

Testing polynomial covariate effects in linear and generalized linear mixed models

Mingyan Huang, *North Carolina State University*
Daowen Zhang, *North Carolina State University*

Abstract

An important feature of linear mixed models and generalized linear mixed models is that the conditional mean of the response given the random effects, after transformed by a link function, is linearly related to the fixed covariate effects and random effects. Therefore, it is of practical importance to test the adequacy of this assumption, particularly the assumption of linear covariate effects. In this paper, we review procedures that can be used for testing polynomial covariate effects in these popular models. Specifically, four types of hypothesis testing approaches are reviewed, i.e. R tests, likelihood ratio tests, score tests and residual-based tests. Derivation and performance of each testing procedure will be discussed, including a small simulation study for comparing the likelihood ratio tests with the score tests.



Full Text: [PDF](#)

Huang, Mingyan, Zhang, Daowen, Testing polynomial covariate effects in linear and generalized linear mixed models, *Statistics Surveys*, , (), 154-169 (electronic). DOI: 10.1214/08-SS036.

References

- [1] Azzalini, A. and Bowman, A. (1993). On the use of nonparametric regression for checking linear relationships. *Journal of Royal Statistical Society - B* 55, 549–557. [MR1224417](#)
- [2] Breslow, N. E. and Clayton, D. G. (1993). Approximate inference in generalized linear mixed models. *Journal of the American Statistical Association* 88, 9–25.
- [3] Brumback, B., Ruppert, D. and Wand, M. P. (1999). Comment on variable selection and function estimation in additive nonparametric regression using data-based prior' by Shively, Kohn and Wood. *Journal of the American Statistical Association* 94, 794–797.
- [4] Cantoni, E. and Hastie, T. (2002). Degrees-of-freedom tests for smoothing splines. *Biometrika* 89, 251–263. [MR1913957](#)
- [5] Claeskens, G., Ding, H. and Jansen, M. (2007). Lack-of-fit tests in semiparametric mixed models. Available on web at www.econ.kuleuven.be/fetew/pdf_publicaties/KBI_0709.pdf
- [6] Cox, D., Koh, E., Wahba, G. and Yandell, B. (1988). Testing the (parametric) null model hypothesis in (semiparametric) partial and generalized spline models. *Annals of Statistics* 16, 903–923. [MR0924859](#)
- [7] Crainiceanu, C. M. and Ruppert, D. (2004). Likelihood ratio tests in linear mixed models with one variance component. *Journal of Royal Statistical Society - B* 66, 165–185. [MR2035765](#)
- [8] Crainiceanu, C. M. and Ruppert, D. (2005). Exact likelihood ratio tests for penalized splines. *Biometrika* 92, 91–103. [MR2158612](#)

- [9] Crainiceanu, C. M., Ruppert, D. and Vogelsang, T. J. (2003). Some properties of likelihood ratio tests in linear mixed models (unpublished).
- [10] Dean, C. (1992). Testing for overdispersion in Poisson and binomial regression models. *Journal of the American Statistical Association* 87, 451–457.
- [11] Fan, J. Q. and Huang, L. S. (2001). Goodness-of-fit tests for parametric regression models. *Journal of the American Statistical Association* 96, 640–652. [MR1946431](#)
- [12] Gu, C. (1992). Penalized likelihood regression: a Bayesian analysis. *Statistica Sinica* 2, 255–264. [MR1152308](#)
- [13] Hardle, W., Mammen, E. and Muller M. (1998). Testing parametric versus semiparametric modeling in generalized linear models. *Journal of the American Statistical Association* 93, 1461–1474. [MR1666641](#)
- [14] Harville, D. A. (1976). Extension of the Gauss-Markov theorem to include the estimation of random effects. *Annals of Statistics* 4, 384–395. [MR0398007](#)
- [15] Hastie, T. and Tishirani, R. (1990). *Generalized additive models*. Chapman & Hall, New York. [MR1082147](#)
- [16] Laird, N. M. and Ware, J. H. (1982). Random effects models for longitudinal data. *Biometrics* 38, 963–974.
- [17] Liang, H. (2006). Checking linearity of non-parametric component in partially linear models with an application in systemic inflammatory response syndrome study. *Statistical Methods in Medical Research* 15, 273–284. [MR2227449](#)
- [18] Lin, D. Y., Wei, L. J., and Ying, Z. (2002). Model-checking techniques based on cumulative residuals. *Biometrics* 58, 1–12. [MR1891037](#)
- [19] Lin, X. (1997). Variance component testing in generalized linear models with random effects. *Biometrika* 84, 309–326. [MR1467049](#)
- [20] Liu, A., Meiring, W. and Wang, Y. (2004). Testing generalized linear models using smoothing spline methods. *Statistic Sinica* 15, 235–256. [MR2125730](#)
- [21] Lombardia, M. J. and Sperlich, S. (2007). Semiparametric inference in generalized mixed effects models. <http://ssrn.com/abstract=1010928>.
- [22] Pan, Z. and Lin, D. Y. (2005). Goodness-of-fit methods for generalized linear mixed models. *Biometrics* 61, 1000–1009. [MR2216193](#)
- [23] Self, S. G. and Liang, K. Y. (1987). Asymptotic properties of maximum likelihood estimates and likelihood ratio tests under non-standard conditions. *Journal of the American Statistical Association* 82, 605–610. [MR0898365](#)
- [24] Smith, P. J. and Heitjan, D. F. (1993). Testing and adjusting for departures from nominal dispersion in generalized linear models. *Applied. Statistics* 41, 31–41.
- [25] Stram, D. O. and Lee, J. W. (1994). Variance components testing in the longitudinal mixed effects model. *Biometrics* 50, 1171–1177.
- [26] Su, J. Q. and Wei, L. J. (1991). A lack-of-fit test for the mean function in a generalized linear model. *Journal of the American Statistical Association* 86, 420–426. [MR1137124](#)
- [27] Wahba, G. (1990). Spline models for observational data. CBMS-NSF regional conference series in applied mathematics, SIAM. [MR1045442](#)
- [28] Zeger, S. L. and Karim, M. R. (1991). Generalized linear models with random effects: A Gibbs sampling approach *Journal of the American Statistical Association* 86, 79–86. [MR1137101](#)

[29] Zhang, D. and Lin, X. (1998). Semiparametric stochastic mixed models for longitudinal data. *Journal of the American Statistical Association* 93, 710–719. [MR1631369](#)

[30] Zhang, D. and Lin, X. (2003). Hypothesis testing in semiparametric additive mixed models. *Biostatistics* 4, 57–74.

[31] Zhang, D. (2004). Generalized linear mixed models with varying coefficients for longitudinal data. *Biometrics* 60, 8–15. [MR2043613](#)

[Home](#) | [Articles](#) | [Past volumes](#) | [About](#) | [Login](#) | [Notify](#) | [Contact](#) | [Search](#)

Statistics Surveys. ISSN: 1935-7516