Causal Inference TA Section (3): IV

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Today's Goals

- Tutorial: IV Regression
- Replication #1: Hager and Krakowski APSR 2022
  - panel data as main specification
  - IV for causal inference
- Replication #2: López-Cariboni CPS 2022 (panel data with IV)

Tutorial: IV Regression

Acknowledgement: This example is adopted from Dr. Stephen Jessee (https://laits.utexas.edu/~sjessee/contact.html)'s lecture on causal inference.

Simulated Data

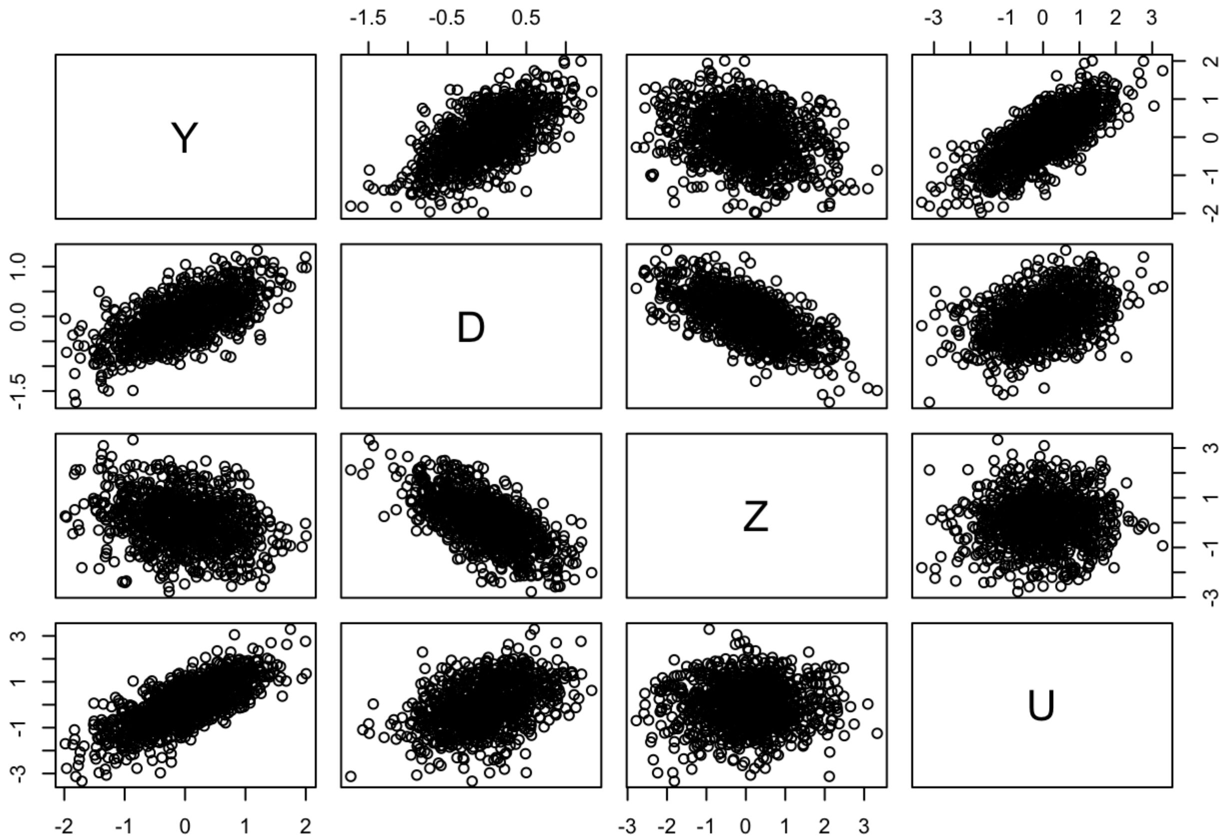
Let's start with generating some simulated data where Y is the outcome of interest, D is the treatment, Z is the instrumental variable, and U is a set of unobserved confounders (sometimes observatble).

```
set.seed(12345)
# setting sample size
N <- 1000

Z <- rnorm(N) # instrumental variable
U <- rnorm(N) # unobserved confounders

D <- .2*U - .3*Z + rnorm(N, sd=.3) # (confounded) treatment variable
Y <- .4*U + .6*D + rnorm(N, sd=.4) # dependent variable

pairs(cbind(Y, D, Z, U))
```



Let's do a naive estimation first. The estimated effect is nearly 1 (when real effect is .6).

```
reg.Y.D <- lm(Y ~ D)
summary(reg.Y.D)
```

```
##
## Call:
## lm(formula = Y ~ D)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -1.94296 -0.35151 -0.01812  0.33887  1.69304
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept) 0.004351   0.016809   0.259    0.796
## D           0.962743   0.036676  26.250   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.5306 on 998 degrees of freedom
## Multiple R-squared:  0.4084, Adjusted R-squared:  0.4078
## F-statistic:   689 on 1 and 998 DF,  p-value: < 2.2e-16
```

