Running MLwiN from within Stata: the runmlwin command

Research Workshop in Multilevel Modelling using MLwiN Bristol 13<sup>th</sup> September 2013

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### What is runmlwin?

- runmlwin is a Stata command to run MLwiN seamlessly from within Stata
  - MLwiN offers fast estimation for a wide range of multilevel models, but has limited data management, graphics and programming facilities
  - Stata offers a limited range of multilevel models, but has excellent facilities for pre- and post-estimation data management and graphics and many model testing and interpretation routines
  - runmlwin capitalises on the best features of both packages

- But what if you use R rather than Stata...
  - Then use the r2mlwin R function to run MLwiN from within R
  - r2mlwin provides all the same functionality as runmlwin

#### 1. EXAMPLE ANALYSES USING THE HEDONISM IN EUROPE DATA

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	female	36496	2	5291813	0	1	Rge in years Female			hedonism.dta
	educ	36082	35	11,92317	0	40	Education in years		Label	
	income	29744	12	5,962816	1	12	Income band		Notes	
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individual	36527	36527	18264	1	36527	Individual ID		female
hedonism	36527	607	2035884	-4.158	3.25	Hedonism score		adua
cons	36527	1	1	1	1	Constant		educ
age	36364	84	46.15595	14	98	Age in years		income
female	36496	2	.5291813	0	1	Female		countryc
educ	36082	35	11.92317	0	40	Education in years		
income	29744	12	5.962816	1	12	Income band		
countrycode	36527	20	10.88318	1	22	Country code		

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**Two-level variance components model hedonism**<sub>ij</sub> =  $\beta_0 + u_j + e_{ij}$   $u_j \sim N(0, \sigma_u^2)$  $e_{ij} \sim N(0, \sigma_e^2)$ 

. runmlwin hedonism cons,

level2(country: cons) ///

level1(individual: cons)





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hedonism <sub>ij</sub> ~ N(XB, $\Omega$ )	
hedonism <sub>ij</sub> = $\beta_{0ij}$ cons	
$\beta_{0ij} = \beta_0 + u_{0j} + e_{0ij}$	
$\begin{bmatrix} u_{0j} \end{bmatrix} \sim \mathbb{N}(0, \Omega_u) : \Omega_u = \begin{bmatrix} 2 \\ \sigma_u \\ 0 \end{bmatrix}$	
$\begin{bmatrix} e_{0ij} \end{bmatrix} \sim \mathbb{N}(0, \Omega_e) : \Omega_e = \begin{bmatrix} 2 \\ \sigma_e 0 \end{bmatrix}$	
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hedonism <sub>ij</sub> ~ N(XB, $\Omega$ )	
hedonism <sub>ij</sub> = $\beta_{0ij}$ cons	
$\beta_{0ij} = -0.203(0.067) + u_{0j} + e_{0ij}$	
$[ \Gamma ] \rightarrow N(0, \alpha) + \alpha = \Gamma $	
$\begin{bmatrix} u_{0j} \end{bmatrix} \sim \mathbb{N}(0, \Omega_u) \cdot \Omega_u = \begin{bmatrix} 0.090(0.029) \end{bmatrix}$	
$\begin{bmatrix} 1 \\ - \end{bmatrix} \sim N(0, \Omega_{1}) \cdot \Omega_{2} = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$	
$\begin{bmatrix} e_{0ij} \end{bmatrix}$ $(0, 32e)$ $(2e) \begin{bmatrix} 0.885(0.007) \end{bmatrix}$	
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Run time (seco Number of iter Log likelihood Deviance	nds) = 4 ations = = -49651 = 99303	3 .676 .352				
hedonism	Coef. S	td. Err.	z P> z	[95% Conf.	[Interval]	
cons	2031523 .	0671835 -3	.02 0.002	3348295	0714752	
Random-effe	cts Parameters	Estimate	Std. Err.	[95% Conf.	Interval]	
Level 2: count	ry var(cons)	.0897654	.0285461	.0338161	.1457147	
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## Refit the model by RIGLS and retrieve the level-2 residuals

