PLSC 30600 - Lab 8 - Regression Discontinuity Design

02/28/2025

Meyersson (2014) - "Islamic Rule and the Empowerment of the Poor and Pious"

In this lab, we will illustrate how to conduct RD analysis with the rdrobust packages. The data comes from Meyersson (2014), and can be downloaded from: https://github.com/rdpackages-replication/CIT_2020_CUP/blob/master/CIT_2020_CUP_polecon.dta. Note that all the codes in this R file can be found from Cattaneo et al. (2019), which is a very nice handbook on the practical guide of running RD analysis.

Meyersson (2014) studies the effect of electing Islamic party on women's education. The variables in the datasets are:

- `Y` - educational attainment of women, measured as the percentage of women aged 15 to 20 in 2000 who had completed high school by 2000
- `X` - vote margin obtained by the Islamic party in the 1994 Turkish mayoral elections, measured as the vote percentage obtained by the Islamic party minus the vote percentage obtained by its strongest secular party opponent.
- `T` - electoral victory of the Islamic party in 1994
- `lpop1994` - Log Population in 1994
- `partycount` - Number of Parties Receiving Votes in 1994
- `vshr_islam1994` - Islamic Vote Percentage in 1994
- `i89` - Islamic Mayor in 1989
- `merkezp` - Province Center Indicator
- `merkezi` - District Center Indicator

```r
# load data from Meyersson (2014, ECTA)
meyersson_2014ecta <- read_dta("meyersson_2014ecta.dta")

# specify outcome, running variable, and treatment variable
Y <- meyersson_2014ecta$Y
X <- meyersson_2014ecta$X
T <- meyersson_2014ecta$T

# Analyzing the running variable
meyersson_2014ecta %>%
  group_by(T) %>%
  summarize(count = n(),
            vote_margin = mean(X))
```

```
## # A tibble: 2 x 3
##       T count vote_margin
##   <dbl> <int>       <dbl>
## 1     0  2314       -33.4
```

```
## 2     1   315        10.3
```

RD validity tests

The first validity test is to test whether or not the density of the running variable is continuous at the cutoff. The idea is that if people can manipulate the running variable to sort themselves to a side where they expect benefits, we would observe discontinuity of the density of the running variables at the cutoff. In Meyersson (2014), we fail to reject the null that there is a manipulation of running variable.

- Running variable test

```
# test H0: the density of the running variable is continuous at the cutoff
out <- rddensity(X)
summary(out)
```

```
##
## Manipulation testing using local polynomial density estimation.
##
## Number of obs =       2629
## Model =               unrestricted
## Kernel =              triangular
## BW method =           estimated
## VCE method =          jackknife
##
## c = 0                 Left of c           Right of c
## Number of obs         2314                315
## Eff. Number of obs    965                 301
## Order est. (p)        2                   2
## Order bias (q)        3                   3
## BW est. (h)           30.539              28.287
##
## Method                T                   P > |T|
## Robust                -1.3937             0.1634
```

