STATISTICAL RESEARCH PROBLEMS IN GOVERNMENT

Fritz Scheuren, Internal Revenue Service*

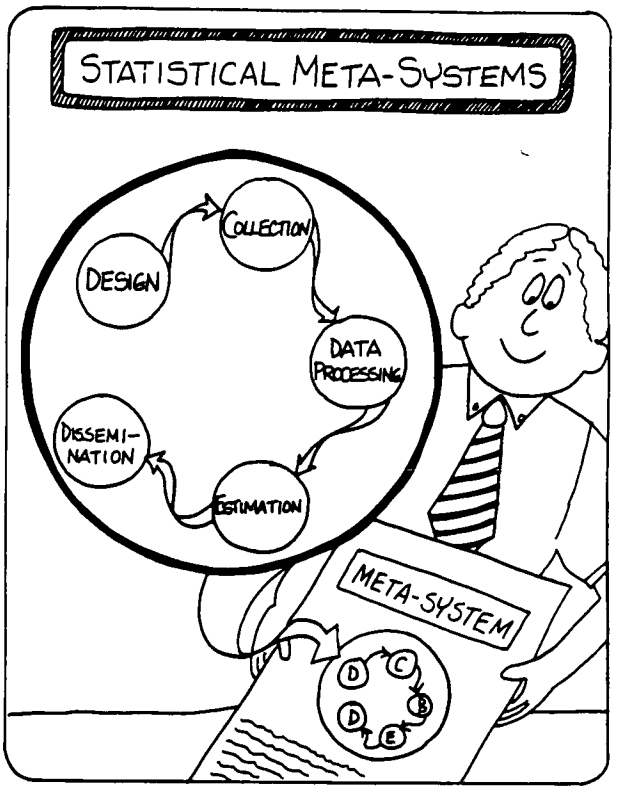
Ivan Fellegi two years ago at these meetings, when discussing statistical research problems in government, presented a general mathematical measurement model. He then went on to describe several interesting issues at the design, collection, data processing, estimation and dissemination stages of the work at Statistics Canada (Fellegi 1987).

In my brief remarks today, I'm going to follow the pattern set by Ivan, except that the general model I would like to begin with is not mathematical, but managerial [1]. Naturally, too, I'll be speaking about U. S. Federal government statistical operations, primarily those at my agency, the Internal Revenue Service. While today's session has a focus that is mainly mathematical, I think you will find that the managerial issues I'm going to mention link right in.

Statistical Meta-Systems

In any event, a manager's view of the government statistical business might conceptualize on core activities (e.g., study design) as systems or subsystems. Graphically, we could reformulate Ivan's list (to oversimplify) as an interlocking set of steps (see Figure A). In point of fact, of course, the connections are not only sequential ones, but, if all the feedbacks were shown, the graph would look like a plate of spaghetti with lots of meatballs and no sauce.

Figure A.--Initial Core Statistical Systems



Supporting this core are what might be called "meta-systems," within which all five of these systems reside. (Maybe these meta-systems are the sauce?)

Some examples might help here and I'll mention four. These will allow me to stress certain general themes that I think bear on how government and academic statisticians can cooperate.

Vision.--First, there is an agency mission or vision within which all else is valued (e.g., "All the news that's fit to print." "Progress is our most important product.") At IRS, at least in terms of nonsampling error issues, it's best summed up by paraphrasing the old saying, "There are only two things certain in life: death and tax avoidance."

Joking aside, there are some important "foundation" issues that are worth noting, because an agency's mission can affect the focus and direction of its statistical programs (e.g., Norwood, 1989). THe mission of some statistical agencies like the Census Bureau is essentially a data-gathering one. Other statistical organizations such as the SOI Division at IRS are also bound by the administrative goals of their agencies.

As Deming and others have pointed out, historically the mainline government statistical agencies have had a much stronger "enumerative" or descriptive focus than an "analytic" or cause-seeking one (Deming 1954). This needs to change if we are to successfully move toward a more integrated structure of national data gathering and information usage. In my opinion, whether or not the mission of government statisticians is to establish causal relationships, the data collection they do must have this as one of its goals.

Tradition.--Second, around an agency mission a tradition develops -- a corporate culture (Deal and Kennedy 1982). Recently at IRS, we have begun changing our cultural tradition under the strong influences of Deming and Juran (Deming 1986; Juran 1964 and 1988).

The Statistics of Income Program at IRS, which I currently head, is 75 years old and has always conceived of itself as producing quality statistical products. Even so, the focus on process quality that Deming and Juran urge, while not really new, is having a revolutionary impact, especially in its emphasis on continuous improvement or KAIZEN (as the Japanese call it).

There are many good statistical problems which have arisen from this effort and I could spend my whole time today on these (Scheuren 1988). Instead, let me just mention one way academic and government statisticians can cooperate in this arena. I'll do this by pointing out opportunities that, so far, have mainly been missed.

