THE SURVEY OF INCOME AND
PROGRAM PARTICIPATION

HANDLING SINGLE WAVE NONRESPONSE IN PANEL SURVEYS

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I. INTRODUCTION

In cross-sectional surveys, nonresponse is categorized in two ways: unit (total) nonresponse and item nonresponse. Unit nonresponse occurs when no data are available on the sampled unit, while item nonresponse occurs when a responding unit fails to provide data for one or more items in the questionnaire. These two types of nonresponse differ in the availability of data for nonresponse compensation and usually in the approaches used for missing data compensation.

For unit nonrespondents, no data are available other than from observation of the nonresponding unit and the sampling frame itself. Compensation for unit nonresponse is usually handled through weighting adjustments, a procedure in which the weights of appropriate respondent records are increased to compensate for nonrespondents. For item nonresponse, much more data are available about the respondent, namely the responses to other items in the questionnaire. As a consequence, some form of imputation, a procedure in which values are assigned for the missing responses, is usually implemented.

In longitudinal surveys, a third type of nonresponse exists--wave nonresponse. Wave nonresponse occurs when a sample unit does not respond in one or more interviews of a longitudinal survey but has provided data for at least one interview. In this situation, considerably more data are missing compared to the item nonresponse situation; however, considerably more data are available for use in nonresponse compensation strategies. This category of nonresponse falls between unit and item nonresponse as far as the availability of data for nonresponse compensation strategies. This paper proposes two simple, inexpensive and easy to implement approaches to handle single wave nonresponse in the Survey of Income and Program Participation (SIPP) for use in longitudinal estimation.

Section II of this paper presents background on the SIPP design and Section III includes a discussion of nonresponse types and their treatment in the SIPP. A general discussion of Wave nonresponse compensation strategies is presented in Section IV. Sections V and VI present imputation and multiple weighting strategies respectively to compensate for a missing interview in the SIPP. A comparison of selected options for handling a missing wave is presented in Section VII. Section VIII presents conclusions and suggestions for implementation and further research.

II. BACKGROUND AND SIPP DESIGN

The Survey of Income and Program Participation (SIPP) is designed to provide cross-sectional and longitudinal data on labor force, income, government programs

and other person and household characteristics that may influence an individual's economic well-being. The data collected from the SIPP enable analysts to understand the relationship between demographic and life events and their affect on socio-economic conditions of the noninstitutional population of the United States. This information is important for improving the ability of U.S. federal agencies to formulate and evaluate policies and programs in the areas of income and social welfare.

The SIPP is a multistage, stratified, systematic sample of the noninstitutionalized resident population of the United States. Initially, sample clusters of living quarters in selected Primary Sampling Units (PSUs) is taken. Persons residing in these living quarters at the time of the first interview are considered to be in sample. However, only persons who are at least 15 years of age at the time of each interview are eligible for interview. Limited data on children are also collected by proxy interviews. Persons 15 years old and over in the sample are interviewed up to eight times at four month intervals. With certain restrictions, only original sample persons (those interviewed in the first interview) are followed if they move to a new address. Persons who began living with original sample persons after the first interview are considered to be part of the sample only while residing with the sample persons.

The sample is divided into four groups of equal size called rotation groups. An introduction of a new SIPP panel is staggered over 4 months (i.e., February - May), one rotation group each month. In general, one cycle of four rotation groups is called a wave. The reference period for each interview is the four months preceding the interview month. For example, for the 1989 SIPP panel, the reference period for the July 1989 interview month was March through June 1989. These sample persons were interviewed again in November 1989 for the July 1989 through October 1989 period. This design enables us to collect up to 32 months of data on sample persons, thus, providing data for the entire panel (i.e., 32 months or eight interviews) and two consecutive calendar years. More details on the SIPP design are given in Nelson, McMillen, and Kasprzyk (1985), Jabine et al. (1990).

Noninterviewed households for Wave 1 are designated as noninterviews for all subsequent waves. Additional noninterviews result when original sample persons move without leaving a forwarding address, move to remote parts of the country and no telephone number is available or refuse to participate at later interviews.

Due to the longitudinal nature (multiple interviews) of the survey, the unit noninterview rate accumulates over the life of the panel. As shown below, starting at about 5%-7% at the time of the first interview, it reaches about 20 percent for the last interview of each panel.

Percent Cumulative Nonresponse Rate by Wave

	1	2	3	4	5	6	7	8
1984 Panel	4.9	9.4	12.3	15.4	17.4	19.4	21.0	22.0
1985 Panel	6.7	10.8	13.3	16.3	18.8	19.7	20.5	20.8
1986 Panel	7.3	13.4	15.2	17.1	19.3	20.0	20.6	--

The 1986 panel noninterview rates of those persons who miss at least one interview are 27%, 21% and 27% for panel, first calendar year and the second calendar year data, respectively. This is what we call wave nonresponse. Since current longitudinal weighting procedures were developed for the estimates of persons, the discussion in this paper focuses on examining options to reduce the effects of wave nonresponse of persons.

The next section briefly explains noninterview adjustment methods developed and currently in use for SIPP longitudinal person estimation.

III. NONRESPONSE TYPES AND THEIR TREATMENT

The following is a discussion of types of nonresponse and their treatment in the estimation procedures currently used in the SIPP.

A. Item Nonresponse

Imputation is used for item nonresponse in the SIPP. Some items (such as race, sex, age etc.) are longitudinally edited or imputed using a hot deck procedure. This approach provides consistency in data between interviews. For most items, hot deck imputation based on multiple variables is used with certain constraints to provide logically consistent data only within a given interview.

B. Unit Nonresponse

Unit nonresponse occurs when every member of the household is a noninterview. This is also called household nonresponse and can occur at any wave of interviewing. However, here we only refer to households not interviewed in the first wave of the reference period for which we wish to develop estimates.

A noninterview weighting adjustment is used to account for all persons in households who could not be interviewed at the first wave of the reference period covered by the interval for which the longitudinal weights are developed.

C. Wave Nonresponse

Wave nonresponse occurs when an interview is not obtained in a succeeding wave for a member of a previously interviewed household.

