

# Running MLwiN from within Stata: the `runmlwin` command

8th International Amsterdam  
Multilevel Conference  
11<sup>th</sup> March 2011

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Centre for Multilevel Modelling  
University of Bristol

# INTRODUCTION

# Existing multilevel modelling commands in Stata

- Stata provide the `xtmixed`, `xtmelogit` and `xtmepoisson` commands to fit multilevel models
  - Limited range of models can be specified
  - Computationally quite slow to fit models
- Sophia Rabe-Hesketh and Anders Skrondal provide the `gllamm` command
  - Wide range of models can be specified
  - Computationally slow to fit models
- Other user-written multilevel modelling commands include: `hlm`, `realcomimpute`, `runmplus`, `sabre`, `winbugs`

# Multilevel modelling in MLwiN

1. Estimation of multilevel models for continuous, binary, **ordered categorical**, **unordered categorical** and count data
2. Fast estimation via classical and **Bayesian** methods
3. Estimation of multilevel models for cross-classified and **multiple membership** non-hierarchical data structures
4. Estimation of multilevel **multivariate response models**, **multilevel spatial models**, **multilevel measurement error models**, **multilevel multiple imputation models** and **multilevel factor models**

# TWO-LEVEL MULTILEVEL MODELS

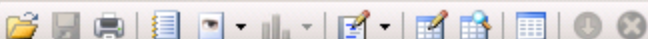
# Two-level variance components model

- Inner-London schools exam scores data set
- Classic MLwiN User Manual example
- First analysed by Goldstein et al. (1993)
- Reanalysed by Goldstein (2010), Rabe-Hesketh and Skrondal (2008), Rasbash et al. (2009) and others
- 4059 students nested within 65 schools

$$\text{normexam}_{ij} = \beta_0 + u_j + e_{ij}$$

$$u_j \sim N(0, \sigma_u^2)$$

$$e_{ij} \sim N(0, \sigma_e^2)$$



Review

Command \_rc

Variables

Name	Label	Type	Format
------	-------	------	--------

**STATA** (R)  
**Statistics/Data Analysis** 11.2  
**MP - Parallel Edition**

Copyright 2009 StataCorp LP  
StataCorp  
4905 Lakeway Drive  
College Station, Texas 77845 USA  
800-STATA-PC <http://www.stata.com>  
979-696-4600 [stata@stata.com](mailto:stata@stata.com)  
979-696-4601 (fax)

2-user 2-core Stata network perpetual license:

Serial number: 50110514919

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Notes:

1. (/m# option or -set memory-) 500.00 MB allocated to data
2. (/v# option or -set maxvar-) 5000 maximum variables

running C:\Program Files (x86)\Stata11\sysprofile.do ...

running C:\Users\gl9158\profile.do ...

.

Command



Review

Command \_rc

Variables

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------	-------	------	--------

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running C:\Program Files (x86)\Stata11\sysprofile.do ...

running C:\Users\gl9158\profile.do ...

.

Command

use "http://www.bristol.ac.uk/cmm/media/runmlwin/tutorial.dta", clear





Review

▲	Command	_rc
1	use "http://www.bristol.ac.uk/cm...	

Variables

Name	Label	Type	Format
school	School ID	byte	%9.0g
student	Student ID	int	%9.0g
normexam	Age 16 exam scor...	float	%9.0g
cons	Constant	byte	%9.0g
standlrt	Age 11 exam scor...	float	%9.0g
girl	Girl	byte	%9.0g
schgend	School gender	byte	%9.0g
avslrt	School average LR...	float	%9.0g
schav	School average LR...	byte	%9.0g
vrband	Age 11 verbal reas...	byte	%9.0g

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running C:\Users\gl9158\profile.do ...

. use "http://www.bristol.ac.uk/cmm/media/runmlwin/tutorial.dta", clear

Command

# The `runmlwin` command syntax

$$\text{normexam}_{ij} = \beta_0 + u_j + e_{ij}$$

$$u_j \sim N(0, \sigma_u^2)$$

$$e_{ij} \sim N(0, \sigma_e^2)$$

```
. runmlwin normexam cons, ///  
    level2(school: cons) ///  
    level1(student: cons)
```



Review

▲	Command	_rc
1	use "http://www.bristol.ac.uk/cm...	

Variables

Name	Label	Type	Format
school	School ID	byte	%9.0g
student	Student ID	int	%9.0g
normexam	Age 16 exam scor...	float	%9.0g
cons	Constant	byte	%9.0g
standlrt	Age 11 exam scor...	float	%9.0g
girl	Girl	byte	%9.0g
schgend	School gender	byte	%9.0g
avslrt	School average LR...	float	%9.0g
schav	School average LR...	byte	%9.0g
vrband	Age 11 verbal reas...	byte	%9.0g

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Notes:

1. (/m# option or -set memory-) 500.00 MB allocated to data
2. (/v# option or -set maxvar-) 5000 maximum variables

running C:\Program Files (x86)\Stata11\sysprofile.do ...

running C:\Users\gl9158\profile.do ...

. use "http://www.bristol.ac.uk/cmm/media/runmlwin/tutorial.dta", clear

Command

runmlwin normexam cons, level2[school: cons] level1[student: cons]



Review

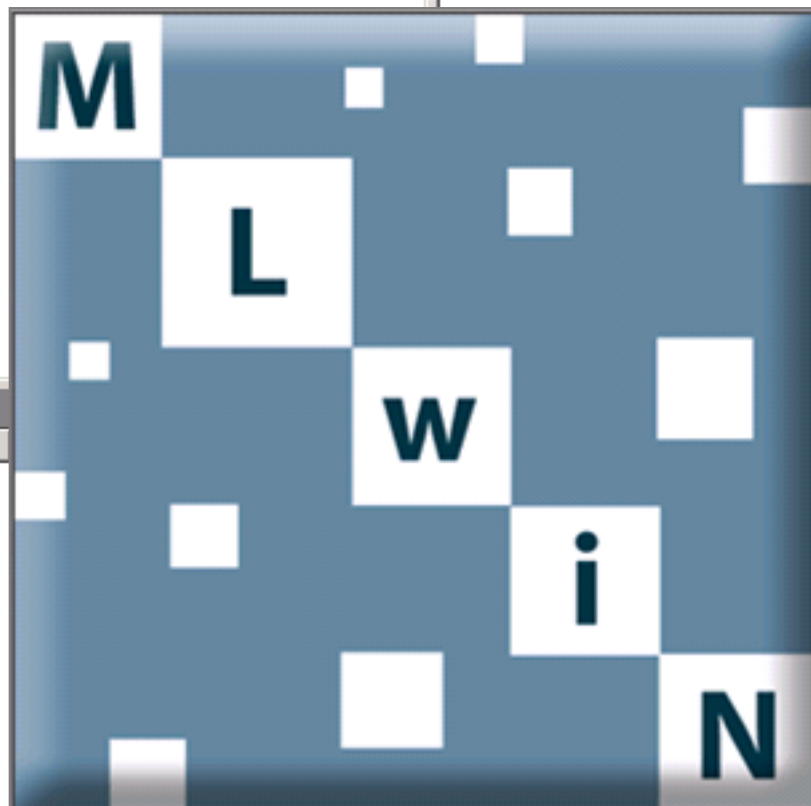
▲	Command	_rc
1	use "http://www.bristol.ac.uk/cm..."	
2	runmlwin normexam cons, level2(...)	

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**11.2**  
 Statistics/Data Analysis  
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Variables

Name
school
student
normexam
cons
standlrt
girl
schgend
avslrt
schav
vrband



**MLwiN**  
 Version 2.23

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 University of Bristol

Software authors :  
 Jon Rasbash

and

William Browne  
 Michael Healy  
 Bruce Cameron  
 Christopher Charlton

March 2011

We are grateful to the ESRC for their sustained support.

Command

$$\text{normexam}_{ij} \sim N(XB, \Omega)$$

$$\text{normexam}_{ij} = \beta_{0ij} \text{cons}$$

$$\beta_{0ij} = \beta_0 + u_{0j} + e_{0ij}$$

$$\begin{bmatrix} u_{0j} \end{bmatrix} \sim N(0, \Omega_u) : \Omega_u = \begin{bmatrix} \sigma_{u0}^2 \end{bmatrix}$$

$$\begin{bmatrix} e_{0ij} \end{bmatrix} \sim N(0, \Omega_e) : \Omega_e = \begin{bmatrix} \sigma_{e0}^2 \end{bmatrix}$$

MLwiN - [Equations]

File Edit Options Model Estimation Data Manipulation Basic Statistics Graphs Window Help

Start More Stop IGLS Estimation control.. Resume macro Abort Macro

$$\text{normexam}_{ij} \sim N(XB, \Omega)$$
$$\text{normexam}_{ij} = \beta_{0ij} \text{cons}$$
$$\beta_{0ij} = -0.013(0.054) + u_{0j} + e_{0ij}$$
$$\begin{bmatrix} u_{0j} \end{bmatrix} \sim N(0, \Omega_u) : \Omega_u = \begin{bmatrix} 0.169(0.032) \end{bmatrix}$$
$$\begin{bmatrix} e_{0ij} \end{bmatrix} \sim N(0, \Omega_e) : \Omega_e = \begin{bmatrix} 0.848(0.019) \end{bmatrix}$$

$-2 * \log \text{likelihood}(\text{IGLS Deviance}) = 11010.648(4059 \text{ of } 4059 \text{ cases in use})$

Name + - Add Term Estimates Nonlinear Clear Notation Responses Store Help Zoom 150

random fixed iteration 3 Equations



Review		
▲	Command	_rc
1	use "http://www.bristol.ac.uk/cm...	
2	runmlwin normexam cons, level2(...	

