0.474)
Observations	5505
Parishes	28
Bandwidth (km)	40
Mean dep. var.	4.133
Coefficient/mean ($\times 100$)	5.9

The sharp geographic RD uses robust bias-corrected inference following Calonico et al. (2014) for the number of workers recorded in the 2000 agricultural census. It estimates the discontinuity within a 40 km bandwidth from observations located within 100 km of the IERAC boundary and clusters standard errors by parish. Because workers are post-treatment, this outcome cannot test pre-reform sorting; it only diagnoses whether observed farm-labor scale differs locally at the boundary in 2000. The specification does not add covariates or apply the doughnut exclusion.
Coefficient/mean multiplies the displayed coefficient-to-mean ratio by 100; it is not a percentage change in workers.
Figure companion: Figure A4. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Figure A5: Administrative PLT correspondence at the polygon edge

(a) Reconstructed administrative PLT share

(b) Fitted probability of lying inside the PLT polygon



Note: Panel (a) plots the continuous share of parish land assigned through PLT in the reconstructed IERAC records. Panel (b) uses that share in a parish-level probability model (probit) and plots the fitted probability that a parish lies inside the digitized PLT polygon. Both panels use parish-centroid distance to the polygon's outer edge and the full 40 km sample. They do not apply the doughnut exclusion. Positive distances lie inside the polygon. The reconstruction matches historical reports to current parishes. When necessary, it assigns a later parish the exposure of its historical parent jurisdiction. The panels show correspondence between the reports and mapped geography. They do not provide a separate treatment assignment.

Table A6: Fuzzy RD robustness: Full sample

	Perennial	Annual	Rice	Cacao	Banana	Main other perennials
First stage	0.410***	0.432***	0.432***	0.410***	0.410***	0.410***
	(0.105)	(0.097)	(0.097)	(0.105)	(0.105)	(0.105)
Fuzzy RD estimate	1.190	-0.678*	-1.651***	-0.035	-3.551**	3.143***
	(1.219)	(0.395)	(0.383)	(0.043)	(1.425)	(1.025)
Observations	6020	4799	4799	6020	6020	6020
Parishes	28	28	28	28	28	28
Bandwidth (km)	40	40	40	40	40	40
Mean dep. var.	3.843	6.475	2.248	0.063	2.061	2.236

The table reports a fuzzy geographic RD that instruments the reconstructed administrative PLT land share with location inside the digitized PLT polygon. The dependent variables are log(1 + revenue per hectare) for the aggregate crop groups and the paper's zero-inclusive transformed yield measures for individual crops. Each column uses the relevant annual- or perennial-crop questionnaire and assigns zeros only to plots observed in that questionnaire. Coefficients are changes in transformed outcomes, not percentage changes in unlogged productivity.

The full sample does not exclude the two parishes closest to the cutoff. Every specification uses a 40 km bandwidth and controls for latitude, longitude, border-segment fixed effects, province fixed effects, land-tenure fixed effects, and banana potential yield. Parentheses report parish-clustered standard errors. The first-stage and fuzzy coefficients use robust bias-corrected inference following Calonico et al. (2014). * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A7: Fuzzy RD robustness: Doughnut sample

	Perennial	Annual	Rice	Cacao	Banana	Main other perennials
First stage	0.506***	0.573**	0.573**	0.506***	0.506***	0.506***
	(0.196)	(0.242)	(0.242)	(0.196)	(0.196)	(0.196)
Fuzzy RD estimate	-0.619	-0.966**	-1.215*	-0.102***	-3.234*	2.250
	(0.976)	(0.465)	(0.694)	(0.033)	(1.752)	(1.735)
Observations	5590	4364	4364	5590	5590	5590
Parishes	26	26	26	26	26	26
Bandwidth (km)	40	40	40	40	40	40
Mean dep. var.	3.910	6.432	2.238	0.064	2.106	2.316

The table reports a fuzzy geographic RD that instruments the reconstructed administrative PLT land share with location inside the digitized PLT polygon. The dependent variables are log(1 + revenue per hectare) for the aggregate crop groups and the paper's zero-inclusive transformed yield measures for individual crops. Each column uses the relevant annual- or perennial-crop questionnaire and assigns zeros only to plots observed in that questionnaire. Coefficients are changes in transformed outcomes, not percentage changes in unlogged productivity.

