Centering in Cross Sectional Data

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27 Jan 2022 13:57:31

# Introduction

These notes represent a brief discussion of centering with cross sectional data. Since so much of my current work focuses on cross national work on parenting and child development, I use these ideas as my substantive example.

Consider a cross-national data set where we are attempting to understand predictors of *behavior problems* as a function of *per capita income* and *parental use of physical punishment*.

# Simulate Some Data

Show / Hide Data Simulation Code

. clear all

. set obs 100  
Number of observations (\_N) was 0, now 100.

. generate income = runiform(10000, 70000)

. generate physical\_punishment = rbinomial(1,.3)

. generate country = int(\_n/10) + 1

. generate e = rnormal(0,1) // individual error

. generate u = country - 5 // random intercept

. generate behavior\_problems = 110 + -.0001 \* income + 10 \* physical\_punishment + u + e // plausib  
> le regression relationship

. list in 1/10, table // list out some data  
  
 ┌───────────────────────────────────────────────────────────┐  
 │ income physic~t country e u behavi~s │  
 ├───────────────────────────────────────────────────────────┤  
 1. │ 38510.68 0 1 .5267254 -4 102.6757 │  
 2. │ 21541.63 1 1 -.514424 -4 113.3314 │  
 3. │ 15810.88 1 1 -.662863 -4 113.7561 │  
 4. │ 30859.68 0 1 -1.792949 -4 101.1211 │  
 5. │ 38156.11 0 1 -.0498053 -4 102.1346 │  
 ├───────────────────────────────────────────────────────────┤  
 6. │ 35222.72 0 1 .7477483 -4 103.2255 │  
 7. │ 14933.72 0 1 -.6618822 -4 103.8447 │  
 8. │ 62175.32 0 1 1.233642 -4 101.0161 │  
 9. │ 44908.59 0 1 -.0998779 -4 101.4093 │  
 10. │ 41251.48 0 2 -.0472168 -3 102.8276 │  
 └───────────────────────────────────────────────────────────┘

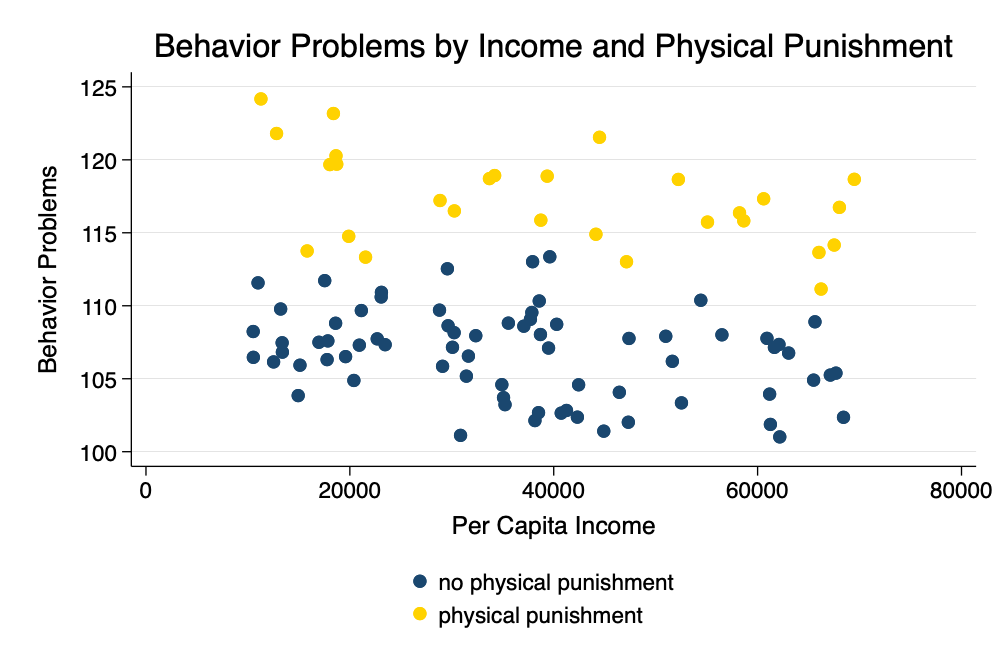
# Uncentered Data

## Equation

## Graph

. twoway (scatter behavior\_problems income if physical\_punishment ==0) ///  
> (scatter behavior\_problems income if physical\_punishment == 1), ///  
> legend(order(1 "no physical punishment" 2 "physical punishment") pos(6)) ///  
> title("Behavior Problems by Income and Physical Punishment") ///  
> xtitle("Per Capita Income") ///  
> ytitle("Behavior Problems") ///  
> scheme(michigan)