Variables			
Name	Label	Type	Format
school	School ID	byte	%9.0g
student	Student ID	int	%9.0g
normexam	Age 16 exam scor...	float	%9.0g
cons	Constant	byte	%9.0g
standlrt	Age 11 exam scor...	float	%9.0g
girl	Girl	byte	%9.0g
schgend	School gender	byte	%9.0g
avslrt	School average LR...	float	%9.0g
schav	School average LR...	byte	%9.0g
vrband	Age 11 verbal reas...	byte	%9.0g

```

. use "http://www.bristol.ac.uk/cmm/media/runmlwin/tutorial.dta", clear
. runmlwin normexam cons, level2(school: cons) level1(student: cons)

MLwiN 2.23 multilevel model           Number of obs       =       4059
Normal response model
Estimation algorithm: IGLS

-----
Level variable      No. of      Observations per Group
                    Groups      Minimum      Average      Maximum
-----
school              65          2            62.4        198

Run time (seconds) =      181.15
Number of iterations =      3
Log likelihood      = -5505.3242
Deviance            = 11010.648

-----
normexam           Coef.      Std. Err.      z      P>|z|      [95% Conf. Interval]
-----
cons              -.0131668   .0536254      -0.25   0.806      -.1182706      .091937

-----
Random-effects Parameters      Estimate      Std. Err.      [95% Conf. Interval]
-----
Level 2:
var(cons)                    .1686251      .0324466      .1050309      .2322194
Level 1:
var(cons)                    .8477613      .0189712      .8105786      .8849441
.
    
```

Command

# Add covariates

$$\text{normexam}_{ij} = \beta_0 + \beta_1 \text{standlrt}_{ij} + \beta_2 \text{girl}_{ij} + u_j + e_{ij}$$

$$u_j \sim N(0, \sigma_u^2)$$

$$e_{ij} \sim N(0, \sigma_e^2)$$

```
. runmlwin normexam cons standlrt girl, ///  
  level2(school: cons) ///  
  level1(student: cons)
```



# Include a random slope

$$\text{normexam}_{ij} = \beta_0 + \beta_1 \text{standlrt}_{ij} + \beta_2 \text{girl}_{ij} + u_{0j} + u_{1j} \text{standlrt}_{ij} + e_{ij}$$

$$\begin{pmatrix} u_{0j} \\ u_{1j} \end{pmatrix} \sim N \left\{ \begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma_{u0}^2 & \\ \sigma_{u01} & \sigma_{u1}^2 \end{pmatrix} \right\}$$

$$e_{ij} \sim N(0, \sigma_e^2)$$

```
. runmlwin normexam cons standlrt girl, ///  
  level2(school: cons standlrt) ///  
  level1(student: cons)
```

# Allow for level 1 heteroskedasticity

$$\text{normexam}_{ij} = \beta_0 + \beta_1 \text{standlrt}_{ij} + \beta_2 \text{girl}_{ij} + u_{0j} + u_{1j} \text{standlrt}_{ij} \\ + e_{2ij} \text{girl}_{ij} + e_{3ij} \text{boy}_{ij}$$

$$\begin{pmatrix} u_{0j} \\ u_{1j} \end{pmatrix} \sim N \left\{ \begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma_{u0}^2 & \\ \sigma_{u01} & \sigma_{u1}^2 \end{pmatrix} \right\}$$

$$\begin{pmatrix} e_{2ij} \\ e_{3ij} \end{pmatrix} \sim N \left\{ \begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma_{e2}^2 & \\ 0 & \sigma_{e3}^2 \end{pmatrix} \right\}$$

```
. runmlwin normexam cons standlrt girl, ///  
  level2(school: cons standlrt) ///  
  level1(student: girl boy, diagonal)
```

# Retrieve the level 2 residuals

$$\begin{aligned} \text{normexam}_{ij} = & \beta_0 + \beta_1 \text{standlrt}_{ij} + \beta_2 \text{girl}_{ij} + u_{0j} + u_{1j} \text{standlrt}_{ij} \\ & + e_{2ij} \text{girl}_{ij} + e_{3ij} \text{boy}_{ij} \end{aligned}$$

$$\begin{pmatrix} u_{0j} \\ u_{1j} \end{pmatrix} \sim N \left\{ \begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma_{u0}^2 & \\ \sigma_{u01} & \sigma_{u1}^2 \end{pmatrix} \right\}$$

$$\begin{pmatrix} e_{2ij} \\ e_{3ij} \end{pmatrix} \sim N \left\{ \begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma_{e2}^2 & \\ 0 & \sigma_{e3}^2 \end{pmatrix} \right\}$$

```
. runmlwin normexam cons standlrt girl, ///  
  level2(school: cons standlrt, residuals(u)) ///  
  level1(student: girl boy, diagonal)
```

# Do not pause in MLwiN

$$\begin{aligned} \text{normexam}_{ij} = & \beta_0 + \beta_1 \text{standlrt}_{ij} + \beta_2 \text{girl}_{ij} + u_{0j} + u_{1j} \text{standlrt}_{ij} \\ & + e_{2ij} \text{girl}_{ij} + e_{3ij} \text{boy}_{ij} \end{aligned}$$

$$\begin{pmatrix} u_{0j} \\ u_{1j} \end{pmatrix} \sim N \left\{ \begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma_{u0}^2 & \\ \sigma_{u01} & \sigma_{u1}^2 \end{pmatrix} \right\}$$

$$\begin{pmatrix} e_{2ij} \\ e_{3ij} \end{pmatrix} \sim N \left\{ \begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma_{e2}^2 & \\ 0 & \sigma_{e3}^2 \end{pmatrix} \right\}$$

```
. runmlwin normexam cons standlrt girl, ///  
  level2(school: cons standlrt, residuals(u)) ///  
  level1(student: girl boy, diagonal) nopause
```



```

Review
-----
Command      _rc
-----
1 use http://www.bristol.ac.uk/cm...
2 runmlwin normexam cons, level2(...
3 generate boy = 1 - girl
4 runmlwin normexam cons standlrt...
    
```

Variables

Name	Label	Type	Format
school	School ID	byte	%9.0g
student	Student ID	int	%9.0g
normexam	Age 16 exam scor...	float	%9.0g
cons	Constant	byte	%9.0g
standlrt	Age 11 exam scor...	float	%9.0g
girl	Girl	byte	%9.0g
schgend	School gender	byte	%9.0g
avslrt	School average LR...	float	%9.0g
schav	School average LR...	byte	%9.0g
vrband	Age 11 verbal reas...	byte	%9.0g
boy		float	%9.0g
u0	u0 residual estimate	float	%9.0g
u1	u1 residual estimate	float	%9.0g
u0se	u0se residual stan...	float	%9.0g
u1se	u1se residual stan...	float	%9.0g

```

. runmlwin normexam cons standlrt girl, level2(school: cons standlrt, residuals(
> u)) level1(student: girl boy, diagonal) nopause
    
```

MLwin 2.23 multilevel model Number of obs = 4059  
 Normal response model  
 Estimation algorithm: IGLS

Level variable	No. of Groups	Observations per Group		
		Minimum	Average	Maximum
<b>school</b>	<b>65</b>	<b>2</b>	<b>62.4</b>	<b>198</b>

Run time (seconds) = 1.56  
 Number of iterations = 4  
 Log likelihood = -4640.71  
 Deviance = 9281.4199

normexam	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
cons	-.111534	.0433072	-2.58	0.010	-.1964145	-.0266536
standlrt	.5529361	.0200758	27.54	0.000	.5135882	.5922841
girl	.1752785	.0324156	5.41	0.000	.1117451	.238812

Random-effects Parameters		Estimate	Std. Err.	[95% Conf. Interval]	
<b>Level 2:</b>					
	var(cons)	.0862511	.017175	.0525887	.1199135
	cov(cons,standlrt)	.0190537	.0066789	.0059632	.0321441
	var(standlrt)	.0148919	.0044702	.0061304	.0236534
<b>Level 1:</b>					
	var(girl)	.5251641	.0152836	.4952088	.5551194
	var(boy)	.5874345	.0209983	.5462786	.6285904

Command



Review

▲	Command	_rc
1	use "http://www.bristol.ac.uk/cm...	
2	runmlwin normexam cons, level2(...	
3	generate boy = 1 - girl	
4	runmlwin normexam cons standlrt...	
5	test [RP1]var(girl) = [RP1]var(boy)	