The doughnut sample excludes the two parishes closest to the cutoff. Every specification uses a 40 km bandwidth and controls for latitude, longitude, border-segment fixed effects, province fixed effects, land-tenure fixed effects, and banana potential yield. Parentheses report parish-clustered standard errors. The first-stage and fuzzy coefficients use robust bias-corrected inference following Calonico et al. (2014). * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A8: OLS-Conley spatial-correlation robustness

	Perennial	Annual	Rice	Cocoa	Banana	Main other perennials
OLS + Conley	0.646	-0.255*	-0.340*	-0.017	-1.470***	1.632***
	(0.467)	(0.152)	(0.204)	(0.015)	(0.414)	(0.200)
Observations	5590	4364	4364	5590	5590	5590
Parishes	26	26	26	26	26	26
Bandwidth (km)	40	40	40	40	40	40

Each outcome uses its relevant crop questionnaire, and zeros are assigned only to plots observed in that questionnaire. Perennial-questionnaire membership is defined before the crop-age restriction; missing ages remain, and only reported ages of 37 years or more are excluded. Cacao and banana yields divide plot-level total production by total usable crop area. The coefficient is the PLT-side jump from a triangular-weighted ordinary-least-squares approximation to the preferred local-linear RD within the 40 km window.
The specification excludes the two parishes closest to the cutoff and controls for latitude, longitude, border-segment fixed effects, province fixed effects, land-tenure fixed effects, and banana potential yield. Parentheses report Conley standard errors that allow spatial correlation within 25 km. The spatial covariance estimate with a 40 km cutoff is not positive semidefinite for banana yield, so the table uses the shorter common cutoff that remains defined for every outcome. Because this ordinary-least-squares spatial-correlation check differs from the main robust bias-corrected estimator following Calonico et al. (2014), its coefficients need not equal the main RD estimates. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A9: Distance-based boundary-discontinuity comparison

	Main RD	Boundary RD doughnut	Boundary RD no doughnut
Perennial	-0.172	0.297*	0.979***
	(0.299)	(0.168)	(0.233)
Annual	-0.524***	-0.349***	-0.044
	(0.165)	(0.125)	(0.101)
Rice	-0.661***	-0.948***	-0.774***
	(0.210)	(0.241)	(0.093)
Cocoa	-0.047***	-0.044***	-0.006
	(0.012)	(0.009)	(0.013)
Banana	-1.645***	-0.896*	-0.589*
	(0.539)	(0.472)	(0.321)
Main other perennials	1.239***	1.773***	1.586***
	(0.189)	(0.109)	(0.088)
Observations	varies by outcome	varies by outcome	varies by outcome
Bandwidth (km)	40	40	40
Doughnut	yes	yes	no

Note: The first column reports the paper's main robust bias-corrected local-linear geographic RD estimates following Calonico et al. (2014). The second and third columns report a distance-based boundary-discontinuity estimator following Cattaneo, Titiunik, and Yu (2026), using a 40 km window with and without the doughnut exclusion. Each outcome uses its relevant crop questionnaire, and zeros are assigned only to plots observed in that questionnaire. Perennial-questionnaire membership is defined before the crop-age restriction; missing ages remain, and only reported ages of 37 years or more are excluded. Cacao and banana yields divide plot-level total production by total usable crop area.

All columns control for latitude, longitude, border-segment fixed effects, province fixed effects, land-tenure fixed effects, and banana potential yield. Parentheses report standard errors clustered by parish. The boundary estimator treats the design as a boundary-discontinuity problem rather than a canonical one-dimensional local-linear RD, so its coefficients need not equal the main estimates. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A10: Residualized local-randomization inference in the preferred window

	Perennial	Annual	Rice	Cocoa	Banana	Main other perennials
Residualized difference in means	0.097	0.029	-0.114	0.002	-0.637	0.223
Randomization p-value	0.156	0.456	0.022	0.616	0.014	0.000
Large-sample p-value	0.206	0.502	0.021	0.543	0.014	0.001
Observations	5590	4364	4364	5590	5590	5590
Left of cutoff	2419	2440	2440	2419	2419	2419
Right of cutoff	3171	1924	1924	3171	3171	3171