Ideally, to get the real effect, we want to control U. But it is unrealistic because U is unobserved/unobservable.

```
reg.Y.DU <- lm(Y ~ D + U)
summary(reg.Y.DU)
```

```
##
## Call:
## lm(formula = Y ~ D + U)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -1.34994 -0.25046 -0.01267  0.25335  1.02902
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept) 0.006515   0.012083   0.539     0.59
## D           0.599115   0.028922  20.715   <2e-16 ***
## U           0.401353   0.013128  30.572   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.3814 on 997 degrees of freedom
## Multiple R-squared:  0.6947, Adjusted R-squared:  0.6941
## F-statistic:  1134 on 2 and 997 DF,  p-value: < 2.2e-16
```

Constant Effects Models

Assuming we have an instrumental variable Z which affects Y through D and is independent from U. We start with estimating the effect of Z on Y.

```
reg.Y.Z <- lm(Y ~ Z)
summary(reg.Y.Z)
```

```
##
## Call:
## lm(formula = Y ~ Z)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -2.0067 -0.4642  0.0171  0.4674  2.0041
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept) -0.01427    0.02115  -0.675      0.5
## Z           -0.17199    0.02116  -8.126  1.3e-15 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.6681 on 998 degrees of freedom
## Multiple R-squared:  0.06206,    Adjusted R-squared:  0.06112
## F-statistic: 66.03 on 1 and 998 DF,  p-value: 1.302e-15
```

The effect of Z on D is -.3 and the effect of D on Y is .6. So the real effect of Z on Y is -.3*.6=-.18, which is very closed to the estimated effect.

We are interested in the real effect of D on Y.

```
reg.Y.Z <- lm(Y ~ Z) #Reduced form
reg.D.Z <- lm(D ~ Z) #First stage
stargazer::stargazer(reg.D.Z,reg.Y.Z,type='text',no.space = TRUE)
```

```
##
## ===========================================================
##                                 Dependent variable:
##                             ----------------------------
##                                     D              Y
##                                    (1)            (2)
## -----------------------------------------------------------
## Z                               -0.296***      -0.172***
##                                  (0.011)        (0.021)
## Constant                         -0.014         -0.014
##                                  (0.011)        (0.021)
## -----------------------------------------------------------
## Observations                      1,000          1,000
## R2                                0.416          0.062
## Adjusted R2                       0.416          0.061
## Residual Std. Error (df = 998)    0.350          0.668
## F Statistic (df = 1; 998)       711.528***     66.035***
## ===========================================================
## Note:                          *p<0.1; **p<0.05; ***p<0.01
```

Then we can calculate the real effect of D on Y:

```
coef(reg.Y.Z)[2] / coef(reg.D.Z)[2]
```

```
##      Z
## 0.5817
```

Two-stage Least Squares (2SLS)

2SLS will be more practical when you have more than 1 IV.

```
reg.D.Z <- lm(D ~ Z)
reg.Y.D_fitted<- lm(Y ~ reg.D.Z$fitted.values)
summary(reg.Y.D_fitted)
```

```
##
## Call:
## lm(formula = Y ~ reg.D.Z$fitted.values)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -2.0067 -0.4642  0.0171  0.4674  2.0041
##
## Coefficients:
##                        Estimate Std. Error t value Pr(>|t|)
## (Intercept)           -0.006164   0.021220  -0.290    0.772
## reg.D.Z$fitted.values  0.581700   0.071584   8.126  1.3e-15 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.6681 on 998 degrees of freedom
## Multiple R-squared:  0.06206,    Adjusted R-squared:  0.06112
## F-statistic: 66.03 on 1 and 998 DF,  p-value: 1.302e-15
```

IV Regression

We can also do it in one step:

```
library(AER) # loading Applied Econometrics with R package
reg.iv <- ivreg(Y ~ D | Z)
#reg.iv<- ivreg(Y ~ D + C| C + Z) if you have control variables C
summary(reg.iv)
```

```
##
## Call:
## ivreg(formula = Y ~ D | Z)
##
## Residuals:
##       Min        1Q    Median        3Q       Max
## -1.950362 -0.387842 -0.000555  0.382135  1.532142
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) -0.006164   0.017740  -0.347    0.728
## D            0.581700   0.059845   9.720   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.5586 on 998 degrees of freedom
## Multiple R-Squared: 0.3445,  Adjusted R-squared: 0.3438
## Wald test: 94.48 on 1 and 998 DF,  p-value: < 2.2e-16
```

Control IV to test Exclusion Restriction? No

Will Y~D+Z help to test the exclusion restriction assumption? NO

```
reg.Y.DZ <- lm(Y ~ D + Z)
summary(reg.Y.DZ)
```

```
##
## Call:
## lm(formula = Y ~ D + Z)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -1.97997 -0.34316 -0.02367  0.34395  1.78548
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept) 0.002932   0.016157   0.181    0.856
## D           1.234409   0.046137  26.755   <2e-16 ***
## Z           0.192983   0.021144   9.127   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.51 on 997 degrees of freedom
## Multiple R-squared:  0.4541, Adjusted R-squared:  0.453
## F-statistic: 414.6 on 2 and 997 DF,  p-value: < 2.2e-16
```

