

Multilevel Workshop

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2024-07-31

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1 Introduction

Workshop materials for a workshop on Multilevel Modeling

2 Two Level Cross Sectional; And Three Level Longitudinal Models

3 Cross Sectional Model

3.1 Get Data

```
use "simulated_multilevel_data.dta", clear
```

3.2 The Equation

$$\text{outcome}_{ij} = \beta_0 + \beta_1 \text{parental warmth} + \beta_2 \text{physical punishment} + \beta_3 \text{time} +$$

$$\beta_4 \text{identity}_2 + \beta_5 \text{intervention} + \beta_6 \text{HDI} +$$

$$u_{0j} + u_{1j} \times \text{parental warmth} + e_{ij}$$

3.3 Descriptive Statistics

```
summarize // descriptive statistics
```

Variable	Obs	Mean	Std. dev.	Min	Max
country	3,000	15.5	8.656884	1	30
HDI	3,000	64.76667	17.24562	33	87
family	3,000	50.5	28.87088	1	100
id	0				
identity	3,000	.4976667	.5000779	0	1
intervention	3,000	.4843333	.4998378	0	1
physical_p~t	3,000	2.478667	1.360942	0	5

warmth	3,000	3.521667	1.888399	0	7
outcome	3,000	52.43327	6.530996	29.60798	74.83553

3.4 Spaghetti Plot

```
spagplot outcome warmth, id(country) scheme(stcolor)
graph export spagplot1.png, width(1000) replace
```

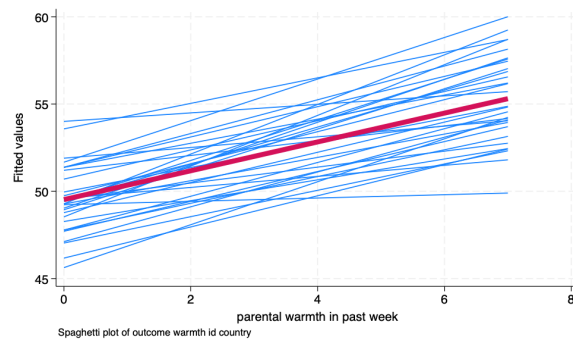


Figure 3.1: Spaghetti Plot of Outcome by Warmth by Country

3.5 Unconditional Model

3.5.1 Model

```
mixed outcome || country: // unconditional model
```

Performing EM optimization ...

Performing gradient-based optimization:

Iteration 0: Log likelihood = -9802.8371

Iteration 1: Log likelihood = -9802.8371

Computing standard errors ...

Mixed-effects ML regression
Group variable: country

Number of obs = 3,000
Number of groups = 30
Obs per group:
min = 100
avg = 100.0
max = 100
Wald chi2(0) = .
Prob > chi2 = .

Log likelihood = -9802.8371

outcome	Coefficient	Std. err.	z	P> z	[95% conf. interval]	
-----+-----						
_cons	52.43327	.3451217	151.93	0.000	51.75685	53.1097
-----+-----						

Random-effects parameters	Estimate	Std. err.	[95% conf. interval]	
-----+-----				
country: Identity				
var(_cons)	3.178658	.9226737	1.799552	5.614658
-----+-----				
var(Residual)	39.46106	1.024013	37.50421	41.52
-----+-----				

LR test vs. linear model: chibar2(01) = 166.31 Prob >= chibar2 = 0.0000

3.5.2 ICC

```
estat icc
```

Intraclass correlation

Level	ICC	Std. err.	[95% conf. interval]	
-----+-----				
country	.0745469	.0201254	.0434963	.1248696
-----+-----				

3.6 Full Model

```
mixed outcome warmth physical_punishment identity i.intervention HDI || country: warmth // m
est store crosssectional // store estimates
```

Performing EM optimization ...

Performing gradient-based optimization:

Iteration 0: Log likelihood = -9626.6279

Iteration 1: Log likelihood = -9626.607

Iteration 2: Log likelihood = -9626.607

Computing standard errors ...