A second noninterview adjustment is made at the person level to account for those persons who could not be interviewed for at least one of the waves and did not live in a nonresponding household at the first wave covering the reference period of interest. In addition, a complete record for individual nonrespondents within an otherwise cooperating household is imputed using a hot deck approach to allow the calculation of household attributes for longitudinal analysis. These persons however, currently receive longitudinal weights (weights for longitudinal analysis) of zero but positive cross-sectional weights. The current approach of handling wave nonresponse is very expensive since resources have been used to collect the data for use in cross-sectional estimation but this information is not being used for longitudinal estimation.

IV. WAVE NONRESPONSE COMPENSATION STRATEGIES

Imputation is commonly used to handle missing data. Values for missing responses are assigned by making use of auxiliary variables. These variables are known or believed to be highly correlated with the data to be imputed. A great deal of literature is available on imputation among which are Rubin (1986, 1987), Kalton and Kasprzyk (1982), Kalton and Lepkowski (1983), Herringa and Lepkowski (1986), Samuhel and Huggins (1985), Little (1982, 1983).

The effectiveness of imputation for cross-sectional estimation is well documented by Kalton and Miller (1986), Cox and Cohen (1985) and others. They found that imputation techniques can work well for some cross-sectional estimates. However, for longitudinal imputation, it is extremely important to have a procedure which provides imputed data logically consistent in a given time period as well as across time periods. In addition, the procedure should maintain the internal covariance structure and should not adversely affect estimates of transition from one state to another. These properties are important for longitudinal analysis in the SIPP since one of the primary goals is to understand underlying reasons for changes in economic well-being cause and effect with regard to labor force participation and the economic condition of the population. However, satisfying these constraints leads to some very complicated imputation procedures.

In the SIPP, cumulative wave nonresponse for each panel in which one or more interviews is missing for a respondent is around 30%. This loss in sample size results in less accurate estimates and higher variances. The reduction in sample size due to nonresponse critically affects whether meaningful analysis is possible for many small but, policy relevant subgroups. Therefore, it is important that every effort be made

examine the feasibility of using the data of persons who participated in some but not all of the interviews of the survey.

One approach to the treatment of individuals who miss one or more interviews in a panel survey is to use imputation procedures. An alternative approach to imputations which satisfies the properties of logical consistency and maintenance of covariance structures while making maximum use of the available data is to use multiple weights. Multiple weights are a selected number of sample weights, each of which is used for a particular interviewing pattern. The multiple weights approach has been used in various panel surveys, including the National Longitudinal Survey of the Class of 1972 and the National Medical Care Utilization and Expenditure Survey (NMCUES).

In a panel survey, both imputation and multiple weight approaches have their advantages and disadvantages. Kalton and Kasprzyk (1982) indicate that the appropriate choice depends on uses of the data. Lepkowski (1989) notes that when longitudinal comparisons are of interest and one wishes to use the maximum data available, all possible multiple weights are required. This means that in a panel survey, the number of weights increases as the number of interviews increases. For an eight-wave SIPP panel, one could produce 247 (28-1-8) weights for longitudinal analysis.

The number of weights required for longitudinal analysis can be reduced if fewer interview patterns are considered. However, depending on the patterns, this approach may still eliminate large amounts of collected data from analyses. For example, in the SIPP 1984 panel file, only 3 weights--panel weight, calendar year 1 and calendar year 2--were developed (Kobilarcik and Singh, 1986). According to this approach, positive weights are assigned to only those who had data for all reference months for the designated time period. Those who missed at least one interview were assigned a weight of zero. This is also the current procedure for the SIPP 1984-1988 panels and is satisfactory when wave nonresponse is low, otherwise alternatives should be investigated to make maximum use of available data.

Kalton (1986), Lepkowski (1989), and Kalton and Lepkowski (1983) studied various approaches for imputation and various patterns of missing waves. One of the approaches they considered was a simple carryover imputation of a completed interview to a subsequent missing interview. Kalton and Miller (1986) found it difficult to draw general conclusions from their limited investigation; however, they did find that the quality of the weighting adjustment for wave nonresponse was comparable to carry-over imputation. While weighting adjustments reduced precision by discarding about 10% of the records, it was better with respect to estimation of transitions. Based on three waves of data from the 1984 SIPP panel, Lepkowski (1989) found the quality of the compensation provided by the carry-over imputation and the weighting methods depended on the type of analysis of interest. The results of these studies should be treated cautiously since the length of the panel was short (12 months) and overall nonresponse was low.

It is not obvious from the literature on imputation and multiple weighting which methodology (if not both) should be implemented in the SIPP. The remainder of the paper describes an investigation into simple imputation and multiple weighting adjustments as they apply to the SIPP and the conclusions reached.

V. COMBINATION OF WEIGHTING AND IMPUTATION TO COMPENSATE FOR A MISSING WAVE IN SIPP

Since wave nonresponse can be high for an 8 wave panel, we researched imputation methods for nonconsecutive missing waves. Crosswave hot decks, multiple item and regression imputation methods were rejected because of complexity, cost and their adverse affect on transitions and internal covariance structures. [See Heeringa and Lepkowski (1986), Cox and Cohen (1985)].

Before investigating imputation and weighting procedures for wave nonresponse, the Census Bureau attempted to collect retrospective data from the missing interview at a subsequent interview (Singh, 1983, 1986; Huggins, 1987). Results from this experiment indicated little change between the missed and bounding interviews, suggesting that a strong correlation exists for most of the items between two consecutive interviews. This is supported by correlations computed by Kalton et al. (1985). As a consequence, we considered a combined imputation and weighting approach. This approach uses imputation when only one wave is missing while other noninterview patterns are ratio adjusted by the weighting approach. The following discussion is based on this combined approach and will be referred to as the "imputation methodology" in this paper.

