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Regression Discontinuity Design

Policy Evaluation

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Introduction

Introduction

Randomized Control Trials (RCTs) are increasing seen as the gold standard for impact evaluations.

- One key reason is that they provide unbiased estimates, are easy to understand, and interpret.
- However, conducting an RCT may not always be feasible.
- It may also be unfair to withhold programs from one section and give to others. Eg: Vaccination intervention

Often policies are implemented without randomization making RCT based evaluation unfeasible eg: Free meals in schools.

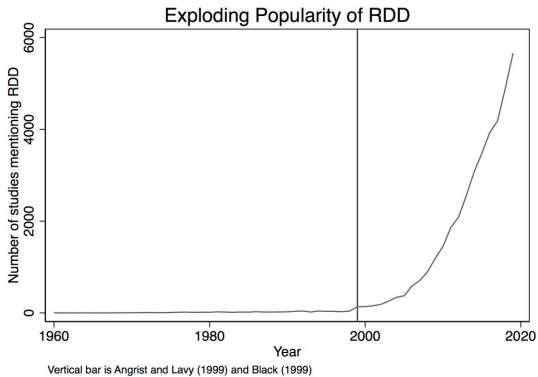
This necessitates the use of non-experimental techniques like Difference-in-Difference (DID), Regression Discontinuity Design (RDD), Instrumental Variables (IV).

Introduction

Over the past
years, interest in RDD has exploded.

Though it was first used
by Thistlehwaite and Campbell(1960),
it became popular after the Angrist
and Lavy (1999) paper published in QJE.

Reasons for popularity:
(i) Mild Assumptions; and (ii) As good
as randomization as agents cannot
control assignment variable (Lee, 2008).



Regression Discontinuity Design

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Regression Discontinuity Design

Regression discontinuity design (RDD)

is an impact evaluation method that can be used for programs that have a continuous eligibility index with a clearly defined eligibility threshold (cutoff score) to determine who is eligible and who is not.

Key Considerations

- To apply RDD, the following main conditions must be met:

1. The index must rank people or units in a continuous or “smooth” way. Categories like age, test scores etc. are smooth and employment status, car ownership are not smooth.
2. The index must have a clearly defined cutoff score: that is, a point on the index above or below which the population is classified as eligible for the program. Eg: households with a poverty index score of less than 50 out of 100 might be classified as poor.
3. The score of a particular individual or unit cannot be manipulated by enumerators, potential beneficiaries, program administrators, or politicians.

Key Considerations

3. *Continuity Assumption*: The cutoff itself cannot be endogenous to some competing intervention. That is, it must be unique to the program of interest; and there should be no other programs, apart from the program to be evaluated, that uses the same cutoff score.
   - Eg., if a poverty score below 50 qualifies a household for a cash transfer, health insurance, and free public transportation, we would not be able to use the RDD method to estimate the impact of the cash transfer program by itself.
   - This is the most important principle. In nature, there is a tendency for things to change gradually. Jumps are so unnatural that when we see them happen, they beg for explanation.

$\Rightarrow$ This is the heart of RDD.

Identification in RDD

- We use our knowledge about selection into treatment in order to estimate average treatment effects.
- Since we know the probability of treatment assignment changes discontinuously at the cutoff, then our job is simply to compare people above and below, to estimate a particular kind of average treatment effect called the local average treatment effect, or LATE (Guideo W. Imbens and Angrist 1994).

Estimating RDD

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A picture is worth a thousand words

Pictures of your main results, including your identification strategy, are absolutely essential to any study attempting to convince readers of a causal effect.

Hoekstra (2009) studies the effect of college education on earnings.