Note: The table reports randomization inference for the outcome-specific questionnaire samples in the preferred 40 km doughnut window. I assign zeros only to plots observed in the questionnaire relevant to each outcome. I first remove the variation explained by latitude, longitude, border-segment fixed effects, province fixed effects, land-tenure fixed effects, and banana potential yield. I then compare the resulting residuals. I define perennial-questionnaire membership before applying the crop-age restriction. I retain missing ages and exclude only reported ages of 37 years or more. Cacao and banana yields divide plot-level total production by total usable crop area. The coefficient reports the local difference in means within the window. Its magnitude therefore does not directly match the bias-corrected local-linear RD coefficient in the main tables. The preferred continuity-based RD follows Calonico et al. (2014). This local-randomization procedure follows Cattaneo et al. (2014) and provides finite-sample p-values rather than clustered standard errors.

Table A11: Parish-level randomization inference across fixed windows

Outcome	10 km	15 km	20 km	25 km	30 km	35 km	40 km
Doughnut sample							
Perennial	-0.223 (0.996)	0.903 (0.263)	0.683 (0.125)	0.673 (0.113)	0.406 (0.156)	0.416 (0.140)	0.063 (0.841)
Annual	-0.275 (0.248)	-0.210 (0.267)	-0.052 (0.694)	0.001 (0.999)	0.087 (0.689)	-0.021 (0.917)	0.029 (0.871)
Rice	-0.885 (0.248)	-0.619 (0.091)	-0.122 (0.592)	-0.120 (0.554)	-0.254 (0.163)	-0.329 (0.063)	-0.304 (0.035)
Cocoa	-0.035 (0.248)	0.001 (0.887)	0.002 (0.821)	0.005 (0.677)	0.000 (0.967)	-0.002 (0.798)	-0.002 (0.831)
Banana	-1.678 (0.488)	-0.210 (0.858)	-0.268 (0.686)	-0.252 (0.696)	-0.645 (0.356)	-0.593 (0.362)	-1.201 (0.110)
Main other perennials	0.766 (0.248)	0.992 (0.087)	0.791 (0.009)	0.685 (0.027)	0.567 (0.011)	0.650 (0.006)	0.334 (0.151)
Number of parishes	8	10	13	14	20	22	26
No-doughnut sample							
Perennial	0.173 (0.574)	0.739 (0.171)	0.599 (0.114)	0.596 (0.088)	0.373 (0.151)	0.383 (0.132)	0.058 (0.833)
Annual	-0.204 (0.186)	-0.179 (0.153)	-0.039 (0.737)	0.005 (0.959)	0.081 (0.702)	-0.018 (0.921)	0.032 (0.849)
Rice	-0.621 (0.045)	-0.528 (0.021)	-0.194 (0.308)	-0.184 (0.320)	-0.274 (0.099)	-0.335 (0.032)	-0.326 (0.019)
Cocoa	-0.018 (0.274)	0.001 (0.914)	0.002 (0.797)	0.005 (0.629)	0.001 (0.932)	-0.002 (0.857)	-0.001 (0.909)
Banana	-0.846 (0.538)	-0.220 (0.838)	-0.444 (0.493)	-0.407 (0.506)	-0.715 (0.294)	-0.657 (0.295)	-1.268 (0.080)
Main other perennials	0.802 (0.090)	0.867 (0.026)	0.703 (0.012)	0.615 (0.030)	0.520 (0.011)	0.595 (0.008)	0.304 (0.170)
Number of parishes	10	12	15	16	22	24	28

Note: Each cell reports the difference in adjusted parish means within the displayed window. Parentheses contain p-values from 9,999 fixed-margin permutations. I use the questionnaire relevant to each outcome and assign zeros only to plots observed in that questionnaire. In the 40 km sample, I first remove the variation explained by latitude, longitude, border-segment fixed effects, province fixed effects, land-tenure fixed effects, and banana potential yield. I then collapse the resulting residuals to parish means and apply randomization inference within each window. The doughnut panel excludes the two parishes closest to the IERAC boundary. Treating parishes as the effective units allows each parish to contribute once and avoids treating plots within the same parish as independent. The small number of parishes limits precision. The preferred continuity-based RD follows Calonico et al. (2014). The local-randomization procedure follows Cattaneo et al. (2014).

