

## Week 4

---

## Research Discontinuity Designs

---

see jupyter notebook

---

two excellent sources:

- Cattaneo, Idrobo and Titiunik (2008) "A Practical Introduction to Regression Discontinuity Designs: Part I," in Cambridge Elements: Quantitative and Computational Methods for Social Science, Cambridge University Press. See also "Part II" paper.
- Meyersson (2014): [Islamic Rule and the Empowerment of the Poor and Pious](#), *Econometrica* 82(1): 229-269.

Links to these papers and data and both Stata and R code for replication at [RD Software Packages site](#).

---

### Sharp RD

Assignment to treatment status is a deterministic and discontinuous function of a covariate (running variable or forcing variable)  $X_i$

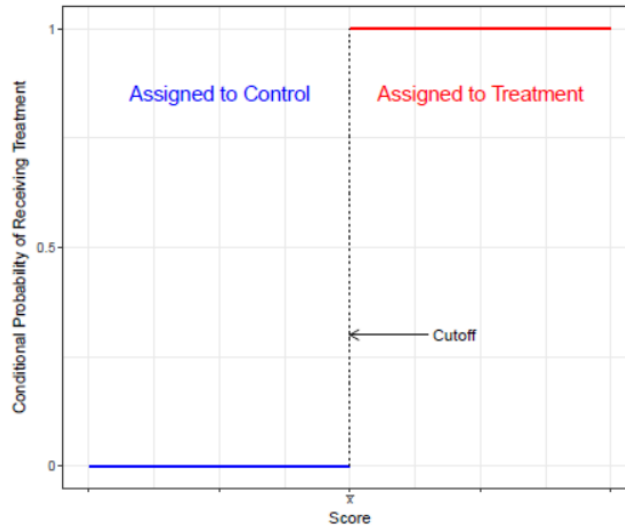
$$D_i = \begin{cases} 1 & \text{if } X_i \geq X_0 \\ 0 & \text{if } X_i < X_0 \end{cases}$$

where  $X_0$  is a threshold or cutoff.

---

**Example:** National Merit scholarship awarded to all students with PSAT score above some threshold.

Figure 2.1: Conditional Probability of Receiving Treatment in Sharp RD Design



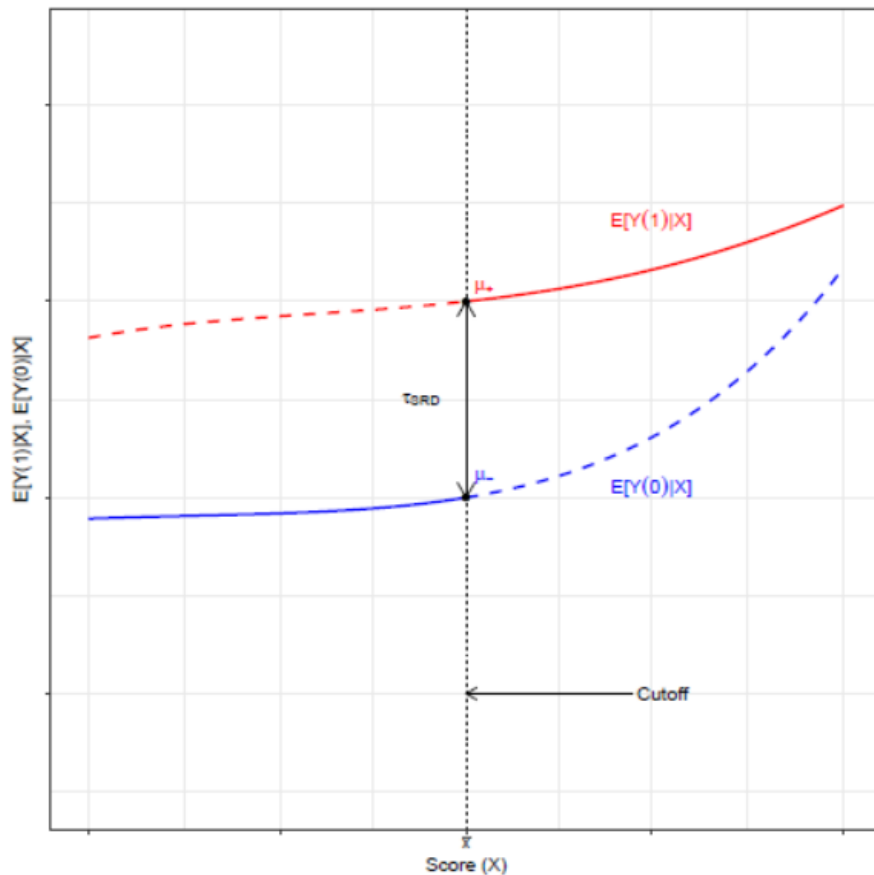
$Y_i(1)$  and  $Y_i(0)$  are potential outcomes observed under treatment or control, respectively.  $E[Y_i(1)|X_i]$  observed only to right of cutoff.  $E[Y_i(0)|X_i]$  only to left.

Treatment effect estimated as

$$\tau_{SRD} = E[Y_i(1) - Y_i(0)|X_i = X_0]$$

Local treatment effect at/near the cutoff. In practice SRD estimate estimated as difference between weighted average of outcomes on the either side of the discontinuity.

Figure 2.2: RD Treatment Effect in Sharp RD Design



---

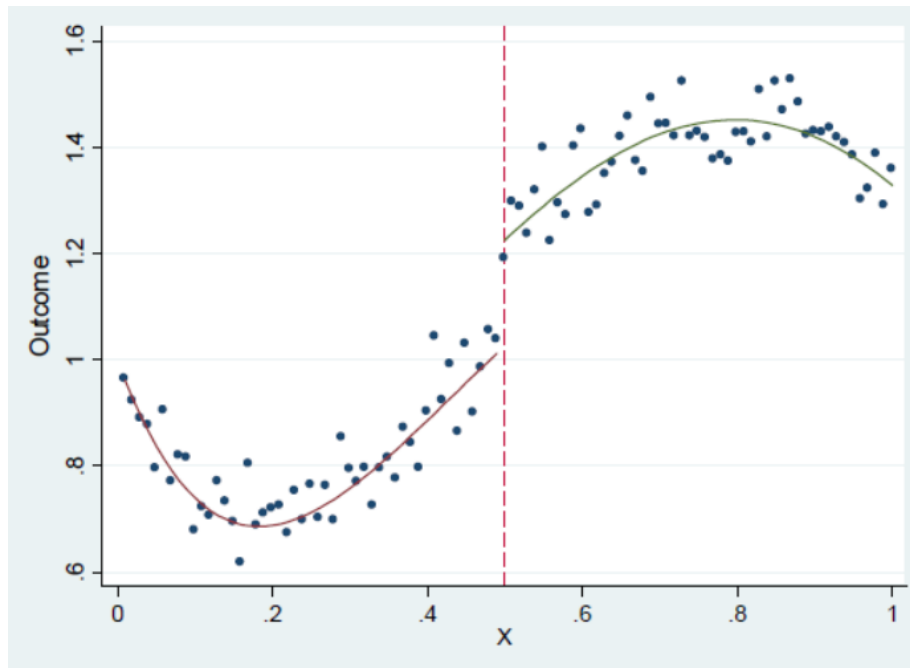
Conditional independence:

$$E[Y_i(0)|X_i, D_i] = E[Y_i(0)|X_i]$$

once we control for cofounder  $X_i$ , treatment assignment as good as random.

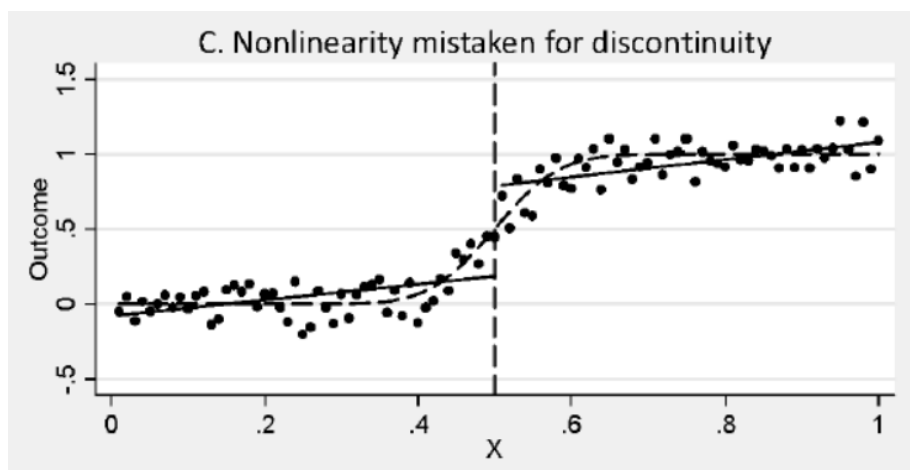
For observations very close to the discontinuity we effectively have an experiment.

---



---

Non-linearity must not be mistaken for a discontinuity. In this example with linear fits on each side, estimate a positive 'treatment' effect. More likely relationship is non-linear with zero treatment effect.



---

Example from Meyersson (2014)

**Identifying impacts of municipal election victories by Islamic political parties on educational attainment of women**

*X - running variable*

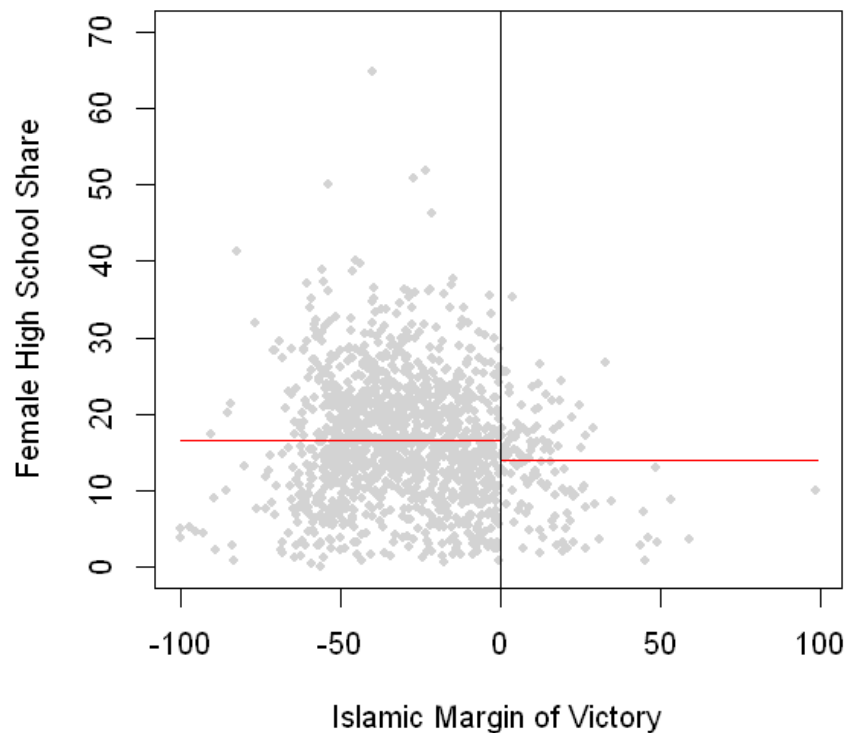
$Y$  - outcome women's high-school completion rate

$T$  - treatment Islamic party comes to power in municipal government

---

### Raw Comparison of means (Figure 2.3a)

If simply compare outcomes in treated (Islamic major) and non-treated (secular majority) areas, we find lower female educational attainment in treated areas.



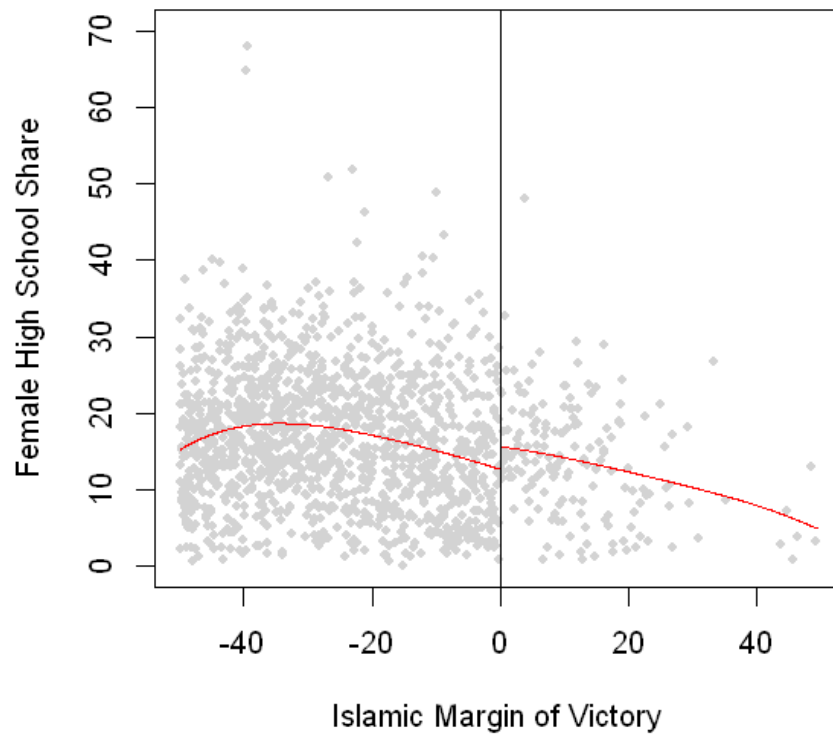
### Local comparison of means: Narrowing the bandwidth

In last plot we compared mean value in treated and control group. But these two groups differ considerably.