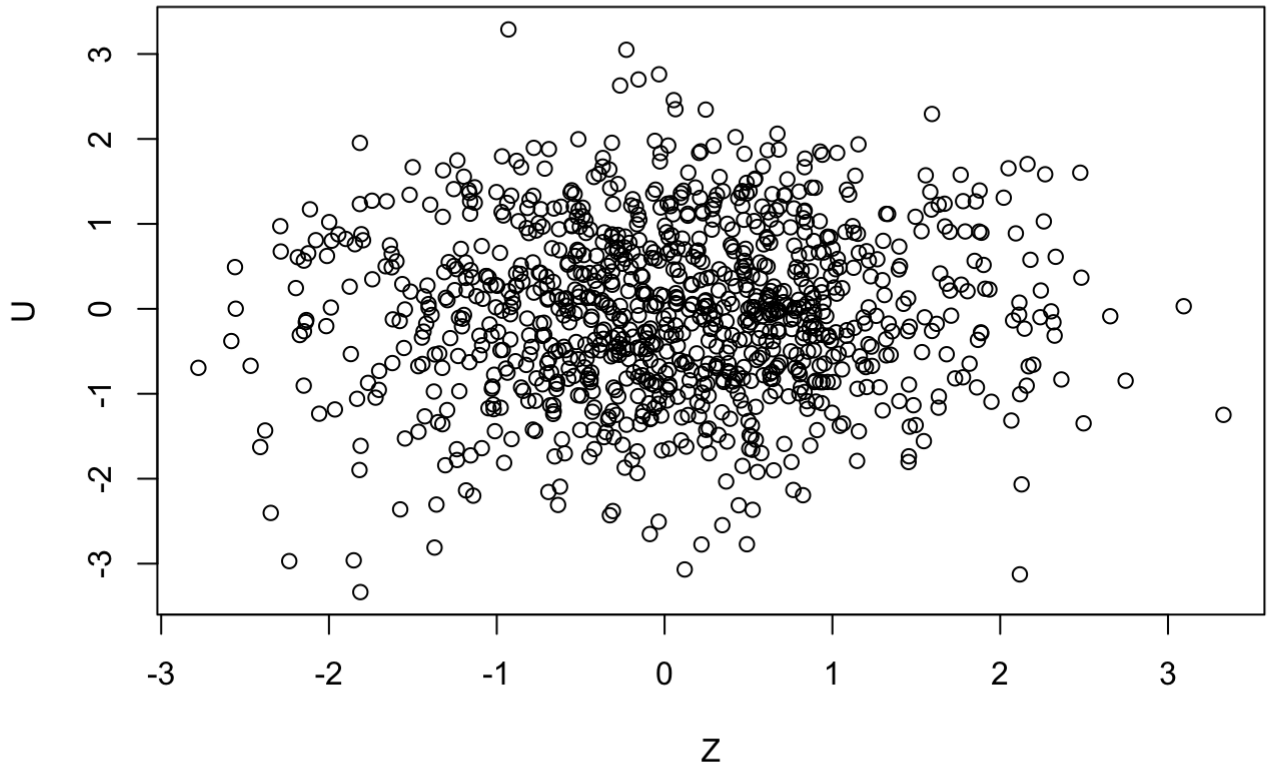
the coefficient on Z is significant even controlling for D! But we created these data such that Z only affects Y through D.

Let's see what happened.

```
reg.U.Z <- lm(U ~ Z)
summary(reg.U.Z)
```

```
##
## Call:
## lm(formula = U ~ Z)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -3.2315 -0.6975  0.0011  0.7156  3.3577
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept) -0.03220    0.03191  -1.009    0.313
## Z            0.03915    0.03193   1.226    0.221
##
## Residual standard error: 1.008 on 998 degrees of freedom
## Multiple R-squared:  0.001504,   Adjusted R-squared:  0.000503
## F-statistic: 1.503 on 1 and 998 DF,  p-value: 0.2205
```