**hedonism**<sub>*ij*</sub> =  $\beta_0 + u_j + e_{ij}$ 

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

. runmlwin hedonism cons, ///

level2(country: cons, residuals(u)) ///

level1(individual: cons) ///

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Estimation alo	orithm: RIGLS					-	cons
Run time (seco	onds) =	2.77					age
Number of iter	rations =	3				-	female
Log restricted	d-likelihood = -4	49651.688					educ
Restricted-dev	viance = 9	99303.375				-	income
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nedonism	COEI. SI	ta. Err.	z P> z	[95% Conr.	Intervalj		
cons	2031516 .0	0689179 -	2.95 0.003	3382282	0680751	ſ	u0 u0se
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Random-effe	ects Parameters	Estimate	Std. Err.	[95% Conf.	Interval]		
Level 2: count	trv						
	var(cons)	.0944864	.0298413	.0359985	.1529742		
Level 1: indiv	vidual						
	var(cons)	.8850616	.0065509	.8722221	.8979011		
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Level 1: individual									
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(Assumption: S	SL nested in VC)		P	rob > chi2 =	0.0000					
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	$H_0: \sigma_u^2$	$= 0; H_1: \sigma_u^2 >$	> 0; $\chi_1^2$ =	= 3286, <i>p</i> < 1	0.01					
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# Caterpillar plot showing country residuals with 95% CIs



- . keep country countrycode u0 u0se
- . duplicates drop
- . isid country
- . sort u0
- . generate u0rank = \_n
- . serrbar u0 u0se u0rank, scale(1.96) yline(0)

# Caterpillar plot showing country residuals with 95% CIs



- . serrbar u0 u0se u0rank, scale(1.96)
- > mvopts(mlabel(countrycode)
- > mlabposition(6) mlabgap(huge))
- > ytitle("Residual") yline(0) xtitle("Country (ranked)")

### Two-level random-intercept model with covariates

 $\mathbf{hedonism}_{ij} = \beta_0 + \beta_1 \mathbf{age46}_{ij} + u_j + e_{ij}$ 

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

- . generate age46 = age 46
- . runmlwin hedonism cons age46, ///

```
level2(country: cons, residuals(u)) ///
level1(individual: cons) ///
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. generate age	a46 = age - 46						Variable
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Normal respons	se model						female
Estimation alg	jorithm: RIGLS	2 46					educ
Number of iter	rations =	3.40					income
Log restricted	d-likelihood = -4	7294.555					countryc
Restricted-dev	viance = 9	4589.109					age46
							 u0
hedonism	Coef. St	d. Err.	z P> z	[95% Conf.	Interval]		u0se
cons	198907 .0	)687597 -2	.89 0.004	3336736	0641404		
age46	0174069 .0	0002581 -67	.45 0.000	0179127	0169011		
Random-effe	ects Parameters	Estimate	Std. Err.	[95% Conf.	Interval]		
Level 2: count	cry	004105	0007507	0257000	1504102		
	var(cons)	.094105	.0297527	.0357908	.1524193		
Level 1: indiv	vidual						
	var(cons)	.7869442	.0058377	.7755025	.7983859		
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### Predicted country lines



- . predict predxb
- . generate predxbu = predxb + u0
- . sort country age46
- . twoway (line predxbu age, connect(ascending)),
- > ytitle("Predicted hedonism")
- > xtitle("Age (in years)") xline(46)

#### Two-level random-slope model

 $\mathbf{hedonism}_{ij} = \beta_0 + \beta_1 \mathbf{age46}_{ij} + u_{0j} + u_{1j} \mathbf{age46}_{ij} + e_{ij}$ 

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

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

. runmlwin hedonism cons age46, ///

```
level2(country: cons age46, residuals(u)) ///
level1(individual: cons) ///
rigls noheader nopause
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hedonism Coef. Std. Err. z P> z  [95% Conf. Interval]	hedonism
	cons
cons1999337 .06904 -2.90 0.00433524960646177	age
age460176279 .0010115 -17.43 0.00001961040156453	female
	educ
	income
Random-effects Parameters Estimate Std. Err. [95% Conf. Interval]	countryc
	age46
Level 2: country	u0
var(cons) = .0948761 = .0301369 = .035809 = .1539433	u1
var(age46) .0000191 6.47e-06 6.41e-06 .0000318	u0se
	u1se
Level 1: individual	_est_RS
var(cons) .7810343 .0057955 .7696754 .7923932	
. estimates store RS	
. lrtest RI RS	
Likelihood-ratio test $LR chi2(2) = 232.19$	
(Assumption: KI nested in KS) $Prob > Cni2 = 0.0000$	
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### Predicted country lines



- . predict predxb
- . generate predxbu = predxb + u0 + u1\*age46
- . sort country age46
- . twoway (line predxbu age, connect(ascending)),
- > ytitle("Predicted hedonism") xtitle("Age (in years)")
- > xline(46)

