Statistical Engineering Division Seminar

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My PhD - Evaluation of Inter-laboratory Comparison in Measurement

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Abstract

The model of inter-laboratory comparison (ILC) in this study coincides with the model of direct repeated measurement of one quantity with p participating laboratories. Each laboratory repeats its measurement on the sample in this way, in the i^{th} laboratory n_i times. Y_{ij} represents measurements in individual laboratories. If we assume in mixed linear model (model of ILC) only one factor $\boldsymbol{\alpha}$ („laboratory"), the model will be following:

$$\boldsymbol{Y} = \boldsymbol{1}\mu + \boldsymbol{Z}\boldsymbol{\alpha} + \boldsymbol{e}\,.$$

The factor $\boldsymbol{\alpha}$ can be understood as a random effect (random effect model) or fixed effect. If we suppose $\boldsymbol{\alpha}$ to be random than the measurements are supposed to be normally distributed with mean μ (the true measured value) and dispersion $\sigma_{\mathrm{L}}^2 + \sigma_{ei}^2$, where σ_{L}^2 being the inter-laboratory variance and σ_{ei}^2 the within-laboratory variance of i^{th} laboratory. In model with one random effect we try to estimate the variability of random effect, so of inter-laboratory variance σ_{L}^2. If $\sigma_{\mathrm{L}}^2 = 0$, the random effect „laboratory" does not have any influence on results.

In the first step of ILC evaluation we test the requirement of normal probability distribution of measurements and the homoscedasticity of measurements (achievement of comparable repeatability of measurements in individual laboratories).

The aim of the ILC evaluation is the determination of consensus value $\hat{\mu}$ and variance components $\sigma_{ei}^2, \sigma_{\mathrm{L}}^2$ (and their confidence intervals).

Estimation of the confidence interval for inter-laboratory variance was studied by more authors: Tukey-Williams, Thomas-Hultquist, Burdick-Eickman, Hartung-Knapp, Wald, which gave confidence intervals suitable only for homoscedastic measurements.

PhD-thesis allows to determine the consensus value for a large class of ILC models also for heteroscedastic measurements (also introducing uncertainty evaluated by means of method type B).

One result of simulations in PhD-thesis in case of heteroscedastic measurements is that it is appropriate to use one of the three following methods: maximum likelihood, Mandel-Paule and modified Mandel-Paule's method to evaluate ILC. The simulation analysis shows that the differences in estimates of consensus value and the length of the confidence interval for the true value for these three methods of estimation are minimal when using different structures of experiment (balanced and unbalanced) and different type of measurements (homoscedastic or heteroscedastic).

The influence of variance components on the consensus value is also being discussed. The possibility of computing the confidence intervals for heteroscedastics measurements for the consensus value and variance components are studied.

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