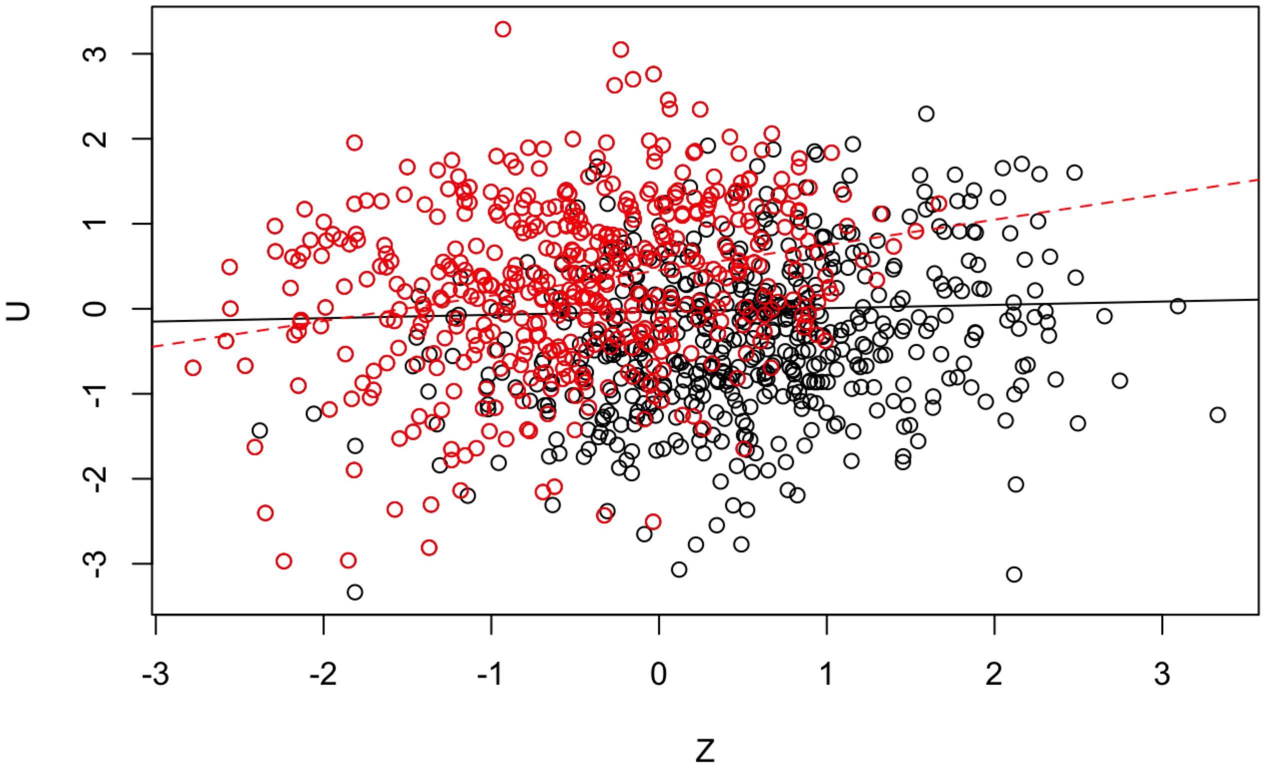
```
plot(Z, U)
```




```
plot(Z, U)
abline(reg.U.Z)
points(Z[D>0], U[D>0], col="red")
reg.U.Z.posD <- lm(U[D>0] ~ Z[D>0])
summary(reg.U.Z.posD)
```

```
##
## Call:
## lm(formula = U[D > 0] ~ Z[D > 0])
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -2.94792 -0.66253  0.03713  0.69522  3.11393
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  0.45232    0.05069   8.923  < 2e-16 ***
## Z[D > 0]     0.29789    0.05200   5.728  1.8e-08 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.9554 on 476 degrees of freedom
## Multiple R-squared:  0.06449,    Adjusted R-squared:  0.06253
## F-statistic: 32.81 on 1 and 476 DF,  p-value: 1.8e-08
```

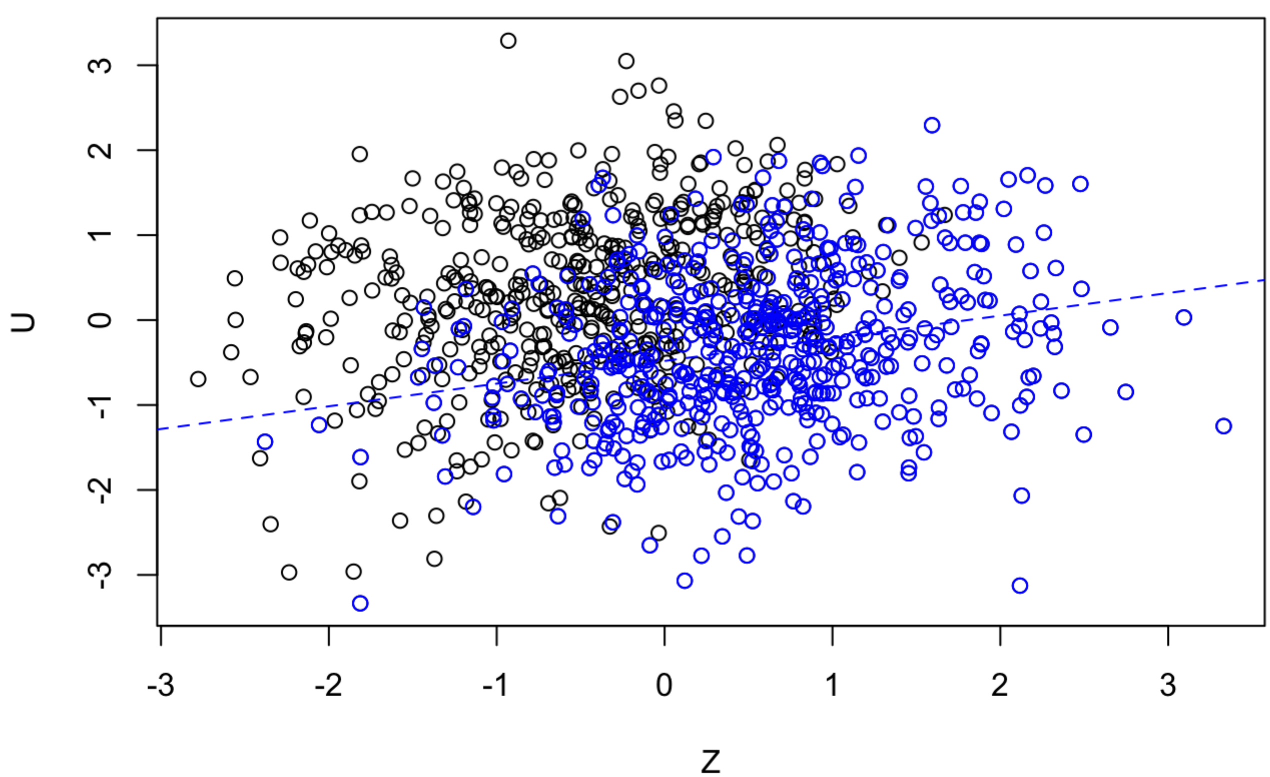
```
abline(reg.U.Z.posD, col="red", lty=2)
```




```
plot(Z, U)
points(Z[D<0], U[D<0], col="blue")
reg.U.Z.negD <- lm(U[D<0] ~ Z[D<0])
summary(reg.U.Z.negD)
```

```
##
## Call:
## lm(formula = U[D < 0] ~ Z[D < 0])
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -3.2089 -0.5604 -0.0299  0.5862  2.3508
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept) -0.48192    0.04640 -10.387  < 2e-16 ***
## Z[D < 0]     0.26672    0.04543   5.871 7.73e-09 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.8991 on 520 degrees of freedom
## Multiple R-squared:  0.06216,    Adjusted R-squared:  0.06036
## F-statistic: 34.47 on 1 and 520 DF,  p-value: 7.734e-09
```

```
abline(reg.U.Z.negD, col="blue", lty=2)
```