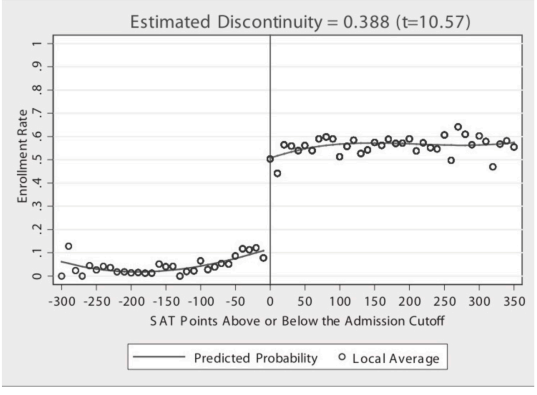

Figure 4-2: Attending the state flagship university as a function of re-centered standardized test scores. Reprinted from Hoekstra (2009).

Discontinuity Graphs

- Horizontal axis is re-centered around the cut-off. Hoekstra does this by subtracting the admission cutoff from the students' actual score.
- The vertical line at zero marks the cutoff i.e university's minimum score for admission. The re-centered SAT score becomes the running variable.
- The dots represent conditional mean enrollments per re-centered SAT score. While the dataset has thousands of observations, the graph shows the conditional means along evenly spaced out bins of the re-centered SAT score.
- There are two curved fitted lines on the left and right of the cutoff point.
- The jump between the two lines: The probability of enrolling at the flagship state university jumps discontinuously when the student just barely hits the minimum SAT score required by the school.

Discontinuity Graphs

- Imagine two students–the first student got a 1240, and the second got a 1250. Are these two students really so different from one another?
- But what if we had hundreds of students who made 1240 and hundreds more who made 1250.
- Why would there be suddenly at 1250 a major difference in the characteristics of the students in a large sample?
- If the university is arbitrarily picking a reasonable cutoff, are there reasons to believe they are also picking a cutoff where the natural ability of students jumps at that exact spot?

College Attendance and Future Earnings

At exactly
the point where workers experienced
a jump in the probability of enrolling
at the state flagship university, there
is, ten to fifteen years later, a separate
jump in logged earnings of around 10%.

Those individuals who just barely made
it in to the state flagship university
made around 10% more in long-term
earnings than those individuals
who just barely missed the cutoff.

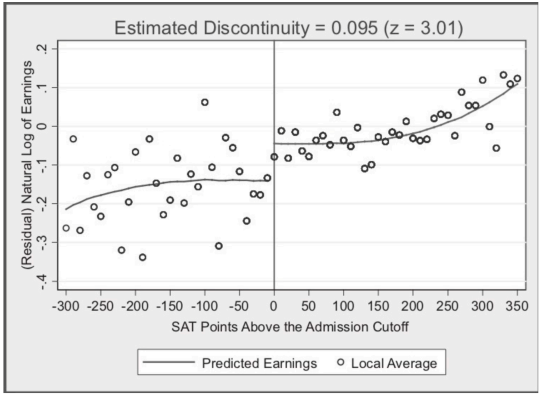

Figure 6.3: Future earnings as a function of re-centered standardized test scores. Reprinted from Hoekstra (2009).

Validating RDD

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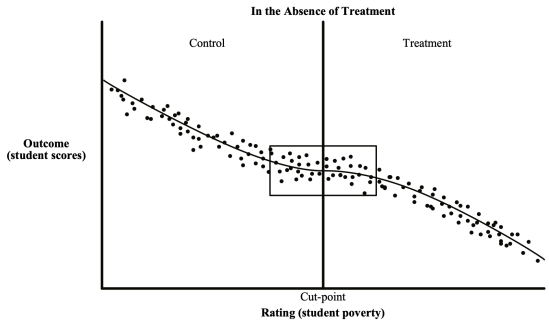
Continuity Assumption

- Recall that under continuity assumption we say that, in the absence of treatment, outcomes do not jump and remain a smooth function of the running variable around the cutoff.
- If potential outcomes are continuous, it implies that there are no other interventions or factors that are changing at the same point as the treatment, which would otherwise introduce bias.
- Continuity, in other words, explicitly rules out omitted variable bias at the cutoff itself. All other unobserved determinants of the outcome are continuously related to the running variable.