Variables

Name	Label	Type	Format
school	School ID	byte	%9.0g
student	Student ID	int	%9.0g
normexam	Age 16 exam scor...	float	%9.0g
cons	Constant	byte	%9.0g
standlrt	Age 11 exam scor...	float	%9.0g
girl	Girl	byte	%9.0g
schgend	School gender	byte	%9.0g
avslrt	School average LR...	float	%9.0g
schav	School average LR...	byte	%9.0g
vrband	Age 11 verbal reas...	byte	%9.0g
boy		float	%9.0g
u0	u0 residual estimate	float	%9.0g
u1	u1 residual estimate	float	%9.0g
u0se	u0se residual stan...	float	%9.0g
u1se	u1se residual stan...	float	%9.0g

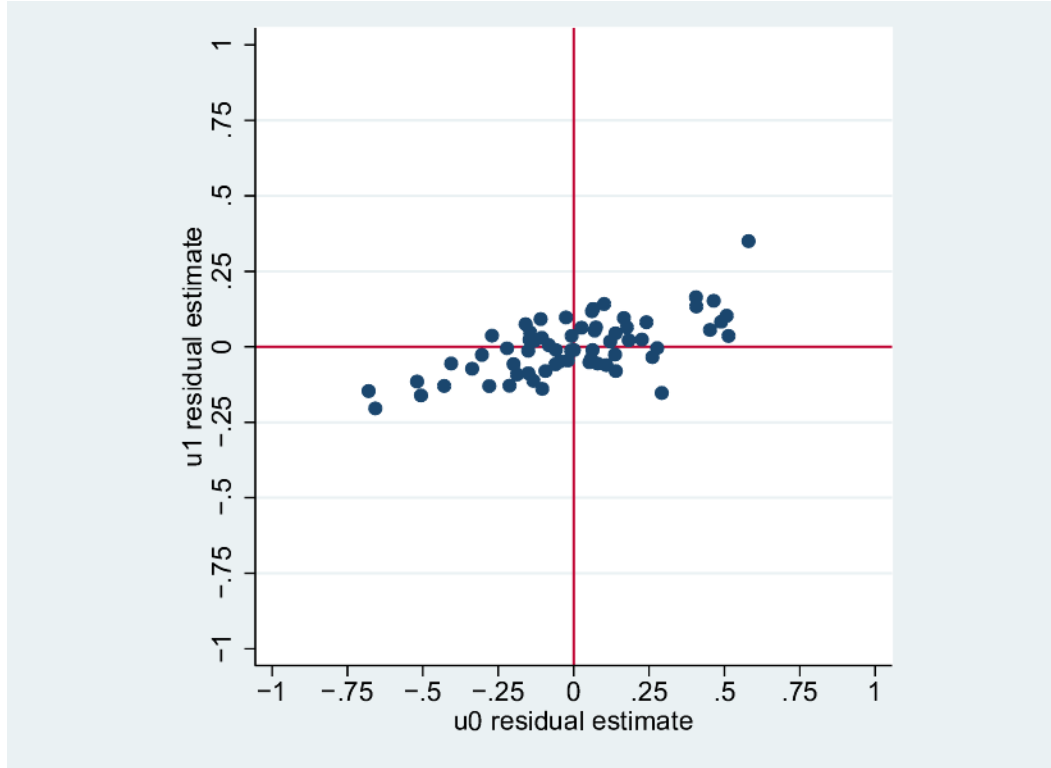
```

. test [RP1]var(girl) = [RP1]var(boy)
( 1)  [RP1]var(girl) - [RP1]var(boy) = 0

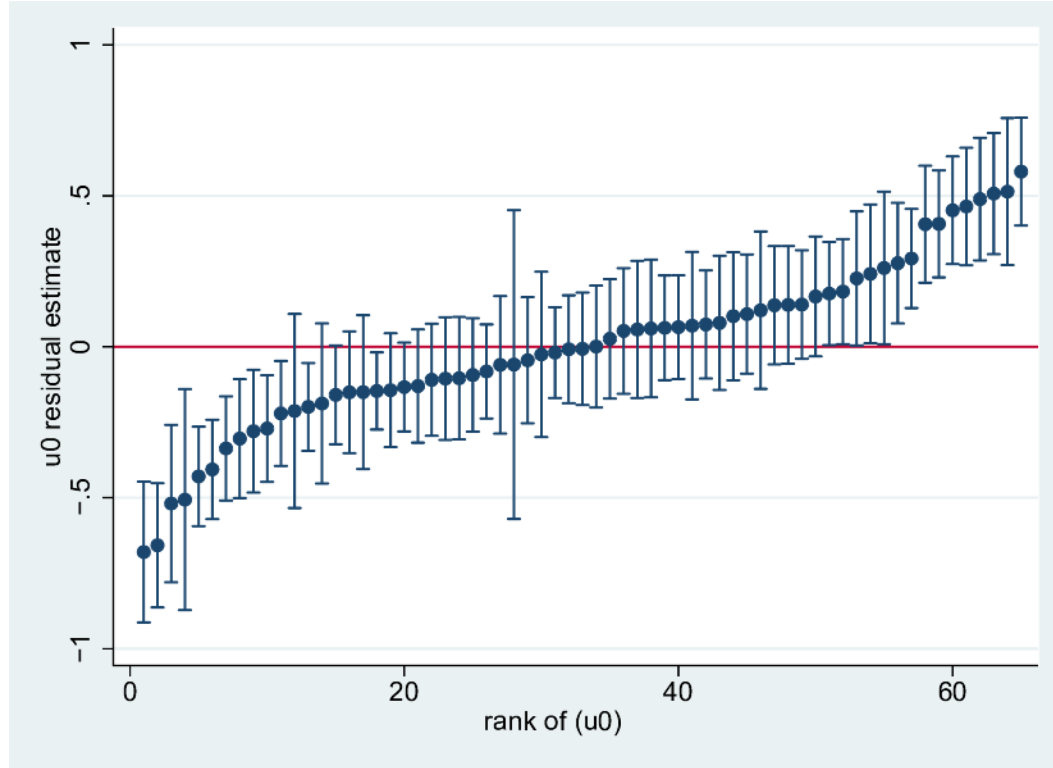
      chi2( 1) =      5.74
      Prob > chi2 =    0.0166

```

Command



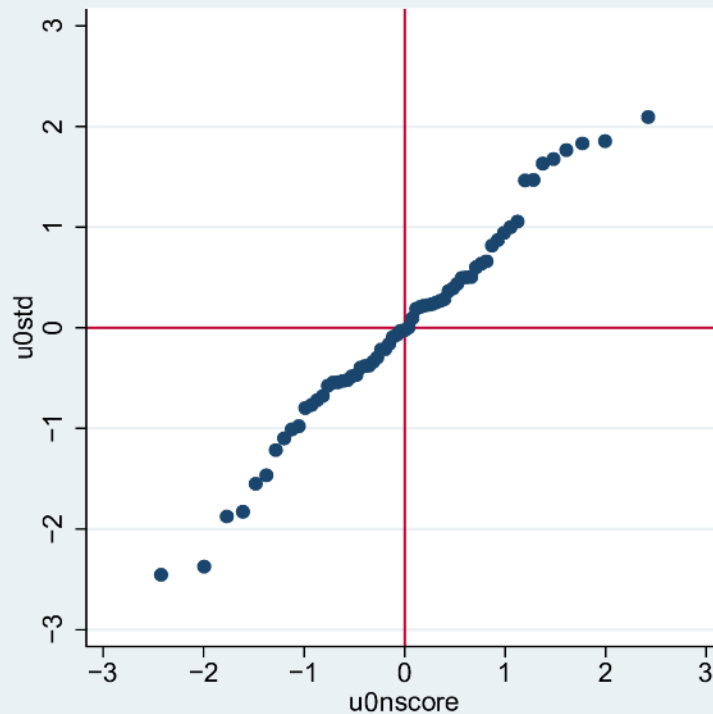
```
. scatter u1 u0, yline(0) xline(0) ///  
    ylabel(-1(.25)1) xlabel(-1(.25)1) aspectratio(1)
```



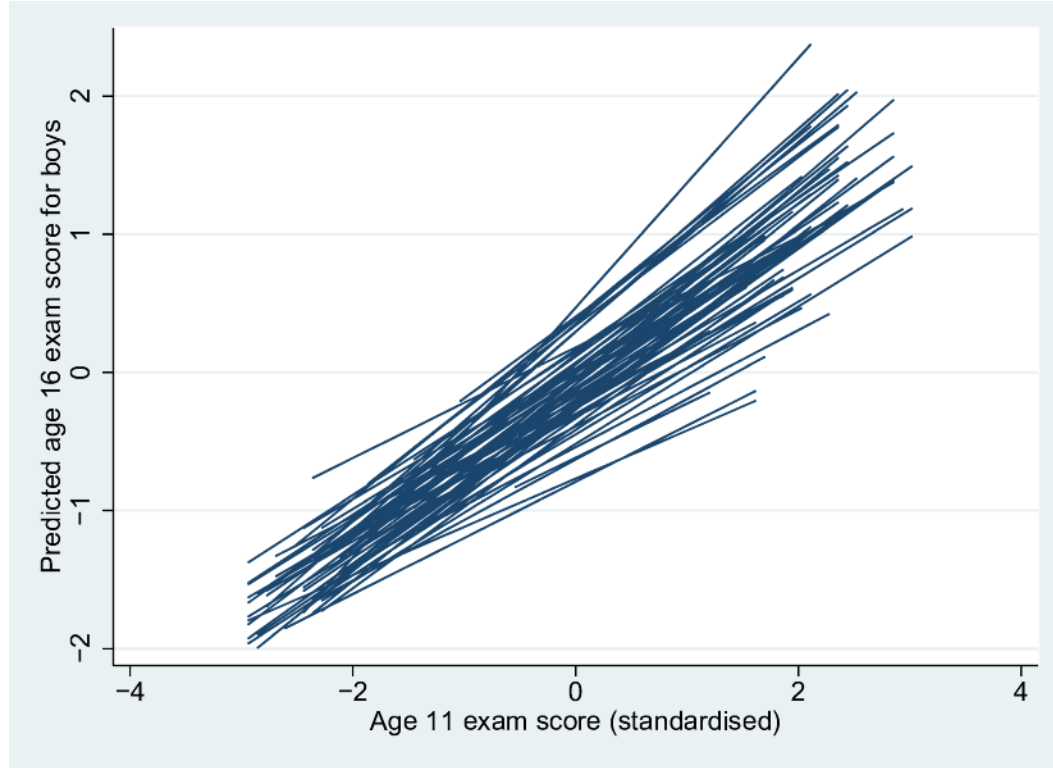
```
. egen u0rank = rank(u0)
```

```
. serrbar u0 u0se u0rank, scale(1.96) yline(0)
```