Conditioning on D (in this case high/low values) creates a non-causal association between Z and U it thus also creates a non-causal association b/t Z and Y, which operates through U. So this specification is just misguiding.

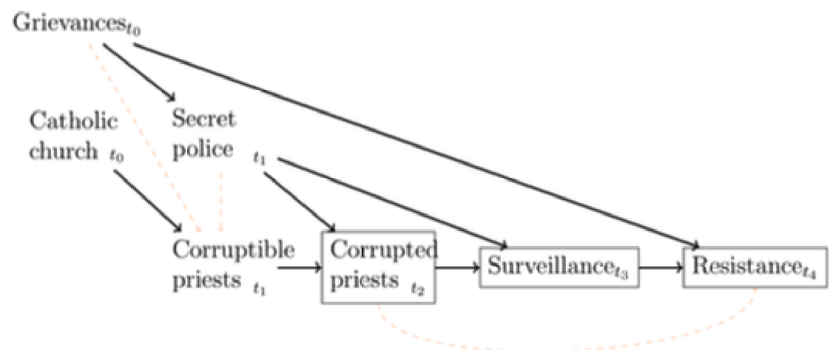
Replication #1: Hager and Krakowski APSR 2022

Hager and Krakowski APSR 2022, Does State Repression Spark Protests? Evidence from Secret Police Surveillance in Communist Poland (10.1017/S0003055421000770)

- Research Question: whether physical surveillance hinder or foster antiregime resistance?
- Data: Communist Poland 1945 - 1989
- Identification: two-way fixed effect panel models + IV
- Result: Secret police -> more protests, less sabotage

Anselm Hager and Krzysztof Krakowski

FIGURE 3. Instrumental Variable Model



Note: Directed acyclic graph of the IV model. *Solid black lines* refer to causal relationships between variables at the indicated points in time. *Dotted orange arrows* indicate causal relations assumed to be *absent*.

- Instrumental variable: corrupted priests
  - Assumptions: causal relationships of these dotted arrows are absent
  - Qualitative and quantitative evidence

Main Finding: Two-ways FE

```
library(readr)
library(plm)
data_t <- read_csv("data_t.csv")
m_2wfe <- plm(strikes ~ commanders, data = data_t, index = c("year", "locality"), model
= "within", effect = "twoways")
summary(m_2wfe)
```

```
## Twoways effects Within Model
##
## Call:
## plm(formula = strikes ~ commanders, data = data_t, effect = "twoways",
##     model = "within", index = c("year", "locality"))
##
## Balanced Panel: n = 7, T = 297, N = 2079
##
## Residuals:
##      Min.   1st Qu.    Median   3rd Qu.      Max.
## -5.455487 -0.251754  0.026979  0.139481 17.436081
##
## Coefficients:
##            Estimate Std. Error t-value  Pr(>|t|)
## commanders 0.162830   0.011818  13.778 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Total Sum of Squares:    1374.2
## Residual Sum of Squares: 1241.4
## R-Squared:      0.096621
## Adj. R-Squared: -0.057589
## F-statistic: 189.846 on 1 and 1775 DF, p-value: < 2.22e-16
```

IV Without Controls

```
data_agg_late <- readr::read_csv("data_agg_late.csv")
m_iv = ivreg(scale(strikes) ~ commanders | priests_continuous, data = data_agg_late)
summary(m_iv)
```

```
##
## Call:
## ivreg(formula = scale(strikes) ~ commanders | priests_continuous,
##     data = data_agg_late)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -7.0902 -0.2032 -0.2032 -0.2032  5.3956
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept) -0.07982    0.04638  -1.721   0.0863 .
## commanders   0.17653    0.02062   8.560 6.33e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.7829 on 295 degrees of freedom
## Multiple R-Squared: 0.3891,  Adjusted R-squared: 0.387
## Wald test: 73.27 on 1 and 295 DF,  p-value: 6.33e-16
```

Replication #2: López-Cariboni CPS 2022

López-Cariboni 2022 Political Regimes and Informal Social Insurance (https://journals.sagepub.com/doi/10.1177/00104140221139378).

