Can agrarian reform cause stunting?

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Abstract

Stunting has been a significant issue in Ecuador and remains a pressing public policy concern. In this paper, I examine the agrarian reform policies of the 1960s and 1970s as a potential explanation for future stunting. The two primary methods of land allocation during the Ecuadorian agrarian reform were public land transfers and expropriations. My findings indicate that regions benefiting from public land transfers exhibit lower rates of stunting compared to areas that were not affected by the reform. However, I did not observe any impact from expropriations. I argue that the underlying mechanism for these results lies in the human capital accumulation of mothers associated with these land allocation policies. Mothers who were exposed to public land transfers and their initial policies during their early years tend to have higher levels of education and are less likely to have children who experience stunting. This effect is not persistent across cohorts.

Keywords: Stunting, agrarian reform, Ecuador

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1. Introduction

Agrarian reforms have played a crucial role in the development of many countries. Recent literature has combined historical narratives with new datasets and innovative identification strategies to analyze their impact (Albertus, 2023; Montero, 2020, 2023; Albertus et al., 2020; Galán, 2020). Additionally, extensive research on early childhood well-being highlights the importance of initial conditions for long-term outcomes (Attanasio et al., 2023; Schady et al., 2016). In Ecuador, stunting, the lack of height relative to age for children under 5 years old, remains a significant public policy challenge (CRISFE, 2023; Gutierrez et al., 2018). While various governments have introduced new policy strategies in recent years to address this issue, their effectiveness has been limited, yielding only modest progress (CRISFE, 2023).

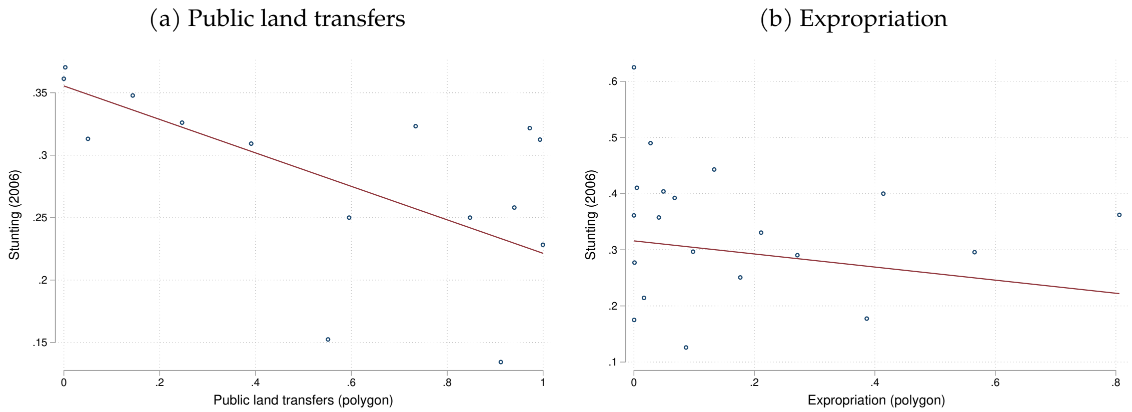
In this paper, I propose to study agrarian reform as a potential factor influencing stunting rates in Ecuador. This agrarian reform mirrored the patterns seen in other Latin American nations that underwent similar reforms during the 1960s and 1970s. Essentially, the reform was governed by two different types of land allocations: public land transfers (PLT) and expropriation. PLT was essentially a public land settlement policy whose aim was to expand the agricultural frontier, while expropriation was a policy looking for social justice and addressing inequalities(Albertus, 2015; Barsky, 1984; de Janvry, 1981).

Figure 1 exhibits the motivation for this paper. Panel a) and b) show a correlation between measures for PLT and expropriation taken from georeferencing historical maps from the main governmental agency that performed the reform: The Ecuadorian Institute of Colonization and Agrarian Reform (IERAC, in Spanish). Panel a) shows a strong negative correlation, at the parish level, between PLT and stunting rates in 2006 measured in the living standards survey[1]. On the other hand, Panel b) shows no relation between expropriations and stunting.[2] Are these relations causal? if so, what is the reason behind it?

[1] This is the first reliable measure made by the official statistic office of Ecuador. Other measures were performed in 2004 and 1986, but they rely on independent projects associated with certain ministries

[2] Figure A2 illustrates that the kernel density distribution of height-for-age-Z-scores for observations in areas that did not receive agrarian reform is skewed to the left, indicating a higher concentration of stunting in those regions.

Figure 1: Correlation stunting (2006) and types of agrarian reforms experimented in Ecuador



Note: PLT and expropriation (polygon) refers to the geo referenced polygon area from Figure A1 divided by parish area

In this research, I present a comprehensive set of results supporting the effectiveness of PLT in reducing child stunting. First, I conduct ordinary least squares (OLS) regressions using child stunting-measured from current and comparable living standards surveys-as the dependent variable, and the amount of land allocated to PLT or expropriation-sourced from a georeferenced IERAC historical map-as the main independent variable. This map was created towards the end of the agrarian reform process in 1978. In this initial analysis, I accurately measure the current parish area relative to the agrarian reform intervention. In a second analysis, I incorporate data from IERAC registries and reports to measure agrarian reform interventions from an alternative source. Since these data come from historical parish-level reports, calculating the effects of agrarian reform relative to current parish areas becomes problematic. To address this issue, I perform this analysis using absolute values instead of relative measures.

To partially bridge the gap regarding what occurred in the intervening years, I present descriptive evidence using the first official survey data available for measuring child stunting in Ecuador, collected in 1986. Although this dataset has limitations in terms of precise geographic identification, it allows me to distinguish between the Santo Domingo region-primarily targeted by PLT-and the highlands region-mainly affected by expropriations. The descriptive patterns align with the main results: stunting rates are lower in the PLT area compared to regions influenced by expropriation.

When comparing areas affected by PLT and expropriation, different concerns about endogeneity arise. These areas may be inherently different because PLT targeted abandoned or unused land, while expropriations aimed to restructure large estates, commonly referred to as *latifundios*. To address this empirical challenge, I employ an instrumental variables (IV) strategy. In the second analysis, I instrument agrarian reform interventions-whether PLT or expropriation-using measures derived from the historical map. In essence, the first stage of my IV model regresses agrarian reform intervention data from IERAC reports on agrarian reform data from the IERAC historical map. The historical map represent the intended objectives of the agrarian reform agency, whereas the reports document the actual number of hectares affected in each parish. I demonstrate that the polygons from the historical map provide variation that is highly correlated with reported intervention hectares (meeting the relevance condition) and independent of current stunting rates (satisfying the exclusion restriction). I argue that discrepancies between the registries and historical maps are unrelated to the impact on child stunting.

In the IV analysis, I focus on land area rather than land share, as reliable data on parish areas in Ecuador from the 1960s and 1970s are unavailable. However, in the appendix, I provide results using land shares based on contemporary parish boundaries. These estimates yield substantially larger magnitudes while maintaining the same qualitative direction. To ensure a conservative approach, I rely on the absolute land measures in the main text. While expropriation shows no significant or even null effects, the strong relationship between PLT and reduced stunting remains robust. A conservative and reliable estimate suggests that PLT contributes to a 3% (from the second analysis) to 17% (from the first analysis) reduction in child stunting.

Why was PLT successful in reducing child stunting while expropriation was not? First, mothers who were more exposed to agrarian reform had a lower probability of having a stunted child, even after controlling for several characteristics. While multiple explanations exist, one key distinction between PLT and expropriation emerges: Mothers born near the start of the agrarian reform (1964) achieved more years of schooling if they were from regions where PLT was implemented. This pattern does not hold for areas affected by expropriation. These findings suggest that the differential impact of land allocation policies on human capital accumulation helps explain why children of PLT-exposed mothers exhibit lower stunting rates.

This paper contributes to the existing literature on the effects of agrarian reform on health outcomes (Kosec and Shemyakina, 2024; Xu, 2021; Ghosh, 2007; Galiani and Schargrodsky, 2004) by introducing a new dimension that distinguishes between two distinct land policies: PLT and expropriations. Specifically, it examines the long-term benefits of investing in agrarian reform during the early years, finding evidence that improvements in well-being can extend to subsequent generations. Long-run estimates regarding height (Baten and Blum, 2012) suggest that Latin America has lagged behind in this indicator and has been surpassed by Asian countries, mirroring trends documented in the agrarian reform literature concerning income levels and land inequality (Kay, 2002). This paper aims to bridge these two areas of literature by exploring the potential effects of contemporary agrarian reforms on stunting, using microdata from a specific case study. Further research is needed to adopt a comparative perspective.

