

## FINAL EXAM FOR ADEL ELGHAFGHUF

The exam consists of 4 parts (below), which should all be answered. The exam starts at 9am, Tuesday 15/12, and ends at 4pm, Thursday 17/12. It is worth 40% of the course mark. All aids except personal assistance are allowed.

The topic of the exam is estimation/prediction of random effects in linear mixed models.

### *Part 1*

Exercise E 13.5 in the textbook (McCulloch, Searle & Neuhaus, 2008).

### *Part 2*

Analyse the `scc40_2level` dataset (from the Epi on the Island course) by an appropriate linear mixed model (including all predictors) in both R, MLwiN and Stata, and check whether you obtain the same parameter estimates, residuals and predicted values of random effects in the three software packages. (*Notes:* In the MLwiN software you get the predicted values via the Residuals window. In Stata, you should use the `xtmixed` command.)

### *Part 3*

Describe in your own words the two main possible uses of predicted random effects in mixed models, following the textbook or Chapter 2 of Goldstein (1995, 2003), *Multilevel Statistical Models*, 2nd/3rd ed. (the course instructor has the book), or other sources. Goldstein developed two sets of standard errors for predicted values of random effects, also available in MLwiN. Determine empirically if the standard errors used in R and Stata for standardising residuals and predicted values seem to be identical to any of these. Indicate also whether the two variances computed in Part 1 in your view correspond to any of the different standard errors considered.

### *Part 4*

Study the distribution of the standardised residuals provided in R by simulating a number of datasets from the estimates of your model for the `scc40_2level` data and assessing the empirical distribution of suitable distribution characteristics, e.g. the mean, standard deviation, skewness, 90% percentile, and  $P$ -value for a test of normality.