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A Primer in Multilevel Modeling for Actuarial Applications

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Agenda

- Overall aim of the paper
- Motivation
- Overview of key points
- Conclusion
- Next steps

Overall Aim of the Paper

- a simple ***introduction***
- suitable for both ***academics and practitioners***
- in order to encourage ***more to use*** this important technique in their future work.

Motivation

- Hammad, Mona S. A., & Harby, Galal A. H. (2013). ***Using Multilevel Modeling for Group Health Insurance Ratemaking: A Case Study from the Egyptian Market***. Paper presented at the Perspectives on Actuarial Risks in Talks of Young Researchers (PARTY2013), Ascona, Switzerland. www3.unil.ch/wpmu/party2013/

Overview of key points

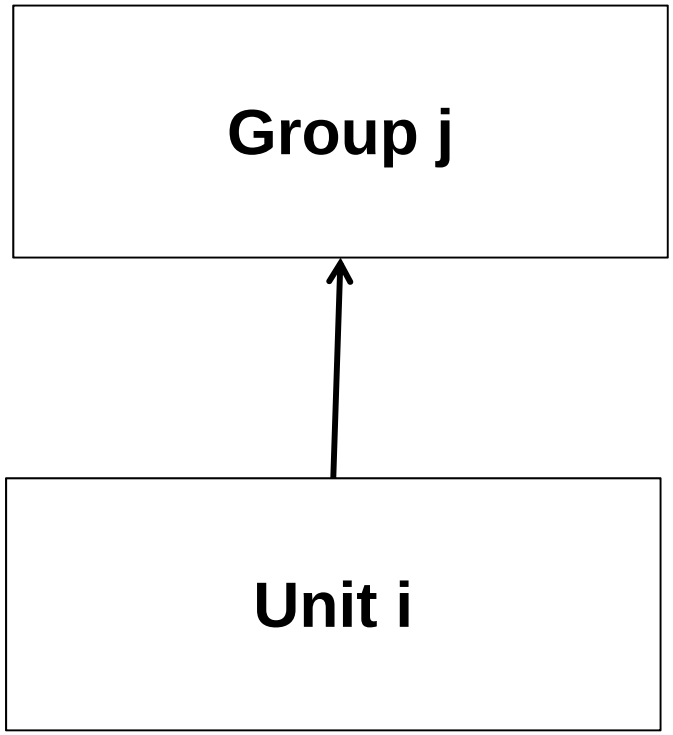
1. ***What*** **is multilevel modeling?**
2. ***Why*** **to use multilevel modeling?**
3. ***When*** **to use multilevel modeling?**
4. ***How*** **to use multilevel modeling?**

1- <u>What</u> is multilevel modeling?

- ***multilevel model*** can be defined as:
  - a model *"specified in stages, with each stage building upon another"* (Searle, Casella, & McCulloch, 2006, p. 315).
  - *"a regression (a linear or generalized linear model) in which the parameters—the regression coefficients—are given a probability model."* (Gelman & Hill, 2007, p. 1)

Simple Illustrative Example

- dataset of observations for units *i* nested groups *j*. *(examples?!)*



- Hierarchical/ clustered/ Nested data structures.
- → Reason for alternative name HLM / limitation
- More layers
- Panel/longitudinal data

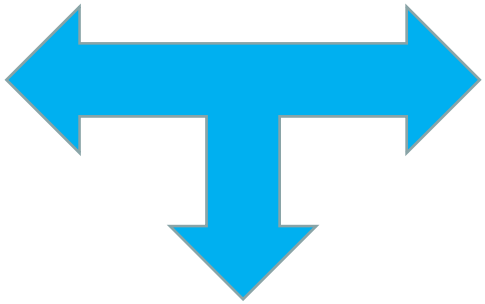
Simple Illustrative Example (Cont.)

Complete Pooling

(one single model)

(-) ignore & correlation

(-) not suitable for all?