Additionally, this research contributes to the ongoing debate on whether land reforms promote human capital accumulation. Seminal work by Galor et al. (2009) argues that land reforms lead to increased public investment in education, while Albertus et al. (2020) finds no such effect in the case of Peru. This paper provides evidence that exposure to PLT during early years is associated with higher educational attainment, whereas expropriation has no significant effect. These findings suggest that the impact of land reform on human capital depends on the type of policy implemented. In particular, when agrarian reform is accompanied by public investment and flexible property rights, as in the case of PLT, positive results are likely to emerge(Gachet, 2024).

This paper is structured as follows: Section 2 provides an overview of the institutional context, Section 3 introduces the data, and Section 4 outlines the empirical strategies employed in the analysis. Section 5 presents the main results, while Section 6 explores the mechanisms driving these findings. Finally, Section 7 concludes.

2. Institutional context

Stunting. Stunting specifically refers to the nutritional condition in which children do not reach the height they are supposed to, according to harmonized statistical tables from the United Nations. This problem can affect children's performance in school and impact their overall human capital accumulation(Walker et al., 2007). Overall, global health indicators have improved, even in situations without inclusive political institutions (Cermeño et al., 2023).

By 2018, Ecuador had a stunting rate of close to 25% for children under five years old, one of the highest in the Latin American region (Gutierrez et al., 2018). By 2023, this rate dropped to 18%, and at 20% for children under two years old. While there have been apparent improvements, certain provinces within the country still have rates close to or above 30%. Furthermore, the sources for measuring stunting have undergone different methodological changes, making it challenging to compare rates across time with a high degree of confidence.

Ecuador's agrarian reform. Ecuador underwent an agrarian reform process during the 1960s and 1970s. It officially began in 1964 under a military dictatorship. The agrarian reforms involved two main policies for land allocation: PLT and expropriations. The aim of PLT was to expand the agricultural frontier in the country, while expropriations sought to address land inequality and eliminate labor exploitation, such as huasipungo.[3]

For two decades, the Colonization and Agrarian Reform Institute (IERAC, in Spanish) managed all administrative tasks related to the reform. Expropriations were particularly vigorous in the Highland and southern Coastal regions, aiming to redistribute land from haciendas and abolish precarious labor systems like huasipungo. In the Amazon region, PLTs were also quite aggressive, targeting frontier lands. Initial efforts were launched in select areas of the highlands and coastal regions, notably in the provinces of Esmeraldas, Santo Domingo, and Quevedo.

Both land allocation processes had their own legislation, which described the procedures and the role of IERAC and the central government. Expropriations were more susceptible to political influence, making it more difficult to allocate land based on agricultural suitability and quality. This may have been particularly important for the highland region, where terrain ruggedness possibly influenced land suitability. Moreover, certain regions were more effective at implementing expropriations, especially the coastal region after the implementation of Decree 1,001 by President Velasco Ibarra (Gachet, 2024; Dávila and Pazmino, 2016). In contrast, the PLT program had more flexibility, both formally and informally, because the goal of expanding the agricultural frontier required freedom in crop selection. Additionally, if the aim was to establish public land settlements, clear expectations and flexibility needed to be provided to beneficiaries to encourage internal migration. However, this was not always realized, as some PLT instances resulted in the legalization of land plots for workers whose landlords had abandoned them (Carrasco, 1994).

3. Data

The main data that I use come from household surveys, along with historical sources (maps and registries), and geographic characteristics. I describe the data below.

3.1. Survey data

The main sources for child stunting data are the Living Standards Surveys conducted in 2006 and 2014 by the Ecuadorian statistical office, INEC. Hence, forming a repeated cross section data set. The primary purpose of these surveys was to measure consumption and calculate poverty

[3] Huasipungo was an informal institution in which indigenous peoples were treated as part of the land, not as a labor force.

indexes based on consumption. Included in the waves were sections that covered children's anthropometrics. Stunting (height-for-age) is calculated using World Health Organization (WHO) standards.[4] From this it is possible to obtain the z-scores commonly used to compare the distribution of heights for children in the sample with the ones from international curves/standards. The two Living Standards Surveys have the advantage of being comparable over time (Gutierrez et al., 2018). From these surveys, it is possible to obtain several individual characteristics, such as parish of residence, mother's education, consumption levels (as a measure of poverty), race, birth order, and gender. I also use the 2010 census to gather population data at the parish level.

An additional source of information that I use separately to provide suggestive evidence that PLT is related to lower stunting during a "middle" period comes from the first stunting survey conducted in Ecuador in 1986. This data was used in CONADE and MSP (1988) and was kindly shared by Wilma Freire (principal investigator) and Phillipe Belmont. While this data is representative of the country, to the best of my knowledge, it is not possible to recover the names of the parishes. I applied a backward induction exercise to identify observations for the Santo Domingo municipality, which was largely part of the PLT program, and municipalities from the Midland region which was in its majority exposed to expropriations.

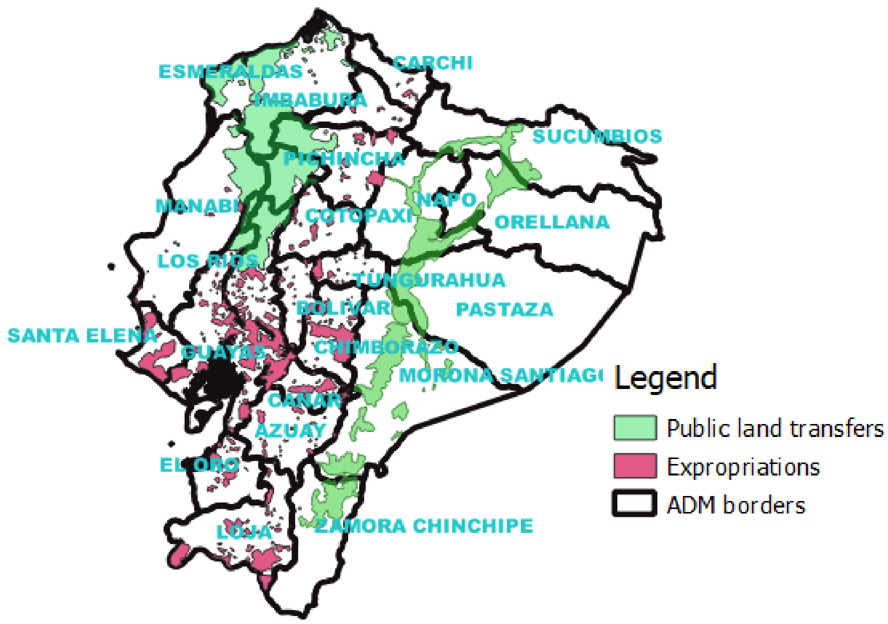
3.2. Historical sources

My primary historical sources are IERAC registries from PLT and expropriation, and an historical map. Data on PLT and expropriation applications at the parish level were gathered from IERAC archives for the years 1964-1970, and 1975 and 1978. Furthermore, the historical map in A1 was located in the IERAC archives, as well as in the Jesuit library "Aurelio Espinosa Polit". The IERAC archives offer information at the parish level.[5] At the same time, I apply GIS techniques to georeference the polygons and overlay them onto INEC shapefiles to extract data from the historical map (Figure 2)

[4] This ensures international comparability of children's height relative to their age. Specifically, this paper relies on the use of the Stata package developed by the World Health Organization and UNICEF

[5] Expropriation data was originally collected in Baquero-mendez (2023)

Figure 2: IERAC historic map: Georeference



Note: Digital version of A1 re-drawn in GIS and geolocated.

3.3. Geographic data

The geographic characteristics utilised include the agricultural suitability index from the Centre of Climatic Research at the University of Wisconsin-Madison, terrain ruggedness from Nunn and Puga (2012), and administrative border shapefiles from INEC.

3.4. Final data set construction

I merge all this data at the parish level (except the data from 1986, which I use separately for descriptive purposes). I standardise the sources according to their parish administrative codes to ensure comparability. The final data set is at the individual children level, alongside variables clustered at the parish level from historical sources and geographical data. Descriptive statistics are available in Tables A8 and A9.

4. Empirical strategies

I essentially follow two empirical strategies: Ordinary Least Squares (OLS) and instrumental variables (IV) regressions. I employ two different methods for measuring agrarian reform: the total amount of land allocated to each intervention when using the information from the IERAC registries and, for the data derived from the historical map, the amount of land allocated to each intervention relative to the area size. I choose to present both results since the denominator (parish area) is unavailable for the 1960s and 1970s. This may result in the outcomes derived from the IERAC registries inflating the OLS and the IV estimate. In the case of the data from the historical map, a more precise estimate can be obtained, thereby providing a better sense of the magnitude. Furthermore, the sign of each result consistently aligns and do not contradict each other.