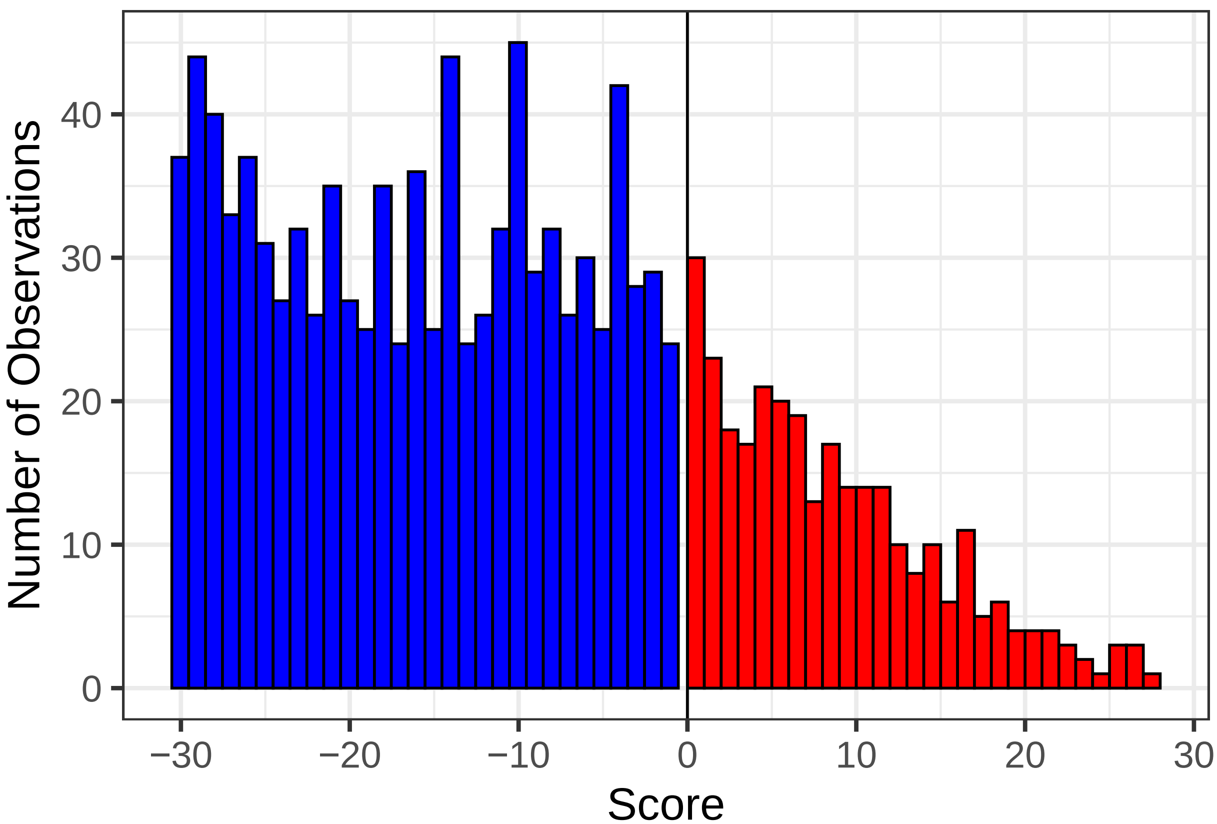
```
## Warning in summary.CJMrddensity(out): There are repeated observations. Point
## estimates and standard errors have been adjusted. Use option massPoints=FALSE
## to suppress this feature.
```

```
##
## P-values of binomial tests (H0: p=0.5).
##
## Window Length / 2          <c     >=c    P>|T|
## 0.874                      20      26    0.4614
## 1.748                      42      49    0.5296
## 2.622                      70      63    0.6030
## 3.496                      95      81    0.3271
## 4.370                     131      98    0.0342
## 5.245                     155     112    0.0100
## 6.119                     183     131    0.0039
## 6.993                     209     148    0.0015
## 7.867                     229     160    0.0005
## 8.741                     257     173    0.0001
```

```
# plot the raw counts of running variable
bw_left <- as.numeric(rddensity(X)$h[1]) #BW est. (h)           30.539              28.287
bw_right <- as.numeric(rddensity(X)$h[2])
```

```
tempdata <- as.data.frame(X)
colnames(tempdata) = c("v1")
plot2 <- ggplot(data=tempdata, aes(tempdata$v1)) +
  theme_bw(base_size = 17) +
  geom_histogram(data = tempdata,
                 aes(x = v1, y= ..count..),
                 breaks = seq(-bw_left, 0, 1),
                 fill = "blue",
                 col = "black",
                 alpha = 1) +
  geom_histogram(data = tempdata,
                 aes(x = v1, y= ..count..),
                 breaks = seq(0, bw_right, 1),
                 fill = "red",
                 col = "black",
                 alpha = 1) +
  labs(x = "Score", y = "Number of Observations") +
  geom_vline(xintercept = 0, color = "black")
plot2
```