Let me start with some background. In the quality literature, there is a concept called "benchmarking" [2]. The Japanese word is DANTOTSU, which means striving to be the "best of the best." Now, currently in the United States, we have a government-wide Federal Committee on Statistical Methodology, which is a highly useful way for the various U.S. statistical agencies to get together and compare methods. Many reports have been generated over the years that, in one way or another, could be related to this concept of benchmarking (although, frankly, the people involved, including myself, would not have used this word at the time). A common problem shared by most of these reports is that the strivers for the "best of the best" have not included enough academic statisticans -- a real missed opportunity.

Vehicles like the U.S. National Academy of Sciences' Committee on National Statistics have helped bring academics in, but, generally speaking, even then there has not been enough attention by the academic community to the real nuts and bolts of our business, nor has the government statistical community really accepted the degree of striving that it needs to make [3].

Tools.--Third, how the work is done depends greatly on the computer environment that exists and the known body of statistical thinking that an agency has assimilated into its ongoing systems. This assimilation step can be all too slow. (In fact, I'm almost certain to find today, from some of you, that specific problems I mention have already been "solved" here in Canada or, at least, that a fruitful line of attack is being pursued.)

In this context, it's useful to make the distinction between a theoretical result and its implementation (i.e., between good theory and good technology). It almost goes without saying that making a good idea in theory become a good idea in practice can sometimes be an incredibly arduous task. Annoying special cases have a tendency of cropping up. Since complex systems have to be able to operate in failure mode, each of these special cases may need to be dealt with in the application. I won't say much more on this, now, except to point to the general need for Computer Assisted Design/Computer Assisted Manufacturing (CAD/CAM) type statistical tools to be used more widely in government. To the extent that toolmaking is the province of academics, there is a wide open opportunity for collaborative work.

People.--Fourth, perhaps the most fundamental meta-system, at least day-to-day, is the people who do the work in a statistical agency. How well motivated is the workforce? How well-trained? How long do you expect them to stay? How much are you willing to do to keep them up-to-date? Obviously, too, some of these same types of questions might apply to an agency's customers, too. In my opinion, the need for expert systems at nearly every stage of an agency's work grows out of, at least, our answers to these questions. We have high turnover rates, in part, due to the low pay we offer and, alas, the tediousness still associated with certain tasks [4].

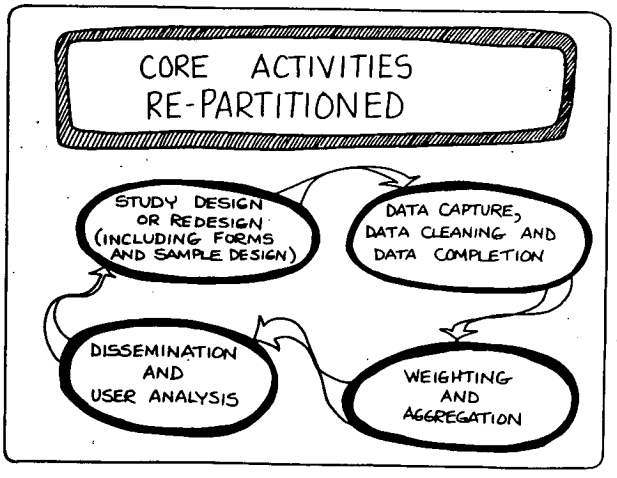
The role of academics here begins with their traditional function of providing well-trained people for the labor pool. The need for a joint government-academic program of continuing professional education is apparent, too -- more and more so. Big gaps exist in "Quantitative Literacy" among the citizenry in general, at least in the United States, and attacking this problem, possibly jointly, is clearly very important (e.g., as has been attempted by the Quantitative Literacy Series 1987).

I could, naturally, go on (and on?) with a discussion of still other general management meta-systems, notably those underlying the social contract which exists between a people and its government, and which leads to there being statistical information gathering by governments in the first place. Lots of changes can be expected here that "Statistics," at least as a profession, will have to cope with; however, it's time to look directly at examples from our core business -- those "meatballs on the plate of spaghetti" that I talked about earlier.

Core Systems

Let's look at what those core systems are, again (see Figure B). Please note that I am employing a different partitioning than Ivan used of the core statistical systems that make up our business (e.g., Scheuren 1986). The computer is so ubiquitious for us that I have

Figure B.--Core Statistical Systems Revisited



already treated it as a meta-system, rather than have something called Data Processing [5]. Also, because I want to emphasize the connectivity of our statistical systems to our customers and suppliers, I have taken the liberty of expanding on Ivan's remaining groupings -- adding user analysis, for example, in addition to weighting and aggregation. I see weighting and aggregation as being nearly pure producer functions, while user analysis is that part of the estimation that is either customer-done or, at least, very closely customer-driven.