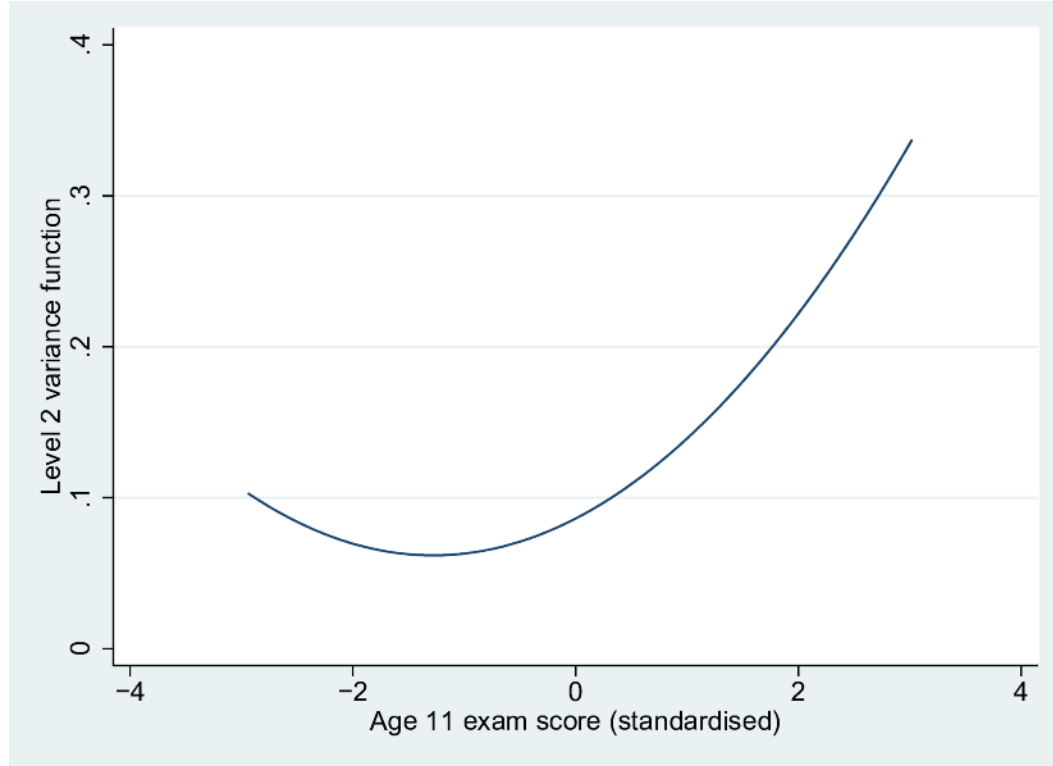




```
. summarize u0  
  
. generate u0std = (u0 - r(mean))/r(sd)  
  
. generate u0uniform = (u0rank - 0.5)/_N  
  
. generate u0nscore = invnorm(u0uniform)  
  
. scatter u0std u0nscore, yline(0) xline(0) ///  
    ylabel(-3(1)3) xlabel(-3(1)3) aspectratio(1)
```



```
. generate prediction = _b[cons]*cons ///  
    + _b[standlrt ]*standlrt + u0 + u1*standlrt  
  
. sort school standlrt  
  
. line xbu standlrt, connect(a) ///  
    ytitle("Predicted age 16 exam score for boys")
```



```
. twoway (function [RP2]var(cons) + ///  
  2*[RP2]cov(cons\standlrt)*x + ///  
  [RP2]var(standlrt)*x^2, ///  
  range(standlrt)), ///  
  ytitle("Level 2 variance function") ///  
  xtitle("Age 11 exam score (standardised)")
```

# MULTILEVEL MODELS FOR BINARY RESPONSES

# The `runmlwin` command syntax

$$binexam_{ij} \sim \text{Binomial}(1, \pi_{ij})$$

$$\text{logit}(\pi_{ij}) = \beta_0 + \beta_1 \text{standlrt}_{ij} + \beta_2 \text{girl}_{ij} + u_{0j} + u_{1j} \text{standlrt}_{ij}$$

$$\begin{pmatrix} u_{0j} \\ u_{1j} \end{pmatrix} \sim N \left\{ \begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma_{u0}^2 & \\ & \sigma_{u1}^2 \end{pmatrix} \right\}$$

```
. runmlwin binexam cons standlrt girl, ///  
  level2(school: cons standlrt) ///  
  level1(student:) ///  
  discrete(dist(binomial) link(logit) denom(cons))
```



```

Review
-----
Command      _rc
-----
1 use http://www.bristol.ac.uk/cm...
2 runmlwin normexam cons, level2(...
3 generate boy = 1 - girl
4 runmlwin normexam cons standlrt...
5 test [RP1]var(girl) = [RP1]var(boy)
6 gen binexam = (normexam>0)
7 runmlwin binexam cons standlrt gi...
    
```

Variables

Name	Label	Type	Format
school	School ID	byte	%9.0g
student	Student ID	int	%9.0g
normexam	Age 16 exam scor...	float	%9.0g
cons	Constant	byte	%9.0g
standlrt	Age 11 exam scor...	float	%9.0g
girl	Girl	byte	%9.0g
schgend	School gender	byte	%9.0g
avslrt	School average LR...	float	%9.0g
schav	School average LR...	byte	%9.0g
vrband	Age 11 verbal reas...	byte	%9.0g
boy		float	%9.0g
u0	u0 residual estimate	float	%9.0g
u1	u1 residual estimate	float	%9.0g
u0se	u0se residual stan...	float	%9.0g
u1se	u1se residual stan...	float	%9.0g
binexam		float	%9.0g

```

. gen binexam = (normexam>0)

. runmlwin binexam cons standlrt girl, level2(school: cons standlrt) level1(stud
> ent:) discrete(distribution(binomial) link(logit) denominator(cons)) nopause
    
```

MLwin 2.23 multilevel model Number of obs = 4059  
 Binomial logit response model  
 Estimation algorithm: IGLS, MQL1

Level Variable	No. of Groups	Observations per Group		
		Minimum	Average	Maximum
<b>school</b>	<b>65</b>	<b>2</b>	<b>62.4</b>	<b>198</b>

Run time (seconds) = 1.50  
 Number of iterations = 6

binexam	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
cons	-.0479964	.101761	-0.47	0.637	-.2474444	.1514515
standlrt	1.232918	.0581067	21.22	0.000	1.119031	1.346805
girl	.186636	.0956229	1.95	0.051	-.0007814	.3740534

Random-effects Parameters		Estimate	Std. Err.	[95% Conf. Interval]	
<b>Level 2:</b>					
	var(cons)	.3701358	.0822183	.208991	.5312807
	cov(cons,standlrt)	.0444551	.0394446	-.0328549	.121765
	var(standlrt)	.06152	.0364277	-.009877	.1329169

```

Command
    
```

# Refit the model using PQL2

$$\text{binexam}_{ij} \sim \text{Binomial}(1, \pi_{ij})$$

$$\text{logit}(\pi_{ij}) = \beta_0 + \beta_1 \text{standlrt}_{ij} + \beta_2 \text{girl}_{ij} + u_{0j} + u_{1j} \text{standlrt}_{ij}$$

$$\begin{pmatrix} u_{0j} \\ u_{1j} \end{pmatrix} \sim \text{N} \left\{ \begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma_{u0}^2 & \\ \sigma_{u01} & \sigma_{u1}^2 \end{pmatrix} \right\}$$

```
. runmlwin binexam cons standlrt girl, ///  
  level2(school: cons standlrt) ///  
  level1(student:) ///  
  discrete(d(binomial) l(logit) de(cons) pql2) ///  
  initsprevious
```



Review	
Command	_rc
1	use "http://www.bristol.ac.uk/cm...
2	runmlwin normexam cons, level2(...
3	generate boy = 1 - girl
4	runmlwin normexam cons standlrt...
5	test [RP1]var(girl) = [RP1]var(boy)
6	gen binexam = (normexam>0)
7	runmlwin binexam cons standlrt gi...
8	runmlwin binexam cons standlrt gi...