Kalton (1986) states that, in general, the value imputed for the ith nonrespondent on a variable y is

$$y_i = f(x) + e_i,$$

where f(x) is often a linear function and covers regression imputation as well as cell imputation - such as cold deck or hot deck procedures by defining x's as dummy variables to represent the cells. A simple case of the regression approach can be defined as

$$y_i = a + bx_i + e_i$$

The approach discussed in this paper is a special case of this model where $a = e_i = 0$, $b = 1$ and x is a value of y from another wave on the same respondent. As discussed later, this approach understates changes; however, this understatement can be avoided by using the above model as a stochastic imputation by assigning e_i's from respondents using a hot deck approach. Because of the strong correlations between consecutive interview data, the method considered is to impute nonconsecutive missing

interviews using data from the completed interviews immediately before or after the missing interview--the carry-over imputation approach. Consideration of a stochastic model is a subject of future research and will not be considered in this paper.

Many variations of the carry over imputation method are possible. An easy approach is to copy the entire four months of person and household data from one of the completed interviews to the missing interview; another approach is to copy data from one of the two months adjacent to the missing interview into each of the four missing months. However, the effect of imputation on transition and spell estimates could be reduced by the following approach: copy data for the last month before the missing interview into the first r ($r=0,1,2,3,4$) missing months and copy data for the first month after the missing interview into the remaining 4-r missing months. The number r would be chosen to reduce the bias of transition and spell estimates for important characteristics. For example, if we assume the status of an item changed between the two months which bracket the four missing months, then we know at least one transition occurred.

Taking $r=2$ for all imputed persons would place any such transition at the middle of the missing interview reference months; r could be selected randomly for each imputed person. A more complex approach to selecting r would be to choose r for a person such that the resultant spell length for a given item for that person would, on average, equal the average spell length for that item. The item on which the choice of r is based could be selected from among items considered to be most important to the survey and could change from person to person depending on the person's pattern of transitions.

Under the combined imputation and weighting methods, a carry-over imputation provides a substitution for one wave of missing data. The imputed data will be identified for data users, but will be treated as real data for developing longitudinal weights for all other nonresponse patterns.

The primary advantage of the imputation method discussed here is its simplicity. Another advantage to this method is the reduction in nonresponse bias for some estimates. McArthur (1988) compared the characteristics of persons who participated in eight interviews of the 1984 SIPP panel to persons who missed only one interview. For example, the group missing one interview contained a higher percentage of nonwhites, renters, and movers than the group who did not miss any interviews. Significant differences between these two groups were found for several other characteristics as well, including age and marital status (but not for recipiency of cash and noncash benefits or monthly income). Therefore, nonresponse bias for renters, movers, and some others may be significantly increased by the exclusion of persons with only one missing interview. Reducing the number of such persons should reduce nonresponse bias due to an increase in the available sample. The possible gains in sample size due to imputation for nonconsecutive missing interviews are discussed in

Section III.A.1. and the effect on bias for transition estimates is discussed in Section III.A.2.

A. Effect on Sample Size and Nonresponse Bias

If the general carry-over method of longitudinal imputation is used, the percent increase in the number of persons with positive weights is expected to be about the same as the percent of persons with one missing interview as shown in table 1 for the SIPP panel, calendar year 1984 (CY84) and calendar year 1985 (CY85) weights. A summary of these interviewing patterns is given in table 2.

Table 1 indicates that almost all the gains in sample size from the carry-over imputation method are achieved by imputation for persons with one missing interview in the time period for which the weights are developed (i.e., panel, 84CY, or 85CY). Therefore, only imputation for one interview in the period covered by a longitudinal weight is considered here.

1. Panel Weights

Table 3 shows the 32,985 persons whose interviewing patterns were considered by McArthur (1988); of these, 23,027 participated in the first eight interviews and, therefore, should have positive panel weights on the longitudinal (8 interview) file. Table 1 shows 1,740 persons missed one of the first eight interviews (but not the first or the eighth interview). Imputing one missing interview for these persons would increase the number of sample cases that can be used in estimation from 23,027 to 24,767 (an increase of 7.5 percent).

Before imputation, the number of completed interviews was about 23,027 X 8 = 184,216. Imputation for one missing interview would add about 1,740 X 7 = 12,180 more completed interviews for panel estimation, an increase of 6.6 percent. Few persons had two or more nonconsecutive missing interviews and imputation for these persons would not add significantly to the sample.

Now, consider the effect the increase in sample would have on the variance of an estimate of the percent of persons, p, in some subgroup of the total population. Assume that within-PSU variance is about 85 percent of total variance and can be approximated by the simple random sampling variance based on a sample size of n:

$$s^2 = \text{deff } p(100 - p)/n \,. \qquad (1)$$

Deff is the design effect of the SIPP sample design. For estimates of demographic characteristics which cannot change over time (such as the percent of persons with a given race or sex), the effect of imputation on the

variance should be about the same as the effect of increasing n by the number of additional sample persons (a 7.5 percent increase). In that case, the total variance will decrease about 5.9 percent and the standard error will decrease about 3.0 percent.

However, note that the number of noninterviewed persons adjusted through the noninterview adjustment is also reduced. The number of noninterviews is reduced about 17.5 percent as shown in the last column of table 1. This is extremely important since we know some nonresponse bias exists in the SIPP. By reducing the number of noninterviews through imputation of missing waves, we reduce nonresponse bias in SIPP estimates.

2. 1984 Calendar Year Weights

Table 3 provides the same information for the 84CY, but using data only from the second through fifth interviews. Of the 32,985 sample persons used in McArthur (1988), 25,856 (78.4 percent as shown in table 3) participated in the second through fifth interviews and should have positive 84CY weights on the longitudinal file.

Table 1 shows that in 1,495 cases, only one of the four interviews was missed. Very few persons missed two nonconsecutive interviews in this time period. Imputing these 1,495 cases would increase the available sample by 5.8 percent to 27,351. A 5.8 percent increase in available sample would cause about a 4.7 percent decrease in total variance and about a 2.4 percent decrease in standard error. Noninterviews are reduced by 21%.