Below we focus on more 'local' effects (closer to just above and below the cutoff).

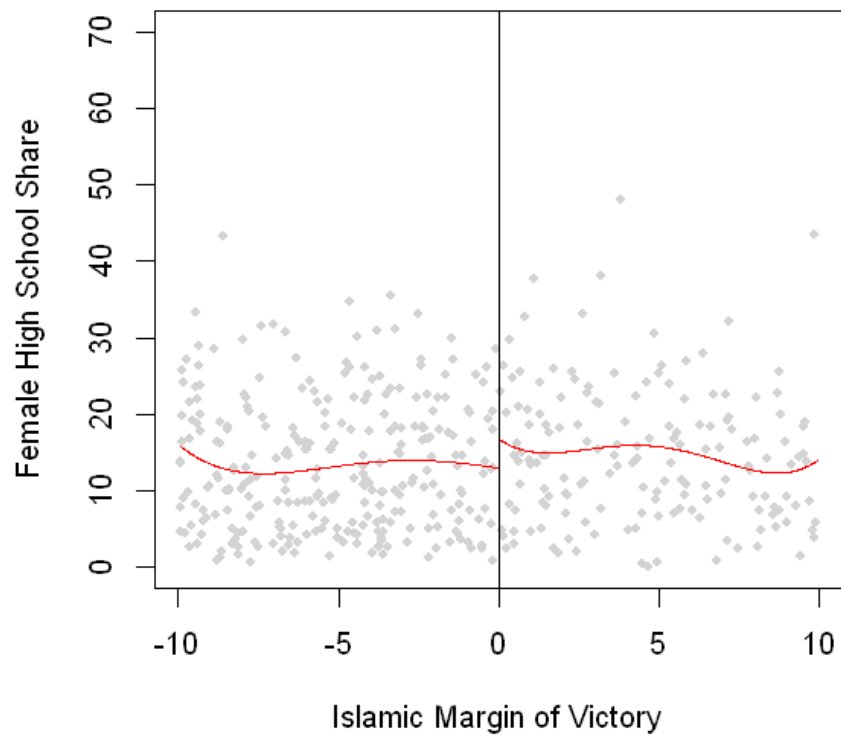
In next plot we fit a 4th degree polynomial on each side but now limit bandwidth to 'closer' contests where absolute victory margin was within 50 points.

---



---

Victory margin was within 10 points.



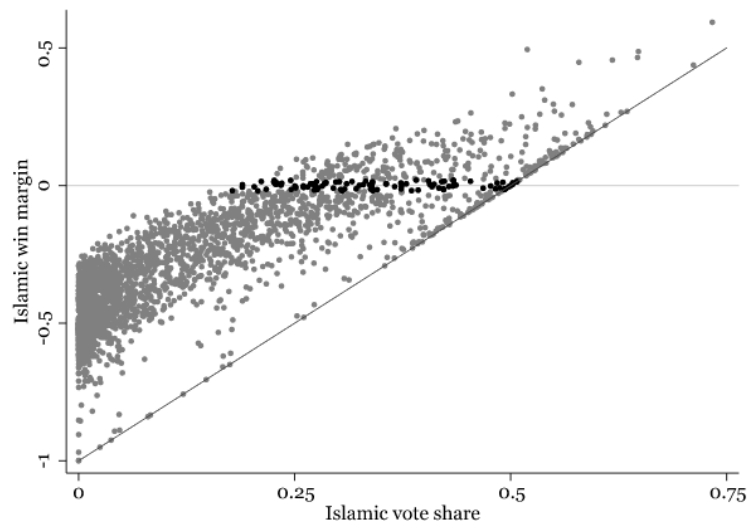


FIGURE 1.—Islamic win margin and Islamic vote share in 1994. The graph shows the total vote share for the Islamic party plotted against the Islamic win margin—the difference between the Islamic party's vote share and the largest secular party's vote share—both in 1994. Observations within 2 percentage points of the threshold at zero are in black. The diagonal line is the hypothetical one-to-one relationship between the two variables in an election with only two parties.

## RD plots

- scatter plots (as above) make it hard to discern 'jumps'
- RD plots aggregate or 'smooth' data before plotting.
  - local sample means (from bins) represented by dots
  - polynomial (or local linear) fits

Plenty of variation in bin and bandwidth selection and curve fitting based on these concepts.

The estimating equation:

$$Y_i(0) = f(X_i) + \epsilon_i$$

$$Y_i(1) = Y_i(0) + \beta$$

All in one:

$$Y_i = f(X_i) + \beta D_i + \epsilon_i$$

The function  $f(X_i)$  (e.g. a polynomial) must be continuous at  $X_0$

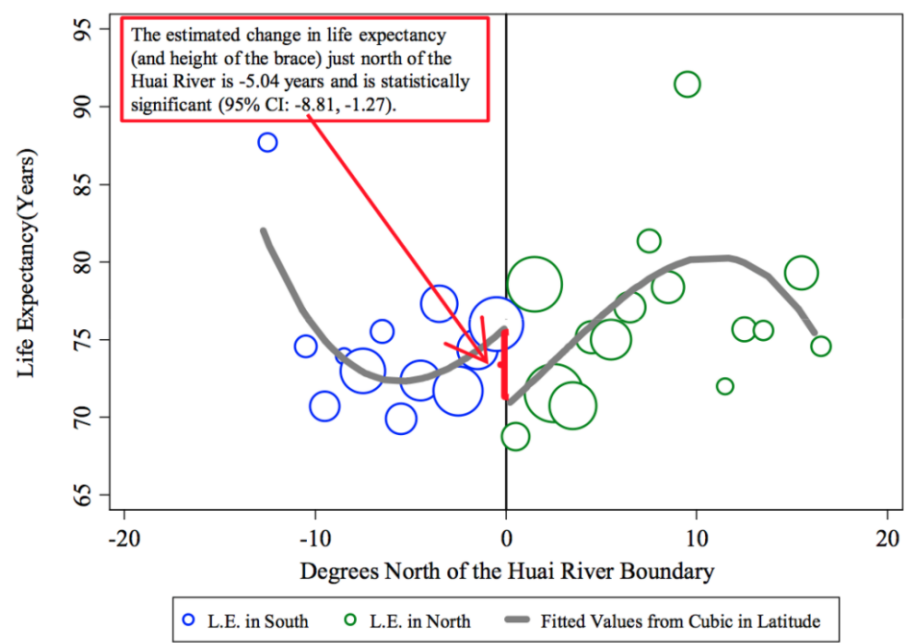
The RD estimate is difference between weighted average of outcomes on the either side of the discontinuity. Fitting a high order polynomial can mean these weighted averages are driven by observations far from the threshold.

Parametric (polynomial on full data) or non-parametric (local regression closer to cutoff) approaches?

Andrew Gelman's [blog post from 8/13](#) discusses this issue. See also [Development Impact Blog](#)

Chen et al (2013) "Evidence on the impact of sustained exposure to air pollution on life expectancy from China's Huai River policy," *PNAS*.

**Policy discontinuity:** North of China's Huai river free coal for heating is distributed in winter. None to the south. Using RDD method find total suspended particulates (TSPs) air pollution 55% higher just North of river compared to just south. Estimates China's coal-burning was reducing lifespan by 5 years for half a billion people.



Are observations far from threshold affecting polynomial fit, driving results?  
Smaller estimates with linear fits?

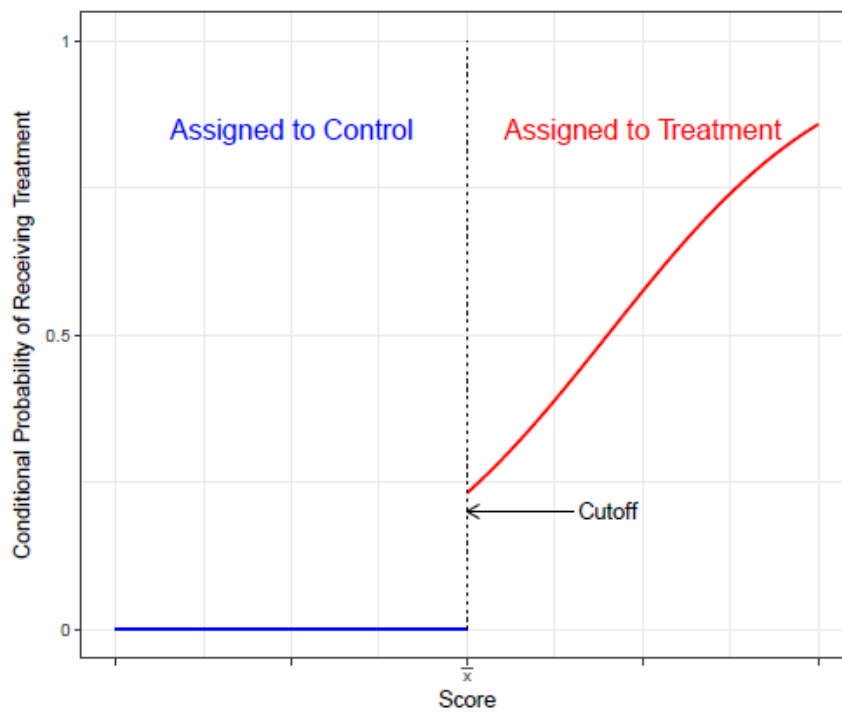
**Table S9**

Robustness checks of choice of functional form for latitude

	Linear & Controls	Quadratic & Controls	Cubic & Controls	Quartic & Controls	Quintic & Controls
	(1)	(2)	(3)	(4)	(5)
Panel 1: Impact of "North" on the Listed Variable, Ordinary Least Squares					
TSP (100 µg/m³)	2.89*** (0.56)	2.63*** (0.49)	1.84*** (0.63)	1.95*** (0.59)	1.52** (0.72)

## Fuzzy RD

A fuzzy RD is like an RD with imperfect compliance or non-compliance. Assignment to Treatment is as before summarized by indicator  $I(X_i \geq X_0)$  but compliance is now imperfect. Like an Intent-to-Treat (ITT) estimator, the measured jump at the cutoff in the outcome needs to be rescaled.



(b) Fuzzy RD (One-Sided)

Structural equation:  $Y_i = f(X_i) + \beta D_i + \epsilon_i$

2nd stage reduced form:  $Y_i = f(X_i) + \pi_2 I(X_i \geq X_0) + \xi_{2i}$

First stage:  $D_i = g(X_i) + \pi_1 I(X_i \geq X_0) + \xi_{1i}$

Standard IV:  $\beta = \frac{\pi_2}{\pi_1}$

## Multi-Score RD design

Example: Third graders have to go to summer school if score below  $X_{10}$  in reading test OR below  $X_{20}$  in math test. Does summer school raise test performance next year?

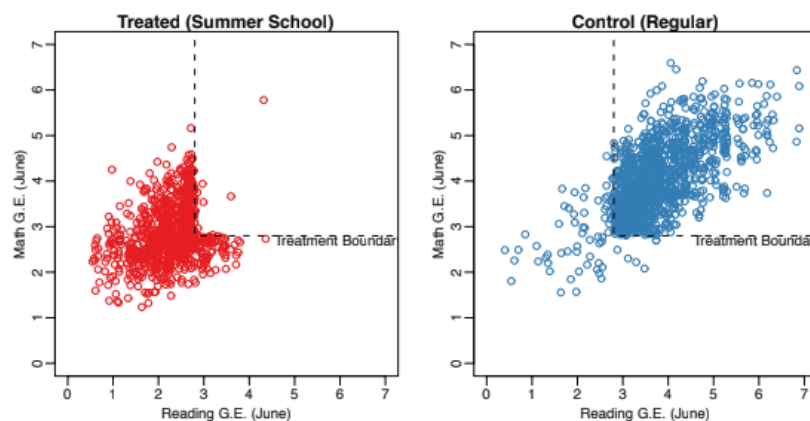
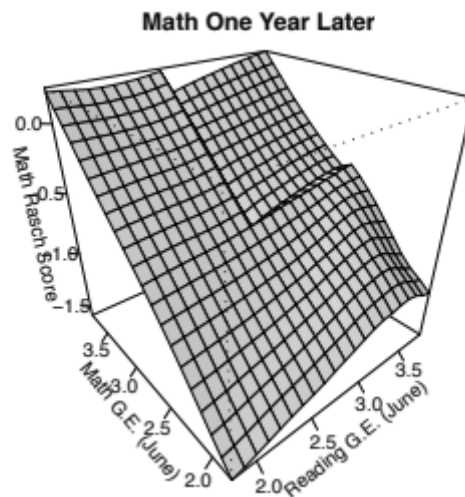


Figure 2.2: June scores and summer school attendance for a random sample of 2,000 third graders.