C.3. Credit-market sample check

Annual crops turn over quickly, so short-horizon informal credit fits them more readily than perennials. Among producers observed in the annual-crop questionnaire, PLT lowers reported borrowing from informal moneylenders by 5.3 percentage points, and parish-clustered inference rejects zero at the 5 percent level. Formal borrowing does not change. This result supports the proposed financing channel, but it does not establish that informal credit caused rice specialization.

Table A12: Credit-market evidence among annual-crop producers

	Informal credit	Formal credit
PLT-side jump	-0.053**	-0.009
	(0.026)	(0.018)
	[0.041]	[0.043]
Observations	4364	4364
Parishes	26	26
Mean dep. var.	0.088	0.087
Coefficient/mean ($\times$100)	-60.3	-10.4
Bandwidth (km)	40	40

The sample includes agricultural units observed in the annual-crop questionnaire. Informal credit identifies loans from informal moneylenders (*chulqueros*); formal credit includes the Banco Nacional de Fomento, private banks, and credit cooperatives. Entries report the PLT-side jump from the preferred robust bias-corrected sharp RD following Calonico et al. (2014), with the two closest parishes excluded and a 40 km bandwidth.

Coefficient/mean multiplies the displayed coefficient-to-mean ratio by 100; it is not a percentage-point effect. Parentheses show parish-clustered standard errors; brackets show Huber–White standard errors. Stars use parish-clustered inference. This annual-crop restriction is a mechanism check, not the baseline credit sample.

Every specification controls for latitude, longitude, border-segment fixed effects, province fixed effects, land-tenure fixed effects, and banana potential yield. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

C.4. Diversification robustness

Table A13: No-doughnut robustness

	Perennial	Annual	Rice	Cocoa	Banana	Main other perennials
PLT-side jump	0.502	-0.292*	-0.712***	-0.014	-1.457***	1.300***
	(0.413)	(0.170)	(0.079)	(0.017)	(0.401)	(0.185)
	[0.221]	[0.073]	[0.153]	[0.008]	[0.698]	[0.188]
Observations	6020	4799	4799	6020	6020	6020
Parishes	28	28	28	28	28	28
Bandwidth (km)	40	40	40	40	40	40
Mean dep. var.	3.843	6.475	2.248	0.063	2.061	2.236
Coefficient/mean ($\times$100)	13.1	-4.5	-31.7	-22.4	-70.7	58.1

Every specification controls for latitude, longitude, border-segment fixed effects, province fixed effects, land-tenure fixed effects, and banana potential yield.
This robustness check uses the questionnaire relevant to each outcome and a 40 km bandwidth, but retains the two parishes closest to the cutoff. Zeros are assigned only to plots observed in the relevant questionnaire.
Coefficient/mean multiplies the displayed coefficient-to-mean ratio by 100. It is not a percentage change in the untransformed outcome.
Robust bias-corrected estimates follow Calonico et al. (2014) and the bandwidth refinements in Calonico et al. (2020). Parentheses show parish-clustered standard errors; brackets show Huber–White standard errors. Stars use parish-clustered inference.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

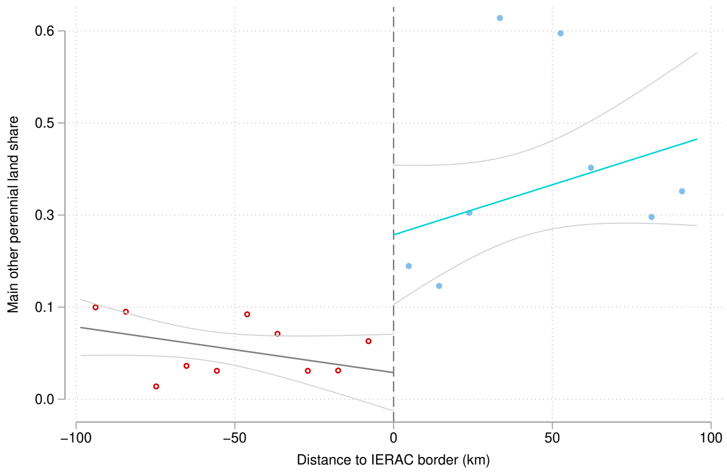
Table A14: Main other-perennial decomposition