. graph export myscatter.png, width(1000) replace  
file /Users/agrogan/Desktop/GitHub/multilevel/centering-in-cross-sectional-data/myscatter.png  
 saved as PNG format



Scatterplot

## Multilevel Model

. mixed behavior\_problems income physical\_punishment || country:  
  
Performing EM optimization:   
  
Performing gradient-based optimization:   
  
Iteration 0: log likelihood = -154.77318   
Iteration 1: log likelihood = -154.77318   
  
Computing standard errors:  
  
Mixed-effects ML regression Number of obs = 100  
Group variable: country Number of groups = 11  
 Obs per group:  
 min = 1  
 avg = 9.1  
 max = 10  
 Wald chi2(2) = 2321.02  
Log likelihood = -154.77318 Prob > chi2 = 0.0000  
  
────────────────────┬────────────────────────────────────────────────────────────────  
 behavior\_problems │ Coefficient Std. err. z P>|z| [95% conf. interval]  
────────────────────┼────────────────────────────────────────────────────────────────  
 income │ -.0000972 5.29e-06 -18.37 0.000 -.0001075 -.0000868  
physical\_punishment │ 10.09371 .21943 46.00 0.000 9.663634 10.52378  
 \_cons │ 110.9816 .9910829 111.98 0.000 109.0391 112.9241  
────────────────────┴────────────────────────────────────────────────────────────────  
  
─────────────────────────────┬────────────────────────────────────────────────  
 Random-effects parameters │ Estimate Std. err. [95% conf. interval]  
─────────────────────────────┼────────────────────────────────────────────────  
country: Identity │  
 var(\_cons) │ 10.21833 4.480481 4.326623 24.13295  
─────────────────────────────┼────────────────────────────────────────────────  
 var(Residual) │ .7733333 .1161378 .5761489 1.038003  
─────────────────────────────┴────────────────────────────────────────────────  
LR test vs. linear model: chibar2(01) = 181.47 Prob >= chibar2 = 0.0000

We note that -0.972 is the effect of every additional $10,000 of per capita income. 10.094 is the effect of physical punishment. Notably, for this handout, 110.982 is the level of behavior problems for a child who did *not receive physical punishment* living in a family with **$0** *income*.

# Grand Mean Centering

Grand mean centering helps us to have more meaningful intercepts of our continuous variables.

Essentially, we are going to create

## Equation

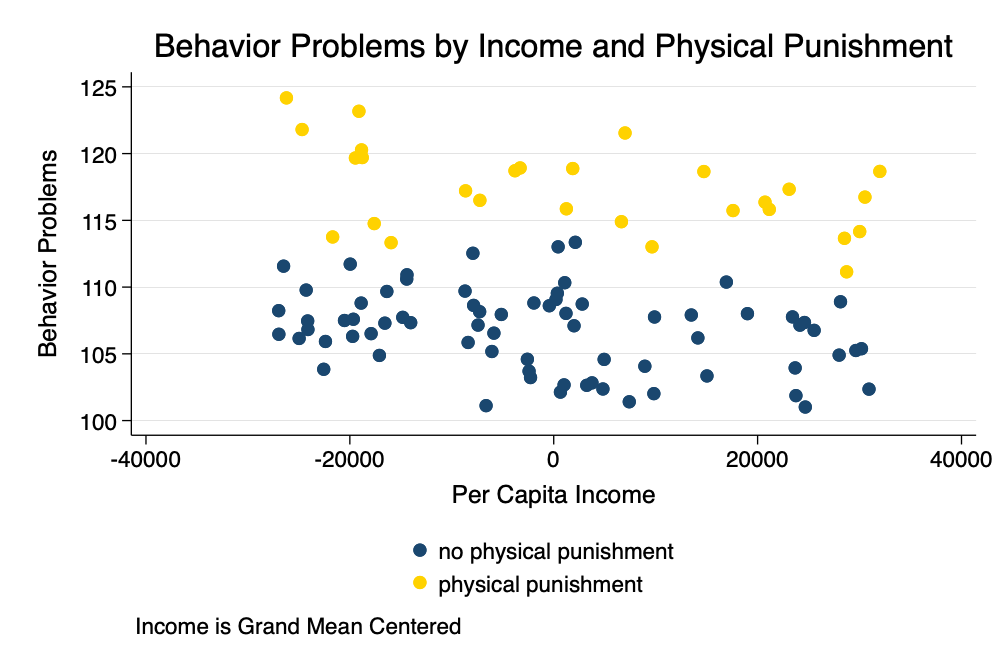
## Graph

. egen m\_income = mean(income) // grand mean of income

. generate c\_income = income - m\_income // grand mean centered income

. twoway (scatter behavior\_problems c\_income if physical\_punishment ==0) ///  
> (scatter behavior\_problems c\_income if physical\_punishment == 1), ///  
> legend(order(1 "no physical punishment" 2 "physical punishment") pos(6)) ///  
> title("Behavior Problems by Income and Physical Punishment") ///  
> caption("Income is Grand Mean Centered") ///  
> xtitle("Per Capita Income") ///  
> ytitle("Behavior Problems") ///  
> scheme(michigan)

