Regression Techniques for MCS

- Deming (and Orthonormal) Regression
- The **mcr** package

Deming Regression

- Conventional regression models are estimated using the ordinary least squares (OLS) technique, and are referred to as ‘Model I regression’ in some papers.
- A key feature of Model I models is that the independent variable(X) is assumed to be measured without error.
- As often pointed out in several papers, including Bland and Altman [1], this assumption invalidates simple linear regression for use in method comparison studies, as both methods must be assumed to be measured with error.

Deming Regression

- The use of regression models that assumes the presence of error in both variables X and Y have been proposed for use instead.
- These methodologies are collectively known as ‘Error in Variables Regression’ or ‘Model II regression’. They differ from OLS regression in the method used to estimate the parameters of the regression.

Deming Regression

- Regression estimates depend on formulation of the model. A formulation with one method considered as the X variable will yield different estimates for a formulation where it is the Y variable.
- With Model I regression,the models fitted in both cases will entirely different and inconsistent. However with Model II regression, they will be consistent and complementary.
- The most commonly encounted approach is called "Deming Regression".

Deming Regression

- Both Variables are assumed to have attendant measurement error.
- The ratio of the variances of measurement errors for the respective methods is known as the **Variance Ratio**, denoted λ.
- Orthonormal Regression is used to describe the case where Variance Ratio is equal to 1. (i.e. variances are assumed to be equal).
- Deming Regression describes the case where the Variance Ration is specified at an value other than 1.
- Dunn [9] cautions against using the approach as there is no straightforward method for determining an estimate for λ.

Deming Regression

- As with conventional regression methodologies, Deming's regression calculates an estimate for both the slope and intercept for the fitted line, and standard errors thereof.
- Therefore there is sufficient information to carry out hypothesis tests on both estimates, that are informative about presence of **fixed** and **proportional** bias.

Deming Regression

- A 95% confidence interval for the intercept estimate can be used to test the intercept, and hence fixed bias, is equal to zero.
- This hypothesis is accepted if the confidence interval for the estimate contains the value 0 in its range. Should this be, it can be concluded that fixed bias is not present.
- Conversely, if the hypothesis is rejected, then it is concluded that the intercept is non zero, and that fixed bias is present.

Deming Regression

- Testing for proportional bias is a very similar procedure. The 95% confidence interval for the slope estimate can be used to test the hypothesis that the slope is equal to 1.
- This hypothesis is accepted if the confidence interval for the estimate contains the value 1 in its range.
- If the hypothesis is rejected, then it is concluded that the slope is significant different from 1 and that a proportional bias exists.

Deming Regression

- Deming's Regression suffers from some crucial drawback. Firstly it is computationally complex, and it requires specific software packages to perform calculations.
- Secondly it is uninformative about the comparative precision of two methods of measurement. Most importantly
- Carol andl Rupert [11] states that Deming's regression is acceptable only when the precision ratio (λ, in their paper as η) is correctly specified ,but in practice this is often not the case, with the λ being underestimated.