The baseline regression takes the following form:

$$Stunting_{i,p,m} = \alpha + \beta AgrarianReform_p + Covariates_{i,p} + \delta_m + \epsilon_{i,p,m} \tag{1}$$

where i represents individuals, specifically children under the age of five, p denotes the parish of origin, and m indicates the province. Equation 1 corresponds to a repeated cross-section for the living standard surveys conducted in 2006 and 2014, with its main regressor being a measure of the agrarian reform enacted during the 1960s and 1970s. $Stunting$ refers to two measures of child stunting: An indicator variable that equals one if a child is identified as having stunting, determined when the height-for-age z-score is below -2 standard deviations. The other measure is the height-for-age-z-score itself as a continuous variable[6]. To calculate stunting, I use the module "igrowup" developed by the World Health Organization (WHO). $AgrarianReform$ refers to the cumulative amount of land allocated to PLT or expropriation in comparison to areas unaffected by the agrarian reform. This measure is divided by current parish area using the INEC shape files. This measure is derived from A1. As covariates, I include agricultural suitability, ruggedness, race, and population data from 2010. Additionally, I incorporate indicators for consumption quintile, gender, survey year, year of birth, and birth order. I include a province-fixed effect to account for heterogeneity among the Ecuadorian regions. Given that the intervention was planned at a micro level, I cluster my standard errors at the parish level.[7]

4.1. Instrumental variables

The regression presented in model 1 may be subject to endogeneity issues, which prevent the coefficient on β from being interpreted causally. To mitigate this problem, I employ an instrumental variables strategy. I have gathered two sources of information that can determine the

[6] This variable is widely used in the literature including in Kosec and Shemyakina (2024) and Duflo (2003) to mention a few.

[7] Removing the province fixed effects results in statistically significant coefficients that are higher in magnitude

amount of land devoted to agrarian reform at the parish level in Ecuador: IERAC archives and an historical map.

The IERAC archives provide data for the years 1964-1970, 1975, and 1978[8], meaning that for several years in the 1970s, there is no information in the archives. In contrast, the historical map collected (Figure A1) shows the data on agrarian reform accumulated up to 1978 (the last year that the agrarian reform was implemented). By using geographic information system techniques and projecting the map onto current administrative boundaries, I can obtain precise information on agrarian reform at the parish level, showing the total amount of land intervened by either PLT or expropriation.

The interpretation I propose is that the historical map represents how IERAC's bureaucracy perceived agrarian reform as policymakers. I assume that any discrepancies and measurement error between the information from the IERAC registries and the historical map, including the missing years from the registries, are independent of the outcome variable $stunting$ in 2006 and 2014.

Thus, I have two measures of agrarian reform application, in absolute terms, for my entire parish sample. The instrumental variables model takes the following form:

$$Stunting_{i,p,m} = \alpha + \beta AReformABS\_IERAC_p + Covariates_{i,p} + parishArea_p + \delta_m + \epsilon_{i,p,m} \quad (2)$$

where $AReformABS\_IERAC_p$ is the absolute amount of land (in logs) devoted to PLT or expropriation from IERAC registries. I include an additional control, which is the area of the parish from contemporary boundaries.[9] The first stage is,

$$AReformABS\_IERAC_p = \gamma + \zeta AReformABS\_MAP_p + Covariates_{i,p} + parishArea_p + \delta_m + \theta_p \quad (3)$$

where $AReformABS\_MAP_p$ is the absolute amount of land devoted to PLT or expropriation (in logs) from georeference the historical map in A1. θ is the error term for the first stage regression.

[8] Baquero-mendez (2023) and Gachet (2024) use the same data sources for expropriations and PLT, respectively.

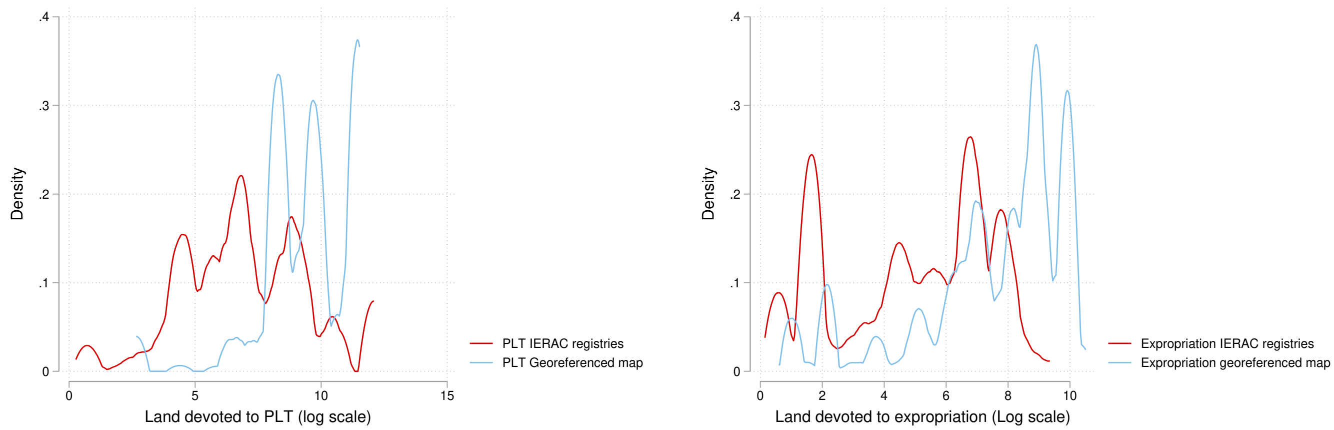
[9] In the appendix, I include an exercise without this control and using parish area as the denominator for PLT or expropriation allocation. As explained above, for the latter, the effects have a very large magnitude that might incorporate effects from changes in parishes across time. Due to this reason, I prefer to present conservative (though robust) estimates in the main text.

4.1.1. Comparing sources

Figure 3 presents kernel density distributions for the main independent variables used in the econometric models: the amount of land devoted to PLT and expropriations (in logs). As expected, data from the historical map shows larger land areas, as the map aggregates information across all years, whereas the registries contain some missing data.

Figure 3: Differences between registries and georeferenced map

(a) PLT (b) Expropriation

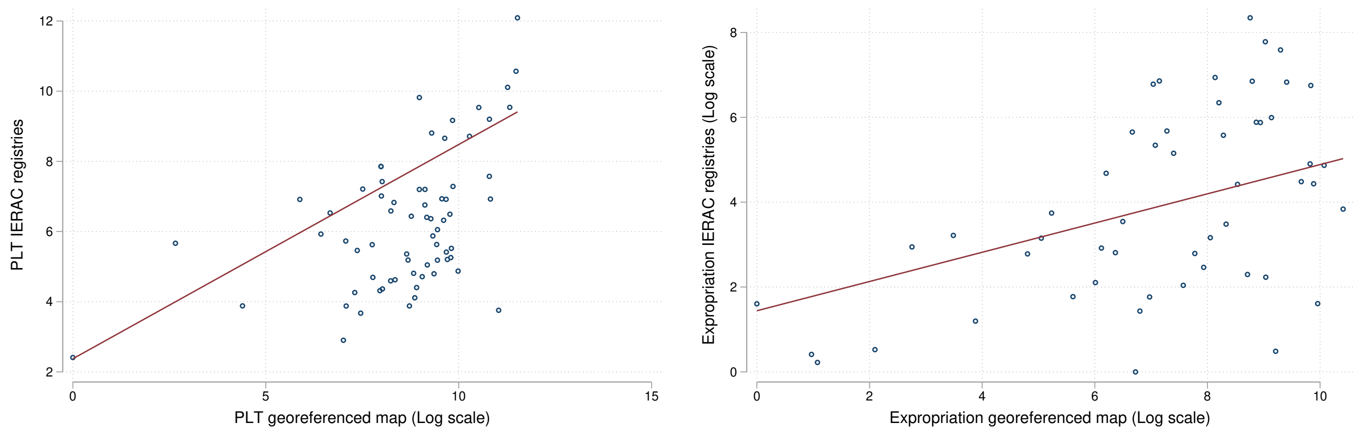


Note: Figure plots kernel densities by the absolute amount land (in log scale) devoted to PLT (Panel a) or expropriations (Panel b)

Figure 4 presents the correlation analysis corresponding to the previous figure. Both regressions display a positive slope, though with varying levels of predictive accuracy. For PLT, where the policy was more uniformly applied, the alignment between the registries and the map is relatively tight. In contrast, expropriation exhibits greater dispersion. Nonetheless, both figures confirm the expected relationship between the two data sources.