The rest of my talk will focus on the research needs that exist within these core areas and how academics can help. I'll draw briefly on about a dozen or so examples from our own experiences at IRS. You may want to ask me to go into depth about these later, if I've intrigued you [6]. As we will see, the degree of cooperation or collaboration that is possible between academic and government statisticians varies greatly from one core activity to another, with possibly different academic disciplines or subdisciplines coming into prominence, as well.

Study Design.--What's new here, and very important, is the contribution that cognitive pyschologists have been making to the restructuring of survey instruments (e.g., Jabine et al. (Eds.) 1984; Fienberg and Tanur 1989). Tax forms, our survey instruments at IRS, have needed this look and now we are undertaking it. We expect, ultimately, that this systematic analysis of the data giver/data gatherer interaction will not only improve the questions that get asked on tax forms, but the questions that our customers ask of us. Significant quality improvements and cost savings are anticipated, as well.

Sample design problems continue to offer new challenges to survey statisticians (e.g., Mulrow and Jones 1989); this is especially true in studies which have multiple competing objectives. For example, how can you simultaneously have good cross-section estimates, good aggregate time series data and good longitudinal microdata for policy simulation "experiments" (e.g., Czajka and Walker 1989; Hinkins, Jones and Scheuren 1988; Hinkins and Scheuren 1989). Clever partial solutions exist; for example, for over a decade we have been using an idea of Morris Hansen's, whereby we convert taxpayer identifiers into pseudo-random numbers (WESTAT 1974; Harte 1986). Alan Sunter also wrote a fine paper recommending this approach (Sunter 1986) and I believe an improved version of what we are doing may be tried soon at Statistics Canada [7].

At least in my experience, the problems here are quite hard and it would be a real contribution for academics to try to bring together what is now known. A paper like that by Duncan and Kalton (1987) is what I have in mind. In particular, what are the options and tradeoffs for stratified designs of highly skewed populations with lots of movement from strata to strata over time? (Incidentally, the recent paper by Holt and Skinner (1989) offers real promise here and definitely should help.)

Data Capture, Cleaning and Completion.--The statistical aspects of the capture, coding, cleaning and completion of data are often considered unpleasant "housekeeping" by many statisticians, even some inside government. A lot of very good work, however, has been done, particularly here in Canada, on these problems. The paper by Fellegi and Holt (1976) is one historical example. The December 1988 issue of Survey Methodology contains others. The need for expert systems at the data cleaning and completion stages is certainly an aspect, therefore, that many of you may be able to relate to. The growing use of Computer Assisted Telephone Interviewing (CATI) and Computer Assisted Personal Interviewing (CAPI) (or, in our context, electronic filing) should open up still other avenues for expert systems. These might be especially fruitful since they can be linked to the cognitive research I mentioned earlier.

There is a lot of conventional mathematical statistical work needed here, too. For example, the pioneering efforts by Rod Little and Don Rubin, partly sponsored by IRS, offer a prototype, I hope, for others (e.g., Little and Rubin 1987; Rubin 1987). Multiple imputation, obviously is a very useful device for many problems, especially if the missingness can be constructed to be ignorable (as is the case in matrix sampling, e.g., Hinkins and Scheuren 1986).

I, personally, have been intrigued for over 20 years by "Hot Deck" techniques which, in their name, if not in their execution, retain to this day a basic ad hoc flavor (e.g., Oh and Scheuren 1980). These and other methods, begun with almost no theory, may be profitably studied by academics (e.g., David et al. 1986). It should go without saying that new theory can sometimes grow out of good practice, just like improved practice can grow out of improved theory.

One final point: I think, so far, that the statistical literature has missed the boat to some extent on the full implications of the multivariate problem of missing data. In a large omnibus survey or other data collection effort, there are many statistics for which the missingness is ignorable; there may well be others for which it is not (Scheuren 1989a). The models needed must encompass both types of missingness. Efforts by Fay, Little and others are to be commended, here, but there is certainly room for a lot more work (e.g., Fay 1986 and 1989; Little 1989).

Weighting and Aggregation.--This stage of the work in a typical study may have wider appeal. Some "housekeeping" activities may remain, like how to reweight for, say, unit nonresponse (if this has not already been dealt with by multiple imputation). Little has a nice paper on the very important issues, here, in the Journal of Business and Economic Statistics (Little 1988).

The application of propensity scores that he talks about has particular appeal (Rosenbaum and Rubin 1983) over more conventional methods (e.g., Oh and Scheuren 1983). Limitations exist, however, as our experience at IRS suggests (Czajka et al. 1987). The notion that there is one all-purpose approach to the problem of multivariate missingness (as data producers might like) probably is mistaken (e.g., Woodburn and Heeringa 1989). Perhaps we need to go back towards a user-driven analysis-by-analysis approach to missingness. Whatever we do, though, our data collection efforts need to be better structured by the uncertainties in this area (Horvitz et al. 1989); one way academics could help here is to develop a richer class of measurement error models, including a lot more on consumer (user) concerns rather than, as we have historically, primarily looking at producer variables (e.g., Anderson et al. 1979). The weight attenuation issue, while perhaps minor in the overall scheme of things, is another place where more collaborative work could help greatly (e.g., Little 1986; Oh and Scheuren 1987a; Potter 1988).