- Research Question: What is the political motivation for deliberate nonenforcement of the law?
- Argument: Democracies * Negative Economic Shock -> Electricity loss
- Data: 110 developing countries 1970-2014
- IV: regional democratic diffusion * Negative Economic Shock

```
library(readr)
dt<- read.csv('dt_replication.csv')
iv_dem <- ivreg(outgap.tdl ~ l.outgap.tdl
    + l.outgap.gdp.hamilton * l.democracy#Estimator
    + as.factor(iso3c)
    + as.factor(year)
    | .
    - l.outgap.gdp.hamilton*l.democracy#Estimator
    + l.outgap.gdp.hamilton*l.wreg.democracy#IV
    ,
    data=dt, na.action=na.omit)
summary(iv_dem)
```

```
##
## Call:
## ivreg(formula = outgap.tdl ~ l.outgap.tdl + l.outgap.gdp.hamilton *
##     l.democracy + as.factor(iso3c) + as.factor(year) | . - l.outgap.gdp.hamilton *
##     l.democracy + l.outgap.gdp.hamilton * l.wreg.democracy, data = dt,
##     na.action = na.omit)
##
## Residuals:
##       Min        1Q    Median        3Q       Max
## -2.793263 -0.111132 -0.008912  0.084379  3.961454
##
## Coefficients:
##                                     Estimate Std. Error t value Pr(>|t|)
## (Intercept)                       -0.0963814  0.0755814  -1.275  0.20233
## l.outgap.tdl                       0.6423725  0.0142227  45.165  < 2e-16 ***
## l.outgap.gdp.hamilton              0.0022054  0.0068398   0.322  0.74714
## l.democracy                        0.0361513  0.1020100   0.354  0.72307
## as.factor(iso3c)ALB                0.1134801  0.1086984   1.044  0.29657
## as.factor(iso3c)ARE                0.0256484  0.0774112   0.331  0.74042
## as.factor(iso3c)ARG                0.0063618  0.1169037   0.054  0.95660
## as.factor(iso3c)ARM               -0.0521678  0.0904658  -0.577  0.56421
## as.factor(iso3c)AZE                0.0271074  0.0904714   0.300  0.76448
## as.factor(iso3c)BGD                0.0228123  0.0975748   0.234  0.81516
## as.factor(iso3c)BGR               -0.0158363  0.1169311  -0.135  0.89228
## as.factor(iso3c)BHR                0.0758740  0.0803829   0.944  0.34529
## as.factor(iso3c)BIH               -0.0649655  0.1390382  -0.467  0.64035
## as.factor(iso3c)BLR               -0.0006109  0.0904769  -0.007  0.99461
## as.factor(iso3c)BOL               -0.0226212  0.1213126  -0.186  0.85209
## as.factor(iso3c)BRA                0.0100936  0.1127514   0.090  0.92867
## as.factor(iso3c)BRN                0.0260661  0.0802893   0.325  0.74547
## as.factor(iso3c)BWA               -0.0284961  0.1321771  -0.216  0.82932
## as.factor(iso3c)CHL                0.0250005  0.1030990   0.242  0.80842
## as.factor(iso3c)CHN                0.0266289  0.0757279   0.352  0.72513
## as.factor(iso3c)CIV                0.0334140  0.0758785   0.440  0.65971
## as.factor(iso3c)CMR                0.0366175  0.0757152   0.484  0.62869
## as.factor(iso3c)COD                0.0645921  0.0758840   0.851  0.39473
## as.factor(iso3c)COG                0.0942302  0.0835898   1.127  0.25971
## as.factor(iso3c)COL               -0.0158241  0.1319608  -0.120  0.90456
## as.factor(iso3c)CRI                0.0065985  0.1322744   0.050  0.96022
## as.factor(iso3c)CUB                0.0337645  0.0757317   0.446  0.65574
## as.factor(iso3c)CYP               -0.0178146  0.1298952  -0.137  0.89092
## as.factor(iso3c)CZE               -0.0641254  0.1335383  -0.480  0.63112
## as.factor(iso3c)DOM               -0.0303150  0.1324636  -0.229  0.81900
## as.factor(iso3c)DZA                0.0310692  0.0757261   0.410  0.68163
## as.factor(iso3c)ECU               -0.0010899  0.1189519  -0.009  0.99269
## as.factor(iso3c)EGY                0.0270464  0.0757228   0.357  0.72098
## as.factor(iso3c)ERI                0.0318902  0.0975178   0.327  0.74368
## as.factor(iso3c)EST               -0.0900163  0.1369359  -0.657  0.51100
## as.factor(iso3c)ETH                0.0585880  0.0810231   0.723  0.46967
## as.factor(iso3c)GAB                0.0305084  0.0757263   0.403  0.68707
## as.factor(iso3c)GEO               -0.0180608  0.1032328  -0.175  0.86113
## as.factor(iso3c)GHA                0.0720550  0.0948404   0.760  0.44746
```

```