3. 1985 Calendar Year Weights

Table 3 again repeats the analysis for the 85CY with the same data file, but uses information from the fifth through eighth interviews. This should approximate results for the 85CY weights of the longitudinal panel (some differences exist because persons who entered the sample after the first interview and persons who turned 15 between the time of the first and fifth interviews are not included in table 3. However, both these groups could have positive 85CY weights.) Imputation for persons with only one missing interview would add 1,046 persons (see table 3) to the 23,971 participants in waves 5 through 8, an increase of 4.4 percent to 25,017 persons. It would cause decreases of about 3.6 percent in total variance and about 1.8 percent in standard error. Again, nonresponse bias would be reduced somewhat since the number of noninterviews declines by 12%.

B. Effect on Bias

Copying data into missing interview months will produce some bias for descriptive statistics. Transition and spell estimates would perhaps be most directly affected, with the amount of bias depending on the stability of the characteristic of interest and the number of imputed interviews. Results using analytical techniques, such as regression, could also be affected. The optimal imputation method is likely to vary for different techniques and is very different from the simple, global imputation method proposed here.

Because of a concern for the effects of imputation on transition estimates, a simple simulation study was conducted to estimate bias in transition estimates using the proposed carry-over imputation approach. Using tables from Coder (1986), the number of transitions (x) within wave 2 of the 1984 Panel was obtained. This number (x) was obtained for nine income types and is found in column 1 of table 4. The data were limited to wave 2 because the tables provided information for only the first three interviews of the panel. We assumed that the rate of within wave transitions for a specific income type is similar for each wave of response.

The pattern of response containing the most cases with only one missing interview, excluding interviews 1 and 8, was the pattern with only wave 4 missing (361 cases in the 1984 panel). The ratio of cases missing only wave 4 to cases with all interviews completed in the 1984 panel is approximately 1.5 percent. We assumed that this same ratio applies to the number of within wave transitions for the 361 cases that would be imputed (i.e., the number of within wave transitions in the estimated imputed cases for one wave is 1.5 percent of the within wave transitions in the 23,027 completed cases).

Multiplying the within wave transitions for one wave by six [i.e., 6(0.015x)] gives an estimate of the maximum number of within wave transitions that should occur for imputed cases for the entire panel. This estimate is a maximum because patterns of response missing only waves 2, 3, 5, 6, or 7 have fewer cases with only one interview missing than the pattern of response missing only wave 4.

Not all of the within wave transitions for the imputed cases would be missed with the proposed imputation methodology. Some would be accounted for due to the imputation method being considered. For example, suppose that in the last month before a missing interview a person received a particular type of income. Also, suppose that in the first month after the missing interview the person did not receive this income. At least one transition occurred during the missing months. With the proposed imputation methodology it is a certainty that one and only one transition would be accounted for; the transition, however, may not be reported in the correct month.

The transition may not always occur during the four missing months. It may occur at the seam between the last missing month and the first month following the missing interview. These transitions are considered within wave transitions for this study. We did not have the data necessary to estimate the percentage of within wave transitions that could be accounted for as in the example above. To get a feel for this percentage we considered all possible recipiency patterns (see tables 5-8) for the six consecutive months from the last month before to the first month after a missing interview.

In these patterns 160 transitions occur, 32 of which can be accounted for with the proposed imputation methodology. Assuming each pattern is equally likely to occur, we estimate that about 80 percent of all within wave transitions for imputed cases would actually be missed. This adversely affects spell estimates with their lengths up to four months. About 60% of these missed transitions will be those that result in one month spells.

The assumption that all patterns of response occur with equal probability at first glance, appears to underestimate the number of transitions that would be missed due to imputation. However, the majority of persons in the SIPP do not participate in any government program during a wave (i.e., all zeros as indicated in the last row of table 6). For these people no transitions occur. This pattern of response occurs with greater probability than any other response pattern. So, assuming that all patterns of response are equally likely will overestimate the number of transitions missed due to imputation. Therefore, any bias estimate obtained will be a comfortable upper bound.

Using the methodology described above and data from Coder (1986), estimates of the number and percent of transitions missed using the proposed imputation procedure were calculated. Column 7 of table 4 indicates that total transitions missed in the 361 imputed cases for the 9 characteristics observed range from 2 to 295. However, the percentage of transitions we expect to miss due to the imputation method is small, approximately 1.2% for all characteristics. This is calculated by dividing column 6 by the sum of columns one and four for any characteristic.

Perhaps transitions are more likely to occur in missed interviews rather than completed interviews. This implies that the ratio of within wave transitions to usable cases is not the same for imputed cases as we had assumed earlier. Therefore, assume that the rates are not equal. Assume that within wave transitions are twice as likely to occur in missed interviews for whatever reasons (e.g., people out of town looking for work at the time of the interview). How will this effect our estimates?

By doubling the estimates of the number of within wave transitions and doubling the within wave transitions we would expect to miss under this procedure, the percentage of within wave transitions we would expect to miss is about 2.3%. We believe that the maximum loss observed in estimates of the number of transitions even with doubling our estimates is not too large considering the simplicity of the imputation procedure.

If for certain items, however, this procedure affects transitions more seriously, the following exception could be applied to the methodology to improve the quality of transitions and spell estimates dealing with Government programs such as social security (SS). All social security income recipients receive cost of living increase (COLA) at a known time. Based on this knowledge, missing interview data for SS recipients could be imputed from a previous interview up to the time of COLA increase and the remaining (including COLA increase) months from the later interview. This approach could be applied to Social Security, Food Stamps, and Supplemental Security Income and possibly other items.

Another important point to mention is that data users are not constrained to use imputations prepared by the Census Bureau. Imputations for items and persons are identified on SIPP data files. Therefore, users may wish to develop their own imputation procedures.

Chart 1 provides a pictorial summary of the bias advantage of the proposed imputation method. In the current longitudinal weighting procedures the weights of 23,027 persons are adjusted to account for 1,740 noninterviews who miss only one wave. Since we know nonresponse bias exists in SIPP estimates, 23,027 persons are affected. With the proposed imputation methodology, bias is reduced for the 23,027 fully interviewed persons by making many more waves of data available from the original noninterviews. A bias is introduced in transition and spell estimates, but it is small and it occurs at the wave level.