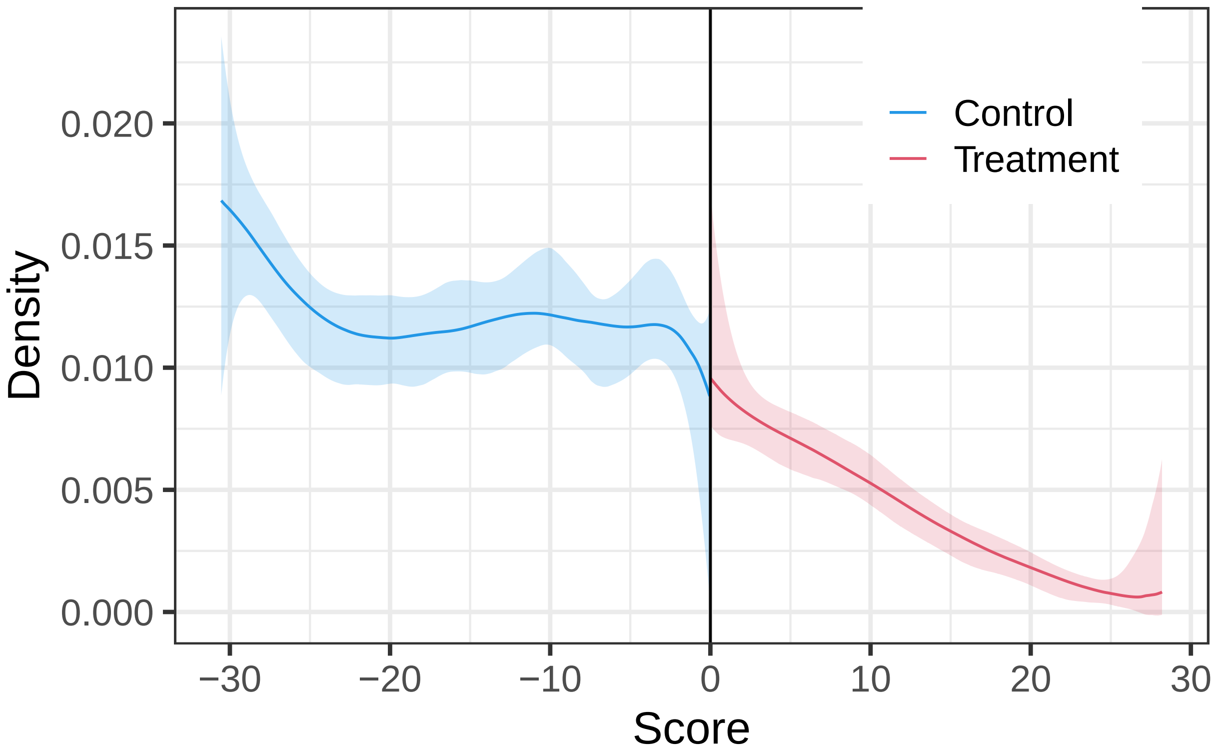
```
## Warning: The dot-dot notation (`..count..`) was deprecated in ggplot2 3.4.0.
## i Please use `after_stat(count)` instead.
## This warning is displayed once every 8 hours.
## Call `lifecycle::last_lifecycle_warnings()` to see where this warning was
## generated.
```



```r
# plot the density of the running variable
# "IMSE" stands for Integrated Mean Squared Error.
# The "lpdensity" function (Local Polynomial Density Estimation) will automatically select the bandwidt
# The ratio sum(X < 0 & X >= -bw_left) / length(X) scales the density estimate according to the proport

est1 <- lpdensity(data = X[X < 0 & X >= -bw_left],
                 grid = seq(-bw_left, 0, 0.1),
                 bwselect = "IMSE",
                 scale = sum(X < 0 & X >= -bw_left) / length(X))

est2 <- lpdensity(data = X[X >= 0 & X <= bw_right],
                  grid = seq(0, bw_right, 0.1),
                  bwselect = "IMSE",
                  scale = sum(X >= 0 & X <= bw_right) / length(X))

plot1 <- lpdensity.plot(est1,
                        est2,
                        CIshade = 0.2,
                        lcol = c(4, 2),
                        CIcol = c(4, 2),
                        legendGroups = c("Control", "Treatment")) +
  labs(x = "Score", y = "Density") +
  geom_vline(xintercept = 0, color = "black") +
  theme_bw(base_size = 17) +
  theme(legend.position = c(0.8, 0.85))
```

```
## Warning: A numeric `legend.position` argument in `theme()` was deprecated in ggplot2
## 3.5.0.
## i Please use the `legend.position.inside` argument of `theme()` instead.
## This warning is displayed once every 8 hours.
## Call `lifecycle::last_lifecycle_warnings()` to see where this warning was
## generated.
```

```r
plot1
```