Partial Pooling

(Multilevel Model)

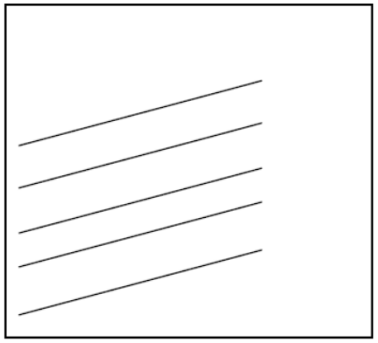
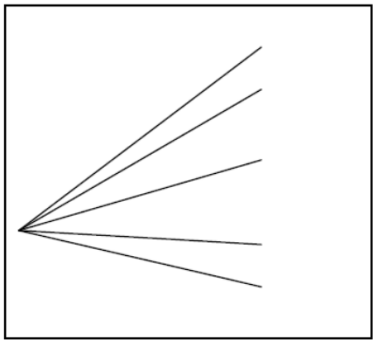
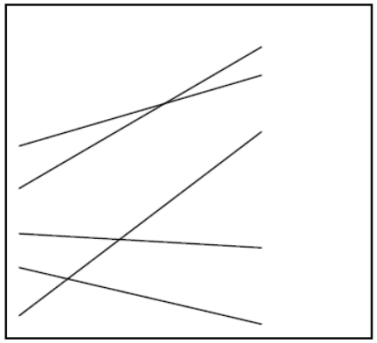
a compromise

No Pooling

(separate models)

Not practical

single model but allows for heterogeneity between subjects and groups in the dataset. (Gelman & Hill, 2007)

A] Varying/Random intercept model	B] Varying/Random slope model	C] Varying/Random intercept and slope model
		

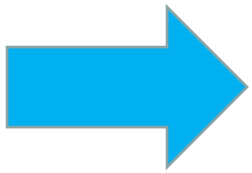
Note: each of these graphs assumes a hypothetical dataset with 6 groups (i.e. six level 2 units), with each fitted line representing a different group, in other words. Source: (Gelman & Hill, 2007, p. 238)

$y_{ij} = \pi_{0j} + \pi_1 \alpha_{ij} + e_{ij}$	$y_{ij} = \pi_0 + \pi_{1j} \alpha_{ij} + e_{ij}$	$y_{ij} = \pi_{0j} + \pi_{1j} \alpha_{ij} + e_{ij}$
$\pi_{0j} = \beta_{00} + \beta_{01} x_j + r_{0j}$	$\pi_{1j} = \beta_{10} + \beta_{11} x_j + r_{1j}$	$\pi_{0j} = \beta_{00} + \beta_{01} x_j + r_{0j}$
		$\pi_{1j} = \beta_{10} + \beta_{11} x_j + r_{1j}$

Possibility of different explanatory variables at different levels

2- *Why* to use multilevel modeling?

- allowance for:
  - ***heterogeneity*** between different subjects in the dataset without the need to fit separate models.
  - possible ***correlations over time*** between observations related to the same subject and/or group.



It can handle complex data structures

3- *When* to use multilevel modeling?

- Complex data structures such as:
  - *Hierarchical data*
  - *Panel data*
  - *Cross-classified data*

4- *How* to use multilevel modeling?

- Specialized software vs. general purpose statistical packages (with mixed model procedure).

Hierarchical Linear Model (HLM)	Linear Mixed Model notation
Level *1*: $y_{ij} = \pi_{0j} + e_{ij}$ Level *2*: $\pi_{0j} = \beta_{00} + r_{0j}$	$y_{ij} = \underbrace{\beta_{00}}_{Fixed} + \underbrace{r_{0j} + e_{ij}}_{Random}$

Conclusion

- Powerful tool

- Open a wide spectrum of potential model designs
  - need for careful planning (i.e. a clear modeling strategy).

Next Steps

- Read the paper?
- Send feedback?

Thank You

References

- Gelman, A., & Hill, J. (2007). *Data Analysis Using Regression and Multilevel/Hierarchical Models*. New York: Cambridge University Press.
- Searle, S. R., Casella, G., & McCulloch, C. E. (2006). *Variance Components*. New Jersey: John Wiley & Sons, Inc.