Figure 4: Correlation between registries and georeferenced map

(a) PLT (b) Expropriation



Note: Binscatter plot between the two sources of measures for the agrarian reform. Panel a) shows the correlation between PLT measured in the historic map A1 using GIS and available IERAC registries. Correlation coefficient is 0.63. For expropriation (Panel b)) the correlation coefficient is 0.45.

5. Results

5.1. PLT and expropriation relative to parish area (analysis # 1)

Analysis #1 are the results from the OLS model, which regresses child stunting on PLT and expropriation relative to land area. These results are presented in Table 1. Column 1 represents the case where stunting is a binary variable (=1 if a child under 5 suffers from stunting). According to the regression, PLT relative to parish area is associated with a 0.05 reduction in stunting, which corresponds to 17% of the outcome variable's mean.

A mirrored effect can be seen in Column 2, where the height-for-age z-score increases by 0.17 standard deviations. Hence, compared to areas that did not experience agrarian reform, PLT is associated with a significant reduction in child stunting.

Table 2, on the other hand, presents the OLS regression using expropriation relative to parish area as the independent variable. The results are not significant for both measures of stunting: the extensive margin (binary stunting indicator, 0-1) and the intensive margin (height-for-age z-score). This result can be interpreted as evidence of an effect not different from zero of expropriations on child stunting relative to areas that did not experience any form of agrarian reform.

5.2. Instrumental variables estimations (analysis # 2)

Analysis # 2 is the instrumental variables regression results presented in Tables 3 and 4. Each table presents three panels that indicate key results for comparison and discussion: Reduced

Table 1: OLS estimates- PLT (georeferenced)-

	(1) Stunting(0-1)	(2) height for age z-score
PLT(GEO)/area	-0.050	0.167
	(0.022)**	(0.064)***
Observations	6843	6843
Controls	Yes	Yes
Province FE	Yes	Yes
Mean Dep.Var	0.30	-1.35

Cluster standard errors in parentheses
$^{*}\ p < 0.10$, $^{**}\ p < 0.05$, $^{***}\ p < 0.01$

Note: PLT(GEO)/area: PLT Polygon area (in hectares) calculated in GIS from the historical map A1 over parish area (in hectares). Stunting (0-1): Indicator variable that takes the value of 1 if a child is suffering from stunting and 0 otherwise. Height-for-age z-score: Continuous variable that standardizes children's height to international tables; this is calculated using WHO's igrowup package for Stata. Controls include: Agricultural suitability, ruggedness, population (Census 2010), race, year of the survey fixed effect (FE), consumption quantile FE, gender, child order FE, year of birth FE. Cluster is at the parish level:366 total (118 PLT, 248 no agrarian reform)

Table 2: OLS estimates- Expropriation same sample as georeference-

	(1) Stunting(0-1)	(2) height for age z-score
Expropriation(GEO)/area	-0.010	0.097
	(0.034)	(0.099)
Observations	11135	11135
Controls	Yes	Yes
Province FE	Yes	Yes
Mean Dep.Var	0.29	-1.31

Cluster standard errors in parentheses
$^{*}\ p < 0.10$, $^{**}\ p < 0.05$, $^{***}\ p < 0.01$

Note: Expropriation(GEO)/area: Expropriation polygon area (in hectares) calculated in GIS from the historical map A1 over parish area (in hectares). Stunting (0-1): Indicator variable that takes the value of 1 if a child is suffering from stunting and 0 otherwise. Height-for-age z-score: Continuous variable that standardizes children's height to international tables; this is calculated using WHO's igrowup package for Stata. Controls include: Agricultural suitability, ruggedness, population (Census 2010), race, year of the survey fixed effect (FE), consumption quantile FE, gender, child order FE, year of birth FE. Cluster is at the parish level: 499 total (248 expropriation, 251 no agrarian reform).

Form, OLS, and IV estimates. Analysis # 2 is characterised by the used of absolute values in the agrarian reform measures.

For the PLT case, the results are significant and clearly indicate a negative relationship between this land allocation strategy and stunting. Panel A in Table 3 presents the reduced-form regression, i.e., the amount of land devoted to PLT based on the historical map. Although the magnitudes are modest, the coefficients are robust, with an IV exceeding the significance threshold. Panels B and C show the results for the OLS and IV estimates, respectively. As is common in IV applications, the coefficient is larger than in OLS, providing evidence that the amount of land allocated to PLT causes a reduction in stunting by 3% (0.03 standard deviations when compared with the z-score).

In the appendix, I show that when the amount of land devoted to PLT is normalized by land area using contemporary boundaries, the coefficient increases substantially in magnitude. This highlights the need for further examination of area size comparisons over time. To the best of my knowledge, there are no reliable estimates of land size for different parishes prior to 2000.

Table 3: IV model

	(1) Stunting(0-1)	(2) height for age z-score
Panel A: Reduced form		
PLT area GEO(Log)	-0.006	0.019
	(0.003)*	(0.010)*
Panel B: OLS estimates		
PLT area IERAC(Log)	-0.006	0.021
	(0.003)**	(0.008)***
Panel C: IV Estimates		
PLT area IERAC(Log)	-0.011	0.033
	(0.006)*	(0.018)*
Observations	6843	6843
Controls	Yes	Yes
Province FE	Yes	Yes
K-P F-stat	82.85	82.85
Mean Dep.Var	0.30	-1.35

Cluster standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: PLT area GEO(Log): PLT polygon area (in hectares) calculated in GIS from the historical map A1 transformed to a log scale. PLT area IERAC(Log): Amount of land (in hectares) devoted to PLT according to IERAC registries transformed to a log scale Stunting (0-1): Indicator variable that takes the value of 1 if a child is suffering from stunting and 0 otherwise. Height-for-age z-score: Continuous variable that standardizes children's height to international tables; this is calculated using WHO's igrowup package for Stata. Controls include: Agricultural suitability, ruggedness, population (Census 2010), race, parish area, year of the survey fixed effect (FE), consumption quantile FE, gender, child order FE, year of birth FE. Cluster is at the parish level:366 total (118 PLT, 248 no agrarian reform)

The aim of this paper is to provide credible evidence that PLT reduces stunting, while expropriation has a non-significant or even null effect. Evidence for the latter is presented in Table 4. While some estimates are significant at the 10% level, these results, along with those from analysis # 1, support the conclusion that expropriation had no impact on stunting.

Table 4: IV expropriation 2

	(1) Stunting(0-1)	(2) height for age z-score
Panel A: Reduced form		
Expropriation area GEO(Log)	-0.002	0.009
	(0.002)	(0.005)*
Panel B: OLS estimates		
Expropriation area IERAC(Log)	0.001	-0.005
	(0.002)	(0.006)
Panel C: IV Estimates		
Expropriation area IERAC(Log)	-0.005	0.025
	(0.005)	(0.015)*
Observations	11135	11135
Controls	Yes	Yes
Province FE	Yes	Yes
K-P F-stat	45.91	45.91
Mean Dep.Var	0.29	-1.31

Cluster standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: Expropriation area GEO(Log): Expropriation polygon area (in hectares) calculated in GIS from the historical map A1 transformed to a log scale. Expropriation area IERAC(Log): Amount of land (in hectares) devoted to expropriation according to IERAC registries transformed to a log scale Stunting (0-1): Indicator variable that takes the value of 1 if a child is suffering from stunting and 0 otherwise. Height-for-age z-score: Continuous variable that standardizes children's height to international tables; this is calculated using WHO's igrowup package for Stata. Controls include: Agricultural suitability, ruggedness, population (Census 2010), race, parish area, year of the survey fixed effect (FE), consumption quantile FE, gender, child order FE, year of birth FE. Cluster is at the parish level:366 total (248 expropriation, 251 no agrarian reform).

5.3. Descriptive evidence from 1986 survey

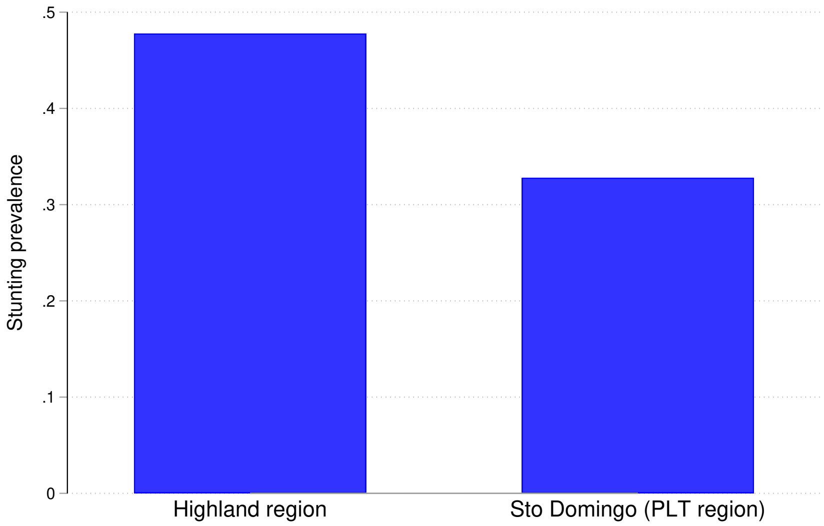
To finalize this section, I present suggestive evidence that the relationship between PLT and stunting is not likely to depend on the specific years of the Living Standards Surveys. In the 1980s, the DANS survey collected data on anthropometrics and produced the first estimates of child stunting in Ecuador, which is acknowledged as the first official source as well. The survey was conducted in certain provinces and, while it is representative at the national level, it is not at the provincial level, except for the two largest cities, Quito and Guayaquil.