Tabulations of various sorts have been the prime outputs of old-line government statistical organizations like the Division I head. Efforts to "jazz up" these often dull products may seem too humble a calling for most of you; nonetheless, there are real untapped possibilities here, especially if tables are approached with the imagination that has been recently bestowed on graphical displays [8].

Dissemination and User Analysis.--There are many, many issues that might be touched on here. Let me talk briefly about just three: Statistical Disclosure Avoidance, Tabular Reanalysis by Outside Users, and Microsimulation Modelling. It turns out that these seemingly different topics are quite related.

First, Statistical Disclosure Avoidance is an enormous problem. On the one hand, we want to make all the microdata we produce publicly available so researchers can benefit fully; on the other hand, we have to protect respondents (or taxpayers, in my case) from having identifiable information inadvertently disclosed. I have done some research on this topic, myself (e.g., Strudler, Oh and Scheuren 1986; Oh and Scheuren 1984). If there is a statistical solution, it may lie in the development of synthetic data sets designed for particular purposes (e.g., Paass 1989). Important pioneering efforts at formulating the problem have been taken (e.g., Duncan and Lambert 1986 and 1989; Paass 1988); even so, I feel this is a wide open area for further research and recommend it highly to you (maybe you can help keep me out of trouble).

Because the microdata release problem is so intractable, a lot of reliance remains on aggregated outputs (those "awful" tables I mentioned a little while ago). Disclosure problems can still exist with aggregation and, while there has been more success here, lots still needs to be done. (Cox et al. 1986 may be a useful recent reference.)

The reanalysis potential of published tables is something that has been uppermost in my mind lately, as we move from publication on paper to simultaneous publication on paper and floppy disk (and eventually on CD-ROM). It's hard to get an agency like mine to make such a change, but we have been getting a lot of help recently from the Ruggles family (Richard, Nancy, when she was alive, and their two daughters). I believe Statistics Canada may also be looking at the Ruggles' software, too (Ruggles et al. 1989). Anyway, what the Ruggles' and, perhaps, others have done is to go several steps beyond LOTUS in easing the reanalysis of aggregate data. To complete the picture, a system like the Ruggles' needs to be connected up with software that carries out various conventional grouped data techniques (like contingency tabulation packages and curve-fitting approaches, such as those in Oh and Scheuren 1987b, among others). It may seem to you that all the work may already have been done here; I think, though, that when you get into it, you will find that this is not the case. Again, a real contribution may be possible.

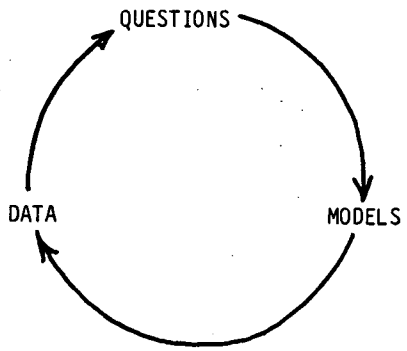
Finally, microsimulation modelling must be mentioned, since many users take government macro- or microdata and restructure them so that policy modelling "experiments" can be conducted. This work has been carried out over many years by a lot of ingenious people. Until recently, government statistical agencies were largely responsible just for some of the inputs; however, last year Statistics Canada, in an excellent piece of work, began to produce public microdata models (Wolfson et al. 1989). Even this superb effort can be justifiably criticized for the inherent weaknesses it has due to the ad hoc nature of many of the data handling techniques that had to be employed (Scheuren 1989b). What is badly needed is a much more statistically-principled approach. In fact, of all the problems I have mentioned today, this microsimulation may be the most important. In the last two years, my agency has run two large Conferences on the topic of Tax Microsimulation Modelling (Alvey and Kilss 1988 and 1989). There was also a Revenue Canada Taxation Conference in 1985 that made important contributions (Revenue Canada Taxation 1985). I would be happy to provide more background on this area after the talk, including copies of the Proceedings of these conferences.

Concluding Comments

Ivan Fellegi began his talk of two years ago, with a section on "motivation." I have left this to last, since it seems a good way to wrap things up.

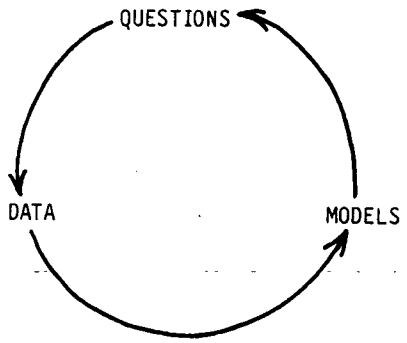
There are many ways to look at the science of statistics. Envision, if you will, first, a view of our science which focusses on the path

from questions to models to data



and then back to the questions, again -- perhaps with a partial answer; usually with information that leads to more and, presumably, better questions.

