Building Meta-regression Models

Overview of Meta-regression

- Meta-regression models are **analogous to regression models** used in primary studies.
  - **Analogous to regression models:** Meta-regression and regression models in primary studies are conceptually similar in terms of structure, often use the same types of procedures, and involve similar challenges.
- Building a meta-regression model involves identifying a set of independent variables to explain variation in effects.
- Some moderators test theories about sample, study, or intervention characteristics, while others control for methodological factors known to influence effect sizes (e.g., evaluation design).

Model-Building Pitfalls

- Limitations on the number of moderators that can be included in a model; a study review could code more moderators than the meta-analytic data can realistically handle.
- Potential for unknown, unmeasured confounding factors that influence the cause (e.g., intervention) and the effect.

Common Practices

Current meta-regression practices include:

- Examining one moderator variable at a time using multiple, single-factor meta-regression models.
- Using **stepwise regression** approaches that can test blocks of covariates at a time.
  - **Stepwise regression:** In this model approach, covariates are added or removed in a selected succession and tested for statistical significance after each iteration.
- Rarely providing details on the model selection process with multiple moderators.

Recommendations for Model Building

- **Determine a goal:** Decide whether the goal is to estimate an overall effect size or focus on effect sizes for each level of a given moderator.
- **Specify clear research questions about average effects and moderators:** Selection of moderators should, first and foremost, be theoretically based.
- **Clearly specify all confirmatory research questions and hypotheses:** Findings that support a priori, confirmatory hypotheses carry greater weight than those that don't. When conducting exploratory analyses, use **family-wise Type I error rate** corrections for **multiple comparisons**.
  - **Family-wise Type I error rate:** Family-wise Type I error rate is the probability of making one or more false discoveries when performing multiple hypotheses tests. Any of a variety of correction methods can be applied (e.g., Bonferroni procedure, Tukey procedure).
  - **Multiple comparisons:** Multiple comparisons may result from conducting multiple models and estimating multiple effect sizes.
- **Adjust for study design:** Certain designs and methodological factors are associated with inflated effect sizes and may need to be adjusted accordingly.

Three Possible Strategies

1. **MUTOS Theoretical Approach:** This theoretically based approach groups factors into five categories: Methods, Unit/sample population, Treatment characteristics, Outcome measures, and Setting.

   Meta-regression models are run separately for the five categories. They are then used to create a single, comprehensive model that includes significant moderators or moderators of a certain effect size magnitude.

   See Chapter 16 of The Handbook of Research Synthesis and Meta-Analysis for further reading on the MUTOS modeling approach.

2. **Information-Criteria Approach:** This approach uses information criteria to indicate which model fits best.

   Multiple meta-regression models are run on the meta-analytic data. Information criteria are then estimated for each model using maximum likelihood estimation, with the smallest value indicating the best-fitting model.

A set of simulations further explains details on the model section approach, the information criteria available, and recommendations on the approach to select given your model and the amount of data.

3. **Random Forests Approach:** This machine-learning tool uses a bootstrapping process with the meta-analytic data and random selection of covariates included in each tree. This process identifies those features that contribute most to the variance around the treatment effect.

   In combination with the MUTOS theoretical approach, this data-driven approach has been applied in a meta-analysis that examined sources of heterogeneity among mathematics intervention programs.

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