# 9: Regression Discontinuity

## Quasi-Experiments Again

* Situations in which you can use a DAG (matching/IPW) to isolate the relationship between treatment and outcome don’t need these other techniques such as DiD or RDD.
* BUT you have to assume that everything in the DAG is observable and measurable, otherwise you can’t perform full adjustment.
* Can use DAGs in a DiD situation to help identify other variables you may wish to control for.

## Key Terms

* Use the cutoff to statistically isolate the relationship between treatment and outcome.

## Hypothetical Tutoring Program

* Can use the arbitrary cut-off to define a treatment and control group.

## Causal Inference Intuition

* Can’t compare subjects that are very different on the running variable e.g. subjects scoring 40 vs subjects scoring 100.
* Compare subjects falling in the zone around that cut-off – in our example it’s 68 – 72 or 65 – 75.
* Essentially the same subjects, except one happened to get treatment and one didn’t, which creates the treatment and control groups.
* Then calculate the causal effect of the program for subjects around that cut-off.
* Essentially draw a line of best fit for the tutor and non-tutor groups to get the causal effect.
* Jump in the regression line at the discontinuity – that’s the causal effect (of having a tutor in this example).
* Compare the subjects either side of the rule and that’s the causal effect – super intuitive.

## RDDs Are All the Rage

* Fewer statistical shenanigans that can be performed to distort the results and make a causal effect.
* Statistical shenanigans are more obvious.
* Typically more credible than DiD or IVs.

## Drawing Lines and Measuring Gaps

* The whole point of RDD is to find a gap and measuring the size of the gap.
* How the lines are drawn will influence the size of the resulting gap.
* Just reporting on one approach (one line/kernel/bandwidth) is very dubious and non-robust.

## Measuring a Gap

* Compare the average of one of the groups just before the cut-off with the average of the other group just after the cut-off.
* Typical approach is to draw a bunch of lines and observe the range of gap sizes that result.

## Drawing Lines

* Bandwidth issues – how wide of an area (window) around the cut-off you want to consider.
* Kernels – how much weight/importance you want to put on the subjects close to the cut-off vs further away.

## Lines

### Parametric

* Lines that have parameters i.e can be expressed as a formula – can be linear or non-linear.
* If the line is of an ‘incorrect’ functional form, it’ll be a bad fit and hence will affect the magnitude and credibility of the causal effect.

## Measuring Gaps

* Easiest approach is to use regression.
* Centred running variable scores are now interpreted as being x units above/below the threshold.
* Centred running variable plus the indicator variable is all that’s needed for a regression to estimate the causal effect.
  + Intercept represents the average score for the control group AT the cutoff.
  + Slope term is less important.
  + Indicator variable is more important: this is the gap between the control and treatment groups at the cut-off.
* Higher-order parametric terms would be included in the model, but again less important.
* Non-parametric estimation can’t be done with regression, and relies on additional packages to estimate the causal effect for you.

## Bandwidth

* Researcher/analyst determines the size of the bandwidth.
* Common sense can be more practical/more intuitive than a algorithm.
* Test the sensitivity of the causal effect size to choice of bandwidth. Also adds credibility to results.

## Kernels

* Different ways of weighting subjects.
* Uniform/rectangular weighting – everyone in the bandwidth is weighted the same.
* Triangular weighting – subjects right at the cutoff are weighted very highly and then weights drop off linearly as you move further away.
* Epanechnikov weighting – subjects near the cutoff are weighted higher than those further away, but not as extremely as the triangular weighting.
* No single rule as to which one is the best all of the time.

## Main Concerns

* Really hard to estimate a valid statistically significant effect/causal effect if you don’t have a lot of observations.
* NOT calculating the average population ATE for the treatment on the outcome.
* Arguably, RCTs and DiD studies are still localised ATEs.
* The only way that something will be a true population ATE would be if we had true external validity, which is rare if not impossible.
* Graphical methods can lead to underestimation of the statistical significance of the gap.

### Manipulation

* Compare density plots either side of the running variable.
* A gap in the density plots indicate that cutoff manipulation is occurring.

### Non-compliance

* Sharp discontinuity means everyone above the cutoff is in one treatment group and everyone below the cutoff is in the other treatment group.
* This is very rare in practice. More often you have fuzzy discontinuity, where some subjects above the cutoff may be in the other treatment group and vice versa.
* Measuring the gap is then no longer intuitive/difficult.
* Addressing this is via instrumental variables and have to ignore the non-compliers.