We can, of course, reverse the direction of the arrows in this picture, so we go from



questions directly to data, then mathematical models, then back to the question step, and so on. Tukey has been particularly influential with his work on exploratory data analysis in focussing us on the notion that we can begin with the data, in the absence of formal mathematical models, and do exceedingly valuable things (Tukey 1977).

Now, in general, both government and academic statisticians take both paths. Most academics, I think it's fair to say, find it more interesting to take the path from models to data. Models are their sine qua non. Meanwhile, government statisticians generally spend their energy collecting data to answer questions, i.e., on the path from data to questions. The data are (seemingly) paramount.

A potential difficulty for both groups lies in their institutional separation -- a separateness that can lead to a mindset that's best explained by reminding you of the modern fable about the drunk and the lamp post. As you may recall, the story goes that --

There was a drunk stumbling around a lamp post and someone came up to him and asked, "ARE YOU O.K.?" to which the drunk replied:

"NO, I LOST SOMETHING."

The good Samaritan, then, said: "CAN I HELP YOU FIND IT? WHERE DID YOU LOSE IT?"

The drunk points, "OVER THERE."

Somewhat perplexed, the passerby says, "WELL, IF YOU LOST IT OVER THERE, WHY ARE YOU LOOKING HERE BY THE LAMP POST?"

Smiling, the drunk answers, "BECAUSE THE LIGHT'S BETTER."

Obviously, telling this story here could be misunderstood. Frankly, though, it's not at all evident who the drunk and who the good samaritan represent -- maybe the best and worst in both groups. Of course, some of the "government types" like to hang on to their data lamp posts. On the other hand, academics can sometimes be excessively fond of their models. Clearly, to re-express the theme of today's session, the light from both lamp posts may be better than just one. In any case, I hope I intrigued at least some of you to share some of your light. Thank you for listening.

FOOTNOTES

* This paper was originally presented at the Annual Meeting of the Statistical Society of Canada, in Ottawa, Ontario, on May 31, 1989.

[1] In defense of my departure from what Ivan did, I might mention that Margaret Martin, in her 1980 Presidential address to the American Statistical Association, talked about government statistics as more of a management science than a mathematical one (Martin 1981); clearly, it is both.

One other point on coverage might be made here. Because I am still largely following Ivan's model, there are certain aspects of our work at IRS that I'm not going to cover at all. These deal principally with how we apply statistics to the job of collecting taxes, rather than to the job of producing publicly available information. For individuals interested "in the rest of the story," some partial sources I might recommend include the most recent issue of Statistical Science, which has a piece on the statistics of auditing (Panel on Nonstandard Mixtures of Distributions 1989). That a lot of problems remain, here, is evidenced by the latest issue of the Journal of Business and Economic Statistics, which has an article in this topic (Wurst et al. 1989). Coincidentally, the second piece in the latest issue of Statistical Science (Panel on Discriminant Analysis, Classification and Clustering 1989) also deals indirectly with an area of major administrative concern at IRS: how to decide which taxpayers to choose to audit. (See, also, Hiniker 1987.) Problems in estimating the so-called

"Underground Economy" are legendary and well-covered, with many other issues, in the just-finished report on Tax Compliance by the U.S. National Academy of Sciences (Committee on National Statistics 1989). Some interesting empirical Bayes applications have come up in some internal IRS work I'm involved with, personally, where we are measuring the quality of our toll-free telephone assistance operation (Batcher and Scheuren 1989).

[2] In the most recent five issues of Quality Progress (from January to May 1989), there has been an excellent series on benchmarking -- see Camp (1989).

[3] A source of real optimism, here, although still without sufficient academic input, is the Washington Statistical Society's Workshop Series on Quality, now in its second year.

[4] An excellent example of an expert system at the analysis stage is contained in a 1987 paper by Gale, about a system called STUDENT. At the U.S. Census Bureau there is a system called SPEER, for the editing and imputation of economic data, that we are looking at (Greenberg and Surdi 1984). While not a fully-developed expert system, SPEER offers great promise for our work.

[5] It might be worth noting that tax forms in the United States, our basic survey instruments, are all designed on computers. The data we capture are increasingly being obtained electronically (Wedick 1986). This year, for example, nearly two million individual income tax returns will be filed via modem; nearly a billion information documents are currently being filed on magnetic tape or floppy disk. Incidentally, as you may know, Revenue Canada Taxation is undergoing roughly the same changes, here, as we are; they're slightly ahead in some things, slightly behind in others. (This is unlike the United Kingdom, for instance, where the tax system is not yet computerized!)

