

Workshop on Multilevel Modeling 2

Cross Classified Models

Andy Grogan-Kaylor

2024-05-13

Table of contents

1	Introduction	1
2	Setup	2
3	Cross Classified Model	2
3.1	Standard (Less Computationally Efficient) Syntax	2
3.2	Cross Classified With Computationally Efficient Syntax	2
4	Three Level Model	4
5	Nice Table of Results of Three Level and Cross Classified Model	5
6	Verification of Syntax Equivalence for Cross Classified Model	6
7	QUESTIONS???	7

1 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.

2 Setup

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

3 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.

3.1 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.

3.2 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: $\chi^2(2) = 1260.84$ Prob > $\chi^2 = 0.0000$

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

4 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 $\chi^2(3) = 1168.69$

Prob > $\chi^2 = 0.0000$

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: $\chi^2(2) = 1260.84$ Prob > $\chi^2 = 0.0000$

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

5 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				

6 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

7 QUESTIONS???