VI. MULTIPLE WEIGHTS TO COMPENSATE FOR A MISSING INTERVIEW

As an alternative to imputation, we investigated the use of multiple weights. Multiple weights allow greater use of the SIPP sample. Using all possible weights results in 247 weights for SIPP longitudinal analysis. These would be very expensive to produce and verify. In addition, documentation and explanation of these weights to users will be confusing, difficult and cumbersome. Use of different weights will also result in different estimates for the same item and the same time period which could lead to additional confusion. Therefore, we did not consider producing all possible weights as a viable operational option. Also, we excluded cases missing the first interview in the time period of interest for which longitudinal weights are developed.

The method considered here is to provide multiple weights on the longitudinal file for selected combinations of interview patterns. As mentioned earlier, the current SIPP longitudinal weighting scheme does not use cases with one or more missing interviews within the time period covered by the weight (i.e., panel, 84CY, 85CY). By providing selected multiple weights, more sample persons could be used in longitudinal estimation since some of the currently zero weighted persons would be assigned positive weights.

For example, suppose a wave one interviewed person misses only one subsequent interview. Instead of not using the data from the other seven interviews, a panel weight for cases with the same interview pattern (those missing no interviews and those missing one interview) could be provided on the file.

As another example, perhaps a weight is desired for persons interviewed in two waves containing topical modules that are to be analyzed together. A separate weight could be provided for each combination of waves for which users express a need. Many options to this basic method are possible. Five of these options are considered below--only option 2 and option 5 assume some type of imputation for missing interviews by the Census Bureau. For those options imputed data would be identified, so that users may either develop their own imputation method or use the current weights (no imputation for missing interviews) provided on the longitudinal file.

The first option discussed is the current SIPP longitudinal weighting scheme. The remaining four options are compared to option one in terms of sample gained for use in estimation and reduction in the standard error for an estimate of persons, p, in some subgroup of the total population. Table 9 provides a summary of the options.

A. Option 1 -- Current Longitudinal Weighting Approach

The first option considered is the current SIPP longitudinal weighting scheme. This option provides three weights on the longitudinal file. One weight is for the panel (cases with no missing interviews for the entire panel), another is for the 84CY (cases with no missing interviews from wave 2 through wave 5), and a third weight for the 85CY (cases with no missing interviews from wave 5 through wave 8).

B. Option 2 -- Combined Weighting and Imputation Approach

The second option is a combination of option 1 and the imputation strategy when only one interview is missed for the period of interest. This option calls for six weights--three weights from option 1 and three additional weights. The three additional weights (panel, 84CY, 85CY) are developed after imputation for cases missing one interview for the time period of interest. The addition of these cases would decrease the standard error of a proportion (p) for the panel, 84CY and

85CY by approximately 5.9 percent 2.4 percent and 1.8 percent, respectively. Another variation providing additional sample for calendar year estimates allows imputation for the first interview covering each of the two calendar years. Since interviews may bound this particular missing interview on either side, imputation based on the simple methodology is possible.

C. Option 3 -- Different Weight for Each Missed Wave

The third option produces a weight when no interviews are missing for the time period and one weight each when one of the interviews is missing during the time period. For example, suppose waves 2-4 constitute the desired time period for analysts. In this case, three weights would be produced--one for cases with all three interviews completed, one for cases with all interviews completed plus cases with only the wave 3 interview missing, and one for cases with all interviews completed plus cases with only the wave 4 interview missing.

Information from the first interview of the time period is needed to classify cases as interviewed or noninterviewed in our noninterview adjustment procedures. As a consequence, no weight would be provided for the cases missing the wave 2 interview because it is the first interview in the desired time period.

1. Panel

A total of eight weights would be provided on the file for the panel. One weight for cases with eight interviews completed and seven other weights, one each for the cases added by including interview patterns with one missing interview.

The first of these seven weights would be based on cases with only the eighth wave interview missing plus cases with all eight interviews completed. The increase in available sample and the reduction in standard error by interview patterns are summarized in option 3 of table 9.

2. 1984 Calendar Year Weights

A total of four weights would be provided on the file for the 84CY. One weight would be for cases with all interviews two through five completed. The other three weights would be for the three interview patterns with one missing interview. The first of these other three weights would be based on cases with only the fifth interview missing plus the cases with all four 84CY interviews completed. The increases in sample and reductions in standard error are summarized in option 3 of table 9. The interview pattern with only wave 5 missing would produce the largest sample gain and standard error reduction for the 84CY.

3. 1985 Calendar Year Weights

A total of four weights would be provided on the file for the 85CY similar to the 84CY weights. One weight would be for cases with all interviews five through eight completed. The other three weights would be for the three interview patterns with one missing interview in addition to the cases with all four interviews completed. The first of these other three weights would be based on cases with only the eighth wave interview missing plus the cases with all four 85CY interviews completed. The increases in sample and reductions in standard error are summarized in option 3 of table 9. The increases in sample using the interview pattern with only wave 8 as a noninterview would produce the largest sample gain and standard error reduction for the 85CY.

D. Option 4 -- Two-Wave Topical Module Weights

This option would provide the three weights currently produced by the SIPP longitudinal weighting scheme as well as several other weights for pairs of waves containing topical modules that could be analyzed together. For example, we consider three pairs of waves--waves 4 and 7, waves 3 and 8, and waves 3 and 6. The total number of weights for this option would be six. Results for the combinations of waves are summarized in option 4 of table 9.

In order for a person to be eligible for this two wave weight, interviews for both waves must be completed.

E. Option 5 -- Option 2 and Option 4 Combined

The final option is a combination of option 2 and option 4. A total of 9 weights would be provided on the file. The first three weights would be the three weights currently produced by the SIPP longitudinal weighting scheme. Another three weights (panel, 84CY, 85CY) would be produced based on the cases with all interviews completed plus all imputed cases with only one missing interview during the time period desired. Three additional weights, one for each pair of completed interviews containing topical modules of interest that could be analyzed together, would be provided.

It is important to note that with any of these multiple weight options, detailed documentation for analysis is extremely important for correct estimation. This documentation should include flags or identifiers on data files about the patterns of interviewing that result in a particular weight.

The goal here is not only to find methods to make better use of all collected SIPP data but also to ensure that the methods are understood and used by the SIPP data user community.