- Covariates variation test

The other RD validity test is to test whether or not pre-treatment covariates vary smoothly at the threshold. The idea is that if individuals cannot perfectly manipulate the running variable near the threshold, then, there should be no systematic differences on pre-treatment covariates around the threshold.

```r
# Log Population in 1994
out <- rdrobust(meyersson_2014ecta$lpop1994, X)
summary(out)
```

```
## Sharp RD estimates using local polynomial regression.
##
## Number of Obs.                 2629
## BW type                       mserd
## Kernel                   Triangular
## VCE method                       NN
##
## Number of Obs.                 2314          315
## Eff. Number of Obs.             400          233
## Order est. (p)                    1            1
## Order bias  (q)                   2            2
## BW est. (h)                  13.320       13.320
## BW bias (b)                  21.368       21.368
## rho (h/b)                     0.623        0.623
## Unique Obs.                    2311          315
##
## =============================================================================
##         Method     Coef. Std. Err.         z     P>|z|      [ 95% C.I. ]
## =============================================================================
##   Conventional     0.012     0.278     0.045     0.964    [-0.532 , 0.557]
##         Robust         -         -     0.001     0.999    [-0.644 , 0.645]
```

```
## =============================================================================
```

```r
# Number of Parties Receiving Votes in 1994
out <- rdrobust(meyersson_2014ecta$partycount, X)
summary(out)
```

```
## Sharp RD estimates using local polynomial regression.
##
## Number of Obs.                 2629
## BW type                       mserd
## Kernel                   Triangular
## VCE method                       NN
##
## Number of Obs.                 2314          315
## Eff. Number of Obs.             373          223
## Order est. (p)                    1            1
## Order bias  (q)                   2            2
## BW est. (h)                  12.166       12.166
## BW bias (b)                  20.064       20.064
## rho (h/b)                     0.606        0.606
## Unique Obs.                    2311          315
##
## =============================================================================
##         Method     Coef. Std. Err.         z     P>|z|      [ 95% C.I. ]
## =============================================================================
##   Conventional    -0.168     0.478    -0.351     0.726    [-1.105 , 0.769]
##         Robust         -         -    -0.429     0.668    [-1.357 , 0.869]
## =============================================================================
```

```r
# Islamic Vote Percentage in 1994
out <- rdrobust(meyersson_2014ecta$vshr_islam1994, X)
summary(out)
```

```
## Sharp RD estimates using local polynomial regression.
##
## Number of Obs.                 2629
## BW type                       mserd
## Kernel                   Triangular
## VCE method                       NN
##
## Number of Obs.                 2314          315
## Eff. Number of Obs.             430          238
## Order est. (p)                    1            1
## Order bias  (q)                   2            2
## BW est. (h)                  13.940       13.940
## BW bias (b)                  22.475       22.475
## rho (h/b)                     0.620        0.620
## Unique Obs.                    2311          315
##
## =============================================================================
##         Method     Coef. Std. Err.         z     P>|z|      [ 95% C.I. ]
## =============================================================================
##   Conventional     0.603     1.479     0.408     0.683    [-2.296 , 3.503]
##         Robust         -         -     0.370     0.711    [-2.794 , 4.095]
## =============================================================================
```

```r
# Islamic Mayor in 1989
out <- rdrobust(meyersson_2014ecta$i89, X)
summary(out)
```

```
## Sharp RD estimates using local polynomial regression.
##
## Number of Obs.                 1908
## BW type                       mserd
## Kernel                   Triangular
## VCE method                       NN
##
## Number of Obs.                 1683          225
## Eff. Number of Obs.             269          149
## Order est. (p)                    1            1
## Order bias  (q)                   2            2
## BW est. (h)                  11.783       11.783
## BW bias (b)                  20.559       20.559
## rho (h/b)                     0.573        0.573
## Unique Obs.                    1681          225
##
## =============================================================================
##         Method     Coef. Std. Err.         z     P>|z|      [ 95% C.I. ]
## =============================================================================
##   Conventional     0.053     0.067     0.800     0.424    [-0.077 , 0.184]
##         Robust         -         -     0.967     0.333    [-0.077 , 0.228]
## =============================================================================
```

```r
# Province Center Indicator
out <- rdrobust(meyersson_2014ecta$merkezp, X)
summary(out)
```

```
## Sharp RD estimates using local polynomial regression.
##
## Number of Obs.                 2629
## BW type                       mserd
## Kernel                   Triangular
## VCE method                       NN
##
## Number of Obs.                 2314          315
## Eff. Number of Obs.             358          216
## Order est. (p)                    1            1
## Order bias  (q)                   2            2
## BW est. (h)                  11.557       11.557
## BW bias (b)                  18.908       18.908
## rho (h/b)                     0.611        0.611
## Unique Obs.                    2311          315
##
## =============================================================================
##         Method     Coef. Std. Err.         z     P>|z|      [ 95% C.I. ]
## =============================================================================
##   Conventional     0.029     0.037     0.788     0.431    [-0.044 , 0.103]
##         Robust         -         -     0.511     0.609    [-0.064 , 0.109]
## =============================================================================
```