An additional limitation of the raw data I accessed is that it is not possible to match specific codes to current or old maps, as the codification followed a different protocol. Because of this, I relied on the companion report published in CONADE and MSP (1988) to identify aggregate regions and the Santo Domingo area. Santo Domingo is a region that emerged exclusively due to PLT intervention (Barsky, 1984).

With this limited information, I plot Figure 5, where I compare Santo Domingo (primarily a PLT region) with the highland region (mainly an expropriation region plus areas not intervened). It is evident that Santo Domingo exhibits a lower stunting rate than the highland region.

This relationship holds across different comparisons between Santo Domingo and other areas that were largely affected by expropriation or not impacted by agrarian reform. This provides suggestive evidence that the impact of PLT on stunting is not dependent on the survey years and can be observed in other datasets.

Figure 5: Stunting prevalence highlands region vs Sto Domingo (PLT region). DANS 1986



Note: Stunting rate in Sto. Domingo, which is a province solely affected by PLT, and the highlands region, which was in its majority affected by expropriations.

5.4. Robustness and additional results

I present a set of additional results and robustness checks to support the main conclusions of the paper. The core findings are framed as a policy intervention-such as PLT-compared with locations that were not affected by the agrarian reform. Tables A2 and A3 report estimates using alternative samples, including all observations (i.e., not limited to comparisons against areas that did not receive agrarian reform). While the results for PLT lose some statistical strength-remaining significant at the 15% level for the binary measure and at the 10% level for the height-for-age-z-score- they continue to support the same qualitative conclusions. In contrast, I find no statistically significant effects for expropriation; even for the binary measure of stunting, the results remain null.

As discussed previously, obtaining shares at the parish level could be misleading since there is no georeferenced information about the size of the parishes prior to the 21st Century. This can cause problems when using the IERAC's registry data. For this reason, I followed a strategy based on the absolute numbers of land transfers in analysis #2 and calculated shares only when using the georeferenced information. Tables A1, A4, and A5 present results for the OLS and IV models, respectively, when calculating shares using IERAC's registry data and current parish area. The magnitudes of the coefficients are large, which might reflect the fact that parishes shrank over time, which affects the information coming from the IERAC registries if one wants to obtain relative measures. However, the qualitative interpretation remains unchanged, along with the sign direction and main conclusions. Finally, I present results for the IV model excluding the parish area as an explicit control (Tables A6 and A7). Results do not change.

6. Mechanism

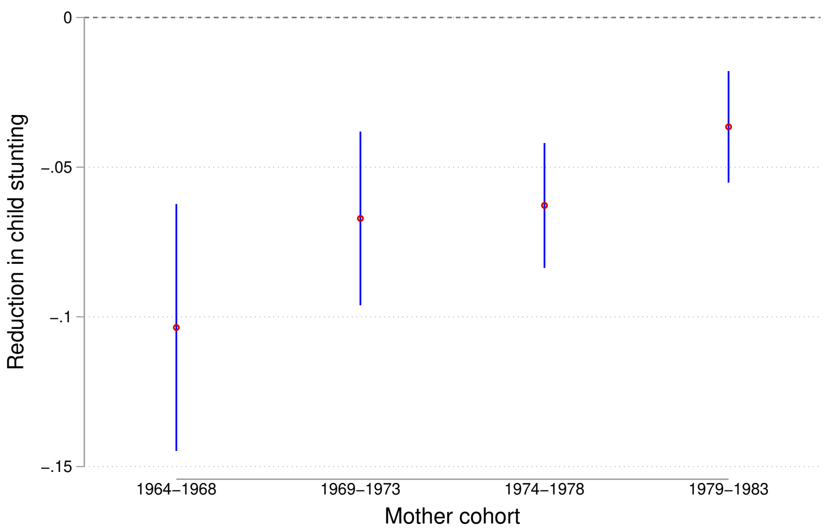
6.1. Human capital driven mechanism

Why is PLT effective in reducing stunting? Public land settlement policies had as their principal aim to expand the agricultural frontier and promote new human settlements for the internal population. When projects were planned to take place in unoccupied areas, the government needed to construct infrastructure in the form of villages, including schools (see Albertus (2023) for a detailed study on Francoist Spain). Some of these initial investments may have occurred since, according to the PLT legislation, social investment must be made to make the new settlement attractive. Barsky (1984) highlights processes of this type, which he labelled as "oriented colonization", to be found in the following provinces: Esmeraldas, Guayas, Imbabura, Manabí, Morona, Napo, and Zamora.

In this section, I will argue in favour of a human capital-driven mechanism. Using the cohorts of mothers from children surveyed in the data sets used, I identified cohorts that were exposed differentially to the agrarian reform. In a nutshell, mothers who were highly exposed to agrarian reform in their early years exhibit lower rates of stunting for their children. Furthermore, the cohort which was more exposed to PLT, those who had between 0-5 years when the reform started, exhibit more years of schooling. This effect is non-significant when analysing cohorts in the expropriation areas.

Figure 6 presents the estimates from a model where the dependent variable is a binary measure of stunting, and the main independent variable is a categorical indicator of a mother's birth cohort relative to the start of the agrarian reform, whereas, mothers born between 1964 and 1968 were highly exposed to the original reform itself, while younger cohorts experienced less exposure. The model includes the same set of controls as in the main analysis. Mothers highly exposed to the reform have, on average, lower stunting rates. This difference is more pronounced and significant when comparing highly exposed mothers to those with lower exposure.

Figure 6: Reduction in stunting by cohort exposure to the agrarian reform

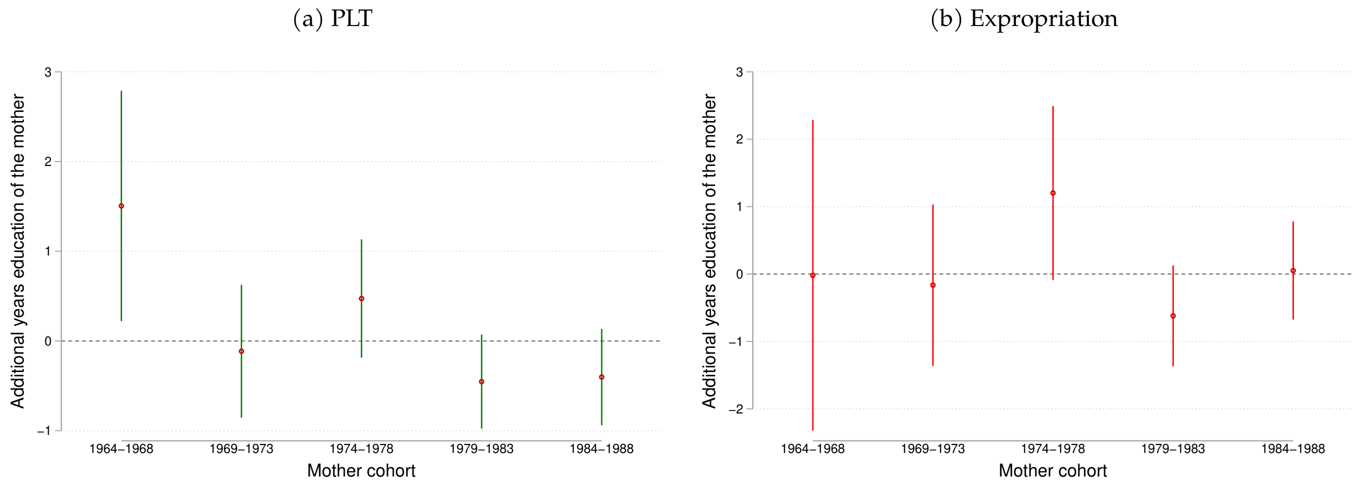


Note: The Figure plots the interaction coefficients between mothers' cohorts and their children's stunting prevalence. Estimations are relative to cohort 1984-1988

One possible explanation for this pattern is that older mothers take better care of their children. However, other explanations could also arise. Human capital is a widely accepted factor for child care. Mothers who were more exposed to the original reform, may have had increase their education. For the case of Peru, Albertus et al. (2020) argues that human capital accumulation did not happen. However, since PLT had a different land allocation structure, this is a different scenario.