Smoothness of Potential Outcomes

Imagine
a scholarship program where students with test scores above 70 receive financial aid. We want to know if this aid causally increases college enrollment.



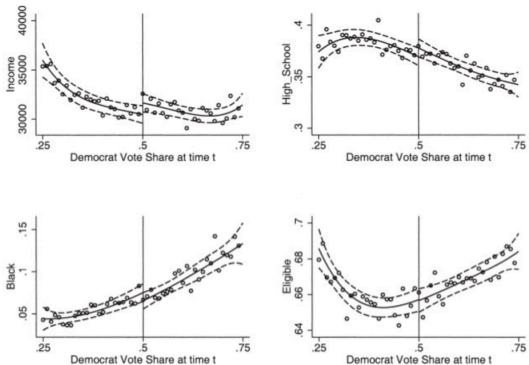
The Challenge: Test scores
correlate with many other factors

RDD's Solution: Compare students just above the cutoff (score = 71) to those just below (score = 69). Students around the boundary must be identical on income, parental education etc.

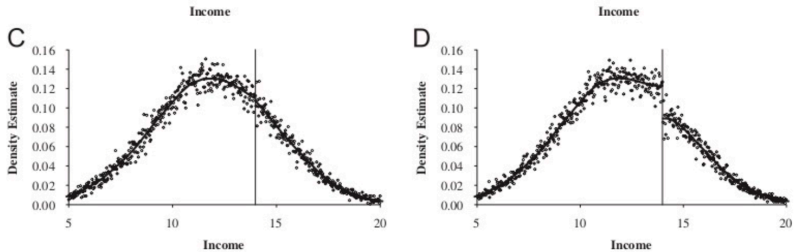
Balance Tests

Checking for balance
amongst the covariates is a good way
to test for the continuity assumption

There must not
be an observable discontinuous change
in the average values of reasonably
chosen covariates around the cutoff.



Test for Manipulation



- If people manipulate the cutoff to benefit from the program then we should observe bunching around the cutoff.
- McCrary (2008) suggests a formal test where under the null, the density should be continuous at the cutoff point. Under the alternative hypothesis, the density should increase at the kink.

Spatial RDD - an Example

Spatial Regression Discontinuity Design

- Spatial Regression Discontinuity Design is a quasi-experimental research design that leverages geographical boundaries to estimate the causal effect of a program or policy.
- It extends the standard RD design by using geographic borders as the ”cutoff” for treatment assignment, assuming that individuals or entities near the border are similar and thus serve as good counterfactuals for each other.
- We will look at Saxena (2022) to see how this is implemented.

Imperial Fault Lines: Colonial Legacy and Fertility in Sub-Saharan Africa

This study investigates the influence colonial institutions and policies exerted on fertility in SSA.

Institutions: British colonies adopted English **common law**; others, mainly French, followed Roman **civil law**.

→ Common law is associated with better economic and financial growth while civil law with better treatment of women's rights.

Policies: Colonizers also diverged in governance and demographic policies:

→ Britain favored Malthusian, **anti-natalist policies**.

→ France promoted **pro-natalist policies** to counter low domestic fertility.

Colonial Institutions

- Colonial institutions refer to the legal systems imposed by colonizers.
- Common law (British colonies) emphasizes property rights and contract enforcement more strongly than civil law (French/others).
  - Evidence links common law to better economic growth and financial development (Porta et al., 1998; Glaeser and Shleifer, 2002; Beck et al., 2003).
- Civil Law provides greater protection to women by providing joint ownership of property.
  - Research shows women in civil law countries have higher bargaining power (Anderson, 2018), often linked to lower fertility (Novignon et al., 2019).

Implication

→ Stronger economic outcomes expand opportunities for women, raising the cost of childbearing–which may reduce fertility.