---

## Polynomial Fit in 2 dimensions



---

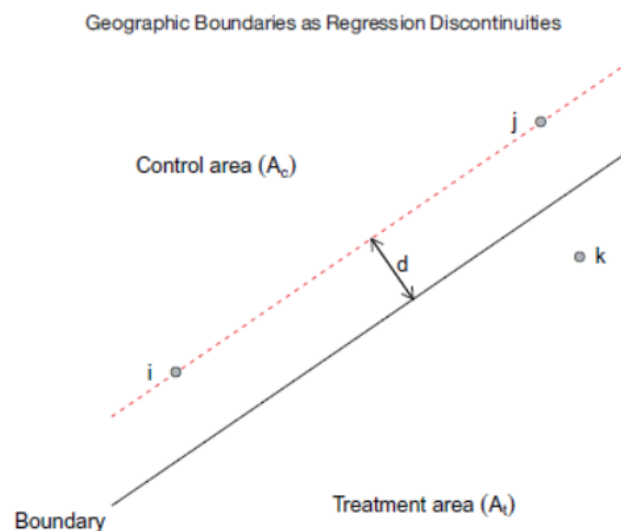
With two forcing variables

- The cutoff is now a boundary
- Heterogenous effects, depending on what segment of the boundary
- with right assumptions (lots of data), can identify one treatment effect for every point  $b$  on boundary. Treatment effect curve  $\tau(b)$
- Average Treatment Effect (ATE) would average over boundary

---

## Geographic RD designs

- Latitude, Longitude forcing variables. Collapse to one-dimensional distance (e.g. 'distance to border') problematic.



**Fig. 3** Failure of one-dimensional distance to single out individual boundary points.  
Keele & Titiunik (2014)

---

## Spatial RDD Applications:

Bubb, R. (2013) The Evolution of Property Rights: State Law or Informal Norms?

*The Journal of Law & Economics* 56 (3): 555–94.

Dell, M. (2010) Persistent Effects of Peru's Mining *Mita*

*Econometrica* (2010) 78 (6): 1863–1903.

---

Bubb, Ryan. 2013. "The Evolution of Property Rights: State Law or Informal Norms?" *The Journal of Law & Economics* 56 (3): 555–94.

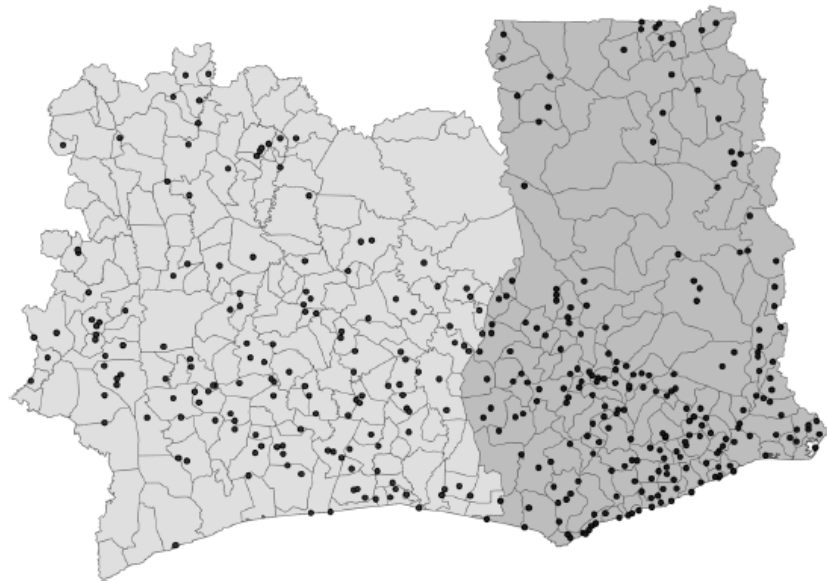


Figure 1. Ghana Living Standards Survey rounds 1 and 2 and Côte d'Ivoire Living Standards Survey enumeration areas.

---

Where do property rights come from?

- Imposed from above by states?
- More organic evolutionary adaptations of norms and customs from below?
  - If the latter, what are correlates of property rights regimes across regions?

Paper uses research discontinuity design to compare measures of *de facto* property rights in Cote d'Ivoire and Ghana. Neighboring countries with very different state legal regimes (e.g. right of individuals to own and transfer land). Finds that:

- *de facto* property rights are "remarkably continuous at the border"
  - property rights appear to vary according to
-

## State law in Cote d'Ivoire and Ghana

- Ghana maintained British common law institutions. Indirect-rule delegated authority to local elites, legalized form of customary law. Slowed individualization of property rights.
- In Cote d'Ivoire French colonial authorities claimed state ownership of all 'unoccupied and uncultivated land', attempting to extinguish customary claims and establish freehold. Independent CI maintained state legal framework and continued to try to weaken customary claims.

---

Compare modern state boundaries to [Murdock Ethnic Atlas Map](#).

- Research discontinuity design (RDD) to explore whether state law or more organic customary law prevails (distance to border as running variable).
- Calculate crop suitability zonal statistics to explore how varies with measures of property rights individualization.

---

Bubb summarizes prevalent views of several authors that:

*...the formal legal system of Ghana has historically supported customary law on land, while that of Cote d'Ivoire has undercut it. If formal law matters in this context, we would expect property rights to be more individualized in Cote d'Ivoire than in Ghana.*

*... in Cote d'Ivoire, lineage heads became outright owners of land, unconstrained by chiefs, because of the undermining of chiefs by the French. In contrast, both commoners and the paramount chiefs whose authority over land extended over a large area in Ghana were empowered by the British, while local chiefs were marginalized.*

---

However, for historical reasons, central states may be weak which

*casts doubt on the view that these state-level institutional differences have had a large impact on the de facto norms that shape decision making.*

---

Data from the first LSMS in Africa:

- Agricultural HH that own land.
- Respondents perceptions of their right to rent out and their right to sell their land as measures of *de facto* property rights institutions.

Besley (1995) found that an index of self-reported rights to sell, rent, gift, mortgage, pledge, and bequeath a field is associated with increased investments in the field.

Customary property rights institutions in much of West Africa placed restrictions on transferring land. Hence, prevalence of transfer rights a measure of extent to which institutions have evolved toward more individualized property rights.

---

Table 2  
Land Rights Variables Correlation Matrix

	Right to Rent out Land	Right to Sell Land	Rented out Land in Last 12 Months	Fraction of Land Fallow
Right to Rent out Land	1.000			
Right to Sell Land	.433**	1.000		
Rented out Land in Last 12 Months	.334**	.212**	1.000	
Fraction of Land Fallow	.186**	.179**	.043*	1.000

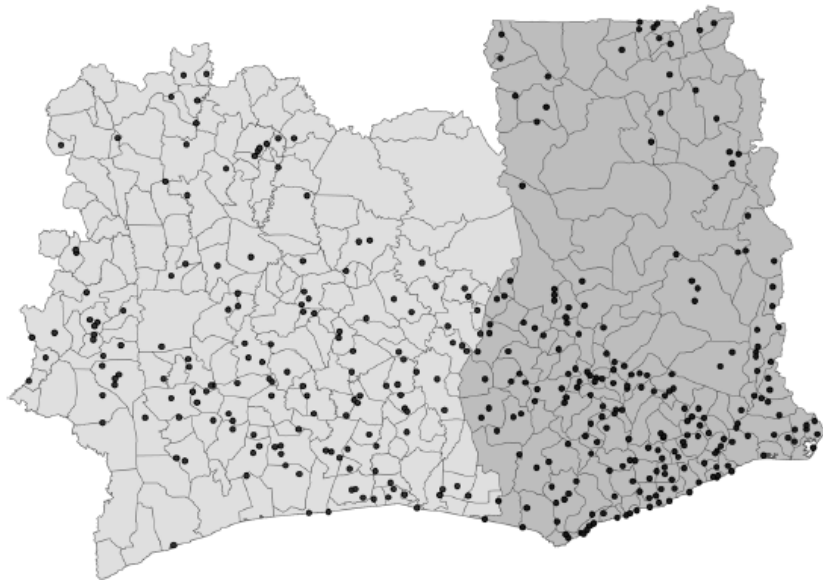
**Note.** The sample is all households in the Ghana Living Standards Survey rounds 1 and 2 (1987–89) and the Côte d'Ivoire Living Standards Survey (1985–88) that owned agricultural land.

\* Significant at the .05 level.

\*\* Significant at the .01 level.

Author's field focus group observations (southern Ghana):

*Most household heads reported that they did not have the right to sell their land. The main reason given was that the land belonged to their extended family. Some ... also reported that they would have to get permission from the chief to sell the land and would have to pay the chief one-third of the sale price.*



**Figure 1.** Ghana Living Standards Survey rounds 1 and 2 and Côte d'Ivoire Living Standards Survey enumeration areas.

## The Persistent Effects of Peru's Mining Mita

Dell, Melissa. 2010. "The Persistent Effects of Peru's Mining 'Mita.'" *Econometrica* 78 (6): 1863–1903.







## Mining and the Spanish Conquest of Peru

- In colonial Peru and Bolivia, a major economic activity was mining, based at Potosí (silver) and Huancavelica (mercury).
- To support the mines, from 1573 to 1812, indigenous communities were forced to send 1 of 7 of their adult male population to work in the mines.
- Local native elites were required to find the conscripts. What might this do? In addition to direct health effects on the conscripts (high mortality rate), might reduce trust, undermine institutions, encourage out migration, make local labor scarce.

The Mita had a well-defined border

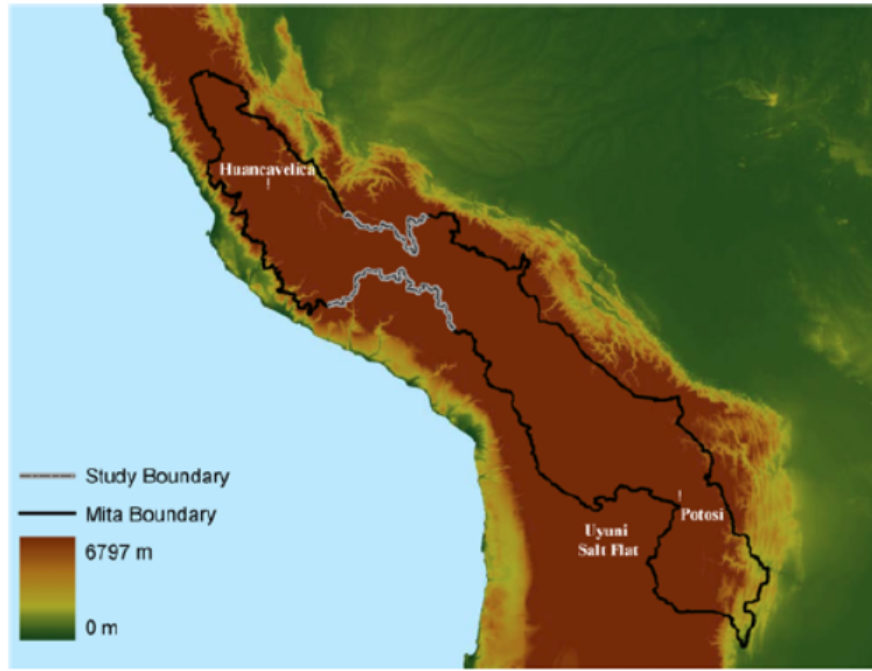


FIGURE 1.—The *mita* boundary is in black and the study boundary in light gray. Districts falling inside the contiguous area formed by the *mita* boundary contributed to the *mita*. Elevation is shown in the background.

- In early 17th century Potosi had a pop. of 200,000, larger than London, Milan or Seville at the time. At one point 70% of world silver production came from 'Cerro Rico' mountain of Potosi.
- daily quota of 25 bags of silver ore, each weighing around 45kg, to the surface .
- Mita boundary established a discontinuity in longitude-latitude space.
- Valid RD design requires all relevant factors besides treatment to vary smoothly at *mita* border. Study segment used has statistically identical elevation, ethnic distribution and other observables.

## Estimation

$$c_{idb} = \alpha + \gamma \cdot mita_d + X'_{id}\beta + f(geolocation_d) + \phi_b + \epsilon_{idb}$$

Observation  $i$  in district  $d$  along segment  $b$  of *mita* boundary.  $mita_d = 1$  if district contributed to *mita*.

$X_{id}$  = covariates (e.g. demographic variables, # of children and adults in HH).  
 $f(geolocation_d)$  RD polynomial controls for smooth functions of geographic location (polynomial in  $lat$ ,  $lon$  and interactions).

$\phi_b$  = set of boundary segment FE that denote which of 4 equal lengthy boundary segments is closes to the observations's district capital.

**Identification.** All relevant factors besides treatment vary smoothly at *mita* boundary:  $E[c_1|x, y]$  and  $E[c_0|x, y]$  are continuous at the discontinuity threshold.

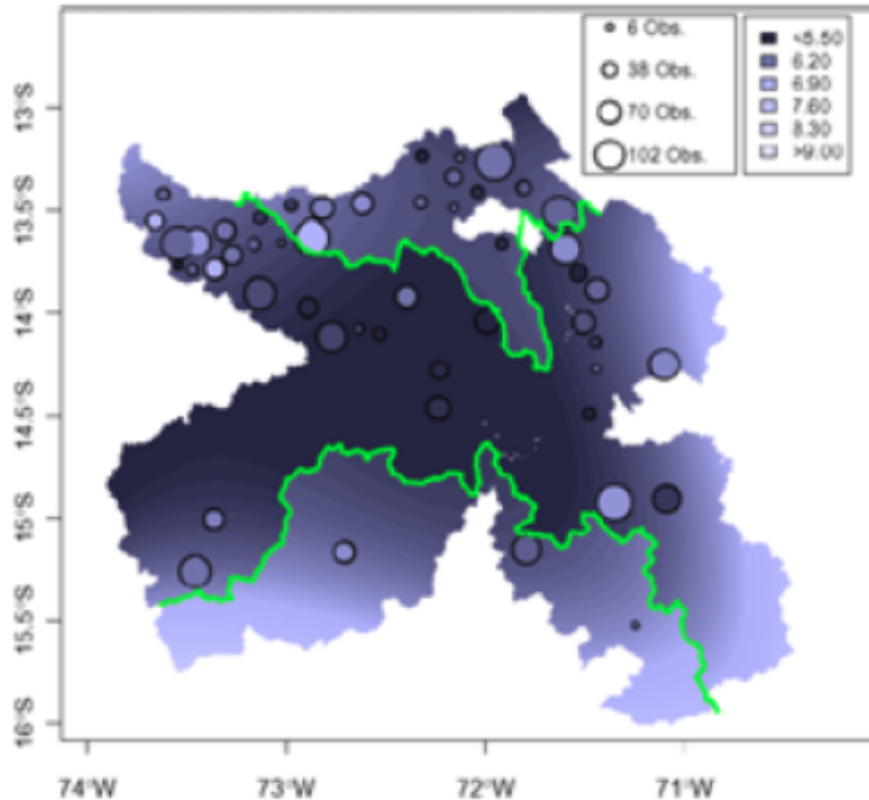
Test if true for important characteristics: elevation, terrain ruggedness, soil fertility, rainfall, ethnicity, preexisting settlement patterns, local 1572 tribute (tax) rates, and allocation of 1572 tribute revenues.

Robustness: try different specs for RD polynomial and different buffers around border from 50 -100 km.