Mixed-effects ML regression

Group variable: country

Number of obs = 3,000

Number of groups = 30

Obs per group:

min = 100

avg = 100.0

max = 100

Wald chi2(5) = 334.14

Prob > chi2 = 0.0000

Log likelihood = -9626.607

	outcome	Coefficient	Std. err.	z	P> z	[95% conf. interval]	
	warmth	.8345368	.0637213	13.10	0.000	.7096453	.9594282
physical_punishment		-.9916657	.0797906	-12.43	0.000	-1.148052	-.8352791
identity		-.3004767	.2170295	-1.38	0.166	-.7258466	.1248933
1.intervention		.6396427	.2174519	2.94	0.003	.2134448	1.065841
HDI		-.003228	.0199257	-0.16	0.871	-.0422817	.0358256
_cons		51.99991	1.371257	37.92	0.000	49.3123	54.68753

Random-effects parameters		Estimate	Std. err.	[95% conf. interval]	
country: Independent					
	var(warmth)	.0227504	.0257784	.0024689	.2096436
	var(_cons)	2.963975	.9737647	1.556777	5.643163

<hr/>				
	+			
var(Residual)		34.97499	.9097109	33.23668 36.80422

LR test vs. linear model: $\chi^2(2) = 205.74$ Prob > $\chi^2 = 0.0000$

Note: LR test is conservative and provided only for reference.

4 Longitudinal Model

4.1 Setup

```
use "simulated_multilevel_longitudinal_data.dta", clear
```

4.2 The Equation

$$\text{outcome}_{ij} = \beta_0 + \beta_1 \text{parental warmth} + \beta_2 \text{physical punishment} + \beta_3 \text{time} +$$

$$\beta_4 \text{identity}_2 + \beta_5 \text{intervention} + \beta_5 \text{HDI} +$$

$$u_{0j} + u_{1j} \times \text{parental warmth} +$$

$$v_{0i} + v_{1i} \times t + e_{ij}$$

4.3 Descriptive Statistics

```
summarize // descriptive statistics
```

Variable	Obs	Mean	Std. dev.	Min	Max
country	9,000	15.5	8.655922	1	30
HDI	9,000	64.76667	17.2437	33	87
family	9,000	50.5	28.86767	1	100
id	0				
identity	9,000	.4976667	.5000223	0	1

intervention		9,000	.4843333	.4997823	0	1
t		9,000	2	.8165419	1	3
physical_p~t		9,000	2.485333	1.373639	0	5
warmth		9,000	3.514222	1.8839	0	7
outcome		9,000	53.37768	6.572285	29.60798	79.02199

4.4 Alternate Plot

```

encode id, generate(idNUMERIC) // numeric version of id

* spagplot outcome t if idNUMERIC <= 10, id(idNUMERIC) scheme(stcolor)

twoway (lfit outcome t) (scatter outcome t) if idNUMERIC <= 10, by(idNUMERIC) scheme(stcolor)

graph export spagplot2.png, width(1000) replace

```

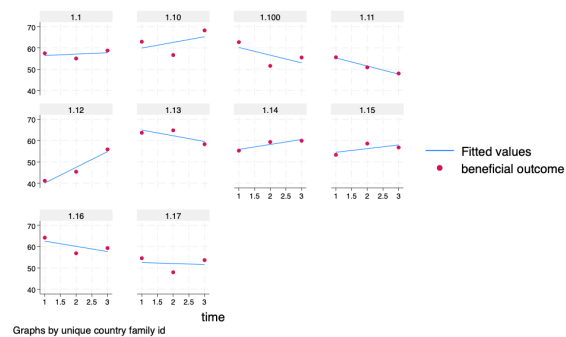


Figure 4.1: Alternate Plot of Outcome by Time by Individual; First 10 Observations

4.5 Unconditional Model

4.5.1 Model

```

mixed outcome || country: || id: // unconditional model

```

4.5.2 ICC

```
estat icc
```

Intraclass correlation

Level	ICC	Std. err.	[95% conf. interval]	
country	.0748336	.0190847	.0450028	.1219141
id country	.3462837	.0171461	.3134867	.3806097

4.6 Full Model

```
mixed outcome t warmth physical_punishment i.identity i.intervention HDI || country: warmth  
est store longitudinal // store estimates
```

Performing EM optimization ...

Performing gradient-based optimization:

Iteration 0: Log likelihood = -28523.49
Iteration 1: Log likelihood = -28499.987
Iteration 2: Log likelihood = -28499.739
Iteration 3: Log likelihood = -28499.604
Iteration 4: Log likelihood = -28499.603

Computing standard errors ...

