

LONGITUDINAL WEIGHTING ISSUES AND ASSOCIATED RESEARCH FOR THE SIPP**

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I. INTRODUCTION

The Survey of Income and Program Participation (SIPP) is an ongoing national panel survey of the noninstitutional population of the United States. The Census Bureau designed the SIPP to provide improved information on income and participation in government programs. Person and household characteristics that may influence income and program participation such as labor force, education, and assets are also available from the SIPP.

The survey produces two types of estimates - cross-sectional and longitudinal. This paper discusses the issues related to longitudinal weighting and associated research for the SIPP.

The following section includes a brief description of the SIPP design. We discuss the current longitudinal weighting scheme and reason for it in Section III. In Section IV, we present concerns/issues raised about the current weighting scheme and related research. Section V presents research underway to deal with the concerns and issues and future research areas.

II. BACKGROUND AND SAMPLE DESIGN

The SIPP is a multistage stratified systematic sample of the noninstitutionalized resident population of the United States. This population includes persons living in group quarters, such as dormitories, rooming houses, and religious group dwellings. Noncitizens of the United States who work or attend school in this country and their families are also eligible. However, only persons who are at least 15 years of age are eligible for interview. All other persons are ineligible. This includes: crew members of merchant vessels, Armed Forces personnel living in military barracks, and institutionalized persons, such as correctional facility inmates and nursing home residents.

We divide the SIPP sample into four groups of equal size called rotation groups and interview one rotation group each month. In general, we call one cycle of four interviews a wave. This design provides a smooth and steady workload for data collection and processing. Field representatives (FRs) interview persons in the sample once every four months for approximately two and one-half years. The reference period for the interview questions is the four months preceding the interview month. For example, the reference period for the August 1992 interview month is April through July 1992. FRs interview sample persons again in December 1992 for the August 1992 through November 1992 period.

Household members who are 15 years old and over and interviewed at the first interview are part of the survey for the entire two and one-half year period. With certain minor restrictions, FRs follow sample persons if they move to a new address. We consider "new" persons living with sample persons to be part of the sample only while they reside with these sample persons. More details on the SIPP design are given in Nelson, et al. (1985) and Jabine (1990).

III. CURRENT LONGITUDINAL WEIGHTING SCHEME AND BACKGROUND

Background

The SIPP is the first longitudinal survey of households conducted by the Census Bureau. Because of this the Bureau did not have any experience in weighting and analyzing the data

from a longitudinal survey. This created a challenge for the Bureau staff to develop a weighting scheme which provided estimates of acceptable quality for the then vaguely defined longitudinal estimates. We held a number of discussions with analysts within and outside the Bureau to identify the estimates and types of analyses they expected to perform using the SIPP data. These discussions were very useful for the development of the initial longitudinal weighting scheme. Later, we discussed some weighting related issues with a group of experts in survey methodology. The issues discussed included:

- Timeliness of availability of SIPP data for longitudinal analysis
- Definition of the universe
- Defining and handling of nonrespondents/respondents
- Number of weights for each person

1. Timeliness:

The Bureau introduced the first panel of SIPP in October 1983. Because analysts were very eager to use the SIPP data, the Bureau made a commitment to release the first three-wave data file in the summer of 1986. Therefore, timeliness of data availability became an important criterion in developing the weighting scheme. Time schedules did not permit implementing a major research program. Thus, we made some conservative decisions concerning the weighting method. For example, we assigned positive weights only to those persons who provided data for all interviews in which they were eligible. However, we expected the increase in bias and/or variance for the three-wave file due to these decisions to be small.

2. Universe:

Analyses identified in late 1984 or early 1985 were primarily cohort based. A cohort is a group of individuals sharing a common characteristic - for example, persons in the noninstitutional U.S. population in January 1985. Thus, the Bureau developed longitudinal weighting methods to satisfy cohort based longitudinal analyses. We defined the cohort in terms of the population at a given point in time. Therefore, we defined the universe as of the time of the cohort.

3. Respondents and Nonrespondents:

The Bureau considered persons who responded to all interviews in which they were eligible to be interviewed. Also, we considered persons who died or moved to an ineligible address to be interviewed as long as they responded to all interviews prior to this change.

We treated the following original sample persons as "noninterviewed" in the weighting procedure: 1) those who at the time of the first interview lived in a noninterviewed household, and 2) those who resided in a wave 1 interviewed household who a FR could not follow or who failed to respond to at least one of the later interviews.

** This paper reports the general results of research undertaken by Census Bureau staff. The views expressed are attributable to the authors and do not necessarily reflect those of the Census Bureau.

We assigned noninterviewed persons a weight of zero. The interviewed persons' weights compensated for noninterviewed persons. Also, persons who joined a SIPP sample person's household after the first wave were given a weight of zero.

This approach to handling nonresponse is not the most efficient since it discards a large amount of data available for persons who miss some, but not all interviews. However, developing an imputation system to handle such persons needed extensive research. Also, we were skeptical whether we could develop an imputation system that will not adversely affect longitudinal analysis.

As an alternative to imputation, we rejected a multiple weight approach which provides a weight for each interview pattern (or each reference month). We rejected the multiple weight approach because of possible confusion in using weights. In addition, multiple weights would be more costly and complex to produce and use for longitudinal analysis.

4. Number of Weights for Each Person

As discussed earlier, fewer weights were desirable to reduce confusion, complexity, and cost for producing and using weights for longitudinal analyses. For the three-wave file, we developed only one weight.

Initial discussions of these issues occurred primarily in reference to the first three-wave file from the SIPP 1984 panel. The group of experts suggested to:

1. Develop cohort based weighting
2. Define cohort based on the first interview population
3. Use only one weight
4. Not impute for missing interviews
5. Use the first file to do research to understand weighting and its impact on longitudinal analyses by getting input from data users and researchers
6. Research alternatives for handling nonresponse
7. Define other longitudinal analyses that may be performed and evaluate the weighting scheme implications on these analyses.

Longitudinal Weighting Scheme

Based on input from data users and survey design experts, we developed the weighting system for the first three-wave file. The following is a brief description. Kobilarcik (1986) provides a detailed description.

Using weights equal to the inverse of probability of selection provides unbiased estimates if the response rate is 100% and the sample has no undercoverage. Unfortunately, this is not true in practice. Therefore, weighting has several stages in which we attempt to compensate for noninterviews and undercoverage.

As explained below, the stages consist of some cell-by-cell adjustments and an adjustment using a "raking" procedure. In the adjustments, we used variables highly correlated to SIPP estimates of interest (Kobilarcik and Singh, 1986).

1. Preparation of Base Weights

The first step in the weighting process was to determine the base weight which is the reciprocal of the probability of selection.

2. Adjustment for Noninterviews

In general, the noninterview weight adjustment consisted of the reassignment of the weights of noninterviewed households or persons to groups of interviewed households or persons who hopefully had similar characteristics. We made noninterview adjustments in two phases. The first phase consisted of a household adjustment, while the second phase was a person adjustment.

In the first phase, the Bureau made a household adjustment to account for persons who resided in a wave 1 noninterviewed household. This is the same adjustment which is done for wave 1 cross-sectional weighting.

The second phase of the adjustment accounted for persons who resided in a wave 1 interviewed household but who failed to respond to at least one of the remaining two interviews for reasons other than death or moving to an ineligible address. This adjustment was on a person basis.

For each of the two adjustment phases, we computed the following ratio within each noninterview adjustment cell using the weighted counts of interviewed households (IHHs) (or persons) and noninterviewed households (NHHs) (or persons):

$$\frac{\text{IHHs (persons)} + \text{NHHs (persons)}}{\text{IHHs (persons)}}$$

We adjusted weights of interviewed persons in a cell by its corresponding ratio and assigned noninterviewed persons zero weights. We limited further processing to interviewed persons.

3. Adjustments To Demographic Differences From Total Population

To reduce the mean square error (MSE) of important survey estimates, the Bureau used two stages of adjustment to bring the weighted sample distribution and the population distribution into closer agreement. We accomplished this by post-stratifying using demographic variables highly correlated with the variables to be measured. The first stage adjusted for sampling error associated with the non-self-representing sample PSUs. The second stage reduced the effect of undercoverage on bias and variance by controlling estimates to predefined independent controls of age, race, sex, and marital and family status (Kobilarcik and Singh, 1986).

We developed the above approach for the first three-wave file of the 1984 panel. Since then, much research has been conducted to understand the impact of this weighting scheme on estimates and how we can improve the weighting. Research continues, and the weighting scheme for the most recent panel is basically the same as it was for the first file.

For each SIPP panel, we compute three weights:

- Panel weight covering the full panel (2.5 year period)
- First calendar year weight (CY1) for the first calendar year covered by the panel
- Second calendar year weight (CY2) for the second calendar year covered by the panel

Each of the weights is cohort based. The cohort is the noninstitutionalized U.S. population at the beginning of the corresponding reference period. Noninterviewed persons are defined as persons missing at least one interview during the reference period after the first interview of the corresponding reference month.

IV. CONCERNS/ISSUES RAISED ABOUT CURRENT WEIGHTS

Since we have implemented the current weighting scheme, data users have raised four basic concerns and/or issues about the weights. These include:

- Can we increase the amount of data that can be analyzed longitudinally?
- Do the current nonresponse adjustment procedures effectively reduce bias for nonrespondents?
- Is the current definition of the SIPP "cohort" and the time for which it is defined appropriate?
- Are the weights appropriate for all types of analyses?

We address each of these issues below.

A. Increasing the Amount of Data for Analysis

A number of analysts have indicated that the amount of usable sample from SIPP for certain types of longitudinal analysis is limited.

For example, Coder and Ruggles (1988) examined Aid to Families with Dependent Children (AFDC) data from the 1984 longitudinal panel research file. This file contains data for everyone we interviewed at least once during the life of the panel. It provides positive weights only for persons interviewed at each wave or who we interviewed at each wave before they died or became institutionalized. The entire file contains 998 cases with apparently valid AFDC receipt and 513 entries onto AFDC. Among the persons with positive weights, the corresponding numbers of cases and entries are only 571 and 318. Over 40% of the cases and entries of interest are not available for weighted analyses because the corresponding sample persons have zero weights. It is likely that these cases differ from those we have assigned positive weights.

In analyzing "nest leaving", Speare, et al. (1990) decided, when possible, to use all available information for completely and non-completely responding persons. They were concerned that limiting the analysis to those with complete interviews could seriously bias results. Doyle and Long (1988), McBride and Swartz (1990), and Ruggles (1990), expressed similar concerns when analyzing serial multiple program participation, health insurance coverage, and program duration, respectively.

Researchers explored two basic approaches to increase the amount of usable data: assign positive weights a) to persons interviewed at the first wave of a reference period who have missed some but not all waves of the reference period (Type 1 persons) and b) to persons who enter the sample after the first wave of the reference period (Type 2 persons). (Currently we use Type 2 persons only for obtaining cross-sectional estimates.)

1. Assigning Positive Weights to Type 1 Persons

Researchers explored two options of providing positive weights to persons interviewed at the first wave of a reference period who have missed some, but not all waves of a reference period - (a) imputing missing wave data and treating the case as complete or (b) increasing the number of sets of longitudinal weights.

Kalton and Miller (1986) explored (a) via a simulation study based on three waves of the 1984 panel. They compared the effect on survey estimates of using the current weighting method versus imputing for missing waves of data and treating the imputed cases as complete in the weighting process. They concluded that weighting may be preferred for large subclasses when the reduction in effective sample size is tolerable. Imputation, however, may be better for estimates based on small subclasses, when the loss in effective sample size matters and when any bias caused by imputation is less important relative to the sampling error. For the three-wave SIPP file, they found the difference in the effective sample sizes between the two solutions was not great. They concluded that weighting might be the safer general purpose solution. However, for a file that covers a period longer than a year this may not be the case.

Singh et al. (1990) used data from the 1984 panel to also explore approach (a). For the three types of estimates mentioned earlier - panel, calendar year 1, and calendar year 2 - they considered imputing data for cases with one missing interview in the period for which weights are developed. They estimated that this approach reduced standard errors about 3.0, 2.4, and 1.8 percent and increased sample size 7.5, 5.8, and 4.4 percent, respectively, for the panel, calendar year one, and calendar year two estimates. They also noted that for most types of estimates this approach would reduce nonresponse bias.

The approach reduces the number of noninterviews by about 17.5, 21, and 12 percent, respectively, for the three weights. The imputation method explored reduced bias and provided many more waves of data from the original noninterviews. The method introduces a bias in transition and spell estimates. However, it is small (the estimated maximum percent of transitions missed in a panel is 2.3%) and occurs at the wave level.

Singh et al. (1990) concluded that implementing the proposed imputation procedure with the current set of SIPP weighting procedures is a reasonable, yet cautious, solution to the problem of using more SIPP data. They suggested the need for more research on the effects of imputation for other characteristics.

Singh et al. (1990) additionally explored option (b). This approach maintains logical consistency and covariance structures and makes maximum use of the available data. When longitudinal comparisons are of interest, to make maximum use of the data, one needs all possible multiple weights. For an eight-wave SIPP panel, this would mean 247 weights for longitudinal analysis (Lepkowski, 1989). Since it would be expensive to produce and verify all possible weights and confusing, difficult, and cumbersome for users, Singh et al. considered limited sets of multiple weights. If the Bureau provided data users one of these sets, they could use more sample persons in longitudinal estimation since more persons have positive weights. While some of the options are attractive because of the increased use of available data, the increase in complexity to use the weights and the increase in cost to produce them are concerns.

If imputation could be done without error, then (a) should result in smaller biases and variances since we could include a larger portion of the sample in the estimates. A major obstacle to (a) is the development of a sound procedure for imputing missed interviews. With less effort, we can make more use of some missing interview cases by using option (b) (Ernst and Gillman, 1988). However, with each additional weight produced, costs increase and analysis becomes more confusing, difficult or cumbersome for users. (Ernst and Gillman, 1988; Singh, et al., 1990.)

2. Assigning Positive Weights to Type 2 Persons

For longitudinal estimates based on the first wave of a reference period cohort, giving persons who enter the sample after the first wave of a reference period positive weights is not necessary to obtain unbiased estimates. Inclusion of them can reduce variances. If their characteristics are similar enough to persons interviewed at the first wave of a reference period who have missed some, but not all waves of a reference period, they can reduce bias (Ernst and Gillman, 1988).

More persons who enter the sample after the first wave of a reference period could be given positive weights, and thus be used for analyses, if we followed such persons who no longer live with an original sample person. Even if we do not follow such persons, we could make more use of such persons by imputing for missing interviews or by using multiple weights.

The concerns mentioned earlier in using imputation and multiple weights also apply here. Additionally, following persons who enter the sample after the first wave of a reference period means an increase in field costs.

B. Effective Reduction of Nonresponse Bias

We currently adjust SIPP weights for person nonresponse using data which are correlated with nonresponse and the major estimates of the SIPP. Even so, for certain types of analysis, nonresponse bias may be a problem. For example, Bianchi (1991) analyzed marital separation and the economic well-being

of children and their absent fathers using the 1984 panel longitudinal research file. She expressed concern that we may introduce bias by restricting the sample to only children living with mothers who we successfully follow for 32 months and to fathers who we successfully follow for 32 months.

Although Bianchi presents no data supporting her point, she is concerned that the longitudinal nonresponse adjustment procedure may not adequately adjust for differences in the fully and partially interviewed cases. Her concern stems from work by Hernandez (1989) suggesting that SIPP's underestimates of number of persons who separate and/or divorce may be partly because the longitudinal weights do not adequately adjust for attrition related to residential moves.

In addition, Hock (1989) suggests that nonresponse may contribute a significant amount of bias to estimates of poverty from the 1984 panel research file.

On the other hand, Fitzgerald and Zuo (1991) conclude that though attrition can alter sample means for some characteristics, attrition may not be a large problem for welfare duration models using SIPP data. They believe that welfare duration analysis based on the panel weights and the complete sample will not suffer large loss of efficiency. Additionally, Klerman (1991) concluded that attrition bias does not appear to be a major problem for health insurance coverage.

Nonresponse research by Petroni (1991) suggests that the current cross-sectional noninterview adjustment while not fully accounting for attrition of low monthly income households, does reduce bias of income estimates. The research also shows that the noninterview adjustment has no apparent effect on reducing nonresponse bias for programs and benefits estimates. Because of these results, we might also expect SIPP longitudinal low income estimates to be biased.

Work by Ernst and Gillman (1988) gives some evidence that longitudinal weighting partially, but not completely, compensates for longitudinal nonresponse. They compared 1984 panel wave 1 estimates based on the wave 1 cross-sectional weight to wave 1 estimates based on the three-wave longitudinal file weight. This comparison suggested weighting partially compensates for nonresponse bias in estimates of marital status, relationship to reference person, educational level, tenure, and having a savings account. It did not give evidence that longitudinal weighting compensated for biases in income as a percentage of food stamp cutoff, household receipt of food stamps, and household receipt of means tested cash benefits. We expect that for the full longitudinal file, weighting also only partially compensates for longitudinal nonresponse.

McCormick (McCormick, 1992 and Petroni, 1991) used the 1984 panel to investigate the potential for a longitudinal mover nonresponse adjustment to reduce bias. Her findings suggest, if we include such an adjustment, bias reduction may be possible for longitudinal estimates of cash benefits, age, poverty, tenure, noncash benefits, and ethnicity.

C. Appropriate Definition of the SIPP "cohort"

Some analysts have also raised concerns about controlling longitudinal weights to a fixed point in time. Doyle and Long (1988) point out that since we adjust the longitudinal weights to independent controls established as of a fixed point in time, the longitudinal sample provides a picture of the dynamic characteristics of a cross-sectional sample of the population rather than a complete picture of the dynamic characteristics of the whole population. For their study of serial multiple program participation, the net effect of the weight adjustment is to suppress estimates of turnover, particularly in that the sample does not capture program entrants arising from births or immigrants. The effect is most severe for programs targeted to

certain groups, such as Supplemental Food Program for Women, Infants, and Children (WIC). It does, however, affect most of the other programs some.

Other analysts have raised the issue of the point-in-time to which we control SIPP estimates. McNeil (1990) states that analysts have to struggle with SIPP longitudinal weights adding to a total considerably less than Current Population Survey (CPS) totals for any point in the SIPP time frame. The SIPP panel universe appears small compared to CPS and SIPP quarterly universes because we control the panel weights to the beginning of the panel and because, when calculating estimates, we exclude positive weights for persons who died or were institutionalized. McNeil suggests viewing the SIPP panel universe as the number of noninstitutional persons as of the end of the panel. In this case, we would classify persons by their age at the end of the panel and give persons who died or were institutionalized a zero weight.

Judkins et al. (1984) considered three methods of defining a longitudinal universe - fix the composition at a given point-in-time, use the union of a set of cross-sectional universes, or use the intersection of a set of cross-sectional universes.

We may define the composition at various points in time. For example, it may be at the time the sample is drawn, at the midpoint of the panel duration, or at the end of the panel. In the first case, we would exclude all entrants from the longitudinal universe and allow only exits to alter the universe. In the second case, we would include entrances and exclude exits until the midpoint, when the situation reverses. In the last case, we would exclude all those who exit during the panel from the longitudinal universe and allow only entries to alter the universe. It is difficult to argue why we should select one point or another as the point in time to define the universe. For some purposes, one may need a different point than the one originally chosen (Judkins, et al. 1984).

Research by Pruitt (1992) shows that for longitudinal poverty estimates, the choice of beginning or ending panel cohort makes very little difference. Using the current cohort method, she found that the differences between poverty rates for all persons with positive weights and only those who remain in the universe are statistically significant, but analytically unimportant.

The union of sets of cross-sectional universes includes members of the target population as well as all persons who enter or exit during the panel period of interest. Of the three universe definitions, it best captures the dynamic characteristics of the population. However, it produces complications for data tabulations and users (Judkins, et al., 1984).

The intersection of sets of cross-sectional universes is more restrictive than the point-in-time definition. It does not allow entrants or exits.

D. Using Current Weights for Various Types of Analysis

The Bureau designed SIPP longitudinal weights for analyzing data from cases completely interviewed for the panel or for one of the two calendar years of the panel. However, due to concerns that limiting analysis to these cases will provide too few cases or will result in biased estimates, some analysts are using adjusted cross-sectional weights so they can use more cases. For example, to analyze "nest leaving", Speare, et al. (1990) applied wave 1 cross-sectional weights to a longitudinal data set. They are seeking guidelines on how to adjust the wave 1 weights to account for longitudinal nonresponse. To analyze SSI data, Vaughn and Wixon (1991) matched topical module data from waves 3 and 4, used data for cases interviewed in both waves, and adjusted the wave 4 weights to account for cases that were not interviewed in both waves.

Using the current weighting procedures, a possible solution to the selection of weights for analysis which includes those who miss some interviews follows. One could pick a given wave period as the cohort of interest. Every person interviewed at that wave receives a positive wave weight. Use these positively weighted persons as the cases to include in the longitudinal analysis and the weights at this wave as the initial longitudinal weight. If the analyst wants to exclude some of these cases as noninterviews because there are too few data for the case, the analyst should perform some type of nonresponse adjustment. Analysts will also need to make corresponding adjustments to variance parameters.

V. RESEARCH IN PROGRESS AND FUTURE PLANS

A number of research projects to address weighting issues and concerns are either in progress or are in the planning stages. The various projects evaluate impacts on the bias and variance of SIPP estimates. Those underway include:

- researching the use of a mover status adjustment to account for nonresponding movers (Petroni, 1991).
- investigating the use of an additional ratio adjustment to account for the undercoverage of movers (Petroni, 1991).
- researching the inclusion of Internal Revenue Service data as part of the current second stage weighting procedure. Research completed to date indicates good overall reductions in variance (Huggins and Fay, 1988).
- investigating alternative methods of compensation for wave and item nonresponse.

Research in the planning stages includes:

- investigating exponential and logistic model based approaches as alternatives to the current weighting scheme (Folsom, 1991).
- researching other regression model based approaches as alternatives to the current weighting scheme.
- investigating the extent to which the treatment of type 1 and type 2 persons in weighting causes or exacerbates SIPP biases in poverty, divorce, and migration estimates.
- integrating and refining the promising weighting approaches to improve SIPP weighting.

We will use results of past research, research in progress, and planned research in conjunction with data users needs to guide decisions about future weighting methodology for the SIPP.

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