VII. COMPARISON OF SELECTED OPTIONS FOR MISSING WAVE COMPENSATION

Option 5 makes the most sample available to users for estimation--7.5 percent more than currently provided due to cases with only one missing interview for the entire panel, 8.8 percent more for the waves 4 and 7 combination, 7.7 percent more for the waves 3 and 8 combination, and 11.7 percent more for the waves 3 nd 6 combination. The standard error reduction due to these increases in sample range from 3.0 percent for the panel to 4.6 percent for the combination of waves 3 and 6. The major disadvantage to this option is that it would require nine weights on the panel file possibly causing confusion for the users and a multitude of changes in the current processing system. But the major advantages of this option are that it provides significant sample gains and flexibility by providing a panel weight, an 84CY weight, an 85CY weight, and two-wave topical module weights.

Options 2 and 4 each provides significant gains in sample, but option 2 provides gains only for the panel, the 84CY, and the 85CY while option 4 only provides gains for the two-wave topical module weights. However, option 2 and option 4 require only six weights each. This would be somewhat less confusing than having nine weights on the longitudinal file as option 5 would provide. Option 3 provides the least amount of sample gain and standard error reduction per weight and would require the most weights--eight panel weights, four 84CY weights, and four 85CY weights.

Complexity and cost are important criteria in examining these options. However, input from the data user community both inside and outside the Census Bureau on their requirements is needed to decide the relative importance of each option.

VIII. CONCLUSION

As the discussion above suggests, there is no clear cut solution to the problem of nonresponse compensation for individuals who miss one or more waves of interviewing in a panel survey. Indeed, in the case of the SIPP, this issue may be even more problematic since the SIPP is a general purpose survey on economic well-being. As such, the survey tries to fill the role of supplying both cross-sectional and longitudinal data. These conflicting analytic goals complicate the selection of one of the options. Lepkowski (1989) suggests the following criteria to help make the decision: 1) practicality; 2) flexibility; 3) quality; 4) precision; and 5) preservation of relationships. The implicit strategy used by SIPP in the past emphasized practicality (from the data producer's point of view) and the preservation of relationships.

With the experience of releasing several panels of multi-wave data the following observations have emerged. First, as in the case of any panel survey, the panel files from the SIPP can be difficult for analysts to use. Thus, it is important in the early years of the SIPP to not overly complicate the files in the interest of statistical rigor

with respect to nonresponse compensation approaches. Second, some analysts of SIPP data feel that current panel estimation procedures do not adequately compensate for panel nonresponse (as defined in the SIPP). Third, most analysts who use data from the SIPP study subgroups of policy importance, and as such want to use as many of the SIPP sample cases as possible to improve the reliability of their estimates. Fourth, any procedure implemented should be subjected to a rigorous empirical evaluation as to the reasonableness of a number of estimates. Fifth, the current panel estimation procedure discards a substantial number of cases, resulting in an inefficient use of the collected data. Sixth, analysts as well as statisticians appear to be divided on the best approach to take in this matter. Seventh, major changes to the current data processing production system will, as they have in the past, lead to delays in the delivery of SIPP data products to the public.

The above observations lead one to implement operational changes conservatively, using the reported data more efficiently, while at the same time performing empirical evaluations of these changes. The first panel data products of the SIPP were research products in the sense that some of the statistical and processing procedures used were preliminary, requiring further study. It is desirable that the next set of panel products released in the early 1990 's represent the next step in the development of SIPP panel products. In our view, implementing the proposed imputation procedure with the current set of SIPP weights represents a reasonable, yet cautious solution to the problem of minimizing the effects of wave nonresponse. This suggestion seems not particularly difficult to implement, yet it adds a considerable number of cases to the database of panel respondents, thus raising Lepkowski's criterion of "precision" to greater importance. However, providing two sets of weights as in option 2 - one with imputed data, one without - does not appear to be of great advantage since simulation results show little degredation, in quality of transition and spell estimates. To be cautious, however, more research on the effects of the imputation should be pursued for other characteristics - only nine were examined here. Providing one set of weights (panel and two calendar years) of which each include imputation for one missing interview is a clear compromise.

In terms of the SIPP program, this strategy is an acceptable one provided that: 1) implementing this option does not delay the release of public data products; 2) imputations for missing wave nonresponse are easily identified by the data user; 3) estimation universes for the three weights are easily identified by the analyst; 4) the public data products developed using these procedures continue to be viewed as "research", requiring evaluation and study; 5) substantive analysis using both the imputed data and nonimputed data to ascertain the robustness of the imputation methodology be conducted (this can be done by imputing data and re-run weighting on earlier panels of SIPP data and comparing estimates); 6) a program of research to determine appropriate cells for panel nonresponse weighting adjustments be initiated; 7) a program of user feedback be initiated to obtain user reactions to the new procedures.

Table 1. Number of Nonconsecutive Interviews Missed for the SIPP 1984 Panel

Number of Missed[1] Nonconsecutive Interviews	Total	Cumulative Total	Cumulative Gain in Usable Sample (%)	Cumulative Reduction of Noninterviews (%)
Panel				
One	1740	1740	7.5	17.5
Two	141	1881	8.2	18.9
Three	4	1885	8.2	18.9
84CY				
One	1495	1495	5.8	21.0
Two	49	1544	6.0	21.7
85CY				
One	1046	1046	4.4	11.6
Two	26	1072	4.5	11.9

[1] Not counting persons who missed the last interview.

Table 2. Interviewing Patterns for the 1984 Panel

Missing Zero Waves

Pattern	Cases
11111111	23,027

Missing One Wave

Pattern	Cases
11111110	655
11101111	361
11111101	334
11111011	334
11011111	295
11110111	253
10111111	163
Total	2,395

Missing Two Waves

Pattern	Cases
11111100	637
11111001	62
11111010	58
11001111	57
11100111	53
11110011	51
10011111	36
11110110	35
11011011	25
11110101	24
11101011	22
11101110	17
11011101	14
11011110	14
11010111	13
10101111	13
11101101	12
10111110	10
10111101	6
10111011	6
10110111	6
Total	1,171

Missing Three Waves

Total 1,044

Missing Four Waves

Total 1,179

Missing Five Waves

Total 1,252

Missing Six Waves

Total 1,365

Missing Seven Waves

Total 1,543

Note: The number of cases for each interview pattern in this table is based on linked cross-sectional files from McArthur (1988).

Table 3. Response Patterns for the SIPP 1984 Panel

	Panel(%)	84CY(%)	85CY(%)
Total Number of Persons[1]	32,985 (100.0)	32,985 (100.0)	32,985 (100.0)
(1) with no missing interviews	23,027 (70.0)	25,856 (78.4)	23,971 (72.7)
(2) with 1+ missing interviews	9,958 (30.0)	7,129 (21.6)	9,014 (27.3)

1 Adults (15+ years old) who participated in the first interview were not part of the March 1985 Sample Reduction

Table 4. Estimates of Transitions Missed Due to Imputation for Selected Characteristics

Characteristics	(1) Within Wave 2 Trans. (x)	(2) Within Wave 2 and between waves 1,2,3 Trans. (y)	(3) % of Transitions Within Wave (x)/(y)	(4) Within Wave 4 Trans. for Imputed Cases (0.015x)	(5) Total Panel Within Wave Transitions for Imputed Cases (Rounded Up) 6(0.015x)	(6) Within Wave 4 Trans. Missed for Imputed Cases (0.8)(0.015x)	(7) Total Panel Within Wave Transitions Missed for Imputed Cases (Rounded Up) (0.8)(6)(0.015x)
Stocks/ Mutual Funds	254	3,532	7.0	3.8	23	3.04	19
Veterans Comp. or Pensions	18	114	15.0	0.3	2	0.24	2
Pensions from Company or Union	64	327	20.0	1.0	6	0.80	5
AFDC	69	303	23.0	1.0	6	0.80	5
Social Security	169	652	26.0	2.5	15	2.00	12
Sav/Money Market/ CDs/NOW Accounts	4,088	15,012	27.0	61.3	368	49.04	295
Food Stamps	269	913	30.0	4.0	24	3.20	20
State Unemploy. Compensation	764	1,801	42.0	11.5	69	9.20	56
Lump Sum Payments	95	176	54.0	1.4	9	1.12	8

Source: U.S. Bureau of the Census memorandum "Monthly Transitions from the SIPP Longitudinal Research File," from J. Coder to P. Schneider, May 20, 1986.

Table 5. Missed Month to Month Transitions Due to Carry-Over Imputation for Interview Patterns Beginning and Ending With an "X"

Wave/Month

1	2				3	Month to Month Transitions	Missed Month to Month Transitions
4	5	6	7	8	9		
X	X	X	X	X	X	0	0
X	X	X	X	O	X	2	2
X	X	X	O	X	X	2	2
X	X	O	X	X	X	2	2
X	O	X	X	X	X	2	2
X	X	X	O	O	X	2	2
X	X	O	X	O	X	4	4
X	O	X	X	O	X	4	4
X	X	O	O	X	X	2	2
X	O	X	O	X	X	4	4
X	O	O	X	X	X	2	2
X	X	O	O	O	X	2	2
X	O	X	O	O	X	4	4
X	O	O	X	O	X	4	4
X	O	O	O	X	X	2	2
X	O	O	O	O	X	2	2
						40	40

X - indicates "on" a program
O - indicates "off" a program

Table 6. Missed Month to Month Transitions Due to Carry-Over Imputation for Interview Patterns Beginning and Ending With an "O"

Wave/Month

1	2				3	Month to Month Transitions	Missed Month to Month Transitions
4	5	6	7	8	9		
O	X	X	X	X	O	2	2
O	X	X	X	O	O	2	2
O	X	X	O	X	O	4	4
O	X	O	X	X	O	4	4
O	O	X	X	X	O	2	2
O	X	X	O	O	O	2	2
O	X	O	X	O	O	4	4
O	O	X	X	O	O	2	2
O	X	O	O	X	O	4	4
O	O	X	O	X	O	4	4
O	O	O	X	X	O	2	2
O	X	O	O	O	O	2	2
O	O	X	O	O	O	2	2
O	O	O	X	O	O	2	2
O	O	O	O	X	O	2	2
O	O	O	O	O	O	0	0
						40	40

X - indicates "on" a program
O - indicates "off" a program

Table 7. Missed Month to Month Transitions Due to Carry-Over Imputation for Interview Patterns Beginning With an "X" and Ending With an "O"

Wave/Month

1	2				3	Month to Month Transitions	Missed Month to Month Transitions
4	5	6	7	8	9		
X	X	X	X	X	O	1	0
X	X	X	X	O	O	1	0
X	X	X	O	X	O	3	2
X	X	O	X	X	O	3	2
X	O	X	X	X	O	3	2
X	X	X	O	O	O	1	0
X	X	O	X	O	O	3	2
X	O	X	X	O	O	3	2
X	X	O	O	X	O	3	2
X	O	X	O	X	O	5	4
X	O	O	X	X	O	3	2
X	X	O	O	O	O	1	0
X	O	X	O	O	O	3	2
X	O	O	X	O	O	3	2
X	O	O	O	X	O	3	2
X	O	O	O	O	O	1	0
						40	24

X - indicates "on" a program
O - indicates "off" a program

Table 8. Missed Month to Month Transitions Due to Carry-Over Imputation for Interview Patterns Beginning With an "O" and Ending With an "X"

Wave/Month

1	2				3	Month to Month Transitions	Missed Month to Month Transitions
4	5	6	7	8	9		
O	X	X	X	X	X	1	0
O	X	X	X	O	X	3	2
O	X	X	O	X	X	3	2
O	X	O	X	X	X	3	2
O	O	X	X	X	X	1	0
O	X	X	O	O	X	3	2
O	X	O	X	O	X	5	4
O	O	X	X	O	X	3	2
O	X	O	O	X	X	3	2
O	O	X	O	X	X	3	2
O	O	O	X	X	X	1	0
O	X	O	O	O	X	3	2
O	O	X	O	O	X	3	2
O	O	O	X	O	X	3	2
O	O	O	O	X	X	1	0
O	O	O	O	O	X	1	0
						40	24

X - indicates "on" a program
O - indicates "off" a program

Chart 1.