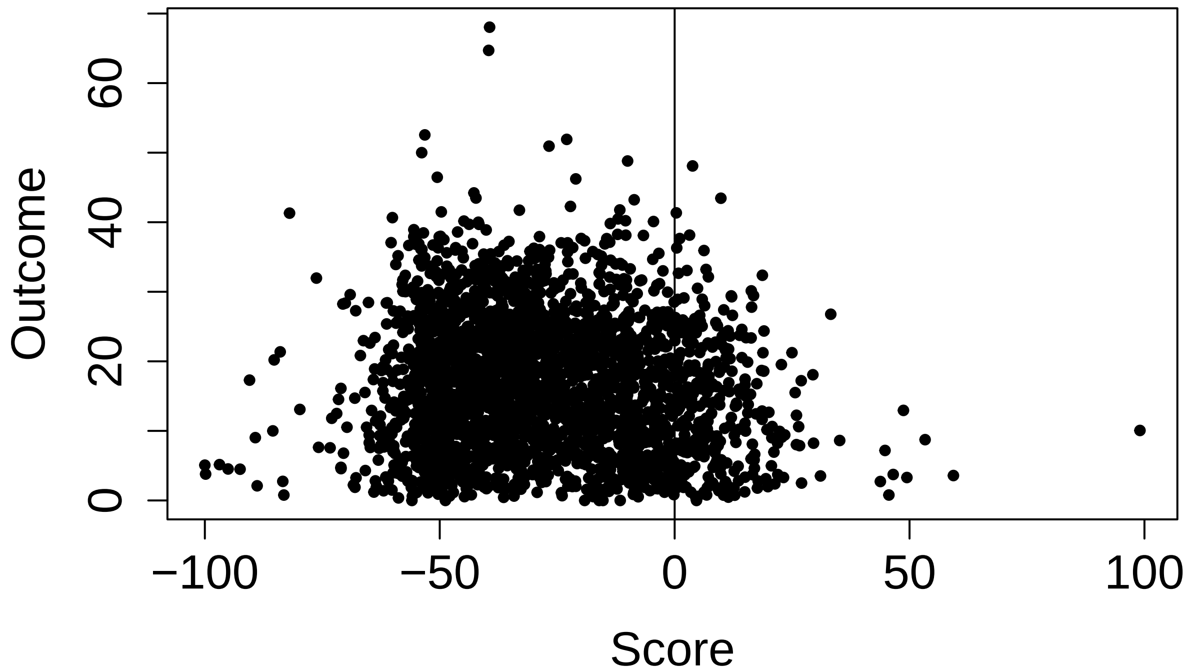
```r
# District Center Indicator
out <- rdrobust(meyersson_2014ecta$merkezi, X)
summary(out)
```

```
## Sharp RD estimates using local polynomial regression.
##
## Number of Obs.                 2629
## BW type                       mserd
## Kernel                   Triangular
## VCE method                       NN
##
## Number of Obs.                 2314          315
## Eff. Number of Obs.             394          230
## Order est. (p)                    1            1
## Order bias  (q)                   2            2
## BW est. (h)                  13.033       13.033
## BW bias (b)                  20.764       20.764
## rho (h/b)                     0.628        0.628
## Unique Obs.                    2311          315
##
## =============================================================================
##         Method     Coef. Std. Err.         z     P>|z|      [ 95% C.I. ]
## =============================================================================
##   Conventional    -0.067     0.089    -0.757     0.449    [-0.241 , 0.107]
##         Robust         -         -    -0.735     0.462    [-0.285 , 0.130]
## =============================================================================
```