Figures 7 show the differential gains in education by mother cohort relative to the start of the agrarian reform, distinguishing between areas subject to PLT and expropriation. On average, mothers highly exposed to PLT during the reform attained more years of education compared to those less exposed, though this effect is primarily driven by the earliest exposed cohort. In contrast, expropriation does not appear to have had a significant impact on human capital accumulation (measured in years of schooling), as the estimates are not significantly different from zero.

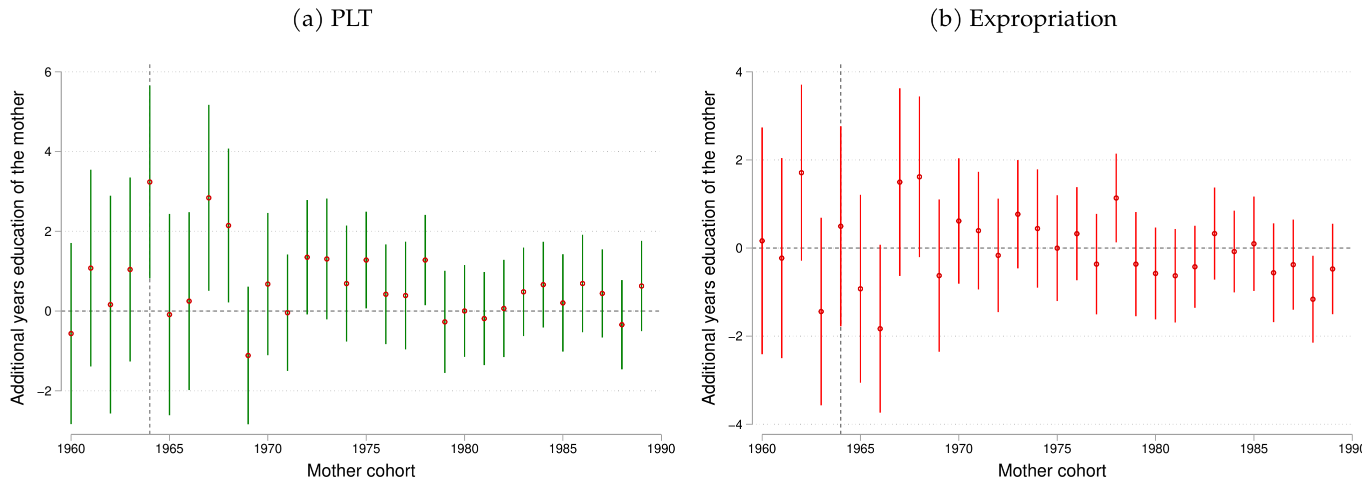
Figure 7: Exposure to PLT and human capital accumulation-Intensive margins'



Note: The Figure plots the interaction between mothers' cohorts and the intensive margin of PLT (Panel a)) and expropriation (Panel b)). The outcome is the mothers' years of schooling.

To strengthen the confidence in these results and provide transparency regarding data limitations, I include Figure 8, which presents results at the extensive margin for the type of policy applied during the agrarian reform-that is, by constructing categorical variables indicating whether a parish was affected by PLT or expropriation. Using individual cohorts, the results again show that expropriation has no effect significantly different from zero (Panel b)). In the case of PLT (Panel a)), there are significant effects for cohorts born around the start of the agrarian reform (1964). While the estimates are clear, the sample size constraints for each individual year may contribute to some effects being non-significant. Taken together, this provides suggestive evidence that the proposed reasoning is plausible and that the short-run effects of PLT investments may have translated into human capital accumulation, ultimately leading to improved child care and lower stunting rates. This mechanism is consistent with Banerjee et al. (2020), who argue that infrastructure does not necessarily lead to permanent or equitable growth in contexts where institutional factors contribute to factor immobility.

Figure 8: Exposure to PLT and human capital accumulation-Extensive margins-All cohorts



Note: The Figure plots the interaction between mothers' cohorts and the intensive margin of PLT (Panel a)) and expropriation (Panel b)). The outcome is the mothers' years of schooling. These estimates are relative to 1989 cohort.

7. Conclusions

In this paper, I have studied the relationship between agrarian reform and child stunting in Ecuador. As a current public policy concern, understanding the impact of different policies on child stunting is instrumental in designing effective development projects.

I use a combination of historical and contemporary data to analyze the effects of the two main land allocation policies implemented during Ecuador's agrarian reform: PLT and expropriation. When examining expropriation, I find that its effect on child stunting is either null or close to null. In contrast, PLT shows a strong and robust negative relationship with stunting. Given the nationwide scope of the analysis, I control for various regional, geographical, and individual factors. To establish a causal relationship, I employ an instrumental variables strategy using historical maps and registries from the agency responsible for implementing the agrarian reform.

Since calculating shares is challenging due to changes in parish boundaries over time, I provide conservative estimates suggesting that PLT reduced stunting by 3% to 17%. In the appendix, I present additional results using contemporary land areas, which yield larger and significant effects. However, to maintain a cautious approach, I rely on the conservative estimates in the main text. Despite this, the findings clearly indicate a strong and significant negative relationship between PLT and stunting. In contrast, the relationship between expropriation and stunting is statistically insignificant, and arguably null.

Regarding the mechanism, I observe that mothers exposed to agrarian reform in their early years experienced a greater reduction in child stunting rates. I show that human capital accumulation, measured in years of schooling, is higher for these mothers in PLT areas. However, I find no significant human capital accumulation effect among mothers exposed to expropriation. This suggests that the reduction in stunting associated with PLT was driven by the educational gains of mothers highly exposed to the policy, rather than those born long after its implementation. Further research is needed to understand the marked differences between mother's cohorts in terms of human capital accumulation, especially when they were exposed to PLT or expropriation.

Declaration of generative AI and AI-assisted technologies in the manuscript preparation process

During the preparation of this work the author(s) used ChatGPT in order to correct spelling and grammar. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the published article.