→ Women in civil law countries are likely to have fewer children than those in common law countries.

Colonizer's Policies

- Britain and France differed in their policies towards fertility.
- Facing rapid population growth, Britain embraced Malthusian ideas - Overpopulation threatens food supply and societal stability.
- On the other hand France was facing declining fertility and WWI population losses. It sought to rebuild itself through pro-natalisim.
- On July 31, 1920, France passed a pro-natalist law in France and its colonies.
  - Criminalized abortion and contraception
  - Encouraged higher birth rates

Implication

↓ Women from Britain's colonies will have lower fertility than those from French colonies.

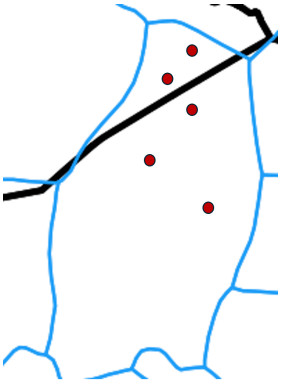
Scramble for Africa

- In 1884-85 at a conference in Berlin, European colonizers divided the African continent among themselves.
- These divisions relied on the minimal information that Europeans had at that time about Africa.
  - ⇒ Arbitrary borders split many ethnic homelands across countries (Herbst, 2014).
  - ⇒ This allows for comparison of populations within the same ethnic group but under different colonial regimes.
  - → Creates a quasi-experimental setting: borders are exogenous, often splitting ethnic homelands at random.
- I treat country borders within a split ethnic-homeland as a discontinuity in space for household's exposure to historical colonial regime.

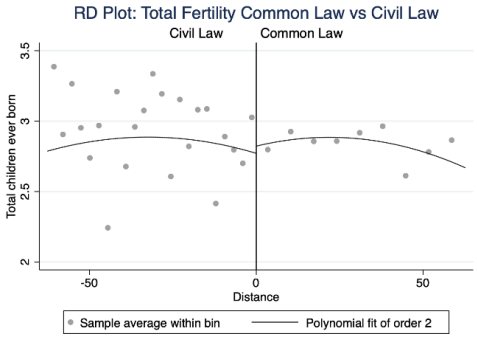
Map with Ethnic Divisions

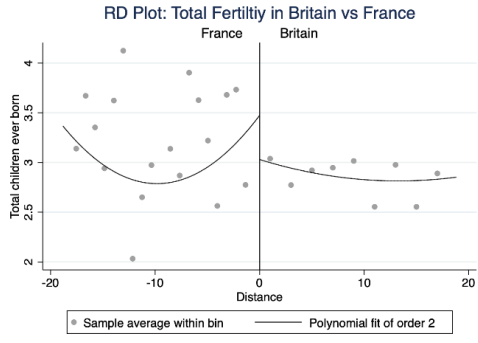
Spatial RDD

By comparing women around the borders of within the same ancestral ethnic homeland, I can estimate the effect of colonial institutions and policies on their fertility.



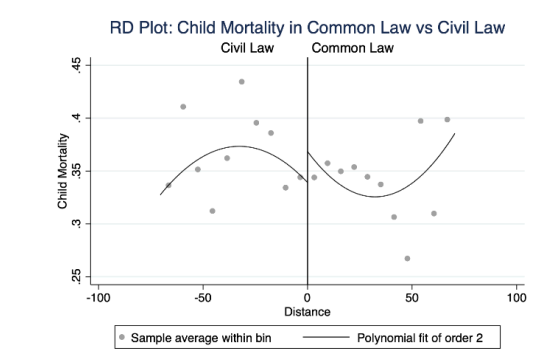
Results - Fertility

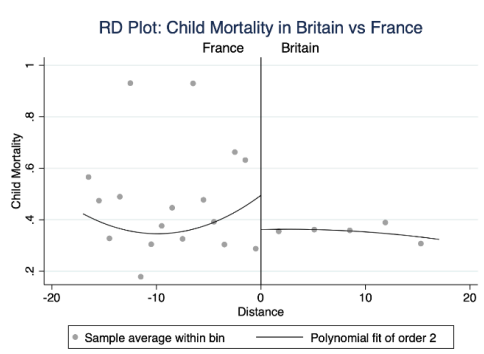




Within the same ethnic group, women on the British side of the border vs those on the French side have 19.3% lower fertility.