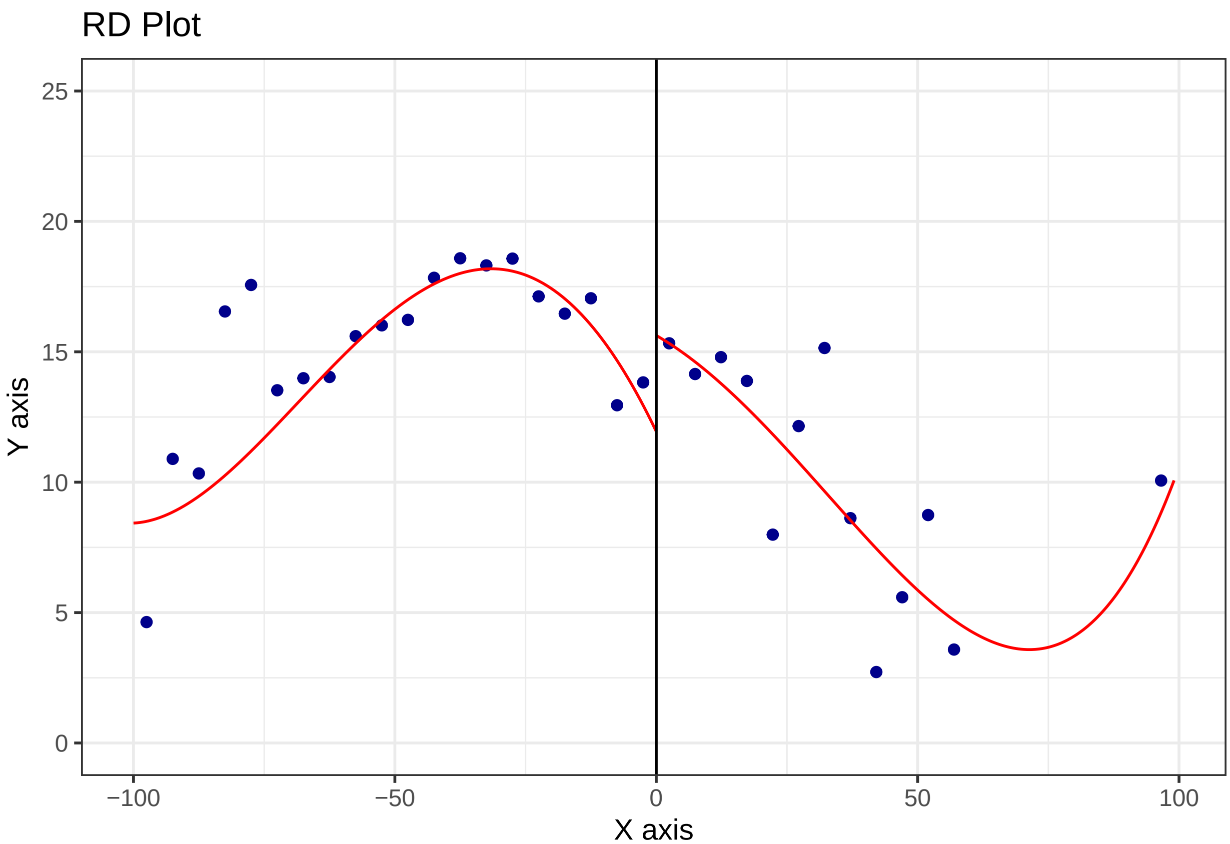
Using RD Plots to Present the Resutls Visually

Before using regression to present the RD results, it is often useful to to draw the plot to show the readers that there is a jump of the outcome at the cutoff. We can use the rdplot package to draw such plot. From the plot that uses Meyersson (2014) data, we can see that there is graphical evidence that electing Islamic part increases woman's education.

```r
# plot the raw data
plot(X,
     Y,
     xlab = "Score",
     ylab = "Outcome",
     col = 1,
     pch = 20,
     cex.axis = 1.5,
     cex.lab = 1.5)
abline(v=0)
```




```r
# use rdplot package to draw plot with evenly spaced bins
# the bins will be equally spaced on both sides of the cutoff.
out <- rdplot(Y,
              X,
              nbins = c(20,20),
              binselect = 'es',
              y.lim = c(0,25))
```