Stata/MP 12.1 - http:	//www.bristol.ac.uk/cmm/m	iedia/runmlwin/hedoni	sm.dta - [Results]				
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. runmlwin, no	oheader correlat:	ions					Variable
							country
hedonism	Coef. St	td. Err.	z P> z	[95% Conf.	Intervall		individual
							hedonism
cons	1999337	.06904 -2	.90 0.004	3352496	0646177		cons
age46	0176279 .0	0010115 -17	.43 0.000	0196104	0156453		age
	1						female
							educ
Random-effe	ects Parameters	Estimate	Std. Err.	[95% Conf.	Interval]		income
							countryc
Level 2: count	try						age46
	var(cons)	.0948761	.0301369	.035809	.1539433		u0
co	orr(cons,age46)	./11/642	.1190144 6 47e-06	.4/85001 6 41e-06	.9450282		u1
	Val (agero)		0.470 00	0.410 00			u0se
Level 1: indiv	vidual						u1se
	var(cons)	.7810343	.0057955	.7696754	.7923932		_est_RS
							predxb
							predxbu
•		<b></b>					
			$\sigma_{u01}$				
		$\rho_{u01} =$					
•			$\sigma_{u0}^2 \sigma_{u1}^2$				
•			V at at				
•							
•						<b>_</b>	
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### Slope vs. Intercept residuals



- . keep country countrycode u0 u1
- . duplicates drop
- . isid country
- . twoway (scatter u1 u0, mlabel(countrycode)),
- > ytitle("Slope residual (u1)") yline(0)
- > xtitle("Intercept residual (u0)") xline(0)

# Between-country variance as a function of age



. generate lev2var = [RP2]var(cons)

- > + 2\*[RP2]cov(cons\age46)\*age46 + [RP2]var(age46)\*age46^2
- . twoway (line lev2var age, sort),
- > ytitle("Between-country variance") xline(46)

Stata/MP 12.1 - http://ww	w.bristol.ac.uk/cm	ım/media/runmlw	in/hedonism.dta	- [Results]				
<u>File E</u> dit <u>D</u> ata <u>G</u> raphics	<u>S</u> tatistics <u>U</u> ser	<u>W</u> indow <u>H</u> elp						8
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								Variables 🔻 🛱 🗙
. estimates table	SL VC RI	RS, stats(	deviance)	b(%4.3f)	<pre>stfmt(%6.0f)</pre>	varwidth(15)		Variable
								country
Variable	SL	VC	RI	RS				individual
								hedonism
FP1		0.000	0 100	0.000				cons
cons	-0.204	-0.203	-0.199	-0.200				age
ayero			0.017	0.010				female
RP1								educ
var(cons)	0.971	0.885	0.787	0.781				income
 PD0								countryc
Var (cons)		0.094	0.094	0.095				age46
cov(cons\age46)		0.001		0.001				<u>u0</u>
var(age46)				0.000				<u>u1</u>
								uUse
Statistics	102590	99303	01580	94357				ulse
deviance	102590	33303	94509	94557				est_RS
								predxb
								preuxbu
•								levzvar
•								
•							•	
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2. RUNNING MLWIN FROM WITHIN STATA MAKES IT EASY TO REPRODUCE AND DOCUMENT ANALYSES

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      * 1. Example analyses using the Hedonism in Europe data
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 42
 43
 44
      * Load the hedonism.dta dataset
 45
      use http://www.bristol.ac.uk/cmm/media/runmlwin/hedonism, clear
 46
      * Describe and summarize all variables in the data
 47
 48
      codebook, compact
 49
 50
 51
      52
      * Variance-components model
                             ************
      53
 54
 55
      * Reload the data
 56
      use http://www.bristol.ac.uk/cmm/media/runmlwin/hedonism, clear
 57
 58
      * Fit the variance-components model by IGLS
 59
      runmlwin hedonism cons, level2(country: cons) level1(individual: cons)
 60
 61
      * Refit the variance-components model by RIGLS and retrieve the level-2
 62
      * residuals
 63
      runmlwin hedonism cons, ///
 64
         level2(country: cons, residuals(u)) ///
         level1(individual: cons) ///
 65
 66
         rigls nogroup nopause
 67
 68
      * Calculate the VPC/ICC
 69
      display 0.094/(0.094 + 0.885)
 70
•
```

## 3. RESOURCES TO HELP YOU LEARN runmlwin



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#### 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 installing runmlwin* 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 Section 2.5 of the MLwiN User Manual)
```

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

```
Two-level random-intercept and random-slope (coefficient) model (fitted using IGLS) (See Section 4.4 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 Section 4.4 of the MLwiN User Manual)
. runmlwin normexam cons standlrt, level2 (school: cons standlrt, residuals(u))
level1 (student: cons) nopause
```

Two-level random-intercent and random-slone (coefficient) model with a complex level