## as.factor(iso3c)GTM                 0.0010470  0.1231700   0.009  0.99322
## as.factor(iso3c)HND                 0.0043575  0.1174728   0.037  0.97041
## as.factor(iso3c)HRV                -0.0484238  0.1396635  -0.347  0.72883
## as.factor(iso3c)HTI                 0.0290805  0.0757351   0.384  0.70102
## as.factor(iso3c)HUN                -0.0397930  0.1346905  -0.295  0.76768
## as.factor(iso3c)IDN                 0.0246921  0.0887359   0.278  0.78083
## as.factor(iso3c)IND                 0.0083989  0.1299221   0.065  0.94846
## as.factor(iso3c)IRN                 0.0311597  0.0759282   0.410  0.68155
## as.factor(iso3c)IRQ                 0.0313712  0.0757278   0.414  0.67871
## as.factor(iso3c)ISR                -0.0190116  0.1321169  -0.144  0.88559
## as.factor(iso3c)JAM                -0.0094266  0.1323173  -0.071  0.94321
## as.factor(iso3c)JOR                 0.0034274  0.0779095   0.044  0.96491
## as.factor(iso3c)KAZ                -0.0093361  0.0904686  -0.103  0.91781
## as.factor(iso3c)KEN                 0.0266775  0.0848121   0.315  0.75313
## as.factor(iso3c)KGZ                 0.0192991  0.0904736   0.213  0.83110
## as.factor(iso3c)KHM                 0.0137153  0.0998556   0.137  0.89076
## as.factor(iso3c)KOR                -0.0209094  0.1067859  -0.196  0.84477
## as.factor(iso3c)KWT                 0.0330063  0.0999465   0.330  0.74124
## as.factor(iso3c)LBN                 0.0529039  0.0878224   0.602  0.54695
## as.factor(iso3c)LBY                 0.2307820  0.1131075   2.040  0.04140 *
## as.factor(iso3c)LKA                 0.0122397  0.0961313   0.127  0.89869
## as.factor(iso3c)LTU                -0.0167540  0.1396229  -0.120  0.90450
## as.factor(iso3c)LVA                -0.0748631  0.1400601  -0.535  0.59303
## as.factor(iso3c)MAR                 0.0369274  0.0757190   0.488  0.62580
## as.factor(iso3c)MDA                -0.0246903  0.1394300  -0.177  0.85946
## as.factor(iso3c)MEX                 0.0193335  0.0872039   0.222  0.82456
## as.factor(iso3c)MKD                -0.0112741  0.1334112  -0.085  0.93266
## as.factor(iso3c)MLT                -0.0008635  0.1321714  -0.007  0.99479
## as.factor(iso3c)MMR                 0.0303363  0.0757495   0.400  0.68883
## as.factor(iso3c)MNE                 0.0161723  0.1907842   0.085  0.93245
## as.factor(iso3c)MNG                -0.0047879  0.1305046  -0.037  0.97074
## as.factor(iso3c)MOZ                -0.0359686  0.0876690  -0.410  0.68163
## as.factor(iso3c)MUS                -0.0324916  0.1304515  -0.249  0.80332
## as.factor(iso3c)MYS                 0.0227709  0.0757211   0.301  0.76365
## as.factor(iso3c)NAM                 0.0367590  0.0920690   0.399  0.68973
## as.factor(iso3c)NER                 0.0360422  0.1382634   0.261  0.79436
## as.factor(iso3c)NGA                 0.0193410  0.0774048   0.250  0.80271
## as.factor(iso3c)NIC                -0.0240256  0.1162458  -0.207  0.83627
## as.factor(iso3c)NPL                 0.0146632  0.0913608   0.160  0.87250
## as.factor(iso3c)OMN                 0.0214063  0.0757140   0.283  0.77741
## as.factor(iso3c)PAK                 0.0008132  0.0932093   0.009  0.99304
## as.factor(iso3c)PAN                 0.0157893  0.1015391   0.155  0.87644
## as.factor(iso3c)PER                 0.0127395  0.1014688   0.126  0.90010
## as.factor(iso3c)PHL                 0.0019961  0.1112535   0.018  0.98569
## as.factor(iso3c)POL                -0.0589610  0.1334053  -0.442  0.65854
## as.factor(iso3c)PRY                 0.0014858  0.0834637   0.018  0.98580
## as.factor(iso3c)QAT                -0.0152580  0.1171755  -0.130  0.89641
## as.factor(iso3c)ROU                -0.0116447  0.1334438  -0.087  0.93047
## as.factor(iso3c)RUS                -0.0038277  0.0925213  -0.041  0.96700
## as.factor(iso3c)SAU                 0.0047119  0.0757561   0.062  0.95041
## as.factor(iso3c)SDN                 0.0225678  0.0770094   0.293  0.76950
## as.factor(iso3c)SEN                 0.0292358  0.0872501   0.335  0.73759
```

```
## as.factor(iso3c)SGP              0.0142157  0.0757210   0.188  0.85109
## as.factor(iso3c)SLV              0.0074315  0.1149239   0.065  0.94845
## as.factor(iso3c)SUR              0.0575049  0.1515375   0.379  0.70436
## as.factor(iso3c)SVK             -0.0298885  0.1352356  -0.221  0.82510
## as.factor(iso3c)SVN             -0.0235229  0.1334988  -0.176  0.86015
## as.factor(iso3c)TGO              0.0418883  0.0784486   0.534  0.59341
## as.factor(iso3c)THA              0.0095160  0.1049851   0.091  0.92778
## as.factor(iso3c)TJK              0.0349217  0.0905161   0.386  0.69967
## as.factor(iso3c)TKM              0.0158482  0.0905251   0.175  0.86104
## as.factor(iso3c)TTO              0.0351470  0.1314149   0.267  0.78914
## as.factor(iso3c)TUN              0.0310974  0.0757267   0.411  0.68135
## as.factor(iso3c)TUR              0.0055834  0.1250410   0.045  0.96439
## as.factor(iso3c)TZA             -0.0051167  0.0877885  -0.058  0.95353
## as.factor(iso3c)UKR             -0.0234375  0.1340214  -0.175  0.86119
## as.factor(iso3c)URY              0.0064197  0.1126347   0.057  0.95455
## as.factor(iso3c)UZB              0.0181445  0.0905778   0.200  0.84124
## as.factor(iso3c)VEN             -0.0169432  0.1137131  -0.149  0.88156