Specification	PLT-side jump	Standard error	Mean dep. var.	Coefficient/mean (×100)
Main basket	1.239***	(0.189)	2.316	53.5
+ coffee	0.826***	(0.191)	2.637	31.3
+ limon	1.194***	(0.189)	2.413	49.5
+ maracuya	0.753**	(0.328)	2.794	27.0
+ palmito	1.202***	(0.181)	2.354	51.1
+ pina	1.405***	(0.255)	2.413	58.2
Coffee only	-0.253***	(0.056)	0.771	-32.8
Limon only	0.209	(0.128)	0.355	58.8
Palmito only	-0.043	(0.034)	0.082	-52.8
Pina only	0.293	(0.266)	0.160	182.9

The main basket contains sugar cane (including cane for sugar and for other uses), African oil palm, and plantain. A row labeled + crop adds that crop's revenue to the main basket. A row labeled crop only retains revenue from that crop alone. In every row, revenue per hectare divides the selected crops' revenue by total harvested area in perennial crops other than cacao and banana. Productive area replaces harvested area when harvested area is unavailable, and planted area is used when neither harvested nor productive area is reported. No additional area values are imputed.

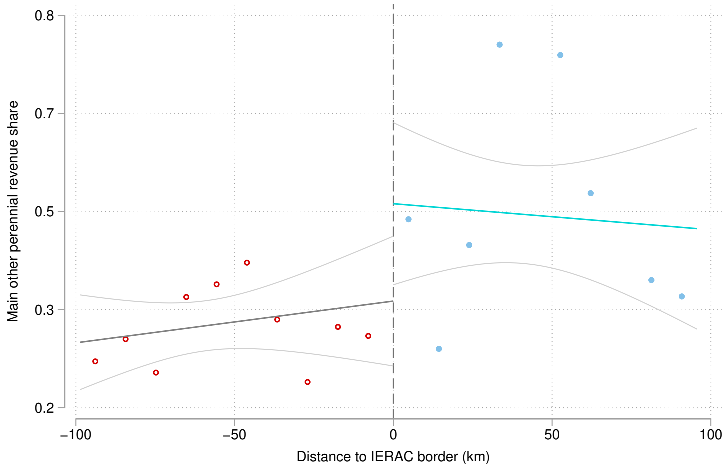
The dependent variable is log(1 + revenue per hectare), valued with a common schedule of Ecuador-wide 2013 producer prices. The sample contains plots recorded in the 2000 agricultural census perennial-crop questionnaire; questionnaire membership is defined before the crop-age restriction, records with missing crop age remain in the sample, and only reported ages of 37 years or more are excluded. Plots that report none of the crops selected in a row receive a zero. The PLT effect is the robust bias-corrected discontinuity following Calonico et al. (2014) on the public-land-transfer side of the IERAC boundary. Coefficient/mean divides that coefficient by the sample mean of the logged outcome and multiplies the ratio by 100; it is not a percentage change in unlogged revenue. The preferred specification excludes the two closest parishes, uses a 40 km bandwidth, controls for latitude, longitude, border-segment fixed effects, province fixed effects, land-tenure fixed effects, and banana potential yield, and clusters standard errors by parish. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Figure A6: RD graph: main other-perennial land share



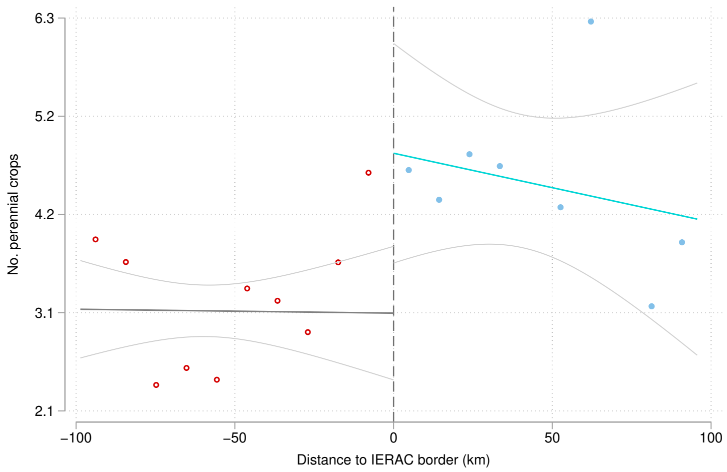
Note: The graph plots parish-level means for the land share of the main other-perennial basket among plots observed in the perennial-crop questionnaire. The corresponding sharp geographic RD uses a 40 km bandwidth, excludes the two parishes closest to the cutoff, and controls for latitude, longitude, border-segment fixed effects, province fixed effects, land-tenure fixed effects, and banana potential yield.

