LAB NOTES

Vol. IV, No. 2 (Winter 2005)

The Official Quarterly Newsletter of the Political Research Laboratory

In This Issue

Director's Corner

by Herb Weisberg

The New Year is always a time of reflection and anticipation. The past year has been one of accomplishment in the Lab, and the outlook for this coming year is even more positive.

The largest challenge of this past quarter was the university-scheduled IP changeover in the middle of Fall quarter. Kudos are due our professional technical staff of James Norman, Bill Miller and David Sweasey for their handling of this mandated change and the attendant (and unpredictable) problems it caused. These three went the extra mile, fixing IP-related problems not only in Derby, but also in locations outside the strict scope of their responsibilities, including the political science faculty in their offices at Mershon.

The largest accomplishment of this past half-year was setting up Room 0125 in the lower level of Derby as our new computer classroom. It holds 40% more student workstations than the old 0150 classroom. At the same time, it is much less crowded, making it a more comfortable teaching and learning environment. The new room also offers increased quality with an upgrade to flat-screen LCD monitors and much faster Dell computers. We also have a new lab monitor for this space, Mallory Smith, who joins Stephen Sayre and Nick Pattison in the role; with her addition, the new classroom will be open to students significantly more often than the old classroom.

A recent class in Room 0125

Our best-kept secret is the department's new IntraNet, along with its new interactive calendar. If you haven't checked them out yet, do so soon. Many useful department forms and listings are on the IntraNet, while the calendar can be used to schedule speakers so that they don't conflict with other department events.

Additionally, work has continued apace on the PRISM side, with David Darmofal and Cory Smidt offering a number of well-attended methods talks. They also were frequently busy with methods questions from both faculty and students. As described later in this issue of

LabNotes, they are offering workshops on Stata and R in the next few months.

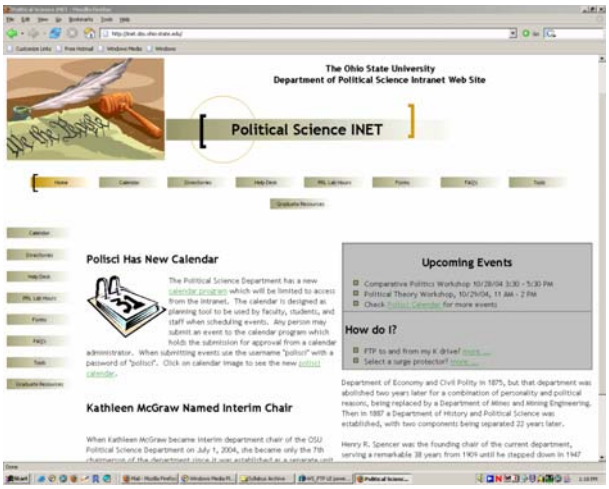
Meanwhile, our department graduate students (Jeff Martinson, Zach Mears, and Jim DeLaet) have done wonderful work in PRL in keeping us going day-to-day.

In terms of equipment and lab resources, things keep getting better. We have been able to upgrade the remaining PAL computers to the latest standard. As before, we will continue to distribute and redistribute newer and better computers to faculty and students as resources allow. At this point in the process, that should soon mean upgraded computers for grad offices. Meanwhile, a much-appreciated new printer has been installed in PAL; among its qualities it prints several times faster than the one it replaces -- please remember to treat it gently so that it survives.

As to 2005, we look forward to a major remake of the department web page, new A/V equipment for 0125 Derby, and hopefully redoing 0150 as a computerized honors college classroom. Lastly and as always, I invite you to share your feedback with the PRL regarding its work and how it can assist you more in your own work.

Projects, Plans, and Services

Political Science Department Intranet



Some faculty, staff and students are already aware of the Political Science Department's Intranet Website (the "I-net"). If you're not one of them, you should get to know it now!

Recently, even more functionality has been added to this resource through a number of improvements. This section highlights some of these improvements, as well as the longstanding benefits of the I-net.

The I-net is accessible from department-networked computers at http://inet.sbs.ohio-state.edu/. (This location is also hot linked from the Department's homepage.) At this time, one cannot access the I-net from computers outside of Derby, although we are exploring this option.

Once at the I-net, visitors can choose from links to an events calendar, directories, the help desk, PRL lab hours, departmental forms, frequently asked questions, computing tools and graduate student resources.

The Department's new calendar program is designed as planning tool to be used by faculty, students, and staff when scheduling events. Any person may submit an event to the calendar program which holds the submission for approval from a calendar administrator. When submitting events use the username "polisci" with a password of "polisci".

Several directories provide office location, phone number, email and job title information for faculty, staff and students.

This is an interactive computer assistance program that allows you to notify PRL of a problem and track the response to that problem.

Schedules for the PAL, room 0125 and individual staff members are available.

Many forms related to payroll, equipment loans, travel reimbursements and other needs are located here.

Need to email from outside Derby? Need to FTP to-and-from the K:drive? Find your answers in this section!

In the budding tools section you can find resources to assist with various computing needs.

Graduate students can find necessary forms such as the P.O.S., information on dissertation requirements, as well as previous general exam questions in this section.

Winter Quarter PRISM Events

All of us at PRISM hope everybody had an enjoyable break and also hope you will find some of the upcoming PRISM events of interest.

Methods Lunches: After our initial trial with methods lunches last quarter, this quarter we have more lunches planned and on different days of the week. We have three methods lunches this quarter: Thursday January 13 at 11:30 AM; Monday February 7 at noon; and Thursday March 10. The lunches serve as a good opportunity for graduate students and faculty to talk about all things related to methods as well as a way to simply get to know each other a little better. We usually meet in the east foyer of Derby and decide on a place to eat from there. All are welcome, as we hope to see you there!

Brownbag Series: PRISM plans on continuing to hold informational brownbag presentations on methods topics. These range from presentations on specific statistical techniques to presentations on statistical software or other computer programs often used in political research. This quarter we are holding a brownbag session with the PRL on LaTeX, the word document preparation system, details are presented below. LaTeX will be used in 686, so it is important that those enrolled in 686 in the Spring attend this workshop.

- ***Introduction to LaTeX***
  Thursday, February 17; 3:30 – 5:00 pm
  Derby 0125 (Basement Computer Lab)
  Presenters: Zach Mears and Corwin Smidt

LaTeX is a document preparation system for high-quality typesetting. It is most often used for medium-to-large technical or scientific documents, but is increasingly used within political science as authors find it much easier to use in editing and presenting mathematical equations and tables as well as other non-standard document elements. LaTeX is not a word processor program, but a language one uses to structure documents. LaTeX encourages authors to let experienced programs worry about the appearance of their documents and instead let the authors concentrate on providing the right content. The brownbag presentation hopes to cover the reasoning for why one should use LaTeX, introduction on getting oneself LaTeX capable, and the basics of the LaTeX language.

R Info: A Notice for Next Quarter Reflecting its increasing usage within political science, the

statistical program R is also gaining prominence as the program of choice for a number of methods classes. It appears R will be encouraged as the statistical program for next quarter's 686. In collaboration, PRISM will present *An Introduction to R* brownbag early in the quarter that will introduce individuals to the free version of the S-plus program. However, if there is anybody interested in learning about R now one should check out the following resources:

- To download R (it's free) go to: http://www.r-project.org/
- Additional program information and downloads can be found at the Comprehensive R Archive: http://cran.r-project.org/
- Imai, King, and Lau's Zelig program runs within R and is an incredibly useful combination of past Gary King programs like *Clarify* and *Amelia*. The manual also provides a helpful introduction to R, see: http://gking.harvard.edu/zelig/

Speaker Series: There is an impressive line-up of methods speakers coming to the department this quarter.

Renee Smith: PRISM, in collaboration with the Survey Research Center, will be bringing Renee Smith from Harris Interactive on Thursday, February 3 from 11:40 AM until 1:10 PM. Renee Smith is one of the chief methodologists at Harris interactive, an internet survey firm, and will be presenting a talk entitled: "The State of Internet-Based Market Research in 2005."

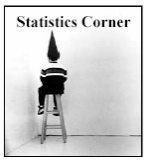
William Greene: PRISM is also very pleased to be bringing William Greene, Professor of Economics and Faculty Fellow of Entertainment, Media and Technology at the Stern School of Business at New York University on Thursday, March 17th. William Greene is well known throughout the social sciences for his textbook *Econometric Analysis* (5th edition, Prentice-Hall 2003) and his estimation software program LIMDEP. His research interests center on econometric methods and applications, particularly nonlinear optimization, panel data, discrete choice modeling and limited dependent variables, efficiency and productivity measurement, and the economics of the entertainment and sports businesses. He will be presenting a talk entitled: "Random Parameters Logit Modeling: Recent Developments and Contrasts with Bayesian estimation."

Office Hours: Faculty or graduate students having questions about methods, either in general or in specific applications, are encouraged to contact one of the PRISM methods fellows or visit them during office hours.

David Darmofal's (darmofal.3@osu.edu) office is 2049N and he has office hours Monday-Wednesday 11-2 and Friday 3-5 and

Corwin Smidt's (smidt.2@osu.edu) office is 2049Q and he has office hours Monday 12-3 and Tuesday/Thursday 12-4.

If you have any questions about any of these events, or if you have ideas for the future, please email Corwin Smidt or stop by his office to chat with him.



Modeling Multilevel Data in Political Science

by Corwin D. Smidt

Political science has shown increasing awareness and implementation of multilevel modeling frameworks for analyzing multilevel data. This is for good reason as in many ways political science data is multilevel and multilevel methods offer tremendous advantages in addressing the issues involved with such data. However, given its power it is

questionable how applicable these methods are in practice within political science. This article attempts to give an overview of what multilevel methods are and why one should care about them by first explaining what multilevel data are and why failing to account for their structure may lead to incorrect inferences. A brief introduction to multilevel modeling will follow as well as some comments on how often practical considerations, such as data limitations, may reduce its usage. This will be followed by a brief description of different estimation programs.

Multilevel data are empirical observations that have a distinguishable hierarchy to them. Almost all data have such a hierarchy and the additional information provides more context and more accurate statistical inferences. For example, if you have the same individual-level survey data across countries, like one often finds in the Eurobarometer, or the same individual surveyed across time, like one finds in panel data, then one can often categorize such data as multilevel. They contain observations that exist within other observational units. The base-level observations, such as individuals, are often called level-1 units and the higher-level observations, such as countries, are called level-2 units. One can also have data with more than two levels. For example, one can examine individuals (level-1 units) that exist within regions (level-2 units) that exist within countries (level-3 units). With these hierarchical data structures, multilevel models are essentially a method to estimate, test, and explain the nature of the level-1 relationship across different higher-level units.

Using the Eurobarometer example, suppose you are interested in examining whether factor x determines an individual's behavior y. A simple way to express the model is with the following expression:

$$1) \qquad y_{ij} = \beta_{0ij} + \beta_{1ij} x_{ij} + \varepsilon_{ij}$$

Here the subscripts i and j index the different levels on which the variable is observed. In this context i refers to the different level-1 units (individuals) existing within the different j level-2 units (countries). At this point model 1 estimates a unique slope parameter (β_{1ij}) and a unique constant (β_{0ij}) for each individual within every country. This model is unidentified, not to mention uninformative, as one suggests there are unique parameters for every individual and that these unique parameters determine one's behavior. Being social scientists, we often attempt to make generalizations about behavior as a whole so we estimate parameters to be constant across units. As a result we often estimate the following:

$$2) \qquad y_{ij} = \beta_0 + \beta_1 x_{ij} + \varepsilon_{ij}$$

The reasoning behind this understandable and defendable, but there are important implications for such a decision which should always be questioned or tested.

Model 2 now asserts each individual's outcome y has the same relationship with x within every country, where the only individual-level differences can be explained by an individual-level error term. This last assumption is often more stringent and potentially harmful within some multilevel data structures than in others. In pooling the model and estimating constant parameters the researcher treats each individual observation as independent. Such an assumption when pooling US individuals across states may not be costly, but in the Eurobarometer example we can reasonably expect there to be some unobserved heterogeneity among individuals. Specifically, we expect people to show greater similarity with individuals from their own country than with individuals from other countries. Often times these similarities within level-2 contexts produce positive error correlations among these individuals, causing estimated standard errors to be too low and false rejection of the null hypothesis (Goldstein 2003, 24). In other words, by failing to model the individual similarities within countries and the differences

across countries that we expect we end up with incorrect inferences.

Of course, there are many common and simple methods to account for these problems. One solution is adding a dummy variable for each country to control for unobserved similarities among these observations. This method essentially estimates a separate constant parameter for each country. A second way further relaxes the slope parameter assumption by estimating separate models for each country. Within both of these methods, statistical tests like a Chow test can be estimated as to whether parameter constraints across levels hold and pooling the data is possible. However, both of these methods have problems. One is that by estimating a specific parameter for each level-2 unit inferences within these models are conditional on the specific countries included within the model. If one were looking at only a sample of countries and trying to make conclusions across a population of countries, then one is constrained in making generalizations. The modeled country-level effects are often a result of factors we do not care about, but estimating these effects for each country in the sample inhibits one from making generalized inferences to the population of all level-1 units.

Along with the problems of generalization, one is constrained in modeling what creates the differences in behavior across level-2 units. What if one wants to explain why these individuals in these countries behave differently? One can create interaction terms with country-level covariates in an attempt to explain what causes these differences, but these factors are often a linear combination of the dummy variable controls and both cannot be used. Thus in implementing interactions to control for parameter heterogeneity one often models the interaction terms as completely accounting for possible differences across level-2 units. As a result, typical attempts to account for the multilevel structure in one's data lead to problems in making generalized statements about behavior and accounting for differences across level-2 units.

Multilevel models are a more proper way to account and test for level-1 differences across level-2 units. Generally, multilevel models are any type of estimation using a level-2 random effect to specifically model clustering within hierarchical data. For example, instead of estimating model 2 one might estimate the following:

3) $$y_{ij} = \beta_{0j} + \beta_{1j} x_{ij} + \varepsilon_{ij}$$

Where:

$$\beta_{0j} = \gamma_{00} + \delta_{0j}, \text{ and}$$

$$\beta_{1j} = \gamma_{10} + \delta_{1j}$$

The model still includes a level-1 error term, but we also specify the two parameters as varying across level-2 units, as denoted by the subscript *j*. The two γ parameters retrieve the overall mean value of both β parameters. But the important distinction between models 2 and 3 is in how one models parameter differences across level-2 units. Instead of including a dummy variable for each level-2 unit in an attempt to treat parameter differences as fixed, one estimates differences across level-2 units as function of a random disturbance term which are expressed here as δ. Here one accounts for parameter differences across level-2 units in a general manner but still can retrieve an overall estimate of the modeled level-1 relationship.

By allowing parameters to vary freely across level-2 units one can also include level-2 predictors in an attempt to explain what accounts for parameter variation across level-2 units. For example, a country-level predictor such as a country's economic condition (z_j) might explain variation in individual-level survey responses. The constant parameter then might be modeled as follows:

$$\beta_{0j} = \gamma_{00} + \gamma_{01} z_j + \delta_{0j}$$

The following test is essentially an ANCOVA model with the addition of the level-2 random effects terms. One might also have theory suggesting differences across countries

influence what impact an individual-level variable has on an individual's response. This would be modeled by using level-2 predictors in the same way as above, except on the β_{1j} parameter. Importantly, the test of whether level-2 predictors influence level-1 behavior is much more appealing than in an interaction context, because one is testing whether the predictor systematically explains parameter variation while still allowing for a random error term.

There are some other common key additional assumptions in multilevel models that should briefly be mentioned (Raudenbush and Bryk 2002, 255). The level-2 error terms (δ_{0j}, δ_{0j}) are allowed to have different variances (τ_{00}, τ_{11}) with an estimated covariance (τ_{01}). Other assumptions which, as discussed below, may be violated are that the predictors at each level (x_{ij}, z_j) are uncorrelated with random effects at all other levels and that there is no relationship between the level-1 error and parameter error term: $Cov(\delta_{0j}, \varepsilon_{ij}) = Cov(\delta_{1j}, \varepsilon_{ij}) = 0$.

For a deeper understanding of multilevel methods one is referred to the suggested references at the end of this piece,[1] but one should understand from the above introduction that multilevel methods are an appealing and generalized method for modeling hierarchical data and testing and explaining heterogeneity across level-2 units. However there are a number of considerations when estimating such models. One is the number of level-2 units from which level-1 units are sampled. Multilevel models are solved through different types of maximum likelihood (ML) estimators. Similar to basic ML estimation, small sample sizes often lead to large biases in coefficient estimates. Unless one uses a Bayesian Markov Chain Monte Carlo (MCMC) estimator, one should look to estimate multilevel models only if the number of level-2 units is as high as one might require in a standard logit or probit. The number of level-2 observations also constrains the number of level-2 predictors one should include. As Raudenbush and Bryk point out (267), the regression rule-of-thumb of at least 10 observations per predictor is not as applicable in multilevel analysis with multiple parameters where random effects across parameters are allowed to be correlated. These considerations combined suggest multilevel analysis is most applicable in instances with a high number of level-2 units or a low number of estimated level-2 outcomes (random effects or slope predictors).

Furthermore, one may want to model differences as fixed as opposed to random. When one has a small number of level-2 units that do not represent a random sample, the fact that these estimates are conditional on the specific level-2 units in the model is of no concern because one is usually specifically interested within only these level-2 units. One still may want to use multilevel methods to explain these differences, but fixed effects controls are still proper. Similarly, often times the level-2 error term is correlated with a level-1 predictor and one violates a key model assumption. For instance, the district-specific constant used in the incumbency advantage literature to capture a district's normal vote is known to be correlated with the presence of an incumbent, the effect of which one is trying to measure. Therefore, even with a high number of level-2 units (435) fixed-effects estimators are used since they can be correlated with other explanatory variables. One should make sure any systematic correlation between level-1 predictors and level-2 units are controlled for before allowing a random effects term to be included.

A final consideration tied into the last two points is the question of how one goes about testing for significant level-2 differences. One should not expect all parameters to vary across level-2 units; in fact one often has greater theory to suggest they should not vary.

[1] Steenbergen and Jones (2002) give an especially good introduction as well as an application within political science.

However, one should be aware of the hierarchical nature of one's data and be able to account for any possible effects. Multilevel software programs commonly estimate the significance of each parameter's error variance that is allowed to vary, but Raudenbush and Bryk (267) strongly recommend against setting all parameters as varying across level-2 units and then fixing only those parameters that are insignificant. The state of estimation methods with correlations among random effects means incorrectly specified parameters create incorrect estimates of all level-2 variances. Steenbergen and Jones (2002) suggest first estimating a random parameters ANOVA to test whether variation among level-2 units explains the overall variance. If such a test indicates level-2 differences as significant one should give random parameter tests further examination. Raudenbush and Bryk suggest the same and also assert a randomized constant should always be modeled first before testing for other level-2 differences in parameters. A useful test is a simple likelihood-ratio test where one can estimate whether allowing level-2 variation leads to a significant decrease in the log-likelihood function.

A brief note should also be made about different software programs. There are many estimation methods currently prominent and easily available that estimate multilevel models. Two programs, HLM and MLWin are designed for the specific use of multilevel model estimation and use different ML algorithms. While there are debates over their comparative performance, both are known to have problems in underestimating parameter variance with small samples and especially for discrete choice models where both use a quasi-likelihood estimator (Rodriguez and Goldman 2001). A single-user version of HLM is available on the PRL's Stats machine. GLLAMM is an add-on program for Stata that is available to download for free at gllamm.org. Gllamm uses what is referred to as an adaptive version of Gauss-Hermite quadrature estimation. Gllamm is well suited to perform initial test like random effects ANOVAs and estimate discrete choice models, but becomes increasingly slower when one increases the number of random effects to be estimated. A final technique is to use simulation methods. Bayesian estimation has small-sample advantages, performs as well as the above programs, and is growing in popularity, as evidenced by its addition into MLWin. Non-Bayesian simulation is available in programs like Limdep, but there are limited models for estimation. There is yet no consensus on what software program is the best.

Political science questions often involve observations that are hierarchical. Multilevel methods are attractive approaches for dealing with the issues of such situations and quite often encapsulate some already known methods. The conditions for their practical applicability may be limited, as key assumptions, motivations, and large data sets are often needed; these points often are not made prominent enough. Nevertheless, possible limitations in their application's frequency should not overshadow the need for one to be aware of their importance and account for the structure within one's data.

Works Cited and Further Reading:

Goldstein, Harvey. 2003. *Multilevel Statistical Modeling*. 3rd Edition. London, UK: Arnold.

Raudenbush, Stephen W. and Anthony S. Bryk. 2002. *Hierarchical Linear Models*. Newbury Park, CA: Sage.

Rodriguez, German and Noreen Goldman. 2001. "An Assessment of Estimation Procedures for Multilevel Models with Binary Responses." *Journal of the Royal Statistical Society* 158: 73-89.

Skrondal, Anders and Sophia Rabe-Hesketh. 2004. *Generalized Latent Variable Modeling: Multilevel, Longitudinal, and Structural Equation Models*. New York: Chapman & Hall/CRC.

Steenbergen, Marco R. and Bradford S. Jones. 2002. "Modeling Multilevel Data Structures" *American Journal of Political Science* 46: 218-237.

PRL Staff Information

Title	Name	Office	Phone	Email
Director	Herb Weisberg	2049D	292-6572	weisberg.1@osu.edu
Associate Director	Jan Box-Steffensmeier	2049S	292-9642	jboxstef+@osu.edu
Assistant Director	Jeff Martinson	2049R	292-1061	martinson.3@osu.edu
Systems Manager	James Norman	2049K	688-3732	norman.67@osu.edu
Systems Manager	Bill Miller	2049E	292-1814	bmiller@polisci.sbs.ohio-state.edu
Systems Manager	David Sweasey	2049R	292-1061	sweasey.1@osu.edu
Graduate Assistant	Jim DeLaet	2049F	292-0511	delaet@polisci.sbs.ohio-state.edu
Graduate Assistant	Zach Mears	2049F	292-0511	mears@polisci.sbs.ohio-state.edu
Undergraduate Assistant	Yared Debebe	2049H	292-0511	debebe.1@osu.edu
Undergraduate Assistant	Matt Thompson	2049H	292-0511	thompson.1070@osu.edu
PRISM Senior Fellow	David Darmofal	2049Q	292-9661	darmofal@polisci.sbs.ohio-state.edu
PRISM Junior Fellow	Corwin Smidt	2049Q	292-9661	smidt@polisci.sbs.ohio-state.edu

At least one staff member is on-call between 8:30 AM and 6:00 PM, Monday through Friday.

To contact all Lab Staff simultaneously, email us at prl@polisci.sbs.ohio-state.edu

To contact the HELP DESK, go to http://inet.sbs.ohio-state.edu/ and click on "HELP DESK."

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