## as.factor(iso3c)VNM             -0.0034668  0.0835089  -0.042  0.96689
## as.factor(iso3c)YEM              0.0101083  0.0908929   0.111  0.91146
## as.factor(iso3c)ZAF              0.0163869  0.0962576   0.170  0.86483
## as.factor(iso3c)ZMB              0.0272836  0.0791966   0.345  0.73049
## as.factor(iso3c)ZWE              0.0385686  0.0757188   0.509  0.61053
## as.factor(year)1978              0.0477726  0.0564564   0.846  0.39751
## as.factor(year)1979              0.0384090  0.0565107   0.680  0.49676
## as.factor(year)1980              0.0262766  0.0564452   0.466  0.64159
## as.factor(year)1981              0.1114896  0.0561780   1.985  0.04728 *
## as.factor(year)1982              0.0521906  0.0556874   0.937  0.34873
## as.factor(year)1983              0.1124997  0.0558479   2.014  0.04405 *
## as.factor(year)1984             -0.0073257  0.0561587  -0.130  0.89622
## as.factor(year)1985              0.0390559  0.0566671   0.689  0.49074
## as.factor(year)1986             -0.0021277  0.0561284  -0.038  0.96976
## as.factor(year)1987              0.0333909  0.0569295   0.587  0.55756
## as.factor(year)1988              0.1060890  0.0566294   1.873  0.06111 .
## as.factor(year)1989              0.1647638  0.0574957   2.866  0.00419 **
## as.factor(year)1990              0.0882197  0.0569067   1.550  0.12118
## as.factor(year)1991              0.1050157  0.0572741   1.834  0.06681 .
## as.factor(year)1992              0.0332995  0.0590216   0.564  0.57267
## as.factor(year)1993              0.0073011  0.0602568   0.121  0.90357
## as.factor(year)1994              0.1031109  0.0601549   1.714  0.08661 .
## as.factor(year)1995              0.0390873  0.0613603   0.637  0.52416
## as.factor(year)1996              0.0934199  0.0605137   1.544  0.12274
## as.factor(year)1997              0.0689713  0.0588758   1.171  0.24150
## as.factor(year)1998              0.0538141  0.0597448   0.901  0.36780
## as.factor(year)1999              0.0628991  0.0596550   1.054  0.29179
## as.factor(year)2000              0.1288616  0.0592191   2.176  0.02963 *
## as.factor(year)2001              0.1081492  0.0595244   1.817  0.06933 .
## as.factor(year)2002              0.0666299  0.0602498   1.106  0.26886
## as.factor(year)2003              0.0608043  0.0601372   1.011  0.31205
## as.factor(year)2004              0.0467735  0.0611736   0.765  0.44457
## as.factor(year)2005              0.0730868  0.0610259   1.198  0.23115
## as.factor(year)2006              0.0690148  0.0605076   1.141  0.25413
## as.factor(year)2007              0.1190551  0.0601148   1.980  0.04774 *
```

```
## as.factor(year)2008               0.1324141  0.0597912   2.215  0.02686 *
## as.factor(year)2009               0.0777981  0.0614147   1.267  0.20533
## as.factor(year)2010               0.0723541  0.0603809   1.198  0.23089
## as.factor(year)2011               0.0608862  0.0604628   1.007  0.31401
## as.factor(year)2012               0.0250867  0.0618298   0.406  0.68496
## as.factor(year)2013               0.0596776  0.0617932   0.966  0.33424
## as.factor(year)2014               0.0927240  0.0617555   1.501  0.13334
## as.factor(year)2015              -0.0312008  0.3234857  -0.096  0.92317
## as.factor(year)2016              -0.0218120  0.3235011  -0.067  0.94625
## l.outgap.gdp.hamilton:l.democracy -0.0607667  0.0256632  -2.368  0.01795 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.3057 on 3096 degrees of freedom
## Multiple R-Squared: 0.4455,  Adjusted R-squared: 0.4183
## Wald test: 16.41 on 152 and 3096 DF,  p-value: < 2.2e-16
```

Another (easier) way to run a 2WFE with IV

```
library(fixest)#Fastest Fixed Effects
iv_dem<- feols(outgap.tdl ~ l.outgap.tdl|iso3c+year|l.outgap.gdp.hamilton * l.democracy~
l.outgap.gdp.hamilton * l.wreg.democracy,se='iid',data=dt)
etable(iv_dem)
```

```
##                                                  iv_dem
## Dependent Var.:                             outgap.tdl
##
## l.outgap.gdp.hamilton                 0.0022 (0.0068)
## l.democracy                           0.0362 (0.1020)
## l.outgap.gdp.hamilton:l.democracy  -0.0608* (0.0257)
## l.outgap.tdl                      0.6424*** (0.0142)
## Fixed-Effects:                    ------------------
## iso3c                                            Yes
## year                                             Yes
## _________________________________ __________________
## S.E. type                                        IID
## Observations                                   3,249
## R2                                           0.44551
## Within R2                                    0.42776
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```