. graph export myscatter2.png, width(1000) replace  
file /Users/agrogan/Desktop/GitHub/multilevel/centering-in-cross-sectional-data/myscatter2.png  
 saved as PNG format



Scatterplot With Grand Mean Centering

In a graph, we see that *grand mean centering* has transformed the intercept so now the term is the level of behavior problems for the *average* child who did *not recieve physical punishment*.

## Multilevel Model

. mixed behavior\_problems c\_income physical\_punishment || country:  
  
Performing EM optimization:   
  
Performing gradient-based optimization:   
  
Iteration 0: log likelihood = -154.77318   
Iteration 1: log likelihood = -154.77318   
  
Computing standard errors:  
  
Mixed-effects ML regression Number of obs = 100  
Group variable: country Number of groups = 11  
 Obs per group:  
 min = 1  
 avg = 9.1  
 max = 10  
 Wald chi2(2) = 2321.02  
Log likelihood = -154.77318 Prob > chi2 = 0.0000  
  
────────────────────┬────────────────────────────────────────────────────────────────  
 behavior\_problems │ Coefficient Std. err. z P>|z| [95% conf. interval]  
────────────────────┼────────────────────────────────────────────────────────────────  
 c\_income │ -.0000972 5.29e-06 -18.37 0.000 -.0001075 -.0000868  
physical\_punishment │ 10.09371 .21943 46.00 0.000 9.663634 10.52378  
 \_cons │ 107.3387 .9719362 110.44 0.000 105.4337 109.2436  
────────────────────┴────────────────────────────────────────────────────────────────  
  
─────────────────────────────┬────────────────────────────────────────────────  
 Random-effects parameters │ Estimate Std. err. [95% conf. interval]  
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country: Identity │  
 var(\_cons) │ 10.21833 4.480481 4.326623 24.13295  
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 var(Residual) │ .7733333 .1161378 .5761489 1.038003  
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LR test vs. linear model: chibar2(01) = 181.47 Prob >= chibar2 = 0.0000

We see that the and regression coefficients have not changed. However, the intercept, has changed, and is now more meaningful.

# Group Mean Centering

In group mean centering, we are doing something slightly different. We are creating a mean for each *group*, which in this data is *country*: e.g. , where is the index for *group* or *country*.

. bysort country: egen m\_g\_income = mean(income) // GROUP mean of income

. generate c\_g\_income = income - m\_g\_income // GROUP mean centered income

. bysort country: egen m\_g\_physical\_punishment = mean(physical\_punishment) // GROUP mean of physic  
> al punishment

. generate c\_g\_physical\_punishment = physical\_punishment - m\_g\_physical\_punishment // GROUP mean c  
> entered physical punishment

Interestingly, *group mean centering* has many implications. Here I focus on how employing different variables might provide *conceptually* or *theoretically* different results. For the sake of parismony, in the brief discussion below I focus on these *conceptual* or *theoretical* differences, and do not provide output. I use the quietly prefix to suppress output.

## Equation

Two versions of the equation are equally appropriate. Both address *conceptually* or *theoretically* different questions.

### Covariate and Group Mean

One parameterization of the multilevel model is to enter the *covariate* and its *group level mean* i.e.  and .

### Group Mean Centered Covariate and Group Mean

A second, equally valid, but conceptually different parameterization of the multilevel model is to enter the *covariate deviated from its group level mean* and the *group level mean* i.e.  and .

## Multilevel Model

Again, for the sake of parsimony, I use the quietly prefix to suppress output of the multilevel models.

### Covariate and Group Mean

This first parameterization focuses on *individual scores on covariates* and their *country level means*.

What is the effect of *income*, *country level mean income*, *physical punishment* and *country level mean of physical punishment* on *behavior problems*?

. quietly: mixed behavior\_problems income m\_g\_income physical\_punishment m\_g\_physical\_punishment |  
> | country:

### Group Mean Centered Covariate and Group Mean

This second parameterization focuses on how *individuals differ from their country level means*, and *country level means*.

What is the effect of *income deviated from its country level mean*, *country level mean income*, *physical punishment deviated from its country level punishment*, and *country level mean of physical punishment* on *behavior problems*?

. quietly: mixed behavior\_problems c\_g\_physical\_punishment m\_g\_income c\_g\_physical\_punishment m\_g\_  
> physical\_punishment || country: