SURVEY DESIGN FOR CONTROL OF MEASUREMENT ERRORS IN DEVELOPING COUNTRIES

Beverley A. Carlson, Karl K. Kindel, and Anthony G. Turner, U.S. Bureau of the Census

Each year the U.S. Census Bureau carries out a multimillion dollar program, funded from various multilateral and bilateral sources, which is dedicated to census and survey statistics in the developing world. This program includes the development of case study materials and workshops such as the familiar Atlantida, AGROSTAN and most recently, POPSTAN (U.S. Bureau of the Census, 1966-67, 1968 and 1969). It also includes a training component where approximately 100 foreign statisticians are given formal training in census and survey (Finkner, Washabaugh 1977). Another key element of this program is the maintenance of an international demographic data base which focuses on developing countries. This program also includes a considerable amount of technical assistance, both short term and long term, to developing nations in all parts of the globe (Turner, et al. 1979).

It is the technical assistance component which is the focus of this paper. This assistance covers many facets of census and survey-taking, including sample design, data collection, data processing and analysis. The assistance we provide ranges from consultative to advisory to (in some cases) implemental.

A vital feature of survey design is the control of nonsampling error, and this commands a substantial portion of our attention in the assistance we provide. Among the sources of nonsampling error that we typically face are (1) errors of validity when the operationalized survey questions fail to capture the intended concept, (2) the usual errors due to nonresponse and from interviewer mistakes, (3) response errors from respondent ignorance or unwillingness to answer certain questions, (4) errors made in coding and in other processing operations and (5) errors stemming from defects in the sample frame.

In developing survey materials that attempt to deal adequately with such problems, that is, by keeping the survey errors to a minimum, we often encounter conditions and situations in the developing world which call for methods which may not be commonly used in the more developed countries. At times, compromises must be taken from traditional or accepted practice.

In this paper we describe two recent examples of how the Census Bureau, working with its host-country counterparts, has chosen to deal with important survey design issues in an effort to hold nonsampling errors down. One example traces the evolution of questionnaire design through a series of surveys dealing with agricultural measures in Latin America, notably in Guatemala, the Dominican Republic and Bolivia. Secondly, there is discussion of two of the special problems of survey design that occur in the process of evaluating intervention-action projects.

Developing Instruments for Agricultural Measures in Latin America

During the 1970's the Agency for International Development (AID) sponsored a series of agriculture farm-household surveys in Latin America. The need for better rural data for planning and policy-making grew out of congressional requirements that AID improve its project design, evaluation and impact assessment. Data on the socioeconomic and agricultural characteristics of the the rural population were largely nonexistent in AID countries. In response to the need for improved data, a series of nationwide farm household surveys were designed and conducted by ourselves and AID in collaboration with counterpart statisticians and economists in each of the countries. Although study objectives varied from one survey to the next, there were many underlying similarities in each of the surveys, such as the measurement of agricultural production and farm/family income, which permitted the incorporation of questionnaire improvements into each successive study. Some of the salient measurement problems are discussed relating to questionnaire development for agricultural surveys in three countries - Guatemala, the Dominican Republic and Bolivia.

The three surveys of interest include the Guatemala Farm Policy Survey conducted in 1974 on a probability sample of 1600 farms and focusing on the differences between credit and noncredit users among farmers (AID, 1975). Secondly, there was the Dominican Republic Cost of Production Survey conducted in 1976 on a probability sample of about 2000 farms and concentrating on a comprehensive analysis of small-farm crop and enterprise activities (AID, 1977). The third survey, variously called the Socioeconomic Survey of Southern Valleys and the Agriculture Sector Loan II Survey, was undertaken in 1977 and covered three southern Departments (Chuquisaca, Potosi and Tarija) of Bolivia, which made up the principal geographic target area for a new AID agriculture sector loan (Riordan, 1977). The survey similarities among these diverse efforts are (1) the unit of enumeration is the farm household, (2) the analytical focus is on rural small farmers, (3) farm income is measured for the agriculture year with one retrospective interview, (4) compreshensive information is gathered on land tenure and use, and on crop production and sales, (5) values for the consumption of self-produced food are imputed, (6) the use or lack thereof of modern technology is characterized, and (7) demographic characteristics of the farm family are collected.

The precursor of these three surveys was another study conducted in 1973 called the Columbian National Farm Unit Survey with a sample size of 20,000 farms. The questionnaire for the Columbian survey suffered severely from the lack of prior review by statisticians or data processors. Its physical size, a large 2-foot by 3-foot bedsheet rendered it unwieldly in the field and difficult to key. Further, it was not a questionnaire per se but rather a schedule in matrix form with brief headings describ-

ing the data items required, leaving interpretation and question formulation to the interviewer.

The Guatemala Farm Policy Survey

While the 1974 Guatemala Farm Policy Survey was fairly similar in content to the Columbian study, significant effort was expended to design an improved questionnaire with respect to formatting. A booklet form was adopted incorporating many features to facilitate both data collection and data processing, such as shading, formulating the concepts into questions, using specific interviewer instructions written into the questionnaire, and adopting skip patterns and "source coding." In addition, design features to facilitate data editing such as lead-in and screening questions were utilized. A small test was run on 30 questionnaires comparing the average time required to key information recorded in the Columbia Matrix format versus the same information recorded in the booklet, source-coded format. The source-coded format required half the time.

A major breakthrough in the Guatemala questionnaire design was the use of "source codes," a data entry scheme frequently used in the U.S., whereby each item of information is identified by its unique code. Source coding is particularly effective when the number of expected responses in any given questionnaire is small relative to the total number of possible questions, since the keyer only has to key data with actual responses, altogether skipping blank fields. For example, the Guatemala questionnaire had a total of 958 possible questions but only one-third of the items were answered by an average farm household because of skip outs. Later in the Dominican Republic study, this ratio was found to be 206 to 1275 items or 15 percent (AID, June 1978). The overall data entry error rate in the Dominican Republic survey was .25% using this method.

The Dominican Republic Cost of Production Survey

While the Dominican questionnaire was similar to its Guatemalan predecessor in both content and format, more attention was given to improving the conceptual measures for the former. Certain characteristics that had proved elusive in the Guatemalan experience were refined, with adaptations to the Dominican agricultural situation and somewhat different emphasis on analytical objectives. Improvements were sought in the measurement of on-farm labor use, characteristics of processed products, and measurement of interplanted crops. These will not be discussed here due to limitations in space. However, one notable problem that merits discussion is that of nonstandard weights, quantities, and measures of area, because it is pervasive in the developing world. In the Guatemala survey, for example, it has been observed that the term cuerda, a measure of land area, had 15 different interpretations among respondents, ranging from 101-1338 square meters (AID, 1975). The Guatemalia case thus pointed up the fact that different responses were possible, varying by crop, region and cultural background of the farmer, but the extent of the variability had not been anticipated before the survey.

In the Dominican questionnaire an effort was made to capture the information in a more standardized format. This required choosing a standard base for weight, quantity and measure of area for each characteristic such as crop type, and then converting the variant cases to the standard base. So, for example, in all questions dealing with quantities the respondent was asked to provide the quantity, unit of measure and conversion factor to the standard unit. When the conversion factor was unknown, it was imputed. A further complication, prevalent in Bolivia, was the variability of conversion factors depending on the crop and region. For example, a fanega of wheat has a different meaning than an fanega of corn. Again, the problem of nonstandard terms reflects the importance of a comprehensive knowledge of the cultural context that must be taken into account in any survey implementation in the developing world (Hursh-Cesar, et al., 1976). It should be noted that all of these surveys would have benefited from more comprehensive presurvey research into the existing special conditions in each country.

Another survey design feature of the Dominican Republic study was a systematic attempt to evaluate some of the survey errors (AID, 1978). The survey sponsors felt that a full-scale reinterview program was too costly. In spite of this, an evaluation of errors and error ratios was conducted at a relatively low cost. The principal sources of information used were (1) counts of the edit changes by item in all questionnaires taken from a comparison of the original unedited data tape, and (2) an analysis of the edit changes, classified by correction class. Using this information it was possible to examine the frequency of edit changes by correction class and the relationship between error rates and the variables which may have influenced them. Errors in this context were thus defined as those raw responses which underwent an editing change.

Highlights of this analysis are as follows and contributed significantly to the decisions taken in later surveys. The complexity of the survey objectives led to lengthy questionnaires in all three surveys. There was significant debate that the quality of the data in the latter sections would suffer due to fatique on the part of both the respondent and interviewer. A review of the item analysis of the Dominican questionnaires indicates that the error rate fluctuates a great deal from section to section but does not increase from the beginning to the end of the questionnaire. Table 1 illustrates the error rates by questionnaire section. While gradual increase in the error rate would support the fatique theory a fluctuation from section to section simply reflects varying difficulty. This conclusion is further corroborated by interviewer reports and observation reports in both the Dominican and Bolivian surveys. The rural respondent is remarkably patient and generally willing to cooperate in long inter-

views (with few exceptions), a significant contrast to current U.S. experience.

The Dominican survey did not appear to have response problems with farm size, land tenancy or land utilization. In part this was due to the disaggregation of the farm in several different ways allowing for cross-checking and verification during the interview. The error rates on these questions were very low as can be seen in Table 1, line for Section II. Information on area planted by crop suffered a nine percent overall error rate. In particular, information gathered on interplanted secondary crops and mulitple cropping was of doubtful accuracy, incomplete, or missing due to very complex cropping systems and dispersed tree crops common in the Dominican Republic and other developing countries. As will be seen later, a major element in the questionnaire design for the Bolivia survey centered around an effort to improve the method of capturing data on inter-and multi-cropping.

A further serious area in reponse error occurred when the respondent was asked to disaggregate the distribution of his crop production by sales, consumption, seed, etc. The average error rate for this series of questions was sixteen percent and raises the question of the ability of rural farmers to reliably provide this type of information. Some comestic improvements can be made to the questionnaire to try to capture this detail better but it may be in vain. More experimental research is needed to quantify and characterize the problems of respondent inability and unwillingness to answer these kinds of questions.

The information for on-farm processed products was unquestionably the worst in terms of data quality. The average error rate for all processed products was 53 percent, principally due to incorrect enumeration of coffee and cacao. The processing of these two crops is often confusing stemming largely from an inadequate familiarity with and specification of the stages of processing by the survey designers. Similar problems had occurred in the Guatemala survey and will likely occur in future undertakings. The complexity of the processing steps that can occur suggests that this may need to be the topic of a separate specialized study.

The Bolivia Southern Valleys Socioeconomic Survey

The Bolivia Southern Valleys Survey questionnaire represented a further effort to apply many of the accumulated recommendations that emerged from the Dominican Republic and Guatemala experiences. In addition, two innovations were attempted - the use of the Dibujo, or farm drawing, and a decision to design the questionnaire to collect data at a very detailed level but to computerize and analyze it at a more aggregated level.

The Dibujo (drawing of the farm) was used to improve the quality of responses concerning details of land use, cropping, interplanting and crop rotation. A foldout sheet was attached to the last page of the questionnaire. On it the interviewer and respondent were asked to draw a picture of the farm showing the limits of each parcel and field and noting the name of the current crops planted, the corresponding area of each, if interplanted the "design" of the interplanting, and to do the same for any previously harvested crops on these fields by indicating them in parentheses. The drawing was then used throughout the interview to assist the farmer in recalling the specific information relating to the production and disposition of each crop and to probe on the use of fertilizers and other inputs and cost of production.

The Dibujo proved to be an extremely effective interviewing tool. The interviewers drew the farms clearly and closely followed their training instructions. The Dibujo was indispensible in the office edit phase for resolving data inconsistencies and providing answers for missing data.

The other major innovation in the Bolivia questionnaire was to collect data on a very detailed level but to analyze it at a more aggregate level. This was possible due to a clear statement and focusing of objectives at the outset, a not always realized ideal. Our users were only interested in farm level income as opposed to needing crop accounts or enterprise accounts as had been the case in the Dominican Republic. So, for example, while information was gathered at the crop level on costs of production, these data were summed to total costs for each of the six crop technology cost rubrics and only these totals were keyed and analyzed. A similar approach was used with cash receipts. Quantity, price and total value received for the sale of processed products were asked but only the total value of all of these, was keyed for subsequent editing, cross-tabulation and analysis. Thus is was felt the overall quality of response was improved. Moreover, the procedure reduced the possible number of data cells dramatically, which significantly reduced editing and data management problems once the file was computerized. Instead of a possible maximum record size of 901 the maximum record size was 415. On the negative side there was less possibility for detecting clerical error in summing to totals since this was a manual operation.

After data collection was completed on the Bolivia survey each interviewer was asked to evaluate respondent performance based on an evaluation questionnaire asking the interviewer's opinions and specific reasons for cited problems (Brown, 1977). There were 15 questions or types of questions where at least 20 percent of the field personnel reported difficulty on the part of the farmer. It is significant to note that the total production by crop (45 percent) and the total value of crop sales (45 percent) were the two questions with highest reported difficulty. Name and area planted to each crop during the year (38 percent) also presented serious problems in spite of the use of the Dibujo device. That is, while the Dibujo aided in the flow of the interview and was useful as a probing and clarifying device, it still could not overcome the two problems most frequently mentioned as contributing to poor response --

the lengthy recall period and the unwillingness of the farmer to respond to certain questions.

The most important issues raised by these evaluations is the questionable quality of key quantitative variables - area, production, sales - needed for calculating an estimate of income. On the other hand, expenditure questions were reportedly less difficult for the farmer. Also, on the positive side, the ano agricola or agricultural year which used a well-known holiday as a reference point was only reported to be a problem by less than four percent of the field staff.

So far we have discussed survey measurement problems of the nonsampling variety in agricultural surveys - problems that are well known but which are receiving ever-increasing attention by survey researchers in Latin America. We have seen that the usual causes of response error are particularly exacerbated in the developing country context, especially in rural settings. The prevalance of illiterate or semiliterate respondents, the predominance of subsistence agriculture, the problems of asking respondents to recall specific quantitative and value information when they often do not participate in a cash economy or do so only on a limited basis, the recall of expenditures and income in the absence of record keeping and the cultural variations in the use of language are all contributing factors. In more developed countries taxation systems demand record keeping by households and individuals. In the absence of this conceptual framework, the ability of a respondent to recall specific quantitative information is questionable.

In developing questionnaires to cope with many of these problems, we have focused on the need to emphasize all facets of questionnaire design, from proper formatting and refining or standarding concepts to introducing detailed probes and other collection devices - all in an effort to reduce nonsampling error so that the final result is a more valid representation of what we set out to measure.

Evaluation and Nonsampling Error -- Special Problems As They Relate to Evaluation Surveys

We turn now to a second major division of our work, on behalf of AID, in developing countries. This is the field of evaluation of action programs usually designed to effect an overall increase in the standard of living in targeted, mostly rural, areas. Most of the evaluations we conduct contain a heavy element of survey taking, usually of the ex ante and ex post facto variety commonly used in experimental or quasi-experimental design.

In evaluating intervention-action projects there are two major constraints which are widespread in the developing world and which are the cause of considerable nonsampling error in the survey components of the evaluation. One is due to the difficulty in travel and transportation to rural areas and the second is the lack of trained, qualified technicians and survey practitioners. There are of course many other causes of non-sampling error in evaluations, including most of the types previously discussed for Latin American agriculture surveys, but we would like to focus our discussion on the two just mentioned.

The first constraint, travel and transportation, is particularly acute because of the design features of the action-intervention projects. Rarely is one able to use a true experimental design in measuring the impacts of project interventions. This is because of political and social considerations, implicit in the kind of projects U.S. foreign assistance finances and supports. That is, it is usually politically and socially unacceptable to withhold an intervention such as water, electrification, sewerage or health facilities from a part of the population (Bryant, 1979).

More generally, a quasi-experimental design is used with the target units (households, clients, farms, etc.), falling into the study dependently, that is as a function of where the intervention geographically occurs (water hook-ups, electrical hook-ups or some other project specific function). Using a before-after approach, it will generally be imprecisely known a priori as to which units will fall into the intervention ("treatment") group and which will not. Only after the system is completed and for example, the water hook-ups made will the evaluator know which study units fall into which stratum of the design. Typically, strata in a water project may be: (1) target area has some water before - new water after, (2) no water before - new water after and (3) no water before - no water after. This latter group will often not be delineated until all construction and hook-ups are completed.

To insure adequate sample size in each stratum, it is often necessary to construct large geographic areas in delineating the project area since hook-ups are practically never predetermined. This can lead to an inordinate amount of rural travel to obtain a sample of adequate size in each stratum. This is because the population is widely dispersed in most developing countries in the rural areas where the action program is usually administered.

The problem of population dispersement is further exacerbated because the cost of transportation is much higher than in the U.S., especially in rural areas. Moreover, travel is much more difficult since the development of road systems is often embryonic. Roads are not paved and travel is very slow. Often there are no roads leading to sample households. This leads to a high cost per interview where the study units are widely spaced, and it also increases the time required for the interviewer to be in the field. The consequences are that noninterviews and/or "curbstoning" are likely to be high.

There are no easy solutions nor are there adequate ones. Adequate supervision is difficult because of the same problem of getting around and the costs involved, so that quality control is difficult to maintain. Unfortunately, a common practice is

to cut the sample size and accept a reduced level of reliability. Though this has the effect of speeding the fieldwork, it does not effectively combat the problem of noninterview or the potential for curbstoning.

An alternative we have been using is to refine the method of stratification before drawing the sample. In the water system evaluation example, this requires a more careful advance determination of probable areas of hook-ups and nonhookups. This is not a perfect solution, but some gains in sampling efficiency can be obtained by closely examining the project implementation plan and the engineering plans and tailoring the sampling scheme to fit it better. For example, in setting up the strata, it should be recognized that hook-ups will usually occur where water mains are located. Defining the service area boundaries in this way helps improve some of the stratification and, at times, reduces the size of the geographic area that must be canvassed. In this way, both sampling reliability is increased and nonresponse error is probably reduced.

The second problem we want to mention which contributes heavily to non-sampling error is that brought about by the type of host-country personnel usually asked to undertake an evaluation study for an AID project or program. Although these persons are often highly educated, they are rarely trained in the methods and skills of statistics or survey techniques, so essential for carrying out most of the evaluations with which we are involved. The difficulty here stems largely from the fact that the agencies we generally work with are not the national statistical office, the census bureau or other statistical agency. Except for some familiarity with cost benefit analysis, most of the program personnel assigned to an evaluation study are poorly trained to undertake the conceptualization, design, planning, data collection, processing and analysis for the project. Usually the technicians do not recognize their own shortcomings and will enter into contractual agreements lacking the technical background to be responsive to the needs of the evaluation. The inadequate skills and training quickly become evident in poor planning, poor organization and management; but it is perhaps most noticeable in poor questionnaire design and poor implementation procedures as well as other facets of the survey plan. The work often results in the over-collection of poorly conceptualized data variables and the surveys frequently have no provisions for integrating data processing and data analysis - a deadly combination.

The solution we have found to be most effective, but not the most expeditious, is to integrate into the evaluation program, a comprehensive training program for evaluation and survey design. This has the added benefit of developing a local capability over time.

This solution requires an integrated approach and more than just a short-term commitment. It means developing a program which will leave the host-country technicians with an at least minimal capability to undertake evaluations and survey design after the evaluation project is completed. Thus, there are two elements: institutionalization of capabilities and completion of a (hopefully) better designed evaluation, most appropriately in that order at least from the foreign development assistance program point of view.