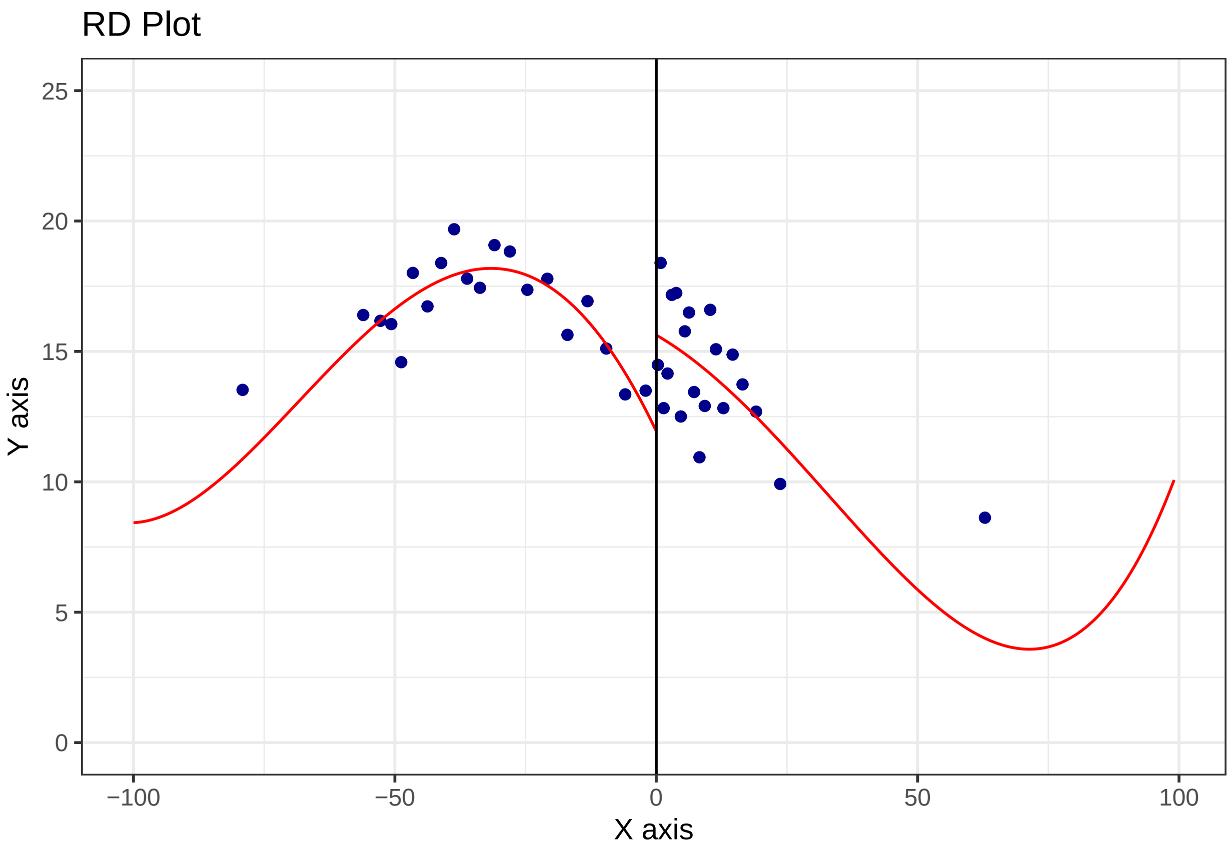



```r
summary(out)
```

```
## Call: rdplot
##
## Number of Obs.                 2629
## Kernel                      Uniform
##
## Number of Obs.                 2314             315
## Eff. Number of Obs.            2314             315
## Order poly. fit (p)               4               4
## BW poly. fit (h)            100.000          99.051
## Number of bins scale              1               1
##
## Bins Selected                    20              20
## Average Bin Length            5.000           4.953
## Median Bin Length             5.000           4.953
##
## IMSE-optimal bins                11               7
## Mimicking Variance bins          40              75
##
## Relative to IMSE-optimal:
## Implied scale                 1.818           2.857
## WIMSE variance weight         0.143           0.041
## WIMSE bias weight             0.857           0.959
```

```r
# use rdplot package to draw plot with quantile spaced bins
# the bins will contain an equal number of observations, making them "quantile-spaced."
out <- rdplot(Y,
```

```r
            X,
            nbins = c(20,20),
            binselect = 'qs',
            y.lim = c(0,25))
```




```r
summary(out)
```

```
## Call: rdplot
##
## Number of Obs.                  2629
## Kernel                       Uniform
##
## Number of Obs.                  2314           315
## Eff. Number of Obs.             2314           315
## Order poly. fit (p)                4             4
## BW poly. fit (h)             100.000        99.051
## Number of bins scale               1             1
##
## Bins Selected                     20            20
## Average Bin Length             4.995         4.950
## Median Bin Length              2.950         1.011
##
## IMSE-optimal bins                 21            14
## Mimicking Variance bins           44            41
##
## Relative to IMSE-optimal:
## Implied scale                  0.952         1.429
```

```
## WIMSE variance weight         0.537           0.255
## WIMSE bias weight             0.463           0.745
```