Missing a Single Wave

Noninterviews by Wave

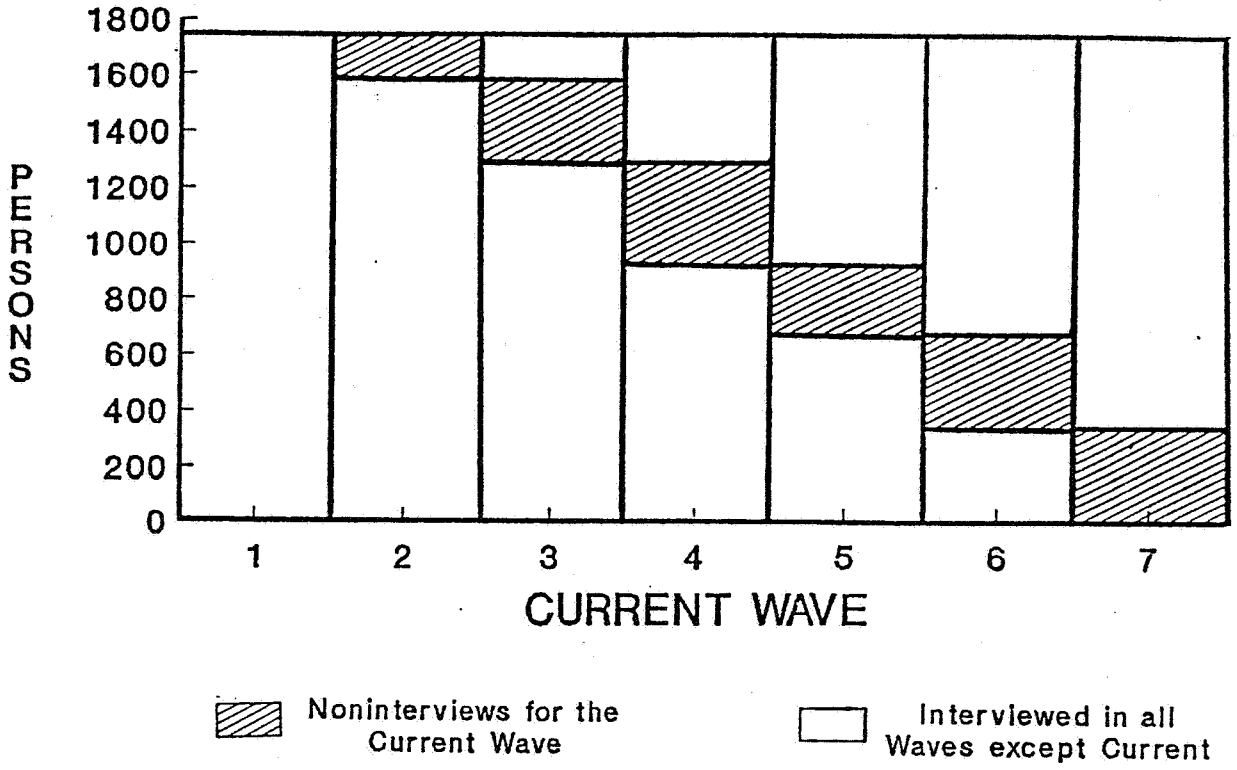

Table 9. NUMBER OF CASES SAVED BY WEIGHTING OPTION

OPTION	Number of Weights	Number of Cases Saved[1]	Sample Increase (%)	Decrease in Standard Error of p (%)[2]
1. Current	3	N/A	N/A	N/A
2. Missing only one wave	6	N/A	N/A	N/A
- Panel	2	1,740	7.5	3.0
- 84CY	2	1,495	5.8	2.4
- 85CY	2	1,046	4.4	1.8
3. Panel	8	N/A	N/A	N/A
- No waves missing	1	-	-	-
- Only Wave 2 missing	1	163	0.7	0.3
- Only Wave 3 missing	1	295	1.3	0.5
- Only Wave 4 missing	1	361	1.6	0.7
- Only Wave 5 missing	1	253	1.1	0.5
- Only Wave 6 missing	1	334	1.5	0.6
- Only Wave 7 missing	1	334	1.5	0.6
- Only Wave 8 missing	1	655	2.8	1.2
CY84	4	N/A	N/A	N/A
- No waves (2-5) missing	1	-	-	-
- Only Wave 3 of (2-5) missing	1	417	1.6	0.7
- Only Wave 4 of (2-5) missing	1	509	2.0	0.8
- Only Wave 5 of (2-5) missing	1	1,404	5.4	2.2
CY85	4	N/A	N/A	N/A
- No waves (5-8) missing	1	-	-	-
- Only Wave 6 of (5-8) missing	1	398	1.7	0.7
- Only Wave 7 of (5-8) missing	1	372	1.6	0.7
- Only Wave 8 of (5-8) missing	1	711	3.0	1.2
4. Current + Topical Modules	6	N/A	N/A	N/A
- No waves missing	3	-	-	-
- Topical Modules 4 and 7	1	2,016	8.8	3.5
- Topical Modules 3 and 8	1	1,773	7.7	3.1
- Topical Modules 3 and 6	1	2,702	11.7	4.6
5. Option 2 + Option 4	9	N/A	N/A	N/A
- No waves missing	3	-	-	-
- Missing only one wave (Option 2)	3	2,395	10.4	4.1
- Topical Modules 4 and 7 (Option 4)	1	2,016	8.8	3.5
- Topical Modules 3 and 8 (Option 4)	1	1,773	7.7	3.1
- Topical Modules 3 and 6 (Option 4)	1	2,702	11.7	4.6

[1] Due to an overlap of saved cases between weights within each option, total sample saved for an option is not the sum of the sample saved for each weight.

[2] "p" is an estimate of the percent of persons in some subgroup of the total population.

Note: The amounts of sample currently used in estimation for panel, 84CY, and 85CY are 23,027, 25,856, and 23,971, respectively.

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