Mixed-effects ML regression

Number of obs = 9,000

Grouping information

Group variable	No. of groups	Observations per group		
		Minimum	Average	Maximum

country	30	300	300.0	300
id	3,000	3	3.0	3

Log likelihood = -28499.603

Wald chi2(6) = 1096.15
Prob > chi2 = 0.0000

outcome	Coefficient	Std. err.	z	P> z	[95% conf. interval]	
t	.943864	.0658716	14.33	0.000	.814758	1.07297
warmth	.9134959	.0423732	21.56	0.000	.830446	.9965459
physical_punishment	-1.007897	.0497622	-20.25	0.000	-1.105429	-.9103647
1.identity	-.1276926	.1515835	-0.84	0.400	-.4247908	.1694057
1.intervention	.8589966	.1519095	5.65	0.000	.5612596	1.156734
HDI	-.0005657	.0196437	-0.03	0.977	-.0390666	.0379352
_cons	50.46724	1.338318	37.71	0.000	47.84418	53.09029

Random-effects parameters	Estimate	Std. err.	[95% conf. interval]	
country: Independent				
var(warmth)	.0107586	.0127845	.0010478	.1104703
var(_cons)	3.167085	.9146761	1.798154	5.578181
id: Independent				
var(t)	3.58e-09	7.06e-07	3.5e-177	3.7e+159
var(_cons)	8.387275	.4724188	7.510631	9.366242
var(Residual)	26.02733	.4753701	25.11211	26.97592

LR test vs. linear model: chi2(4) = 1247.03 Prob > chi2 = 0.0000

Note: LR test is conservative and provided only for reference.

5 Nice Table of Results

```
est table crossectional longitudinal, ///
b(%9.3f) star stats(N ll chi2) ///
varwidth(20) modelwidth(15)
```

Variable		crossectional	longitudinal
outcome			
	warmth	0.835***	0.913***
	physical_punishment	-0.992***	-1.008***
	identity	-0.300	
	intervention		
	1	0.640**	0.859***
	HDI	-0.003	-0.001
	t		0.944***
	identity		
	1		-0.128
	_cons	52.000***	50.467***
lns1_1_1			
	_cons	-1.892***	-2.266***
lns1_1_2			
	_cons	0.543***	0.576***
lnsig_e			
	_cons	1.777***	1.630***
lns2_1_1			
	_cons		-9.724

-----+-----			
lns2_1_2			
	_cons		1.063***
-----+-----			
Statistics			
	N		3000 9000
	ll		-9626.607 -2.85e+04
	chi2		334.143 1096.148

Legend: * p<0.05; ** p<0.01; *** p<0.001			

6 QUESTIONS???

7 Cross-Classified Models

8 Introduction

A two level multilevel model imagines that *Level 1* units are nested in *Level 2* units. A three level multilevel model imagines that *Level 1* units are nested in *Level 2* units, which are in turn nested in *Level 3*.

A cross-classified model imagines that the nesting is not hierarchical, but rather that there are two sets of clusters or nestings in which individuals may be nested.

9 Setup

```
use "simulated_multilevel_longitudinal_data.dta", clear
```

10 Cross Classified Model

We can treat these random effects as being *cross classified*.

This might be useful if we had data where individuals lived in different countries at different times.

However, because `id` is in fact nested inside `country`, in this case, estimating the random effects as cross classified will be more time consuming, but will give us equivalent results to a three level model.

10.1 Standard (Less Computationally Efficient) Syntax

The below syntax will take a very long time to run with the full sample, and thus we have commented it out.

```
* mixed outcome t warmth physical_punishment || _all: R.country || _all: R.id  
* est store crossed1
```

The documentation notes that we can use a *much* more computationally efficient version of the above command, which is what we do in these notes. The user can verify that both versions of the command will produce equivalent results.

In fact, at the end of handout we verify the similarity of both sets of syntax using a random sample.

10.2 Cross Classified With Computationally Efficient Syntax

```
mixed outcome t warmth physical_punishment || _all: R.country || id:  
est store crossed2 // store crossed effects result
```

Performing EM optimization ...

Performing gradient-based optimization:

Iteration 0: Log likelihood = -28516.314

Iteration 1: Log likelihood = -28516.277

Iteration 2: Log likelihood = -28516.277

Computing standard errors ...