Results - Child Mortality





Within the same ethnic group, women on the British side of the border vs those on the French side have 63.6% lower child mortality.

Regression Results

	Total Children				Child Mortality			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: Legal Institutions								
Common Law	-0.0261	-0.0283	-0.0483	-0.0484	-0.0506	-0.0462	-0.0526	-0.0538
(vs Civil Law)	(0.1236)	(0.1138)	(0.1055)	(0.1034)	(0.0358)	(0.0364)	(0.0354)	(0.0355)
N	50351	62790	64920	65666	50351	62790	64920	65666
r2	0.5435	0.5426	0.5402	0.5397	0.1656	0.1607	0.1594	0.1585
Panel B: Colonizer Identity								
Britain (vs France)	-0.3845*	-0.4874**	-0.5092**	-0.5131**	-0.1441*	-0.1850**	-0.1916**	-0.1915**
	(0.1991)	(0.1990)	(0.2022)	(0.2028)	(0.0763)	(0.0777)	(0.0788)	(0.0787)
N	12815	15580	15948	15961	12815	15580	15948	15961
r2	0.5133	0.5165	0.5149	0.5149	0.1595	0.1549	0.1555	0.1556
Panel C: Colonizer Identity (ex. France)								
Britain	0.1873	0.1789	0.1431	0.1321	-0.0366	-0.0030	-0.0215	-0.0261
(vs other European)	(0.1848)	(0.1513)	(0.1653)	(0.1725)	(0.0474)	(0.0425)	(0.0453)	(0.0466)
N	59667	79263	85918	88967	59667	79263	85918	88967
r2	0.5636	0.5641	0.5611	0.5592	0.1854	0.1937	0.1915	0.1903
Distance (bandwidth)	50 kms	100 kms	150 kms	200 kms	50 kms	100 kms	150 kms	200 kms
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Ethnic Homeland FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Birth year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Regression Results

	Contraception Demand				Contraception Unmet Need			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: Legal Institutions								
Common Law	0.0904***	0.1007***	0.1021***	0.1025***	-0.0151	-0.0110	-0.0101	-0.0102
(vs Civil Law)	(0.0311)	(0.0324)	(0.0327)	(0.0324)	(0.0196)	(0.0159)	(0.0156)	(0.0154)
N	50336	62772	64901	65647	50336	62772	64901	65647
r2	0.0985	0.1075	0.1091	0.1105	0.0339	0.0313	0.0311	0.0309
Panel B: Colonizer Identity								
Britain (vs France)	0.0225	0.0295	0.0301	0.0299	-0.0870***	-0.0780***	-0.0791***	-0.0769***
	(0.0211)	(0.0221)	(0.0238)	(0.0237)	(0.0250)	(0.0214)	(0.0215)	(0.0215)
N	12805	15570	15938	15951	12805	15570	15938	15951
r2	0.0691	0.0669	0.0674	0.0673	0.0345	0.0321	0.0316	0.0312
Panel C: Colonizer Identity (ex. France)								
Britain	0.1514***	0.1549***	0.1600***	0.1602***	-0.0424	-0.0372	-0.0337	-0.0338
(vs other European)	(0.0513)	(0.0499)	(0.0506)	(0.0497)	(0.0295)	(0.0252)	(0.0254)	(0.0260)
N	59626	79216	85868	88917	59626	79216	85868	88917
r2	0.1209	0.1414	0.1440	0.1477	0.0361	0.0332	0.0331	0.0339
Distance (bandwidth)	50 kms	100 kms	150 kms	200 kms	50 kms	100 kms	150 kms	200 kms
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Ethnic Homeland FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Birth year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Balance Test Results – Institutions