Variables			
Name	Label	Type	Format
school	School ID	byte	%9.0g
student	Student ID	int	%9.0g
normexam	Age 16 exam scor...	float	%9.0g
cons	Constant	byte	%9.0g
standlrt	Age 11 exam scor...	float	%9.0g
girl	Girl	byte	%9.0g
schgend	School gender	byte	%9.0g
avslrt	School average LR...	float	%9.0g
schav	School average LR...	byte	%9.0g
vrband	Age 11 verbal reas...	byte	%9.0g
boy		float	%9.0g
u0	u0 residual estimate	float	%9.0g
u1	u1 residual estimate	float	%9.0g
u0se	u0se residual stan...	float	%9.0g
u1se	u1se residual stan...	float	%9.0g
binexam		float	%9.0g

```

. runmlwin binexam cons standlrt girl, level2(school: cons standlrt) level1(stud
> ent:) discrete(dist(binomial) link(logit) denom(cons) pql2) initsprevious nopa
> use

Model fitted using initial values specified as parameter estimates from previous
> model
    
```

MLwin 2.23 multilevel model Number of obs = 4059  
 Binomial logit response model  
 Estimation algorithm: IGLS, PQL2

Level variable	No. of Groups	Observations per Group		
		Minimum	Average	Maximum
<b>school</b>	<b>65</b>	<b>2</b>	<b>62.4</b>	<b>198</b>

Run time (seconds) = 1.81  
 Number of iterations = 8

binexam	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
cons	-.0367105	.1120693	-0.33	0.743	-.2563622	.1829413
standlrt	1.358886	.0642726	21.14	0.000	1.232914	1.484858
girl	.2012481	.1013948	1.98	0.047	.0025179	.3999782

Random-effects Parameters		Estimate	Std. Err.	[95% Conf. Interval]	
<b>Level 2:</b>					
	var(cons)	.4740776	.1031501	.2719071	.676248
	cov(cons,standlrt)	.0625434	.0491646	-.0338175	.1589043
	var(standlrt)	.0764959	.0443148	-.0103596	.1633514

Command



**SIMULATION STUDIES ARE EASY**



rodriguez and goldman (1995).do

▼ ×

```
1  set seed 12345
2  postfile MQL1 ix fx cx sigmaf sigmac using "MQL1.dta", replace
3  set obs 2
4  generate cx = _n - 1
5  expand 10
6  sort cx
7  generate cid = _n
8  expand 2
9  bysort cid: gen fx = _n - 1
10 expand 10
11 bysort cid (fx): generate fid = _n
12 expand 2
13 bysort cid fid: gen ix = _n - 1
14 expand 10
15 bysort cid fid (ix): gen iid = _n
16 generate cons = 1
17 forvalues iteration = 1/10 {
18     display _n(5) as txt "Iteration " as res "`iteration'" as txt " of " as res "100"
19     generate c = rnormal(0,1)
20     bysort cid (fid iid): replace c = c[1]
21     generate f = rnormal(0,1)
22     bysort cid fid (iid): replace f = f[1]
23     generate y = rbinomial(1,invlogit(0*cons + 1*ix + 1*fx + 1*cx + f + c))
24     runmlwin y cons ix fx cx, level3(cid: cons) level2(fid: cons) level1(iid:) ///
25         discrete(distribution(binomial) link(logit) denominator(cons)) ///
26         nopause
27     post MQL1 ([FP1]ix) ([FP1]fx) ([FP1]cx) (sqrt([RP2]var(cons))) (sqrt([RP3]var(cons)))
28     drop c f y
29 }
30 postclose MQL1
31 use "MQL1.dta", clear
32 tabstat ix fx cx sigmaf sigmac, format(%3.2f)
```

# MCMC ESTIMATION

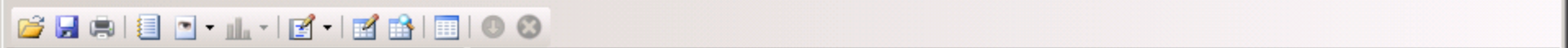
# The `runmlwin` command syntax

$$\text{binexam}_{ij} \sim \text{Binomial}(1, \pi_{ij})$$

$$\text{logit}(\pi_{ij}) = \beta_0 + \beta_1 \text{standlrt}_{ij} + \beta_2 \text{girl}_{ij} + u_{0j} + u_{1j} \text{standlrt}_{ij}$$

$$\begin{pmatrix} u_{0j} \\ u_{1j} \end{pmatrix} \sim N \left\{ \begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma_{u0}^2 & \\ & \sigma_{u1}^2 \end{pmatrix} \right\}$$

```
. runmlwin binexam cons standlrt girl, ///  
  level2(school: cons standlrt) ///  
  level1(student:) ///  
  discrete(d(binomial) l(logit) de(cons) pql2) ///  
  mcmc(burnin(500) chain(5000)) initsprevious
```



```

Review
-----
Command      _rc
-----
1  use "http://www.bristol.ac.uk/cm...
2  runmlwin normexam cons, level2(...
3  generate boy = 1 - girl
4  runmlwin normexam cons standlrt...
5  test [RP1]var(girl) = [RP1]var(boy)
6  gen binexam = (normexam>0)
7  runmlwin binexam cons standlrt gi...
8  runmlwin binexam cons standlrt gi...
9  runmlwin binexam cons standlrt gi...
    
```

Name	Label	Type	Format
school	School ID	byte	%9.0g
student	Student ID	int	%9.0g
normexam	Age 16 exam scor...	float	%9.0g
cons	Constant	byte	%9.0g
standlrt	Age 11 exam scor...	float	%9.0g
girl	Girl	byte	%9.0g
schgend	School gender	byte	%9.0g
avslrt	School average LR...	float	%9.0g
schav	School average LR...	byte	%9.0g
vrband	Age 11 verbal reas...	byte	%9.0g
boy		float	%9.0g
u0	u0 residual estimate	float	%9.0g
u1	u1 residual estimate	float	%9.0g
u0se	u0se residual stan...	float	%9.0g
u1se	u1se residual stan...	float	%9.0g
binexam		float	%9.0g

```

. runmlwin binexam cons standlrt girl, level2(school: cons standlrt) level1(stud
> ent:) discrete(d(binomial) l(logit) de(cons)) mcmc(burnin(500) chain(5000)) in
> itsprevious nopause
    
```

MLwiN 2.23 multilevel model Number of obs = 4059  
 Binomial logit response model  
 Estimation algorithm: **MCMC, MQL1**

Level Variable	No. of Groups	Observations per Group Minimum	Average	Maximum
<b>school</b>	<b>65</b>	<b>2</b>	<b>62.4</b>	<b>198</b>