Mixed-effects ML regression

Number of obs = 9,000

Grouping information

Group variable		No. of groups	Observations per group		
			Minimum	Average	Maximum
_all		1	9,000	9,000.0	9,000
id		3,000	3	3.0	3

Log likelihood = -28516.277

Wald chi2(3) = 1168.69

Prob > chi2 = 0.0000

outcome	Coefficient	Std. err.	z	P> z	[95% conf. interval]	
t	.9434605	.065866	14.32	0.000	.8143654	1.072556
warmth	.9053924	.0380439	23.80	0.000	.8308277	.9799572
physical_punishment	-1.014385	.0499354	-20.31	0.000	-1.112257	-.916514
_cons	50.8301	.4123007	123.28	0.000	50.022	51.63819

Random-effects parameters		Estimate	Std. err.	[95% conf. interval]	
_all: Identity					
	var(R.country)	3.429974	.930313	2.015668	5.836634
id: Identity					
	var(_cons)	8.608872	.4757699	7.725107	9.59374
	var(Residual)	26.02862	.4752444	25.11363	26.97695

LR test vs. linear model: $\text{chi2}(2) = 1260.84$ Prob > chi2 = 0.0000

Note: LR test is conservative and provided only for reference.

11 Three Level Model

```
mixed outcome t warmth physical_punishment || country: || id: // 3 level w/ random intercept
est store threelevel // store random intercept model
```

Performing EM optimization ...

Performing gradient-based optimization:

Iteration 0: Log likelihood = -28516.314

Iteration 1: Log likelihood = -28516.277

Iteration 2: Log likelihood = -28516.277

Computing standard errors ...

Mixed-effects ML regression

Number of obs = 9,000

Grouping information

Group variable		No. of groups	Observations per group		
			Minimum	Average	Maximum
country		30	300	300.0	300
id		3,000	3	3.0	3

Log likelihood = -28516.277

Wald chi2(3) = 1168.69

Prob > chi2 = 0.0000

outcome	Coefficient	Std. err.	z	P> z	[95% conf. interval]	
t	.9434605	.065866	14.32	0.000	.8143654	1.072556
warmth	.9053924	.0380439	23.80	0.000	.8308277	.9799572
physical_punishment	-1.014385	.0499354	-20.31	0.000	-1.112257	-.916514

_cons		50.8301	.4123007	123.28	0.000	50.022	51.63819

Random-effects parameters		Estimate	Std. err.	[95% conf. interval]			
-----+-----							
country: Identity							
	var(_cons)	3.429974	.930313		2.015668		5.836634
-----+-----							
id: Identity							
	var(_cons)	8.608872	.4757699		7.725107		9.59374
-----+-----							
	var(Residual)	26.02862	.4752444		25.11363		26.97695

LR test vs. linear model: chi2(2) = 1260.84					Prob > chi2 = 0.0000		

Note: LR test is conservative and provided only for reference.

12 Nice Table of Results of Three Level and Cross Classified Model

```
est table threelevel crossed2, ///
b(%9.3f) star stats(N ll chi2) ///
varwidth(20) modelwidth(15)
```

Variable	threelevel	crossed2
outcome		
t	0.943***	0.943***
warmth	0.905***	0.905***
physical_punishment	-1.014***	-1.014***
_cons	50.830***	50.830***
lns1_1_1		
_cons	0.616***	0.616***
lns2_1_1		
_cons	1.076***	1.076***
lnsig_e		
_cons	1.630***	1.630***
Statistics		
N	9000	9000
ll	-2.85e+04	-2.85e+04
chi2	1168.689	1168.689

Legend: * p<0.05; ** p<0.01; *** p<0.001

13 Verification of Syntax Equivalence for Cross Classified Model

```
keep if family <= 5 // random sample of families

quietly mixed outcome t warmth physical_punishment || _all: R.country || _all: R.id

est store crossed1A // less efficient syntax

quietly mixed outcome t warmth physical_punishment || _all: R.country || id:

est store crossed2A // more efficient syntax

est table crossed1A crossed2A, ///
b(%9.3f) star stats(N ll chi2) ///
varwidth(20) modelwidth(15)
```

(8,550 observations deleted)

Variable		crossed1A	crossed2A
-----+-----			
outcome			
t		0.745**	0.745**
warmth		0.871***	0.871***
physical_punishment		-1.262***	-1.262***
_cons		51.755***	51.755***
-----+-----			

lns1_1_1			
	_cons		0.404
			0.404
-----+-----			
lns1_2_1			
	_cons		0.846***
-----+-----			
lnsig_e			
	_cons		1.581***
			1.581***
-----+-----			
lns2_1_1			
	_cons		0.846***
-----+-----			
Statistics			
	N		450
			450
	ll		-1398.626
			-1398.626
	chi2		72.575
			72.575
-----+-----			

Legend: * p<0.05; ** p<0.01; *** p<0.001

14 QUESTIONS???