Figure A7: RD graph: main other-perennial revenue share



Note: The graph plots parish-level means for the revenue share of the main other-perennial basket among plots observed in the perennial-crop questionnaire. Revenue uses fixed Ecuador-wide 2013 producer prices. The corresponding sharp geographic RD uses a 40 km bandwidth, excludes the two parishes closest to the cutoff, and controls for latitude, longitude, border-segment fixed effects, province fixed effects, land-tenure fixed effects, and banana potential yield.

Figure A8: RD graph: number of perennial crops



Note: The graph plots parish-level means for the number of distinct perennial crops cultivated among plots observed in the perennial-crop questionnaire. The corresponding sharp geographic RD uses a 40 km bandwidth, excludes the two parishes closest to the cutoff, and controls for latitude, longitude, border-segment fixed effects, province fixed effects, land-tenure fixed effects, and banana potential yield.

C.5. Landholding structure

Table A15 reports descriptive comparisons of landholding inequality across the two sides of the policy border.

Table A15: Landholding inequality from the agricultural census

	40 km window	60 km window
Pooled plot Gini, expro side	0.740	0.770
Pooled plot Gini, PLT side	0.763	0.731
Mean parish Gini, expro side	0.718	0.726
Mean parish Gini, PLT side	0.702	0.680
PLT jump in parish Gini	0.100*	0.047
	(0.050)	(0.040)
Parishes in RD window	26	42
PLT parishes	14	17
Expropriation parishes	12	25

The first four rows describe inequality in plot-level agricultural area. Pooled plot Gini uses all plots on each side of the boundary; mean parish Gini averages parish-specific Gini coefficients. The PLT-jump row estimates an unadjusted local-linear specification in the RD framework of Calonico et al. (2014), with separate slopes on each side and Huber–White standard errors.
Both columns exclude the two parishes closest to the boundary. The estimates offer descriptive evidence on landholding structure rather than a primary test of the paper's mechanism. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

C.6. Broader regional benchmark

The Manabi benchmark provides supportive regional evidence but does not enter the core RD identification.

C.6.1. Manabi benchmark

The broader regional comparison tests whether the crop ranking extends beyond the RD corridor. I use Manabi plots outside the digitized PLT area as the benchmark. The PLT category combines mapped PLT areas in Guayas, Los Rios, Manabi, Esmeraldas, Pichincha, Santo Domingo de los Tsachilas, and Zona No Delimitada. The expropriation category contains the corresponding areas in Guayas and Los Rios. I report unconditional differences with parish-clustered standard errors. Province fixed effects would absorb the Manabi benchmark. Latitude and longitude controls would require extrapolation across this broad comparison. This exercise remains descriptive and outside the core identification strategy.

Table A16 preserves the relative ranking across reform regimes. PLT areas exceed the non-PLT Manabi benchmark in perennial and main other-perennial revenue. Expropriation areas show no statistically distinguishable difference in total perennial revenue and fall below the benchmark in main other-perennial revenue. Expropriation also shows the much larger annual and rice differences. Cacao yield does not differ detectably from the benchmark in either regime. I treat these estimates as a descriptive benchmark rather than a causal comparison.

Table A16: Manabi regional benchmark

	Perennial	Annual	Rice	Cacao	Banana	Main other perennials
PLT	1.461***	0.162	0.554***	0.012	0.589**	1.543***
	(0.232)	(0.275)	(0.180)	(0.013)	(0.233)	(0.248)
Expropriation	-0.293	1.377***	2.462***	-0.000	1.769***	-0.376**
	(0.298)	(0.144)	(0.181)	(0.013)	(0.420)	(0.187)
Observations	23,804	19,165	19,165	23,804	23,804	23,804
Parishes	194	194	194	194	194	194

Columns report log revenue per hectare for perennial crops, log revenue per hectare for annual crops, rice yield, cacao yield, banana yield, and log revenue per hectare for the main other-perennial basket. Each outcome uses its corresponding crop questionnaire, and zeros are assigned only to plots observed in that questionnaire. Perennial-questionnaire membership is defined before the crop-age restriction, and cacao and banana yields divide plot-level total production by total usable crop area.
The omitted category contains Manabí plots outside the digitized PLT area. The PLT category contains mapped PLT areas in Guayas, Los Ríos, Manabí, Esmeraldas, Pichincha, Santo Domingo de los Tsáchilas, and Zona No Delimitada. The expropriation category contains the corresponding areas in Guayas and Los Ríos. The unconditional ordinary-least-squares regressions add no covariates. Province fixed effects would absorb the Manabí benchmark, while latitude and longitude controls would require extrapolation across this broad regional comparison. Standard errors are clustered by parish and shown in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

C.7. Productivity-reallocation calibration

This back-of-the-envelope adaptation of Kim and Wang (2025) asks a narrow question. Can a negative aggregate agricultural-productivity estimate after agrarian reform coexist with gains from crop diversification and labor reallocation? The answer is yes in the accounting sense. Negative results in incumbent crops can dominate the agricultural average, while diversification and movement out of agriculture contribute positively. The exercise makes those offsets visible. It uses the reallocation formula in McCaig and Pavcnik (2018). It remains suggestive, not a structural estimate or a replacement for the RD.

C.7.1. Model and equations

Consider a two-sector economy with agriculture (a) and non-agriculture (n). Each sector uses a Cobb–Douglas technology,

$$Y_s = A_s L_s^{\alpha_s} K_s^{1-\alpha_s}, \qquad s \in \{a, n\}.$$

Aggregate labor productivity is

$$\frac{Y}{L} = \frac{Y_a + Y_n}{L_a + L_n}.$$

Define sectoral output per worker as

$$ARPL_a = \frac{Y_a}{L_a}, \qquad ARPL_n = \frac{Y_n}{L_n},$$

and let the agricultural employment share be

$$s_a = \frac{L_a}{L_a + L_n}.$$

Aggregate labor productivity then equals

$$\frac{Y}{L} = s_a ARPL_a + (1 - s_a) ARPL_n.$$

Following Kim and Wang (2025), if b_a is a proportional change in agricultural labor productivity, its direct contribution to aggregate labor productivity is

$$\text{Productivity contribution} = s_a \times b_a.$$

The aggregate residual-productivity coefficient provides the closest available counterpart to b_a, but it remains a proxy based on $\log(1 + \text{revenue})$. Crop-specific coefficients measure zero-inclusive transformed revenue per hectare or crop yields, not proportional changes in agricultural labor productivity. I therefore label $s_a b_a$ a scaled agricultural term and treat the crop rows as specialization scenarios.

Following McCaig and Pavcnik (2018), I hold sectoral output per worker fixed and change only agriculture's employment share. Labor reallocation then contributes:

$$\Delta \left(\frac{Y}{L} \right)^{realloc} = -\Delta s_a (ARPL_n - ARPL_a).$$

I divide by baseline aggregate labor productivity and define

$$g = \frac{ARPL_n}{ARPL_a},$$

which gives

$$\text{Reallocation contribution} = -\Delta s_a \cdot \frac{g - 1}{s_a + (1 - s_a) g}.$$

C.7.2. Calibration

Ecuador's 2000 GGDC/UNU-WIDER Economic Transformation Database (ETD), documented by Kruse et al. (2023), provides the aggregate inputs. Agriculture's employment share is

$$s_a = \frac{1450.226}{1450.226 + 3142.816} = 0.316,$$

and the productivity gap is

$$g = \frac{ARPL_n}{ARPL_a} = 2.458.$$

The paper's supporting structural-transformation input is the PLT-versus-expropriation difference in the agricultural employment share,

$$\Delta s_a^{PLT-EXP} = -0.136,$$

which implies a common reallocation contribution of about

$$0.099.$$

The calculations below use the unrounded inputs.

The supporting pooled canton-level exercise within 50 km of the border provides the employment-share estimate; the core plot-level RD does not. The employment share and productivity gap come from national ETD data rather than local coastal aggregates. The calculation therefore provides an interpretive benchmark, not a separate causal estimate.