[6] Now there are obvious trade-offs between covering a lot of topics briefly or a few topics in detail (as Ivan did). My "solution" to this dilemma is to just advertise where I think some of the research needs exist that academics could help on.

[7] In the U.S tax system there are two sets of taxpayer identification numbers (or TIN's) used: for individuals there is the social security number (SSN), which roughly corresponds to the social insurance number (or SIN) in Canada. For businesses we have the employer identification number (EIN). Both the SSN and EIN can be transformed into pseudo-random numbers which can be shown to have reasonably good properties (Harte 1986).

[8] What I have in mind, here, might be as simple as the devices talked about in recent issues of Chance. More elaborate examples are found in Scheuren et al. (1980) or Oh and Scheuren (1975). Ehrenberg (1985) is also a helpful reference.

BIBLIOGRAPHY

Alvey, Wendy L. and Kilss, Beth (Eds.). (1988) "Selected Statistical Background Papers" (Volume 1) and "Afterthoughts and Future Directions" (Volume 2), handouts for the Workshop on Microsimulation Modelling, Statistics of Income Division, Internal Revenue Service, Washington, DC, May 10, 1988.

Alvey, Wendy L. and Kilss, Beth (Eds.). (1989) "Selected Background Papers" (Volume I), a handout for the Workshop on Tax Microsimulation Modelling for Businesses, Statistics of Income Division, Internal Revenue Service. Washington, DC, May 11-12, 1989.

Anderson, Ronald; Kasper, Judith; Frankel, Martin R. et al. (1979) Total Survey Error, Jossey-Bass Publishers: San Francisco, CA.

Batcher, Mary and Scheuren, Fritz. (1989) "Developing a Large Scale Test Call System," a paper presented at the 1989 ASA Winter Conference, San Diego, CA.

Camp, Robert C. (1989) "Benchmarking: The Search for Best Practices that Lead to Superior Performance," a 5-part series in Quality Progress, January - May. (See, also, Camp's book by the same title, released by Quality Press and UNIPUB/Quality Resources.)

Committee on National Statistics, National Academy of Sciences. (1989) Taxpayer Compliance, Volume I: An Agenda for Research, University of Pennsylvania Press: Philadelphia, PA.

Cox, Larry; Fagan, Jim; Greenberg, Brian and Hemmig, Robert. (1986) "Research at the Census Bureau into Disclosure Avoidance Techniques for Tabular Data," 1986 American Statistical Association Proceedings, Section on Survey Research Methods, 388-393.

Czajka, John L. and Walker, Bonnye. (1989) "Combining Panel and Cross-sectional Selection in an Annual Sample of Tax Returns," a paper to be presented at the 1989 Annual Meeting of the American Statistical Association, Section on Survey Research Methods, Washington, DC.

Czajka, John L.; Hirabayashi, Sharon M.; Little, Roderick J.A. and Rubin, Donald B. (1987) "Evaluation of a New Procedure for Estimating Income and Tax Aggregates from Advance Data," Statistics of Income and Related Administrative Record Research: 1986-87, Internal Revenue Service, 109-136.

David, Martin; Little, Roderick J.A.; Samuhel, Michael E. and Triest, Robert K. (1986)

"Alternative Methods for CPS Income Imputation," Journal of the American Stastistical Association, 81, 393, 29-41.

Deal, Terrence E. and Kennedy, Allen A. (1982) Corporate Cultures, Addison-Wesley: Reading, MA.

Deming, W. Edwards. (1954) Some Theory of Sampling, Dover Press: NY.

Deming, W. Edwards. (1986) Out of the Crisis, Massachusetts Institute of Technology, Center for Advanced Engineering Study: Cambridge, MA.

Duncan, Gregory J. and Kalton, Graham. (1987) "Issues of Design and Analysis of Surveys Across Time," International Statistical Review, 55, 97-117.

Duncan, George and Lambert, Diane. (1986) "Disclosure - Limited Data Dissemination," (with comments) Journal of the American Statistical Association, 81, 10-28.

Duncan, George and Lambert, Diane. (1989) "The Risk of Disclosure for Microdata," Journal of Business and Economic Statistics, 7, 2, 207-217.

Ehrenberg, A.S.C. (1985) Data Reduction, John Wiley: London and New York.

Fay, Robert. (1986) "Causal Models for Patterns of Nonresponse," Journal of the American Statistical Association, 81, 354-365.

Fay, Robert E. (1989) "Estimating Nonignorable Nonresponse in Longitudinal Surveys Through Causal Modeling," Panel Surveys (G. Duncan, D. Kasprzyk, and M. P. Singh, Eds.) John Wiley: NY.

Fellegi, Ivan. (1987) "Some Mathematical Statistical Research Problems in Statistics Canada," a paper presented at the Annual Meeting of the Statistical Society of Canada, Quebec, Quebec, May 31 - June 3, 1987.

Fellegi, I. and Holt, D. (1976) "A Systematic Approach to Automatic Edit and Imputation," Journal of the American Statistical Association, 71, 17-35.