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Appendix

Figure A1: IERAC historic map: Original

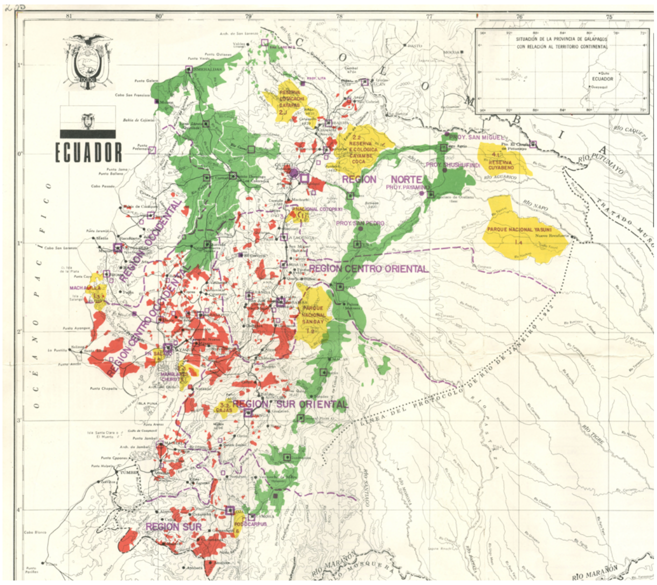


Figure A2: Density z scores

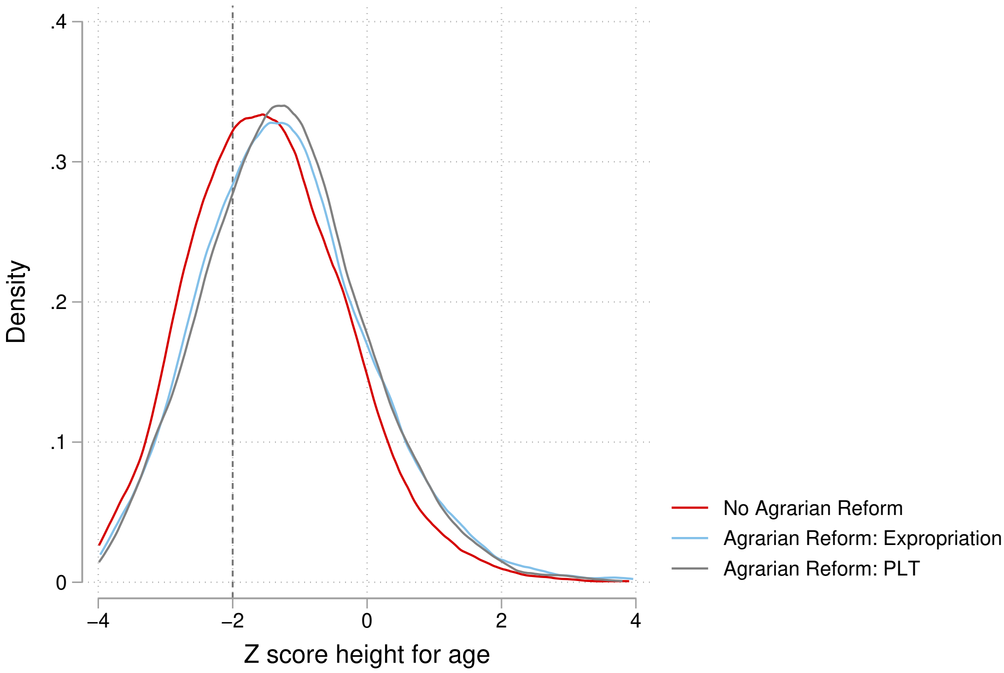


Table A1: OLS estimates- PLT as a share of contemporary parish area-

	(1) Stunting(0-1)	(2) height for age z-score
PLT(IERAC)/area	-0.284	0.455
	(0.080)***	(0.201)**
Observations	6843	6843
Controls	Yes	Yes
Province FE	Yes	Yes
Mean Dep.Var	0.30	-1.35

Cluster standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: PLT(IERAC)/area: Amount of land (in hectares) devoted to PLT according to IERAC registries over parish area (in hectares). Stunting (0-1): Indicator variable that takes the value of 1 if a child is suffering from stunting and 0 otherwise. Height-for-age z-score: Continuous variable that standardizes children's height to international tables; this is calculated using WHO's igrowup package for Stata. Controls include: Agricultural suitability, ruggedness, population (Census 2010), race, year of the survey fixed effect (FE), consumption quantile FE, gender, child order FE, year of birth FE. Cluster is at the parish level:366 total (118 PLT, 248 no agrarian reform)

Table A2: OLS estimates- PLT all sample-

	(1) Stunting(0-1)	(2) height for age z-score
PLT(GEO)/area	-0.027	0.103
	(0.018)$^{+}$	(0.058)*
Observations	15943	15943
Controls	Yes	Yes
Province FE	Yes	Yes
Mean Dep.Var	0.29	-1.29

Cluster standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: PLT(GEO)/area: PLT Polygon area (in hectares) calculated in GIS from the historical map A1 over parish area (in hectares). Stunting (0-1): Indicator variable that takes the value of 1 if a child is suffering from stunting and 0 otherwise. Height-for-age z-score: Continuous variable that standardizes children's height to international tables; this is calculated using WHO's igrowup package for Stata. Controls include: Agricultural suitability, ruggedness, population (Census 2010), race, year of the survey fixed effect (FE), consumption quantile FE, gender, child order FE, year of birth FE. Cluster is at the parish level:712 total (195 PLT, 517 no agrarian reform or expropriation)

Table A3: OLS estimates- Expropriation all sample-

	(1) Stunting(0-1)	(2) height for age z-score
Expropriation(GEO)/area	-0.000	0.074
	(0.030)	(0.089)
Observations	15943	15943
Controls	Yes	Yes
Province FE	Yes	Yes
Mean Dep.Var	0.29	-1.29

Cluster standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: Expropriation(GEO)/area: Expropriation polygon area (in hectares) calculated in GIS from the historical map A1 over parish area (in hectares). Stunting (0-1): Indicator variable that takes the value of 1 if a child is suffering from stunting and 0 otherwise. Height-for-age z-score: Continuous variable that standardizes children's height to international tables; this is calculated using WHO's igrowup package for Stata. Controls include: Agricultural suitability, ruggedness, population (Census 2010), race, year of the survey fixed effect (FE), consumption quantile FE, gender, child order FE, year of birth FE. Cluster is at the parish level: 712 total (287 expropriation, 425 no agrarian reform or PLT).

Table A4: IV Results using shares relative to contemporary parish area-PLT

	(1) Stunting(0-1)	(2) height for age z-score
	Panel A: Reduced form	
PLT(GEO)/area	-0.050	0.167
	(0.022)**	(0.064)***
	Panel B: IV Estimates	
PLT(IERAC)/area	-0.553	1.837
	(0.252)**	(0.810)**
Observations	6843	6843
Controls	Yes	Yes
Province FE	Yes	Yes
K-P F-stat	18.94	18.94
Mean Dep.Var	0.30	-1.35

Cluster standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: PLT(GEO)/area: PLT polygon area (in hectares) calculated in GIS from the historical map A1 over parish area. PLT(IERAC)/area: Amount of land (in hectares) devoted to PLT according to IERAC registries over parish area. Stunting (0-1): Indicator variable that takes the value of 1 if a child is suffering from stunting and 0 otherwise. Height-for-age z-score: Continuous variable that standardizes children's height to international tables; this is calculated using WHO's igrowup package for Stata. Controls include: Agricultural suitability, ruggedness, population (Census 2010), race, year of the survey fixed effect (FE), consumption quantile FE, gender, child order FE, year of birth FE. Cluster is at the parish level:366 total (118 PLT, 248 no agrarian reform)

Table A5: IV Results using shares relative to contemporary parish area-Expropriation

	(1) Stunting(0-1)	(2) height for age z-score
Panel A: Reduced form		
Expropriation(GEO)/area	-0.010	0.097
	(0.034)	(0.099)
Panel B: IV Estimates		
Expropriation(IERAC)/area	-0.145	1.423
	(0.509)	(1.658)
Observations	11135	11135
Controls	Yes	Yes
Province FE	Yes	Yes
K-P F-stat	9.02	9.02
Mean Dep.Var	0.29	-1.31

Cluster standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: Expropriation(GEO)/area: Expropriation polygon area (in hectares) calculated in GIS from the historical map A1 over parish area. Expropriation(IERAC)/area: Amount of land (in hectares) devoted to expropriation according to IERAC registries over parish area. Stunting (0-1): Indicator variable that takes the value of 1 if a child is suffering from stunting and 0 otherwise. Height-for-age z-score: Continuous variable that standardizes children's height to international tables; this is calculated using WHO's igrowup package for Stata. Controls include: Agricultural suitability, ruggedness, population (Census 2010), race, year of the survey fixed effect (FE), consumption quantile FE, gender, child order FE, year of birth FE. Cluster is at the parish level:366 total (248 expropriation, 251 no agrarian reform).

Table A6: IV estimates- PLT not including area control

	(1) Stunting(0-1)	(2) height for age z-score
Panel A: Reduced form		
PLT area GEO(Log)	-0.006	0.019
	(0.003)*	(0.010)**
Panel B: OLS estimates		
PLT area IERAC(Log)	-0.006	0.021
	(0.003)**	(0.008)***
Panel C: IV Estimates		
PLT area IERAC(Log)	-0.011	0.034
	(0.006)*	(0.018)*
Observations	6843	6843
Controls	Yes	Yes
Province FE	Yes	Yes
K-P F-stat	79.82	79.82
Mean Dep.Var	0.30	-1.35

Cluster standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: PLT area GEO(Log): PLT polygon area (in hectares) calculated in GIS from the historical map A1 transformed to a log scale. PLT area IERAC(Log): Amount of land (in hectares) devoted to PLT according to IERAC registries transformed to a log scale Stunting (0-1): Indicator variable that takes the value of 1 if a child is suffering from stunting and 0 otherwise. Height-for-age z-score: Continuous variable that standardizes children's height to international tables; this is calculated using WHO's igrowup package for Stata. Controls include: Agricultural suitability, ruggedness, population (Census 2010), race, year of the survey fixed effect (FE), consumption quantile FE, gender, child order FE, year of birth FE. Cluster is at the parish level:366 total (118 PLT, 248 no agrarian reform)