Regression Presentation of the RD estimator

We now proceed to use the rdrobust package to produce an estimate and the associated confidence interval of the RD estimand. The rdrobust package can use robust bias correction for constructing confidence intervals, which has smaller coverage errors than competing approaches. Overall, the results show that there is a positive effect of electing Islamic party on women's education. The results are significant at 10% level when not conditioning on covariates, and are significant at 5% level when conditioning on covariates.

```r
# rdrobust without covariates
# the local polynomial order for density estimation is 1
# the method for bandwidth selection is "mserd" (Mean Squared Error - RD)
out <- rdrobust(Y,
                X,
                kernel = "triangular",
                p = 1,
                bwselect = "mserd",
                all = TRUE)

summary(out)
```

```
## Sharp RD estimates using local polynomial regression.
##
## Number of Obs.                 2629
## BW type                       mserd
## Kernel                   Triangular
## VCE method                       NN
##
## Number of Obs.                 2314          315
## Eff. Number of Obs.             529          266
## Order est. (p)                    1            1
## Order bias  (q)                   2            2
## BW est. (h)                  17.240       17.240
## BW bias (b)                  28.576       28.576
## rho (h/b)                     0.603        0.603
## Unique Obs.                    2311          315
##
## =============================================================================
##         Method     Coef. Std. Err.         z     P>|z|      [ 95% C.I. ]
## =============================================================================
##   Conventional     3.020     1.427     2.116     0.034     [0.223 , 5.816]
## Bias-Corrected     2.983     1.427     2.090     0.037     [0.186 , 5.780]
##         Robust     2.983     1.680     1.776     0.076    [-0.309 , 6.276]
## =============================================================================
```

```r
# rdrobust with covariates
Z <- cbind(meyersson_2014ecta$vshr_islam1994,
           meyersson_2014ecta$partycount,
           meyersson_2014ecta$lpop1994,
           meyersson_2014ecta$merkezi,
           meyersson_2014ecta$merkezp,
           meyersson_2014ecta$subbuyuk,
           meyersson_2014ecta$buyuk)
```

```r
colnames(Z) <- c("vshr_islam1994",
                 "partycount",
                 "lpop1994",
                 "merkezi",
                 "merkezp",
                 "subbuyuk",
                 "buyuk")

out <- rdrobust(Y,
                X,
                covs = Z,
                kernel = 'triangular',
                scaleregul = 1,
                p = 1,
                bwselect = 'mserd',
                all = TRUE)

summary(out)
```

```
## Covariate-adjusted Sharp RD estimates using local polynomial regression.
##
## Number of Obs.                 2629
## BW type                       mserd
## Kernel                   Triangular
## VCE method                       NN
##
## Number of Obs.                 2314          315
## Eff. Number of Obs.             448          241
## Order est. (p)                    1            1
## Order bias  (q)                   2            2
## BW est. (h)                  14.410       14.410
## BW bias (b)                  23.733       23.733
## rho (h/b)                     0.607        0.607
## Unique Obs.                    2311          315
##
## =============================================================================
##         Method     Coef. Std. Err.         z     P>|z|      [ 95% C.I. ]
## =============================================================================
##   Conventional     3.108     1.284     2.421     0.015     [0.592 , 5.624]
## Bias-Corrected     3.163     1.284     2.463     0.014     [0.646 , 5.679]
##         Robust     3.163     1.515     2.088     0.037     [0.194 , 6.132]
## =============================================================================
```

Reference

Cattaneo, Matias D., Nicolás Idrobo, and Rocıo Titiunik. "A Practical Introduction to Regression Discontinuity Designs: Foundations." arXiv preprint arXiv:1911.09511 (2019).

Meyersson, Erik. "Islamic Rule and the Empowerment of the Poor and Pious." Econometrica 82, no. 1 (2014): 229-269.