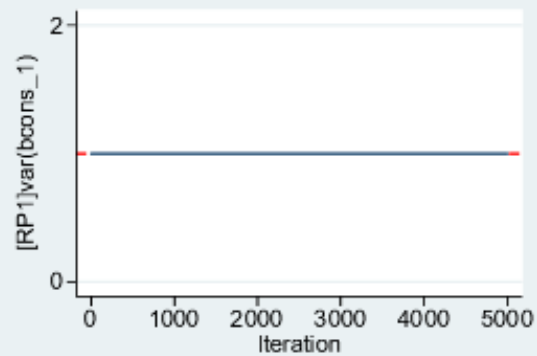
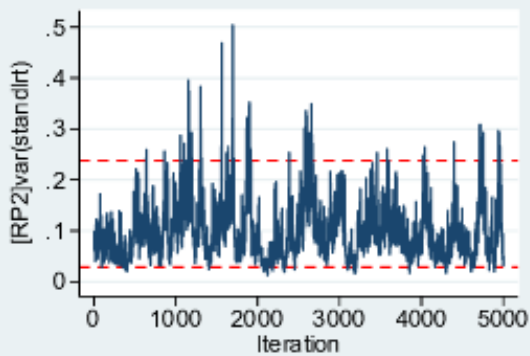
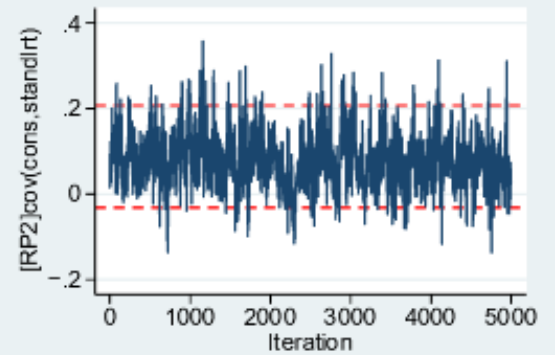
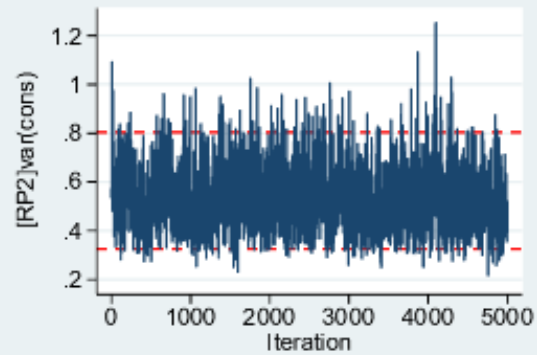
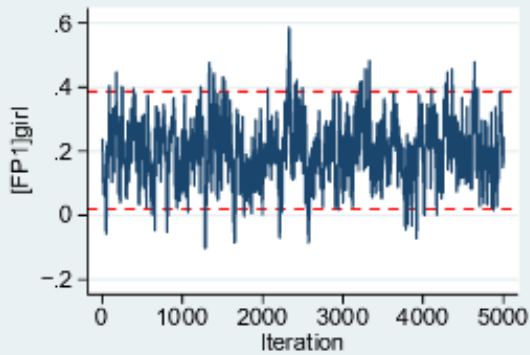
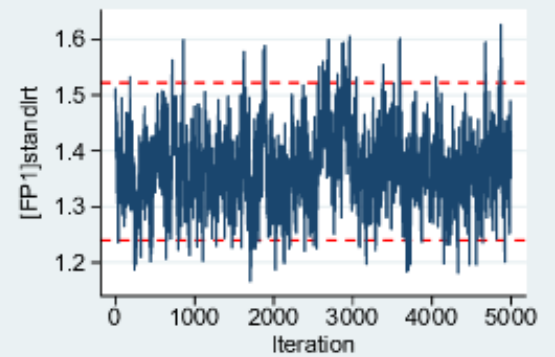
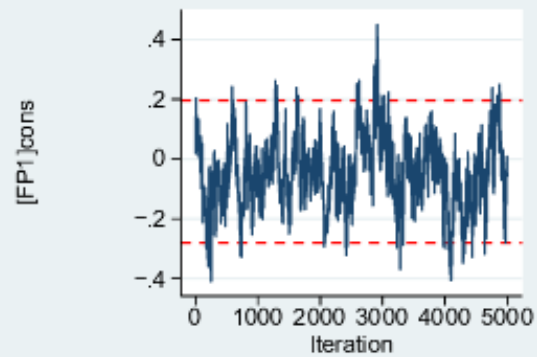
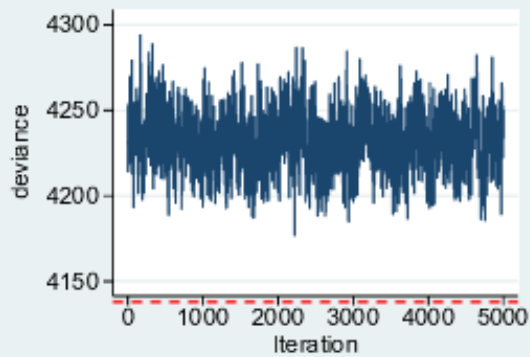
```

Burnin = 500
Chain = 5000
Run time (seconds) = 27
Deviance (dbar) = 4232.10
Deviance (thetabar) = 4159.24
Effective no. of pars (pd) = 72.86
Bayesian DIC = 4304.96
    
```

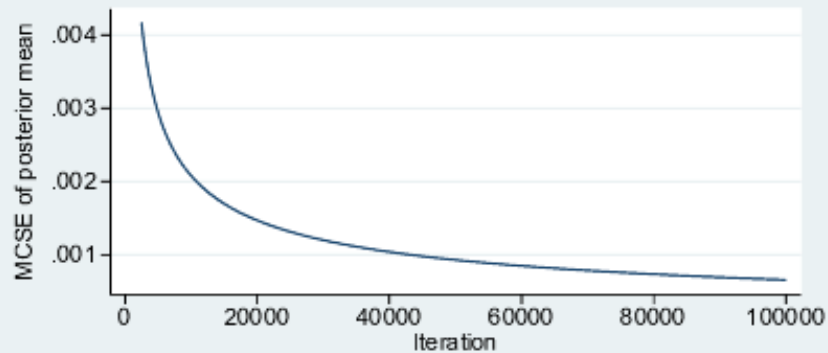
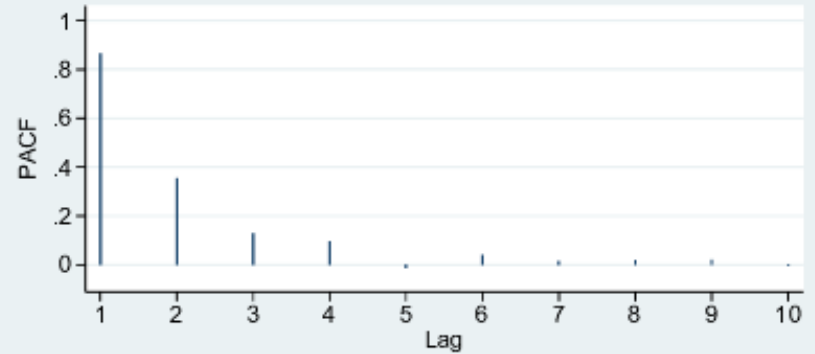
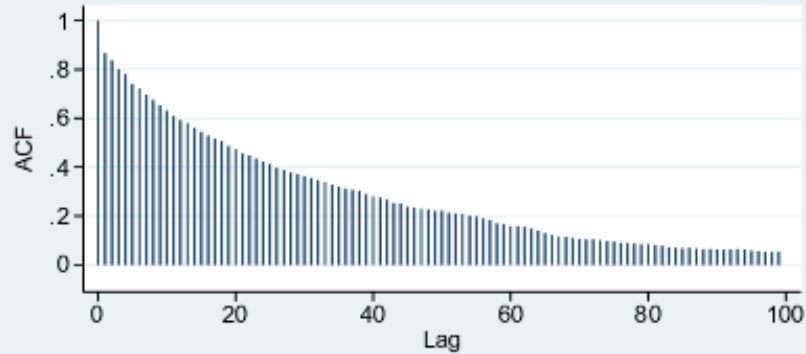
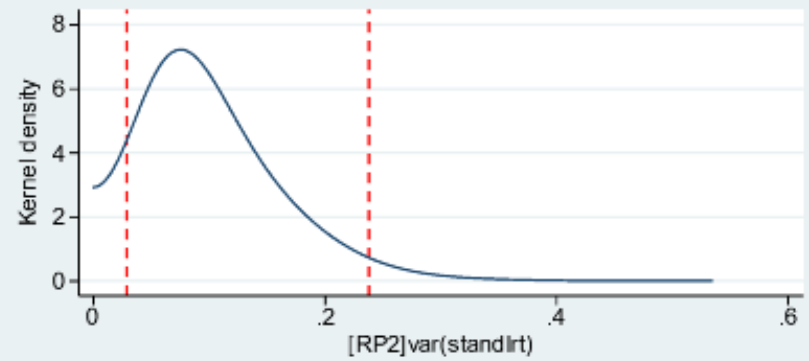
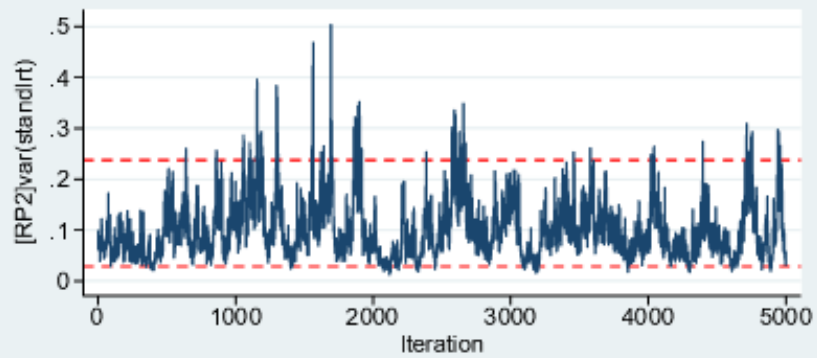
binexam	Mean	Std. Dev.	z	ESS	[95% Cred. Interval]	
cons	<b>-.0347943</b>	<b>.1073479</b>	<b>-0.32</b>	<b>94</b>	<b>-.2506524</b>	<b>.1779318</b>
standlrt	<b>1.35652</b>	<b>.0624149</b>	<b>21.73</b>	<b>496</b>	<b>1.231931</b>	<b>1.480608</b>
girl	<b>.1873172</b>	<b>.1005095</b>	<b>1.86</b>	<b>196</b>	<b>-.0023705</b>	<b>.3851183</b>

Random-effects Parameters	Mean	Std. Dev.	ESS	[95% Cred. Int]	
<b>Level 2:</b>					
var(cons)	<b>.5135376</b>	<b>.1199011</b>	<b>1030</b>	<b>.3204156</b>	<b>.7835187</b>
cov(cons,standlrt)	<b>.0668458</b>	<b>.0581714</b>	<b>198</b>	<b>-.0387322</b>	<b>.1982548</b>
var(standlrt)	<b>.0862781</b>	<b>.0467082</b>	<b>99</b>	<b>.0243268</b>	<b>.2023509</b>

