Understanding Confounders: Street Lighting and Crime Rates

Dr. Marsella's DAT 280 Class

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Rules:

1. Groups of no more than two.
2. You may not use AI or collaborate with other groups.

Introduction

Some very good research suggests that street lighting reduces crime. This exercise explores the relationship between street lighting improvements and crime rates, considering potential confounding factors. Suppose that this data is a cross-section of city blocks in a major city, where the following information is recorded

- Average income of those who live on the block.
- Whether or not the block has functioning, quality street lighting.
- Average rainfall per year in inches.
- The number of unique species of wildlife recorded on that block.
- Violent crimes per 1000 residents.

This is stored in `data.csv`

It is up to you to determine which variable is a potential confounder. Remember, a confounder is related to BOTH treatment and outcome.

Note that there is some true relationship that I have simulated and then sampled from with some random noise, such that $CrimeRate = \beta_0 + \beta_1 StreetLighting + \beta_2 Confounder + \epsilon$. You will be able to get an unbiased estimate of β_1 given you control for the confounder, then you will get $\hat{\beta}_1 \approx \beta_1$

Exercise 1: Identify your confounder and justify why you think it is a confounder.(3pt)

The average income of the residents in that block is likely a confounder in the relationship between street lighting and crime rates.

Exercise 2: Theorize the sign of its relationship to both X and Y, then determine the sign of the bias it introduces. (3pt)

Average income of the block is positively correlated with quality street lighting as higher income areas are nicer and therefore have higher quality ammenities, on average. Income is also negatively correlated with violent crime rates as higher income areas are generally safer. Thus, the bias introduced by average income of the block is negatuve.

Exercise 3: Run two linear regressions to examine the effect of street lighting on crime. One should NOT contain the confounder, one SHOULD contain the confounder. Display the estimates using the included stargazer code. (3pt)

```
data <- read.csv('data.csv')
model1 <- lm(crime_rate ~ street_lighting ,data = data)
model2 <- lm(crime_rate ~ street_lighting + avg_income,data=data)
library(stargazer)
```

```
##
## Please cite as:
##  Hlavac, Marek (2022). stargazer: Well-Formatted Regression and Summary Statistics Tables.
##  R package version 5.2.3. https://CRAN.R-project.org/package=stargazer
```

```
stargazer(model1, model2, type = "text",
          column.labels = c("Biased", "Unbiased"),
         title = "Comparative Analysis of Models")
```

```
##
## Comparative Analysis of Models
## ================================================================================
##                                        Dependent variable:
##                          ---------------------------------------------------
##                                              crime_rate
##                                  Biased                      Unbiased
##                                    (1)                          (2)
## --------------------------------------------------------------------------------
## street_lighting                -18.566***                   -10.368***
##                                 (0.590)                      (0.209)
##
## avg_income                                                  -0.001***
##                                                             (0.00001)
##
## Constant                       54.041***                    99.205***
##                                 (0.416)                      (0.502)
##
## --------------------------------------------------------------------------------
## Observations                     1,000                        1,000
## R2                               0.498                        0.948
## Adjusted R2                      0.498                        0.948
## Residual Std. Error       9.327 (df = 998)            2.993 (df = 997)
## F Statistic           990.506*** (df = 1; 998) 9,158.656*** (df = 2; 997)
## ================================================================================
## Note:                                            *p<0.1; **p<0.05; ***p<0.01
```

Exercise 4: Explain how the estimated effect of street lighting on crime differs between the two models and how it relates to the bias you described in exercise 2. (3pt)

The estimated effect of street lighting on crime rates in the biased model has a stronger negative effect than when the confounder of average income is controlled for as a covariate in the regression model. This is evidenced by a 8.198 difference in the effect street lighting has on crime rate after controlling for the confounder. The difference highlights that the negative bias introduced by the confounder made the effect

street lighting has on crime rates stronger than the true relationship.

Exercise 5: Provide a literal interpretation of the unbiased estimate of street lighting's effect on violent crime, directly referencing the units/context of the data. (3pt)

On blocks with high quality street lighting, violent crime rates are estimated to decrease by 10.468 crimes per thousand residents relative to blocks without high quality street lighting.

Exercise 6: Theorize the mechanism through which you believe street lighting affects crime. Explain. (3pt)

Good lighting makes events more visible, when a crime or a person committing the crime is more visible they are more likely to be found guilty of the crime. If someone is likely to be caught or found guilty of a crime they will avoid committing the crime in the first place until they are able to do so with a greater probability of not getting caught.

Exercise 7: Based on your findings and assuming your unbiased estimate is causally interpretable, briefly explain a policy recommendation for urban planners considering investments in street lighting. Discuss any caveats or conditions where your recommendation might not hold, based on the limitations of your analysis. (2pts)

Urban planners should invest in quality street lighting in areas of low income. Doing so, will make the residential area safer for all residents. The recommendation might not hold in low income over-policed areas. This is because crime rates are higher in these areas regardless of street lighting quality. Essentially, if there is already high crime in the area, then introducing street lighting is not likely to decrease crime rates in the area.