Fienberg, Stephen and Tanur, Judith M. (1989) "Combining Cognitive and Statistical Approaches to Survey Design," Science, 243, 1017-1022.

Gale, William A. (1987) "Student: A Tool for Constructing Consultation Systems in Data Analysis," Bulletin of the International Statistical Institute, 46, 3, 305-321.

Greenberg, Brian and Surdi, Rita. (1984) "A Flexible and Interactive Edit and Imputation System for Ratio Edits," 1984 American Statistical Association Proceedings, Section on Survey Research Methods, 421-426.

Harte, James M. (1986) "Some Mathematical and Statistical Aspects of the Transformed Taxpayer Identification Number: A Sample Selection Tool Used at IRS," 1986 American Statistical Association Proceedings, Section Survey Research Methods, 603-608.

Hiniker, John P. (1987) "The Selection of Returns for Audit by the IRS," 1987 American Statistical Association Proceedings, Section on Survey Research Methods.

Hinkins, Susan and Scheuren, Fritz. (1986) "Hot-Deck Imputation Procedure Applied to a Double Sampling Design," Survey Methodology, 12, 181-195.

Hinkins, Susan and Scheuren, Fritz (1989) "Evaluating Sample Design Modifications: Balancing Multiple Objectives," a paper to be presented at the 1989 Annual Meeting of the American Statistical Association, Section on Survey Research Methods, Washington, DC.

Hinkins, Susan; Jones, Homer and Scheuren, Fritz. (1988) "Updating Tax Return Selection Probabilities in the Corporate Statistics of Income Program," Proceedings of the International Symposium on Statistical Uses of Administrative Data, Ottawa, Ontario, Nov. 23-25, 1987, 379-386.

Holt, D. and Skinner, C. J. (1989) "Components of Change in Repeated Surveys, International Statistical Review, 57, 1-18.

Horvitz, Daniel; Folsom, Ralph and LaVange, Lisa. (1989) "Adjusting Survey Statistics for Measurement Method Bias Relative to a Consensus Standard," invited paper to be presented at the 1989 Annual Meeting of the American Statistical Association, Section on Survey Research Methods, Washington, DC.

Jabine, T.B.; Straf, M.; Tanur, J.M. and Tourangeau, R. (Eds.). (1984) Cognitive Aspects of Survey Methodology: Building A Bridge Between Disciplines, National Academy Press: Washington, DC.

Juran, Joseph M. (1964) Managerial Breakthrough, McGraw Hill, Inc.: NY.

Juran, Joseph M. (1988) Juran on Planning for Quality, The Free Press: NY.

Little, Roderick J.A. (1986) "Survey Nonresponse Adjustments for Estimates of Means," International Statistical Review, 54, 2, 139-157.

Little, Roderick J.A. (1988) "Missing-Data Adjustments in Large Surveys," Journal of Business and Economic Statistics, 6, 3, 287-301 (including "Comments" by I.G. Sande and Fritz Scheuren).

Little, Roderick J.A. and Rubin, Donald B. (1987) Statistical Analysis with Missing Data, John Wiley & Sons: NY.

Little, Roderick J.A. and Su, Hong-Lin. (1989) "Item Nonresponse in Panel Surveys," Panel Surveys (G. Duncan, D. Kasprzyk, and M.P. Singh, Eds.) John Wiley: NY.

Martin, Margaret. (1981) "Statistical Practice

in Bureaucracies," Journal of the American Statistical Association, 76, 373, 1-8.

Mulrow, Jeri M. and Jones, Homer W. Jr. (1989) "Sampling Administrative Records: Detection and Correction of Stratification Error," a paper presented at the 1989 ASA Winter Conference, San Diego, CA.

Norwood, Janet L. (1989) "The Influence of Statistics on Public Policy," Proceedings of the Symposium on Statistics in Science, Industry and Public Policy, National Academy Press: Washington, DC, 30-42.

Oh, H. Lock and Scheuren, Fritz. (1980) "Estimating the Variance Impact of Missing CPS Income Data" and "Differential Bias Impacts of Alternative Census Bureau Hot Deck Procedures for Imputing Missing CPS Income Data," 1980 American Statistical Association Proceedings, Section on Survey Research Methods.

Oh, H. Lock and Scheuren, Frederick J. (1983) "Weighting Adjustment for Unit Nonresponse," Incomplete Data in Sample Surveys -- Volume 2, Theory and Bibliographies, (W.G. Meadow, I. Olkin and D.B. Rubin, Eds.), Academic Press: NY, 143-184.

Oh, H. Lock and Scheuren, Fritz. (1987a) "Modified Raking Ratio Estimation," Survey Methodology, 13, 2, 209-219.

Oh, H. Lock and Fritz J. Scheuren. (1987b) "Osculatory Interpolation Revisited," 1987 American Statistical Association Proceedings, Section on Survey Research Methods."