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Research	esearch runmlwin is a Stata command which allows Stata users to run the powerful MLwiN multilevel modelling								
Learning and training	solware norn within Stata.								
Links	The multilevel models fitted by <b>runmlwin</b> are o	he multilevel models fitted by <b>runmlwin</b> are often considerably faster than those fitted by the Stata's							
Publications	Imixed, xtmelogit and xtmepoisson commands. The range of models which can be fitted by runmiwin also much wider than those commands, runmiwin also allows fast estimation on large data sets for								
Software	many of the more complex multilevel models av	nany of the more complex multilevel models available through the user written <b>gliamm</b> command.							
→ MLwiN									
→ Realcom	MLWIN has the following features:								
→ Stat-JR	1. Estimation of multilevel models for continuous, binary, count, ordered categorical and unordered								
→ MLPowSim	categorical data								
→ R2MLwiN	2. Fast estimation via classical and Bayesia	n methods							
→ runmlwin	<ol> <li>Estimation of multilevel models for cross- structures</li> </ol>	classified and multiple membership nonhierar	Chical data						
→ Presentations	<ol> <li>Estimation of multilevel multivariate response</li> </ol>	nse models, multilevel spatial models, multile	vel						
→ Examples	measurement error models and multilevel	multiple imputation models							
→ Citations	These details with a screen shot are available	on our <b>runmlwin</b> leaflet (pdf_0_1mb)							
→ User Forum		(P al, 0 )							

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Links	These do files and log files replicate the analyses reported in the ML will Lloer Manual (RDE 4.6 mb)								
Publications	e do-files and log files replicate the analyses reported in the MLWIN User Manual (PDF, 4.6 mb) bash, J., Steele, F., Browne, W.J. and Goldstein, H. (2012) Centre for Multilevel Modelling, University of								
Software	Bristol.								
→ MLwiN	Note that we have not created do files for Chapters 1, 8 or 19 of the manual as no models are fitted in								
→ Realcom	hose chapters. We have also not vet created the do-file for Chapter 17.								
→ Stat-JR									
→ MLPowSim	1 Introducing Multilevel Models								
→ R2MLwiN	<ul> <li>2 Introduction to Multilever Modelling (do   log)</li> <li>3 Residuals (do l log)</li> </ul>								
→ runmlwin	<ul> <li>4 Random Intercept and Random Slope Models (do Llog)</li> </ul>								
→ Presentations	<ul> <li>5 Graphical Procedures for Exploring the Model (do   log)</li> </ul>								
→ Examples	<ul> <li>6 Contextual Effects (do   log)</li> </ul>								
→ Citations	<ul> <li>7 Modelling the Variance as a Function of Explanatory Variables (do   log)</li> </ul>								
→ User Forum	<ul> <li>8 Getting Started with your Data</li> </ul>								
	<ul> <li>9 Logistic Models for Binary and Binomial Responses (do Llog)</li> </ul>	-							

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	Make sure you have latest version of runmlwin: 24/03/2013 by GeorgeLeckie » Tue May 01, 2012 4:21 pm	0	1498	by GeorgeLeckie <table-cell> Tue May 01, 2012 4:21 pm</table-cell>				
	<b>Do-files to replicate entire MLwiN User &amp; MCMC Manuals</b> U by GeorgeLeckie » Mon Apr 18, 2011 5:30 pm	7	2846	by GeorgeLeckie 😡 Tue Mar 13, 2012 3:47 pm				
	Welcome to the runmlwin discussion forum by GeorgeLeckie » Fri Apr 01, 2011 4:06 pm	0	1658	by GeorgeLeckie <table-cell> Fri Apr 01, 2011 4:06 pm</table-cell>				
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	Cross-classified model with negative binomial distribution by VBMHealthEcon » Tue Jul 09, 2013 4:25 pm	5	273	by GeorgeLeckie 😡 Wed Jul 31, 2013 11:06 am				
	Error message when running Multiple Membership Model by VBMHealthEcon » Tue Jul 30, 2013 3:54 pm	0	9	by VBMHealthEcon D Tue Jul 30, 2013 3:54 pm				
	Mixed-effects, mixed distribution model by turrell » Sat Jul 13, 2013 8:19 am	1	1006	by GeorgeLeckie D Tue Jul 16, 2013 5:24 pm				
	Getting MCMC residuals and their chains from RS model by andrewjdbell » Fri Jul 12, 2013 3:33 pm	1	53	by ChrisCharlton D Mon Jul 15, 2013 9:29 am				
	Testing the proportional odds assumption in runmlwin by Eagg1986 » Tue Jul 02, 2013 2:46 pm	4	85	by Eagg1986 D Fri Jul 05, 2013 4:45 pm				•