Command



. mcmcsum, trajectories



. mcmcsum [RP2]var(standlrt), fiveplot

File Edit Data Graphics Statistics User Window Help



Review

X

▲	Command	_rc
1	use "http://www.bristol.ac.uk/cm...	
2	runmlwin normexam cons, level2(...	
3	generate boy = 1 - girl	
4	runmlwin normexam cons standlrt...	
5	test [RP1]var(girl) = [RP1]var(boy)	
6	gen binexam = (normexam>0)	
7	runmlwin binexam cons standlrt gi...	
8	runmlwin binexam cons standlrt gi...	
9	runmlwin binexam cons standlrt gi...	
17	mcmcsum, trajectories	
18	mcmcsum [RP2]var(standlrt), five...	
19	mcmcsum [RP2]var(standlrt)	

Variables

X

Name	Label	Type	Format
school	School ID	byte	%9.0g
student	Student ID	int	%9.0g
normexam	Age 16 exam scor...	float	%9.0g
cons	Constant	byte	%9.0g
standlrt	Age 11 exam scor...	float	%9.0g
girl	Girl	byte	%9.0g
schgend	School gender	byte	%9.0g
avslrt	School average LR...	float	%9.0g
schav	School average LR...	byte	%9.0g
vrband	Age 11 verbal reas...	byte	%9.0g
boy		float	%9.0g
u0	u0 residual estimate	float	%9.0g
u1	u1 residual estimate	float	%9.0g
u0se	u0se residual stan...	float	%9.0g
u1se	u1se residual stan...	float	%9.0g
binexam		float	%9.0g

. mcmcsum [RP2]var(standlrt)

[RP2]var(standlrt)

		Percentiles			
Mean	<b>.1002665</b>	0.5%	<b>.0211397</b>	Thinned Chain Length	<b>5000</b>
MCSE of Mean	<b>.0029374</b>	2.5%	<b>.0285475</b>	Effective Sample Size	<b>94</b>
Std. Dev.	<b>.0559779</b>	5%	<b>.0338817</b>	Raftery Lewis (2.5%)	<b>35055</b>
Mode	<b>.0753875</b>	25%	<b>.0597935</b>	Raftery Lewis (97.5%)	<b>18278</b>
		50%	<b>.0870834</b>	Brooks Draper (mean)	<b>6632</b>
		75%	<b>.1289442</b>		
		95%	<b>.2096789</b>		
		97.5%	<b>.2377593</b>		
		99.5%	<b>.308234</b>		

. . . . .

Command



**EXPORT MODELS TO WINBUGS**

# The `runmlwin` command syntax

$$\text{binexam}_{ij} \sim \text{Binomial}(1, \pi_{ij})$$

$$\text{logit}(\pi_{ij}) = \beta_0 + \beta_1 \text{standlrt}_{ij} + \beta_2 \text{girl}_{ij} + u_{0j} + u_{1j} \text{standlrt}_{ij}$$

$$\begin{pmatrix} u_{0j} \\ u_{1j} \end{pmatrix} \sim N \left\{ \begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma_{u0}^2 & \\ & \sigma_{u1}^2 \end{pmatrix} \right\}$$

```
. runmlwin binexam cons standlrt girl, ///  
  level2(school: cons standlrt) ///  
  level1(student:) ///  
  discrete(d(binomial) l(logit) de(cons) pql2) ///  
  mcmc(b(500) c(5000) savewinbugs(model(m.txt) ///  
  inits(i.txt) data(d.txt) nofit)) ///  
  initsprevious
```

```
# WINBUGS 1.4 code generated from MLwin program
```

```
#----MODEL Definition-----
```

```
model
{
# Level 1 definition
for(i in 1:N) {
binexam[i] ~ dbin(p[i],denom[i])
logit(p[i]) <- beta[1] * cons[i]
+ beta[2] * standlrt[i]
+ beta[3] * girl[i]
+ u2[school[i],1] * cons[i]
+ u2[school[i],2] * standlrt[i]
}
# Higher level definitions
for (j in 1:n2) {
u2[j,1:2] ~ dmnorm(zero2[1:2],tau.u2[1:2,1:2])
}
# Priors for fixed effects
for (k in 1:3) { beta[k] ~ dflat() }
# Priors for random terms
for (i in 1:2) {zero2[i] <- 0}
tau.u2[1:2,1:2] ~ dwish(R2[1:2, 1:2],2)
sigma2.u2[1:2,1:2] <- inverse(tau.u2[,])
}
```

**WORK EFFICIENTLY**



Amsterdam.do

▼ ×

```
40
41 * Open the tutorial data set
42 use "http://www.bristol.ac.uk/cmm/media/runmlwin/tutorial.dta", clear
43
44
45 * Fit a two-level (students within schools) variance components model to
46 * a continuous educational response variable, normexam. Note, you will need
47 * to click the "Resume Macro" button twice in MLwiN to return the model
48 * results to the Stata output window.
49 runmlwin normexam cons, ///
50     level2(school: cons) ///
51     level1(student: cons)
52
53 * Generate a boy dummy variable
54 generate boy = 1 - girl
55
56 * Extend the previous model to include fixed part covariates, a random school
57 * level slope and separate level 1 residuals for boys and girls. The runmlwin
58 * command also requests that runmlwin extracts the predicted values for the
59 * school level residuals from MLwiN and returns them to Stata. The nopause
60 * option prevents MLwiN from pausing before and after model estimation and so
61 * returns the model results automatically to Stata.
62 runmlwin normexam cons standlrt girl, ///
63     level2(school: cons standlrt, residuals(u)) ///
64     level1(student: girl boy, diagonal) nopause
65
66 * Perform a Wald test to compare the boy and girl residual variances
67 test [RP1]var(girl) = [RP1]var(boy)
68
69 * Preserve the data as we will shortly be collapsing the data to the school
70 * level, but afterwards we will want to return to the original data
71 preserve
72
73     * Tag one child in each school
74     egen pickone = tag(school)
75
```

RESOURCES TO HELP YOU LEARN  
RUNMLWIN

## help runmlwin

---

### Title

**runmlwin** - Run the MLWIN multilevel modelling software from within Stata

### Syntax

```
runmlwin responses_and_fixed_part, random_part [discrete(discrete_options)] [mcmc(mcmc_options)]
[general_options]
```

where the syntax of *responses\_and\_fixed\_part* is one of the following

for univariate continuous, binary, proportion and count response models

```
depvar indepvars [if] [in]
```

for univariate ordered and unordered categorical response models

```
depvar indepvars1 [(indepvars2, contrast(numlist)) ... ] [if] [in]
```

where *indepvars1* are those independent variables which appear with separate coefficients in each of every log-odds contrast, while *indepvars2* are those independent variables which appear with common coefficients for those log-odds contrasts specified in **contrast**(*numlist*). Contrasts can be thought of as the separate "subequations" or "arms" of a multinomial response model. These contrasts are indexed 1,2,... up to the total number of contrasts included in the model. The total number of contrasts will be one less than the number of response categories.

for multivariate response models

```
(depvar1 indepvars1, equation(numlist))
(depvar2 indepvars2, equation(numlist))
[(depvar3 indepvars3, equation(numlist))]
[... ]
[if] [in]
```

where **equation**(*numlist*) specifies equation numbers. Equation numbers are indexed 1,2,... up to the total number of equations (i.e. response variables) included in the model.

and the syntax of *random\_part* is

```
[ ... ] [level2(levelvar: [varlist] [, random_part_options])]
level1(levelvar: [varlist] [, random_part_options])
```



## Examples

IMPORTANT. The following examples will only work on your computer once you have installed MLwin and once you have told **runmlwin** what the mlwin.exe file address is. See *Remarks on installation instructions* above for more information.

### (a) Continuous response models

Two-level models

---

Setup

- use <http://www.bristol.ac.uk/cmm/media/runmlwin/tutorial>, clear

Two-level random-intercept model, analogous to xtreg (fitted using IGLS)

*(See page 28 of the MLwin User Manual)*

*(You will need to click the "Resume macro" button twice in MLwin to fit the model.)*

- `runmlwin normexam cons standlrt, level2(school: cons) level1(student: cons)`

Two-level random-intercept and random-slope (coefficient) model (fitted using IGLS)

*(See page 59 of the MLwin User Manual)*

- `runmlwin normexam cons standlrt, level2 (school: cons standlrt) level1 (student: cons)`

Refit the model suppressing the two pauses in MLwin (fitted using IGLS)

*(See page 59 of the MLwin User Manual)*

- `runmlwin normexam cons standlrt, level2 (school: cons standlrt) level1 (student: cons) nopause`

Refit the model, where this time we additionally calculate the level 2 residuals (fitted using IGLS)

*(See page 59 of the MLwin User Manual)*

- `runmlwin normexam cons standlrt, level2 (school: cons standlrt, residuals(u)) level1 (student: cons)`

Two-level random-intercept and random-slope (coefficient) model with a complex level 1 variance function (fitted using IGLS)

*(See page 99 of the MLwin User Manual)*

- `matrix A = (1,1,0,0,0,1)`
- `runmlwin normexam cons standlrt girl, level2(school: cons standlrt) level1(student: cons standlrt girl, elements(A))`

Two-level random-intercept and random-slope (coefficient) model using MCMC (where we first fit the model using IGLS to obtain initial values for the MCMC chains)

*(See page 71 of the MLwin MCMC Manual)*

- `runmlwin normexam cons standlrt, level2 (school: cons standlrt) level1 (student: cons)`
- `runmlwin normexam cons standlrt, level2 (school: cons standlrt) level1 (student: cons) mcmc(on) initsprevious`

Multivariate response models

---



Bristol University | Centre for Multilevel Modelling | runmlwin: Running MLwiN from within Stata - Mozilla Firefox

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## runmlwin: Running MLwiN from within Stata

**runmlwin** is a Stata command which allows Stata users to run the powerful MLwiN multilevel modelling software from within Stata.