Paass, Gerhard. (1988) "Disclosure Risk and Disclosure Avoidance for Microdata," Journal of Business and Economic Statistics, 6, 487-500.

Paass, Gerhard. (1989) "Stochastic Generation of a Synthetic Sample from Marginal Information," a paper presented at the U.S. Bureau of the Census Annual Research Conference, March 1989; to appear in the Journal of Business and Economic Statistics (forthcoming).

Panel on Discriminant Analysis, Classification, and Clustering. (1989) "Discriminant Analysis and Clustering," Statistical Science, 4, 1, 34-69.

Panel on Nonstandard Mixtures of Distributions. (1989) "Statistical Models and Analysis in Auditing," Statistical Science, 4, 1, 2-33.

Potter, Frank J. (1988) "A Survey of Sample Weight Trimming Strategies," 1988 American Statistical Association Proceedings, Section on Survey Research Methods.

Quantitative Literary Series. (1987) Dale Seymour Publications: Palo Alto, CA.

Revenue Canada Taxation. (1985) Multi-National Tax Modelling Symposium Proceedings, September 17-19, 1985, Mont Ste. Marie, Lac Ste. Marie, Quebec.

Rosenbaum, P.R. and Rubin, D. B. (1983) "The Central Role of the Propensity Score in Observational Studies for Causal Effects," Biometrika, 70, 41-55.

Rubin, Donald B. (1987) Multiple Imputation for Nonresponse in Surveys, John Wiley & Sons: NY.

Ruggles, R. et al. (1989) "The PRTAB System: User's Manual and Reference Guide," 13363 Saticoy, North Hollywood, CA 91606.

Scheuren, Fritz J. (1986) "Role of Government Statistics in a Democratic Society," Record--Society of Actuaries, New Orleans, (Annual), Oct. 14-16, 1985, 11, 4A, 1929-1953.

Scheuren, Fritz. (1988) "Quality Improvement Project Teams at the Internal Revenue Service," Symposium Proceedings: Quality Assurance in the Government, Washington Statistical Society, May 24-25, 1988.

Scheuren, Fritz. (1989a) "Discussion," of papers by Lepkowski, Little and Fay on Nonresponse in Panel Surveys, Panel Surveys (G. Duncan, D. Kasprzyk and M.P. Singh, Eds.), John Wiley: NY.

Scheuren, Fritz. (1989b) "Discussion" of Wolfson et al. (1989), Survey of Current Business.

Scheuren, F.J. and Oh, H.L. (1975) "A Data Analysis Approach to Fitting Square Tables," Communications in Statistics.

Scheuren, Fritz and Oh, H. Lock. (1984) "Statistical Disclosure Avoidance," a speech presented to the Washington Statistical Society, May 22, 1984.

Scheuren, Frederick, Oh, H. Lock; Alvey, Wendy L.; Kilss, Beth; and DelBene, Linda. (1980) "Matching Administrative and Survey Information: Procedures and Results of the 1963 Pilot Link Study," Report No. 3 in the series Studies from Interagency Data Linkages, Social Security Administration.

Singh, M.P. (Ed.). (1988) Survey Methodology, Statistics Canada, 14, 2. (See, in particular, the papers by J. Lorigny, M. J. Wenzowski, and W. Mudryk, 289-316.)

Strudler, Michael; Oh, H. Lock and Scheuren, Fritz. (1986) "Protection of Taxpayer Confidentiality with Respect to the Tax Model," Proceedings of the American Statistical Association, Section on Survey Research Methods, 375-381.

Sunter, Alan B. (1986) "Implicit Longitudinal Sampling from Administrative Files: A Useful Technique," Journal of Official Statistics, Statistics Sweden, 2,2.

Tukey, John W. (1977) Exploratory Data Analysis, Addison-Wesley Publishing Company: Reading, MA.

Westat, Inc. (1974) "Result of a Study to Improve Sampling Efficiency of Statistics of Corporation Income," Bethesda, MD (unpublished).

Wedick, J.L. (1986) "Electronic Filing at the IRS: The Goal is Global," Journal of Accountancy, 110-116.

Wolfson, Michael; Gribble, Stephen; Bordt, Michael; Murphy, Brian and Rowe, Geoff. (1989) "The Social Policy Simulation Database and Model: An Example of Survey and Administrative Data Integration," Survey of Current Business.

Woodburn, Louise and Heeringa, Steve. (1989) "Using Supplementary Information to Investigate Nonresponse Bias," a paper to be presented at the 1989 Annual Meeting of the American Statistical Association, Section on Survey Research Methods, Washington, DC. (Note: This paper appears on pp. 105-110 of this volume.)

Wurst, John; Neter, John and Godfrey, James. (1989) "Efficiency of Sieve Sampling in Auditing," Journal of Business and Economic Statistics, 7, 2, 199-205.