The Philippines Rural Electrification Evaluation (National Electrification Administration, 1978) exemplifies many of the characteristics of such a training program. The staff of the evaluation group was assigned from the Franchise Division of the National Electrification Administration of the Philippines. Those professionals were mostly business majors with some strength in economics, but little knowledge or experience in evaluation or information collection. The training we provided them, around the live evaluation project, had to begin at the basic levels of evaluation theory and the processes of data collection. The project itself started with the conceptualization, planning and design phases before going into any implementation, data processing or analysis.

The group now has expertise in each of these areas from our working with them as well as from formal training they undertook on their own as they began to get into the project. They now have the capability to undertake and direct major nationwide evaluation studies and in fact, have completed two national studies of rural electrification, the last of which is presently in the data processing stage. They have also developed competence in writing and monitoring evaluation scopes of work demonstrated by the various smaller studies they have completed (Aquinas University Research Bureau (Visayas), 1978, University of the Philippines (Iloilo), 1978, University of the Philippines (Baguio), 1978.

This approach to a solution involves identifying appropriate host-country counterpart technicians to serve as the evaluators and data collection specialists. It also requires that a large amount of the authority and autonomy be given up to the counterparts, something most of us find difficult to do. Training the counterparts in the theory, practice and methodology of evaluation and related survey methods is done through formal instruction and by example, using the evaluation project as the "live" basis for on-the-job training.

It is important not only to maintain the goal of the final evaluation product, but also to maintain contact with elements of good training principles. That is, the training usually does not follow exactly the events in planning and implementing the evaluation. Training for planning the evaluation should be done from the top down, that is, from the defined outputs needed for the evaluation analysis to the data collection elements needed for those outputs, concurrently defining and inculcating the principles of data collection planning and implementation. This necessarily includes the integrated design of the data processing

and data analysis, which as indicated above, is generally a major failing.

One of the major areas in which this kind of interaction with counterparts is most effective is in the area of operations and field operations and field implementation. It is rare in most developing countries to observe a field operation for an evaluation study where the interviewers were adequately prepared for interviewing and where adequate manuals for training, interviewing, supervising, editing and field coding were prepared. Inadequacy of documentation leads to inconsistent application of definitions, questionnaire administration and field control. It is more common that interviewers are given a questionnaire, asked if they have any questions and are given their assignments.

Hence training programs for interviewers, trainers and field supervisors go far toward eliminating those problems, and, of course, reduce a major source of nonsampling error--bias introduced by interviewers. We have overseen training done by host-country people in order to help them upgrade their system, suggested changes and improvements in techniques to overcome these problems with a high return on our efforts. Generally, the technicians have just not been aware of the level of methodology and techniques that can be applied. Once a standard is set and met, the local technicians are able to improve upon it because of their knowledge of local customs and thinking.

We should hasten to add that this picture we are painting is not universal. However, care should be exercised in developing countries to be aware of the existence of these kinds of problems rather than assume that they do not occur.

Evaluation planning and theory are quickly learned by the local counterparts. But the application of the principles and ideas is the more difficult aspect in developing countries. We have felt it is important to set and expect high standards and to make a commitment to develop the needed capabilities in counterpart agencies. This commitment must be established not only with the host-country agency, but also with the sponsoring agency. Only that way will there be a lasting ability to carry out high-quality evaluations.

In conclusion we have talked about only two aspects of evaluation of action projects where survey design and methods come into play. In one instance, the inexactness of advance delineation of the target area means that the "control group" may be defined over such a large, rural geographic area to accommodate the requirements for sample size that noninterview or curbstoning result. We have indicated the need to study the project implementation plan with greater care and skill to assist in developing more efficient stratification. In the second instance, we have shown that an evaluation when attempted by persons who are not trained statisticians can result in survey applications which are fraught with error; and we have emphasized the need to have both formal and on-the-job training to improve matters.

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