Table A7: IV estimates- Expropriation not including area control

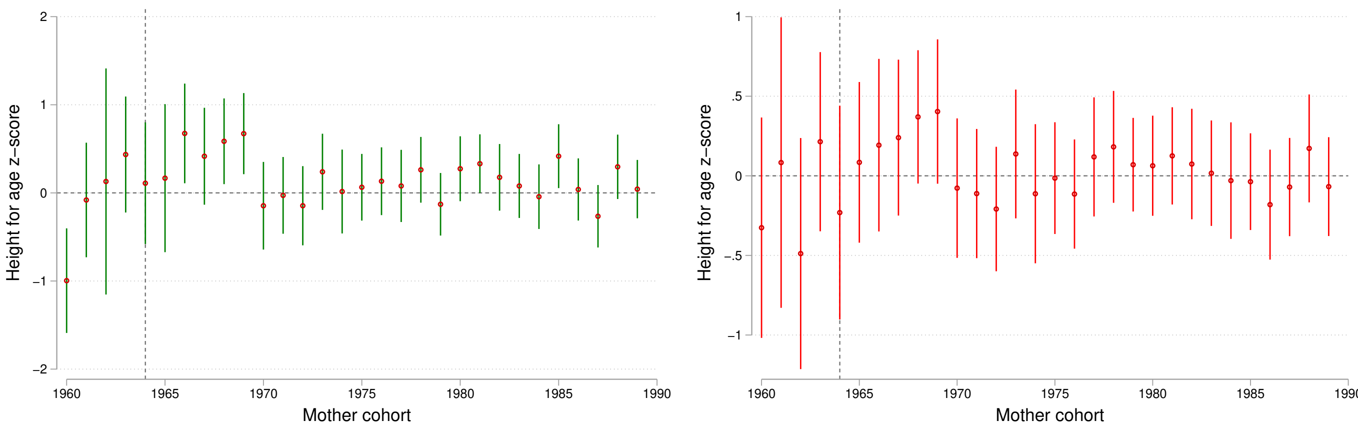
	(1) Stunting(0-1)	(2) height for age z-score
Panel A: Reduced form		
Expropriation area GEO(Log)	-0.002	0.008
	(0.002)	(0.005)*
Panel B: OLS estimates		
Expropriation area IERAC(Log)	0.001	-0.005
	(0.002)	(0.006)
Panel C: IV Estimates		
Expropriation area IERAC(Log)	-0.005	0.023
	(0.005)	(0.015)
Observations	11135	11135
Controls	Yes	Yes
Province FE	Yes	Yes
K-P F-stat	44.44	44.44
Mean Dep.Var	0.29	-1.31

Cluster standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: Expropriation area GEO(Log): Expropriation polygon area (in hectares) calculated in GIS from the historical map A1 transformed to a log scale. Expropriation area IERAC(Log): Amount of land (in hectares) devoted to expropriation according to IERAC registries transformed to a log scale Stunting (0-1): Indicator variable that takes the value of 1 if a child is suffering from stunting and 0 otherwise. Height-for-age z-score: Continuous variable that standardizes children's height to international tables; this is calculated using WHO's igrowup package for Stata. Controls include: Agricultural suitability, ruggedness, population (Census 2010), race, year of the survey fixed effect (FE), consumption quantile FE, gender, child order FE, year of birth FE. Cluster is at the parish level:366 total (248 expropriation, 251 no agrarian reform).

Figure A3: Stunting reduction-All cohorts-

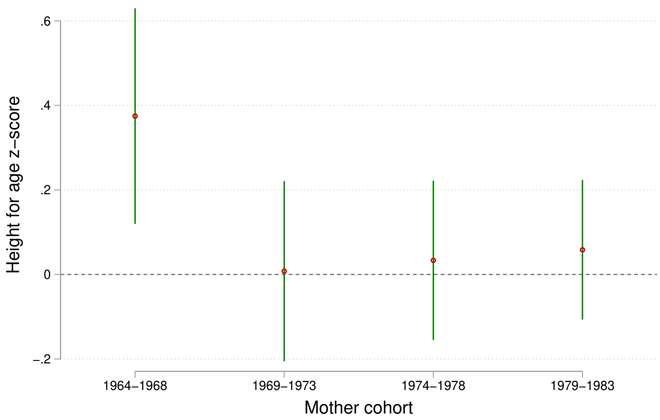
(a) PLT (b) Expropriation



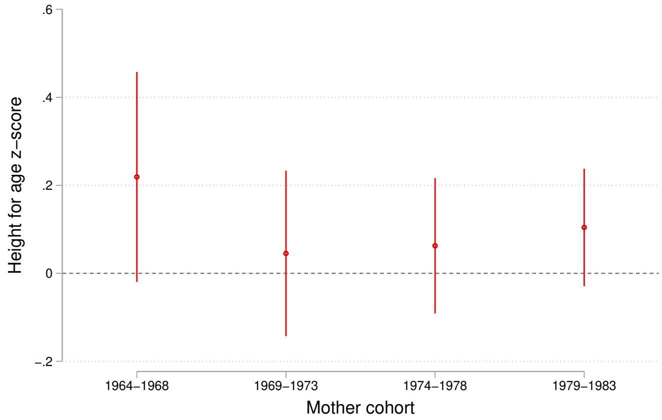
Note: The Figure plots the interaction between mothers' cohorts and the intensive margin of PLT (Panel a)) and expropriation (Panel b)). The outcome is the stunting prevalence of mothers' children. These estimates are relative to 1989 cohort.

Figure A4: Stunting reduction-group cohort-

(a) PLT



(b) Expropriation



Note: The Figure plots the interaction coefficients between mothers' cohorts and their children's stunting prevalence by type of policy, PLT (Panel a)) and expropriation (Panel b)). Estimations are relative to cohort 1984-1988

Table A8: Descriptive

	(1) No agrarian reform					(2) PLT					(3) Expropriation				
	mean	sd	min	max	count	mean	sd	min	max	count	mean	sd	min	max	count
Stunting indicator(0-1)	0.35	0.48	0.00	1.00	4045	0.29	0.45	0.00	1.00	4463	0.27	0.44	0.00	1.00	8059
Length/height-for-age z-score	-1.51	1.25	-5.92	4.57	4045	-1.25	1.34	-5.88	5.09	4463	-1.25	1.27	-5.97	5.23	8059
Race(1=Indigenous)	0.17	0.37	0.00	1.00	4045	0.30	0.46	0.00	1.00	4463	0.13	0.34	0.00	1.00	8059
Mother education(years)	8.99	4.23	0.00	22.00	3884	8.95	3.89	0.00	21.00	4242	9.64	4.39	0.00	21.00	7742
Gender(1=male)	1.47	0.50	1.00	2.00	4045	1.49	0.50	1.00	2.00	4463	1.48	0.50	1.00	2.00	8059
Consumption quantile	1.69	1.04	1.00	5.00	4036	1.57	0.97	1.00	5.00	4452	1.97	1.16	1.00	5.00	8049
Observations	4045					4463					8059				

Table A9: Descriptive2

	(1) No agrarian reform					(2) PLT					(3) Expropriation				
	mean	sd	min	max	count	mean	sd	min	max	count	mean	sd	min	max	count
PLT(GEO)/area	0.00	0.00	0.00	0.00	283	0.51	0.36	0.00	1.00	177	.	.	.	.	0
PLT(GEO)/area(all sample)	0.00	0.00	0.00	0.00	283	0.51	0.36	0.00	1.00	177	0.00	0.00	0.00	0.00	288
PLT area GEO(Log)	0.00	0.00	0.00	0.00	283	3.69	4.55	0.00	11.52	177	0.00	0.00	0.00	0.00	288
PLT area IERAC(Log)	0.79	1.80	0.00	7.69	283	4.11	3.70	0.00	12.09	177	0.97	2.08	0.00	9.33	288
Expropriation(GEO)/area	0.00	0.00	0.00	0.00	283	.	.	.	.	0	0.22	0.23	0.00	1.00	288
Expropriation(GEO)/area(all sample)	0.00	0.00	0.00	0.00	283	0.00	0.00	0.00	0.00	177	0.22	0.23	0.00	1.00	288
Expropriation area GEO(Log)	0.00	0.00	0.00	0.00	283	0.00	0.00	0.00	0.00	177	7.19	1.84	0.04	10.51	288
Expropriation area IERAC(Log)	1.26	2.03	0.00	8.16	283	0.20	1.13	0.00	8.31	177	3.34	3.16	0.00	9.35	288
Agricultural suitability	0.62	0.26	0.01	0.98	248	0.64	0.22	0.08	0.98	177	0.73	0.18	0.05	0.95	269
Ruggedness	2.0e+05	1.4e+05	638.40	6.0e+05	283	1.0e+05	1.1e+05	1135.24	4.6e+05	177	2.1e+05	1.5e+05	1392.85	5.7e+05	288
Population(2010 Census)	10241.85	21363.13	370.58	2.3e+05	283	11072.03	30334.92	423.20	3.2e+05	177	31854.60	1.7e+05	592.54	2.4e+06	288
Parish area(contemporary boundaries)	19594.45	69741.92	302.46	8.2e+05	283	37411.68	39059.43	2456.11	2.9e+05	177	19069.75	21510.14	978.32	2.4e+05	288
Observations	283					177					288				