The multilevel models fitted by **runmlwin** are often considerably faster than those fitted by the Stata's **xtmixed**, **xtmelogit** and **xtmepoisson** commands. The range of models which can be fitted by **runmlwin** is also much wider than those commands. **runmlwin** also allows fast estimation on large data sets for many of the more complex multilevel models available through the user written **gllamm** command.

MLwiN has the following features:

1. Estimation of multilevel models for continuous, binary, count, ordered categorical and unordered categorical data
2. Fast estimation via classical and Bayesian methods
3. Estimation of multilevel models for cross-classified and multiple membership nonhierarchical data structures
4. Estimation of multilevel multivariate response models, multilevel spatial models, multilevel measurement error models and multilevel multiple imputation models

These details with a screen shot are available on our **runmlwin** [leaflet](#) (pdf, 0.1mb)

### Presentations

We have provided a range of presentations showcasing **runmlwin**. These presentations provide a quick overview of how the command works and the range of models which can be fitted. [More >>](#)

### Download



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## Presentations using runmlwin

- UK Stata Users' Group, 17th Meeting (16th September 2011)
  - [Slides](#) (PDF, 2.0mb)
  - [Stata do-file](#) (do, 0.1mb) to replicate all analyses presented in the slides.
- University of Bristol, Mplus/MLwiN User Group (MUGS) meeting (14th June 2011)
  - [Slides](#) (PDF, 2.3mb)
  - [Stata do-file](#) (do, 0.1mb) to replicate all analyses presented in the slides.
- Modern Modeling Methods (M3) Conference, University of Connecticut (26th May 2011)
  - [Slides](#) (PDF, 3.2mb)
  - [Stata do-file](#) (do, 0.1mb) to replicate all analyses presented in the slides.
- 2011 American Sociological Association Spring Methodology Conference, Tilburg University (20th May 2011)
  - [Slides](#) (PDF, 2.0mb)
  - [Stata do-file](#) (do, 0.1mb) to replicate all analyses presented in the slides.
- University of Bristol, e-Stat meeting (7th April 2011)
  - [Slides](#) (PDF, 1.7mb)
  - [Stata do-file](#) (do, 0.1mb) to replicate all analyses presented in the slides.
- 8th International Amsterdam Multilevel Conference (17th March 2011)



## Centre for Multilevel Modelling



### SOFTWARE

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## 🔥 Examples using runmlwin

### MLwiN User Manual

These do-files and log files replicate the analyses reported in the [MLwiN User Manual](#) (PDF, 4.6 mb) Rasbash, J., Steele, F., Browne, W.J. and Goldstein, H. (2009) Centre for Multilevel Modelling, University of Bristol.

Note that we have not created do-files for Chapters 1, 8 or 19 of the manual as no models are fitted in those chapters. We have also not yet attempted to replicate the analysis in Chapter 17.

- 1 - Introducing Multilevel Models
- 2 - Introduction to Multilevel Modelling ([do](#) | [log](#))
- 3 - Residuals ([do](#) | [log](#))
- 4 - Random Intercept and Random Slope Models ([do](#) | [log](#))
- 5 - Graphical Procedures for Exploring the Model ([do](#) | [log](#))
- 6 - Contextual Effects ([do](#) | [log](#))
- 7 - Modelling the Variance as a Function of Explanatory Variables ([do](#) | [log](#))
- 8 - Getting Started with your Data
- 9 - Logistic Models for Binary and Binomial Responses ([do](#) | [log](#))
- 10 - Multinomial Logistic Models for Unordered Categorical Responses ([do](#) | [log](#))
- 11 - Fitting an Ordered Category Response Model ([do](#) | [log](#))
- 12 - Modelling Count Data ([do](#) | [log](#))
- 13 - Fitting Models to Repeated Measures Data ([do](#) | [log](#))
- 14 - Multivariate Response Models ([do](#) | [log](#))

- Rasbash, J., Charlton, C., Browne, W.J., Healy, M. and Cameron, B. 2009. MLwiN Version 2.1. Centre for Multilevel Modelling, University of Bristol.

For models fitted using MCMC estimation, we ask that you additionally cite:

- Browne, W.J. 2009. MCMC Estimation in MLwiN, v2.13. Centre for Multilevel Modelling, University of Bristol.

### Papers using runmlwin

Please let George Leckie ([g.leckie@bristol.ac.uk](mailto:g.leckie@bristol.ac.uk)) know of any further publications using **runmlwin** including forthcoming papers, books, PhD theses, etc.

- Cheung, C., Goodman, D., Leckie, G. and Jenkins, J. (2011) [Understanding Contextual Effects on Externalizing Behaviors in Children in Out-of-home Care: Influence of Workers and Foster Families](#). *Children and Youth Services Review*, 33, 2050-2060.
- Chung, H. and Beretvas, S.N. (2011) [The Impact of ignoring multiple membership data structures in multilevel models](#). *British Journal of Mathematical and Statistical Psychology*. *Forthcoming*.
- Leckie, G. and Baird, J.-A. (2011) [Rater effects on essay scoring: A multilevel analysis of severity drift, central tendency and rater experience](#). *Journal of Educational Measurement*. *Forthcoming*.
- Leckie, G., Pillinger, R., Jones, K. and Goldstein, H. (2011) [Multilevel modelling of social segregation](#). *Journal of Educational and Behavioral Statistics*. *Forthcoming*.
- Paternoster, L., Howe, L. D., Tilling, K., Weedon, M. N., Freathy, R. M., Frayling, T. M., Kemp, J. P., Davey Smith, G., Timpson, N. J. Ring, S. M., Evans, D. M. and Lawlor, D. A. (2011) [Adult height variants affect birth length and growth rate in children](#). *Human Molecular Genetics*. *Forthcoming*

### Books discussing runmlwin

- Snijders, T. and Bosker, R. (2011) [Multilevel Analysis: An Introduction to Basic and Advanced Multilevel Modeling](#), Second Edition. *Sage*. *Forthcoming*.



## runmlwin user forum

## Forum rules

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20 topics • Page 1 of 1

## ANNOUNCEMENTS

REPLIES

VIEWS

LAST POST

**Do-files to replicate entire MLwiN User & MCMC Manuals**

by GeorgeLeckie » Mon Apr 18, 2011 5:30 pm

0

123

by GeorgeLeckie

Mon Apr 18, 2011 5:30 pm

**Welcome to the runmlwin discussion forum**

by GeorgeLeckie » Fri Apr 01, 2011 4:06 pm

0

130

by GeorgeLeckie

Fri Apr 01, 2011 4:06 pm

## TOPICS

REPLIES

VIEWS

LAST POST

**MVs & error message 'line too long'**

by julia1633 » Mon Aug 15, 2011 3:17 pm

1 2

17

125

by julia1633

Sun Aug 28, 2011 12:05 am

**runmlwin in Batch mode - gui causing error?**

by ash » Sat Aug 27, 2011 6:43 am

2

20

by ash

Sat Aug 27, 2011 9:07 pm

**Bug in residuals(u, savechains("u.dta", replace)) ?**

by ash » Mon Aug 01, 2011 7:06 pm

4

76

by GeorgeLeckie

Wed Aug 03, 2011 6:25 pm

**Predictions via the runmlwin interface: a clarification**

by ewancarr » Tue Jul 26, 2011 6:49 pm

6

84

by GeorgeLeckie

Wed Jul 27, 2011 7:04 pm

**highly correlated multivariate dependents -> numerical error**

by ash » Sat Jul 23, 2011 10:48 am

1

67

by GeorgeLeckie

Mon Jul 25, 2011 3:49 pm

**Input dataset contains double precision data...**

by ewancarr » Wed Jul 13, 2011 3:55 pm

2

81

by ewancarr

Wed Jul 13, 2011 9:16 pm

**Modelling Count Data (example do-file) - mismatch error**

by leap » Tue Jul 12, 2011 10:18 am

1

48

by ChrisCharlton

Wed Jul 13, 2011 3:32 pm

**Error code: r(-1073740777);**

by pd65 » Mon Jul 04, 2011 11:01 am

7

207

by GeorgeLeckie

Thu Jul 07, 2011 3:15 pm

**MCMC estimation**

by janna » Fri Apr 08, 2011 9:20 am

5

293

by ChrisCharlton

Thu Jul 09, 2011 10:09 am

# Citing `runmlwin`

- If you use `runmlwin` in your work, please cite `runmlwin`
- Leckie, G. and Charlton, C. (2011) *runmlwin: Stata module for fitting multilevel models in the MLwiN software package*. Centre for Multilevel Modelling, University of Bristol.
- We can then add you to the list of papers using `runmlwin` on our website
- <http://www.bristol.ac.uk/cmm/software/runmlwin/citations>