Model assessment plots for multilevel logistic regression

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Abstract

This paper extends the Bayes marginal model plot (BMMP) model assessment technique from a traditional logistic regression setting to a multilevel application in the area of criminal justice. Convicted felons in the United States receive either a prison sentence or a less severe jail or non-custodial sentence. Researchers have identified many determinants of sentencing variation across the country, some individual such as type of crime and race, and some based on geographical units such as county crime rate. Multilevel rather than conventional regression should be used to quantify any interplay between such individual- and county-level effects since the covariates have a hierarchical structure. Questions arise, however, as to whether a multilevel model provides an adequate fit to the data, and whether the computational burden of a multilevel model over a conventional model is justified. Residual plots, traditionally used to assess regression models, are difficult to interpret with a binary response variable and multilevel covariates, as in this case. BMMPs, an alternative graphical technique, can be used to visualize goodness of fit in such settings. The plots clearly demonstrate the need to use multilevel modeling when analyzing data such as these.
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Keywords: Bayesian methodology; Criminal justice; Diagnostic; Graphical method; Hierarchical model; Random effect

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1. Introduction

In 2001, the United States imprisoned its citizens at a rate of 470 per 100,000, 6–12 times higher than in other western countries. Furthermore, there is large variation in imprisonment levels within the US. For example, in 2001, Louisiana's rate per 100,000 residents was 800, while Maine's was 127 (Harrison and Beck, 2002, p. 4). Studies of differences in prison use among the states have found various factors to play a key role, including: higher levels of crime (McGarrell, 1993), in particular violent crime (Greenberg and West, 2001); percent of the population that is African American (McGarrell, 1993); political conservatism (Steffensmeier et al., 1993; Greenberg and West, 2001); and geographic region—Southern states appear to punish more severely (Michalowski and Pearson, 1990). There is also some empirical evidence of a relationship between state sentencing schemes and levels of incarceration, since such schemes often dictate which types of offense warrant prison time (Wooldredge, 1996). Other studies examining aggregate punishment variation using a county as the unit of analysis have found unemployment in urban counties and violent crime (McCarthy, 1990), and percent of the population that is African American and Southern region (Weidner and Frase, 2001) to be significantly related to prison use.

By contrast, most sentencing studies focus on individuals, whereby effects of case characteristics, criminal history, and demographics are determined. However, effects of individual-level variables may vary according to the cultural, political, economic, and social contexts in which courts operate (Dixon, 1995). Studies of pooled statewide data have found several contextual variables to have an effect on sentencing, such as level of unemployment and crime rate (Myers and Talarico, 1987) and racial composition (Steffensmeier et al., 1993). However, these studies use conventional logistic regression which does not correctly account for individual-level effects that vary according to a jurisdiction's cultural context and organizational constraints (Britt, 2000; Mears, 1998). To properly account for the hierarchical nature of individual-level covariates and county-level contextual covariates, multilevel modeling is more appropriate.

There has been some previous use of multilevel modeling in criminal justice research. For example, Rountree et al. (1994) use a multilevel model for intra-city neighborhood differences in victimization risk, while Wooldredge et al. (2001) compare multilevel and conventional models for the impact of prison and inmate characteristics on misconduct. Britt (2000) investigates whether social context and racial disparities affected punishment decisions in Pennsylvania counties for 1991–1994. Controlling for urbanization, racial threat, economic threat, and crime control, punishment severity varies by race across jurisdictions, but measures of social context explain little of this variation.

Pardoe et al. (2003) analyze data from the Bureau of Justice Statistics' State Court Processing Statistics (SCPS) program, a biennial collection of data on felony defendants in state courts in 39 of the 75 most populous US counties. That study uses the multilevel logistic regression model described in Section 3. Given the lack of consensus regarding determinants of variation in prison use, it is important to assess the fit of this model before it is used to inform policy. Furthermore, from a practical viewpoint, it is useful to gauge the relative worth of going beyond a conventional (non-multilevel)