---

## Long run impacts of the Mita

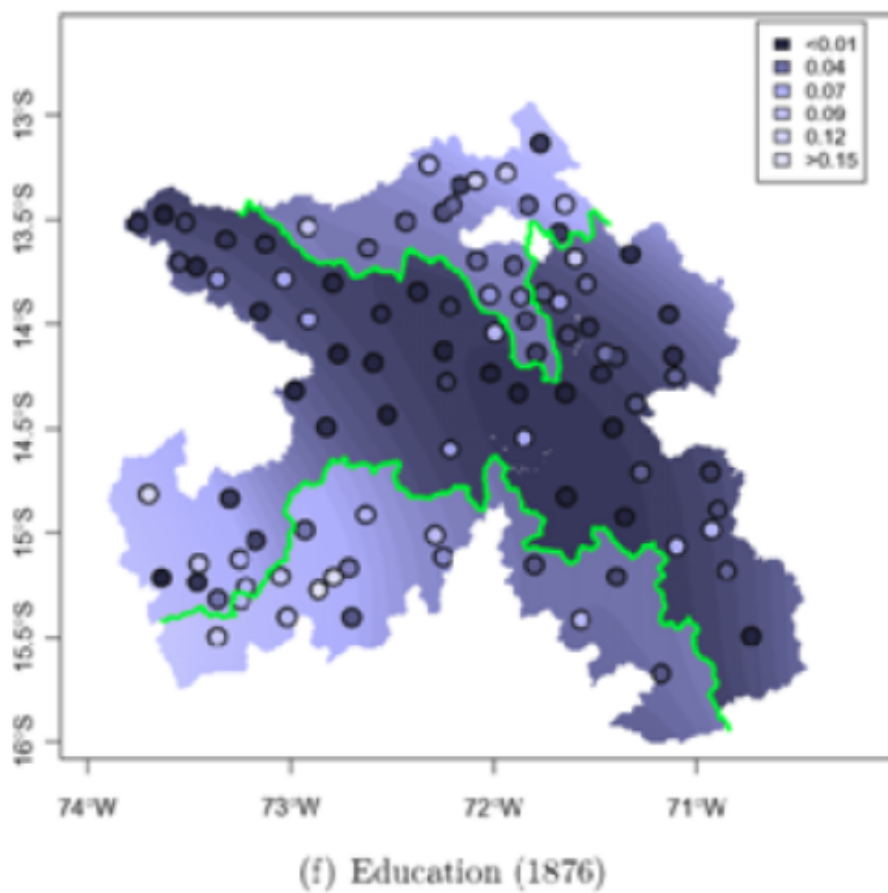
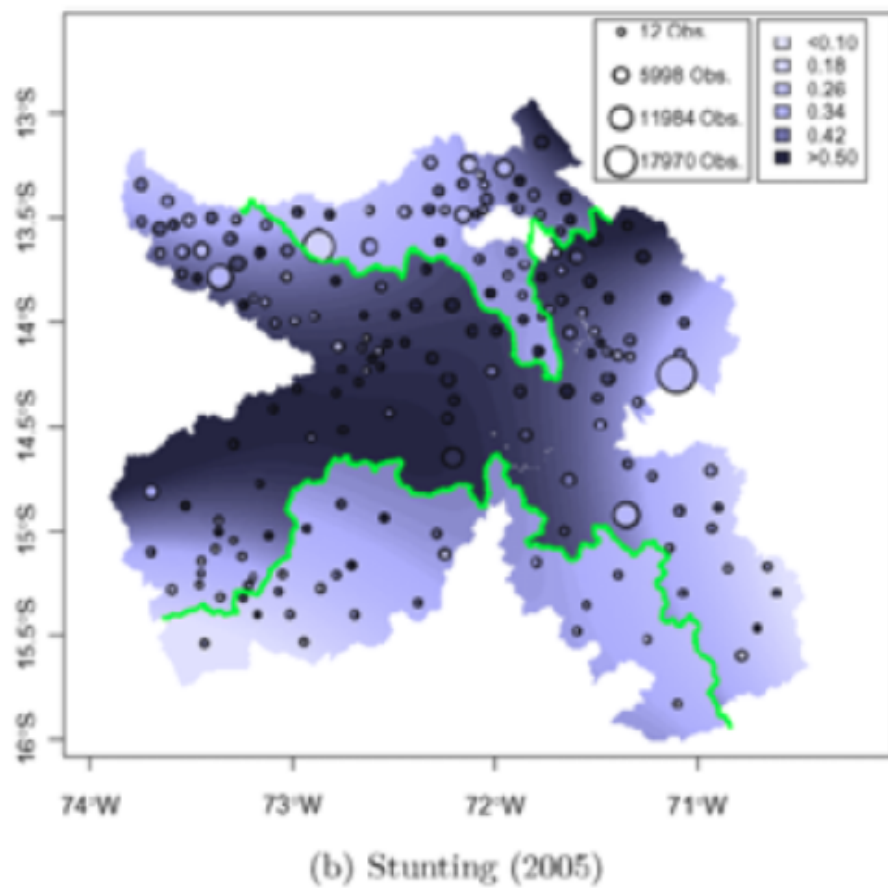
- Consumption in present day Mita areas is 25% lower
  - 6% more height stunting in 6-9 years old students
    - This is an ATE. Along the boundary estimated effect ranges from 0.5% to 11.5%.
- 
- Diagrams in next slides are analogous to standard two-dimensional plots with one forcing variable (x)
  - Here two forcing variables (x-longitude) and (y-latitude)
  - Mita region sandwiched between non-Mita regions to North and South.
  - Dot size indicates # of observations in district (at capital location).
  - Shading indicates predicted outcome variable. Cubic polynomial in lon-lat and the mita dummy.
- 



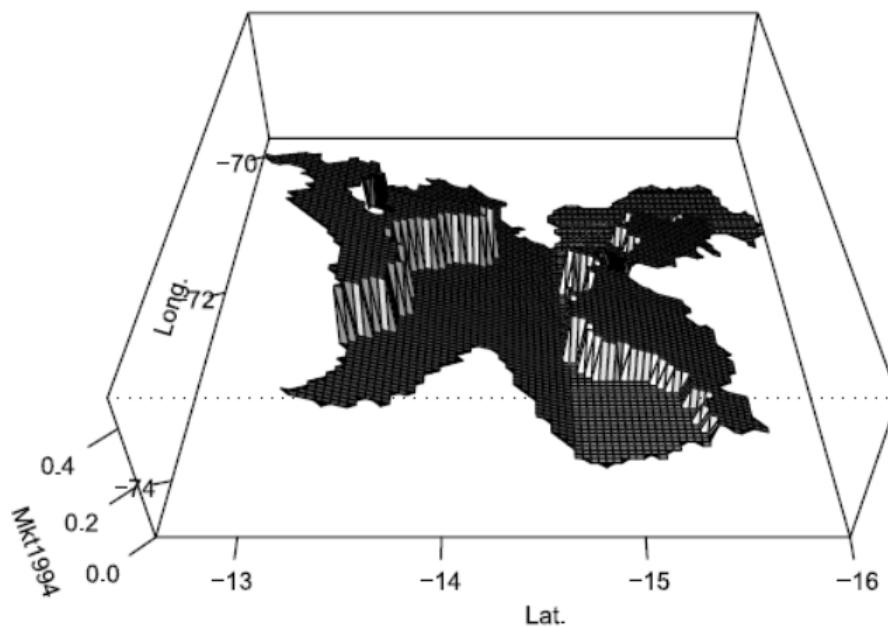
(a) Consumption (2001)

---





Market Participation



(j) Linear Polynomial in Lon-Lat

---

## Channels of Persistence

- Land tenure
  - Public Goods
  - Market Participation
- 

## Land Tenure

- Peru was first parceled off into *encomiendas*. Right to collect tribute.
  - Population falls rapidly due to disease and over-exploitation of labor, particularly in mining.
  - *Mita* system partly effort to rationalize (1 in 7 ratio)
  - *Haciendas* were discouraged in Mita areas to limit power of landlords politically and in labor market competition. Haciendas secluded peasants from Mita.
  - Much lower concentration of Haciendas in Mita areas.
  - Unequal but secure property rights.
- 

## Land Tenure

- Mita abolished in 1812 as well as indigenous communal tenure that had been predominant.
- Did not replace it with enforceable peasant titling. Led to *hacienda* expansion through land grabs and violence.
- Peasant rebellions, banditry and livestock rustling, property insecurity.

- 1969 land reform dissolved *haciendas*. Much higher allocation of land to peasants outside *mita* catchment (20% of HH heads) compared to within (9%).
- 

## Public Goods

- More schooling and education attainment outside *Mita* areas measured in 1876, 1940. Not significant by 2001
  - Greater road density in non-mita
- 

## A recent critique

Abad, Leticia Arroyo, and Noel Maurer. 2019. "The Long Shadow of History? The Impact of Colonial Labor Institutions on Economic Development in Peru." [LINK](#)

---

- Spaniards did move to regions of population density Coercive labor institutions led to drastic population drops
  - People react:
    - migrate
    - resist, revolt
    - political mobilization
  - Weaker evidence of reversal of fortune, particularly if look outside Dell Mita areas.
  - Long run poor performance in LAC: 19th century political instability
-