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

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- **What** 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

Gelman & Hill, 2007
|----------------------------------|-------------------------------|-------------------------------------------|

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)

\[
y_{ij} = \pi_{0j} + \pi_{1j} \alpha_{ij} + e_{ij}
\]

\[
\pi_{0j} = \beta_{00} + \beta_{01} x_j + r_{0j}
\]

\[
\pi_{1j} = \beta_{10} + \beta_{11} x_j + r_{1j}
\]

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).

<table>
<thead>
<tr>
<th>Hierarchical Linear Model (HLM)</th>
<th>Linear Mixed Model notation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Level 1:</strong> $y_{ij} = \pi_{0j} + e_{ij}$</td>
<td>$y_{ij} = \underbrace{\beta_{00}}<em>{Fixed} + \underbrace{r</em>{0j}}<em>{Random} + e</em>{ij}$</td>
</tr>
<tr>
<td><strong>Level 2:</strong> $\pi_{0j} = \beta_{00} + r_{0j}$</td>
<td></td>
</tr>
</tbody>
</table>
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
