SOFTWARE

askSam. askSam Systems, P.O. Box 1428, Perry, FL 32347; telephone: 800-800-1997; 904-584-6590 (support); fax: 904-584-7481.

HyperREASEARCH. ResearchWare, Inc., P.O. Box 1258, Randolph, MA 02368-1258; telephone: 617-961-3909; e-mail: `paul@bcvms.bc.edu`.

NUD.IST. Qualitative Solutions and Research Party Ltd. [Developer], Box 171, La Trobe University Post Office, Melbourne, Victoria 3083, Australia; telephone: 61-3-459-1699; fax: 61-3-479-1441; e-mail: `NUDIST@qsr.com.au`. U.S. and Canada distributor: Scolari, Sage Publications Software, 2455 Teller Road, Thousand Oaks, CA 91310. Phone: 805-499-1325; fax: 805-499-0871; e-mail: `NUDIST@SAGEPUB.COM`.

Storyspace–s. Eastgate Systems, Watertown, MA.

The Ethnograph. Qualis Research Associates, P.O. Box 2070, Amherst, MA 01004; telephone: 413-256-8835; fax: 413-256-8472; e-mail: `qualis@mcimail.com`.

WordPerfect. Corel Corporation, 1600 Carling Ave., Ottawa, Ontario, Canada K1Z8R7; telephone: 800-772-6735; fax: 613-728-9176; Internet site: `http://www.corel.com/`.

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Beverly A. Smith is a doctoral candidate in the Department of Sociology at Boston College. She received her MBA degree in 1993 from Boston College.

Sharlene Hesse-Biber, Ph.D., is associate professor, graduate director, and assistant chair, Department of Sociology, Boston College, Chestnut Hill, Massachusetts. She is a codeveloper of HyperREASEARCH, *a computer-assisted software program for qualitative data analysis. She has coauthored several articles which describe the features of this program: "HyperResearch: A computer program analysis of qualitative data using the Macintosh: Hypermedia features" (Hesse-Biber, DuPuis, & Kinder, 1991) in* Qualitative Sociology, 14*; "Hypothesis testing" (Hesse-Biber & DuPuis, 1995) in* Computer-aided Qualitative Data Analysis: Theory, Methods and Practice*, edited by Udo Kelle and published by Sage (London).* HyperRESEARCH *is available for the Macintosh and IBM/Windows environment. Hesse-Biber is currently conducting research on the impact of computer-assisted instruction in the classroom.*

REPORTS AND COMMUNICATION

A Preview of *EI* and *EzI*

Programs for Ecological Inference

KENNETH BENOIT
GARY KING
Harvard University

Ecological inference, as traditionally defined, is the process of using aggregate (i.e., "ecological") data to infer discrete individual-level relationships of interest when individual-level data are not available. Existing methods of ecological inference generate very inaccurate conclusions about the empirical world—which thus gives rise to the ecological inference *problem*. Most scholars who analyze aggregate data routinely encounter some form of this problem.

EI (by Gary King) and *EzI* (by Kenneth Benoit and Gary King) are freely available software that implement the statistical and graphical methods detailed in Gary King's forthcoming book *A Solution to the Ecological Inference Problem* (King, in press). These methods make it possible to infer the attributes of individual behavior from aggregate data. *EI* works within the statistics program *Gauss* and will run on any computer hardware and operating system that runs *Gauss* (the *Gauss* module, *CML*, or constrained maximum likelihood—by Ronald J. Schoenberg—is also required). *EzI* is a menu-oriented stand-alone version of the program that runs under MS-DOS (and soon *Windows 95*, *OS/2*, and *HP-UNIX*). *EI* allows users to make ecological inferences as part of the powerful and open *Gauss* statistical environment. In contrast, *EzI* requires no additional software, and provides an attractive menu-based user interface for non-*Gauss* users, although it lacks the flexibility afforded by the *Gauss* version. Both programs presume that the user has read or is familiar with *A Solution to the Ecological Inference Problem.*

THE PROBLEM OF ECOLOGICAL INFERENCE

The best prior methods of ecological usually lead to very inaccurate conclusions about the empirical world; indeed, frequently, they give impossible answers, such as 20% of Israeli Labor Party voters remaining loyal between the last two elections. Ecological inferences are required in political science research when individual-level surveys are unavailable (e.g., local or comparative electoral politics), unreliable (racial politics), insufficient (political geography), or infeasible (political history). They are also required in numerous areas of public policy (e.g., for applying the Voting Rights Act) and other academic disciplines ranging from epidemiology and marketing to sociology and quantitative history. The ecological inference problem has been among the longest standing, most actively pursued,

Social Science Computer Review, Vol. 14 No. 4, Winter 1996 433-438

public records, we know that the true value of this cell is 64%. The estimate from the method reported in the book, based only on aggregate data, is only a fraction of a percentage point under this mark. In this example, like numerous others reported in the book, the method gives accurate statewide estimates, which has been the goal of past research.

But the solution to the ecological inference problem provides much more interesting information than accurate statewide estimates. It also provides, in these data for example, accurate estimates of the fraction of Blacks who vote (and fraction of Whites who vote) for each of Louisiana's 3,262 electoral precincts. For example, Figure 1 compares *estimates* from aggregate data of the percent of Blacks who vote to the true percent of Blacks who vote in all Louisiana precincts (with each precinct represented by a circle sized proportional to its black population). The center of almost all of the circles falls on or near the diagonal line, indicating that the estimated percent of Blacks voting is very close to the true individual-level percentage. This figure is not merely a plot of the observed values of a variable by the fitted values of the same variable used during the estimation procedure; it is a much harder test because the true fractions of Blacks voting (the vertical dimension in the figure) were not used during the estimation procedure.

USING THE SOFTWARE

Installation of the software is straightforward. Installing *EI*, which requires that the user already have *Gauss* installed, involves copying the library and source code files for *EI* into the appropriate subdirectories of the *Gauss* program directory tree. The *EI* library is then accessed using the *Gauss* command `library ei`. The whole process involves only four copy commands. Getting the *EzI* standalone program working is also trivial. Simply extract the *ezi.zip* file to the directory where you want it installed and it runs immediately.

A postscript file containing a detailed reference manual is available with both programs. For users who lack access to a postscript printer, a copy of the manual is also available on-line at Gary King's Web site (`http://GKing.Harvard.Edu`). A short supplement describing the differences between *EI* and *EzI* is also included with the latter. Anyone with access to *Gauss* and little experience in this statistical programming environment will prefer to use *EI*, because the *EI* offers all of the advantages of remaining within the open *Gauss* environment while still being very easy to use. For example, the output quantities from an *EI* model can easily be fed to other models available in *Gauss*, something which the stand-alone version cannot offer. If you prefer not to use *Gauss*, however, you can still use *EI*. *EzI* is easier to use than its direct-*Gauss* counterpart, although it offers less flexibility. It has an attractive color menu system and provides context-based help messages that summarize the material included in the *EI* manual. *EzI* is written in *Gauss* and uses the *EI* library directly, so there are no differences in their statistical procedures. All of the procedures available in *EI* are implemented in *EzI*.

One of the best features of the *EI* library is the ease with which it makes it possible to distribute the information necessary to replicate your empirical results. All data are stored in a single "data buffer"—*Gauss* data construct that permits data of different types to be stored along with identifying labels in a single file. *EI* data buffers contain not only all of the input data, but the values of all of the globals set by the user before estimating the ecological inference model, as well as the quantities resulting from the estimation. The data buffer acts as a large container for all of the inputs and outputs of the model run. Subsequent user requests for resulting quantities or for graphs are simply read quickly from the data buffer, eliminating the need for any significant recalculation once the model has already been public records, we know that the true value of this cell is 64%. The estimate from the method reported in the book, based only on aggregate data, is only a fraction of a percentage point under this mark. In this example, like numerous others reported in the book, the method gives accurate statewide estimates, which has been the goal of past research.

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It is a relatively simple matter to read in data for use in *EI* and *EzI*. Both programs easily import an ASCII data set that is delimited by tabs, spaces, or commas. *EzI* also lets users include a separate variable definition (**.var*) file that includes variable names and even variable specifications—such as which variables will correspond to which standard elements for the model—that is loaded automatically upon import of the ASCII file. Data may also be loaded from a data buffer (created from a previous model estimation) for use in a new model.

Estimating the ecological inference model requires only a single command. Once data have been loaded from either an ASCII or a data buffer file, the model is run simply by specifying which variables will constitute the five input items, which the *EzI* model requires. The length of time that the model requires to estimate varies in proportion to computer speed, model complexity, and data set size. In our development of the software, this varied in practice from several minutes to nearly an hour for very large data sets. For a typical problem of about 300 observations, the estimation procedure takes about 5 minutes on an HP 715/80 workstation. All subsequently computed graphics and numerical results are then instantaneously available.

EI and *EzI* include a large number of predefined graphs and summary statistics. Built into both programs are more than 50 detailed graphs for visualizing the results, and nearly 100 numerical items that may be read from the data buffer after estimating the model. In many cases, the user will want to perform subsequent statistical estimations on these quantities. In *EI*, this is done directly using standard *Gauss* techniques; in *EzI*, the user can collect quantities from the model into an export data set that is written in a form that can easily be reloaded as an ASCII data set. *EzI* even created the corresponding variable name definition file for this purpose.

We present a short example here showing how easy *EI* is to use. From *Gauss*, only a few lines of commands are required to initialize the library, load in a data set, run the model, and view the results.

```
library ei,cml,pgraph;        @ initialize EI @
loadvars sample.asc t x n;    @ load variables t, x, and n into memory @
dbuf = ei(t,x,n,1,1);         @ run main procedure, save results in dbuf @
eigraph(dbuf,"tomog");        @ draw tomography graph, with data in dbuf @
v = eiread(dbuf,"betab");     @ extract precinct-level estimates from dbuf @
```

In *EI*, these steps involve selecting analogous menu items. The user first selects a menu item to load in an ASCII data set. If a `sample.var` is present specifying the variable names and their assignment as the required elements of *t*, *x*, and *n*, then the next step can be choosing to run the model. Otherwise the user can specify or respecify the model and variable names from a model editing screen. Once the model is finished, *EzI* graphs and quantities are available from their corresponding pull-down menus.

In practice, the user will want to view some descriptive statistics on the data set before running the model, and possibly change some *EI* globals. In *EI*, these involve simple one-line commands, whereas in *EzI* these actions are available as menu choices.

HARDWARE AND SOFTWARE REQUIREMENTS

EI will run on any computer system that already runs *Gauss*. *EzI* is currently available for only MS-DOS, although 32-bit *Windows* and *HP-UNIX* versions are planned. The MS-DOS binaries run well in DOS sessions of *OS/2* and *Windows 95*, however. *EzI* requires 8 megabytes of free memory and about 2 megabytes of disk space.

OBTAINING THE SOFTWARE

Before attempting to use *EI* or *EzI*, we recommend that the user read *A Solution to the Ecological Inference Problem*. Until its publication, a postscript version of the manuscript is available for download from Gary King's home page (`http://GKing.Harvard.Edu`). The software is available from the same source. The *Gauss* statistical programming language and the *CML* module are available for *DOS/Windows*, *Windows 95*, *UNIX*, and other operating systems from Aptech Systems, Inc., 23804 S.E. Kent-Kangley Road, Maple Valley, WA 98038; phone: 206-432-7855; fax: 206-432-7832; e-mail: `sales@aptech.com`.

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