	Agricultural cover				Grid-cell area			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Common Law	3.086	4.108	4.358	4.351	23.33	19.41	18.79	18.16
	(0.84)	(1.15)	(1.23)	(1.23)	(0.61)	(0.68)	(0.67)	(0.65)
	Mean Elevation				Presence of Gold Deposits			
Common Law	-0.00456	0.00958	0.00878	0.00860	0.0253*	0.0197	0.0192	0.0189
	(-0.21)	(0.36)	(0.33)	(0.33)	(2.44)	(1.24)	(1.22)	(1.20)
	Presence of Water Bodies				Population Density			
Common Law	0.870	0.776	0.859	0.866	96.69	78.10	78.11	77.69
	(0.67)	(0.72)	(0.79)	(0.80)	(0.67)	(0.73)	(0.74)	(0.74)
	Mean Night Lights				Mean Annual Precipitation			
Common Law	0.796	0.632	0.623	0.618	10.11	10.87	11.12	10.70
	(0.72)	(0.76)	(0.76)	(0.76)	(0.97)	(0.94)	(0.96)	(0.93)
N	94018	114464	117028	118120	94018	114464	117028	118120
Distance (bandwidth)	50	100	150	200	50	100	150	200
Countries	21	21	21	21	21	21	21	21
Ethnic Groups	83	83	83	83	83	83	83	83
Ethnic Homeland FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Balance Test Results – Colonizers

	Agricultural cover				Grid-cell area			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Britain	5.848	5.728	6.280	6.280	3.542	3.395	3.069	3.069
	(0.70)	(0.72)	(0.80)	(0.80)	(0.04)	(0.04)	(0.04)	(0.04)
	Mean Elevation				Presence of Gold Deposits			
Britain	0.00724	0.00573	0.00671	0.00671	0.0275	0.0369	0.0368	0.0368
	(0.63)	(0.53)	(0.57)	(0.57)	(1.28)	(1.24)	(1.24)	(1.24)
	Presence of Water Bodies				Population Density			
Britain	2.930	3.072	3.140	3.140	291.9	240.8	238.1	238.1
	(1.14)	(1.38)	(1.41)	(1.41)	(0.73)	(0.73)	(0.73)	(0.73)
	Mean Night Lights				Mean Annual Precipitation			
Britain	2.022	1.727	1.710	1.710	31.56*	33.32*	33.79*	33.79*
	(0.65)	(0.66)	(0.67)	(0.67)	(2.70)	(3.30)	(3.28)	(3.28)
N	21070	23940	24591	24591	21070	23940	24591	24591
Distance (bandwidth)	50	100	150	200	50	100	150	200
Countries	9	9	9	9	9	9	9	9
Ethnic Groups	26	26	26	26	26	26	26	26
Ethnic Homeland FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Conclusion

- Colonization had a profound impact on fertility outcomes in SSA
  - Legal institutions do not significantly explain current fertility outcomes in SSA but colonizer's policies do.
  - Particularly, effects of the colonial French law of 1920 might still persist in its influence on current fertility.
  - While demand for contraception is similar, women from French colonies are less likely to do it through modern contraception methods.
- Colonizer's identity matters and their policies continue to determine current outcomes and hence socio-economic well-being in colonized countries.
- Understanding historical persistence can help improve policy design.

Stata Exercise

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Stata Exercise

We are going to implement a spatial RDD analysis of school fee abolition for the Republic of Akwaaba

Download the required dataset and codes from:
`https://github.com/Kritika-Saxena/Ghana-Summer-School-2025`

university of groningen

Thank you for your attention

Dr. Kritika Saxena

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