I apply the scaling term to aggregate residual productivity, perennial and annual revenue per hectare, rice, cacao, and banana yields, and main other-perennial revenue per hectare. I calculate the residual-productivity proxy following Montero (2022) and Aragon et al. (2020). Because the crop coefficients measure zero-inclusive transformed revenue per hectare or yields rather than proportional changes in agricultural labor productivity, those rows remain illustrative specialization scenarios.

C.7.3. Results

The aggregate residual-productivity term contributes -0.181, while labor reallocation contributes 0.099, leaving an index of -0.082. Movement out of agriculture offsets more than half, but not all, of the weak within-agriculture result. The specialization scenarios reveal the opposing margins: main other perennials produce a strongly positive index, while rice and bananas produce negative indices. Incumbent-crop persistence and diversification therefore pull the aggregate in opposite directions.

Table A17: Why aggregate productivity looks weak: suggestive accounting

Margin	Scaled agricultural term	Reallocation term	Combined index
Panel A. Aggregate benchmark			
Aggregate residual-productivity proxy	−0.181	0.099	−0.082
Panel B. Illustrative specialization scenarios			
Perennial	−0.054	0.099	0.045
Annual	−0.165	0.099	−0.066
Rice	−0.209	0.099	−0.110
Cacao	−0.015	0.099	0.084
Banana	−0.519	0.099	−0.420
Main other perennials	0.391	0.099	0.490

Note: Panel A combines the aggregate residual-productivity proxy with the labor-reallocation term. The proxy is the robust bias-corrected PLT-side discontinuity following Calonico et al. (2014) in a residual from log(1 + revenue) regressed on transformed land, labor, temperature, and precipitation. It uses the 40 km bandwidth, excludes the two parishes closest to the boundary, controls for latitude, longitude, border-segment fixed effects, province fixed effects, land-tenure fixed effects, and banana potential yield, and clusters standard errors by parish. Panel B mechanically inserts the crop-specific RD coefficients to illustrate the offsetting specialization margins. The Economic Transformation Database supplies Ecuador's 2000 agricultural employment share and sectoral productivity gap; the authorized canton-year IPUMS aggregate supplies the local employment-share difference. Crop outcomes use their corresponding questionnaires and zero-inclusive transformations. The crop coefficients, scaled terms, and combined indices are not percentage effects on aggregate labor productivity.

C.7.4. Break-even perennial exercise

The break-even exercise finds the inserted perennial coefficient that makes the accounting index positive. It does not identify any crop as the cause of the aggregate perennial coefficient. Using the unrounded employment share and reallocation benchmark, define the index for an inserted coefficient b^{cf} as

$$I(b^{cf}) = 0.315744 \cdot b^{cf} + 0.099023.$$

The index becomes positive whenever

$$I(b^{cf}) = 0.315744 \cdot b^{cf} + 0.099023 > 0,$$

which implies

$$\boxed{b^{cf} > -0.313617 \approx -0.314.}$$

Because the observed perennial margin lies near zero, a modest change in the inserted coefficient makes the index positive. Table A18 reports the arithmetic. The threshold applies to the accounting index; it does not estimate a counterfactual change in perennial or aggregate labor productivity.

Table A18: Break-even perennial accounting scenarios

Scenario	Coefficient inserted	Scaled term	Combined index
Observed perennial coefficient	-0.172	-0.054	0.045
No perennial gap	0.000	0.000	0.099
Small positive insertion	0.100	0.032	0.131
Moderate positive insertion	0.250	0.079	0.178
Large positive insertion	0.500	0.158	0.257
Illustrative main other-perennial insertion	1.239	0.391	0.490

Note: Each row inserts a perennial coefficient b^{cf} into $I(b^{cf}) = 0.315744b^{cf} + 0.099023$. The first number is Ecuador's unrounded agricultural employment share, and the second is the unrounded labor-reallocation contribution. The combined index becomes positive when $b^{cf} > -0.313617$. These rows are mechanical scenarios, not estimates of counterfactual changes in perennial or aggregate labor productivity. The exercise does not identify any crop as the cause of the aggregate perennial coefficient.

The break-even calculation compares the aggregate perennial coefficient with the reallocation benchmark without assigning the weak aggregate result to one crop. The broader evidence points instead to offsetting patterns: expropriation preserved incumbent activities, while PLT widened the perennial portfolio and supported labor reallocation.