Issues of Rotation in Panel Surveys

FAWEYA OLANREWAJU.[1], AKINYEMI OLUWADARE.[2], AYENI TAIWO MICHAEL[3]
[1, 2, 3] *Department of Statistics, Ekiti State University Ado-Ekiti, Nigeria*

***Abstract*—Panel surveys are surveys for which the respondents are interviewed more than once .i.e. the sample respondents are interviewed on more than one occasion. One of the most unavoidable problems of panel surveys is nonresponse which results in nonrectangular structure of data subject to missing values. In this paper, different methods in use for compensating for nonresponse to get rectangular data structure in panel surveys have been examined. The problems associated with each of them are clearly identified and a new method based on panel rotation is considered.**

***Indexed Terms*—Wave Nonresponse, Panel Design, Nonresponse Compensation, Panel Rotation.**

I. INTRODUCTION

Panel surveys are surveys for which the respondents are interviewed more than once .i.e. the sample respondents are interviewed on more than one occasion, an alternative term in medical and biological sciences is longitudinal studies. This survey has recently become a mainstay of sample survey practice (Binder 1998), widely used in the survey of public opinion, health and social sciences and is preferred to the one contact or cross sectional surveys because of its wider scope of information, reduced sampling variation in the measurement of change and low cost of panel recruitment among other reasons.

A. Panel Designs

In designing a panel survey, the choice of design is dependent on the data structure and the purpose of collecting such data; the first wave sample is chosen to give a representation of the survey population, this is then followed for subsequent waves and the rules guiding the dropout process from one wave to another is designed. Duncan and Kalton (1987) suggest that the design can be dependent on the changing composition of the population over time or the extent to which they retain the same elements in the sample for each wave. Such designs include:

(i) Pure panel

A pure panel (also called cohort study) is one in which the chosen sample are followed continuously over time, respondents here can be seen as sample with the same characteristics such as being born within a particular time period or being employed during the same period, this is quite good when the panel drawn can retain the same elements in the sample at different time periods and it is sometimes good for panels with short period of time. An example is the National Survey of Health and Development which initially took all babies born in the week 3rd-9th March in 1946 in Britain (Douglas 1964). In a pure panel, change only indicates changing values and not changing populations since the sample does not incorporate new entrants.

A major advantage of this design is that components of individual change can be measured.

(ii) Rotating panels

Here, sample elements are designed to have a restricted duration of time in the panel, new elements enter into the panel and others drop out on completion of their time. The limited membership in a rotating panel acts to reduce the probability of panel conditioning and panel loss in comparison to non-rotating panel and continuous introduction of new samples help to maintain an up to date sample of a changing population (Duncan and Kalton 1987). This as well reduces behavioral changes of respondents staying longer in the panel.

(iii) Split or supplemented panel

In a split panel, a set of repeated independent samples or rotating panel is added to the pure panel to compensate for panel loss in the original panel (see Fuller 1999). For example, an independent panel with identical characteristics as the pure panel can be added to the pure panel to compensate for panel loss.

B. Nonresponse in Panel surveys

In any survey of human population, one difficulty encountered by survey statisticians or researchers is in respondents failing to cooperate thereby leading to nonresponse. This becomes more pronounced in panel surveys where the same units or respondents are contacted on more than one occasion. The two major causes of nonresponse in panel surveys are refusals and failure to trace or contact geographically mobile but otherwise cooperative respondents. The problems of nonresponse increase as the panel wave increases. Methods of tracing respondents are discussed by Eckland (1968) and Crider et al. (1971).

C. Classification of nonresponse

Nonresponse can be classified as unit nonresponse and item non-response. It is unit when no data is collected for a sampled unit such as in a particular wave due to noncontact by the interviewer or refusal by respondents. It is item when respondents fail to respond to some particular items .i.e respondents fail to provide data for some survey items. Other forms of nonresponse are wave and partial nonresponse. Units that respond to some waves and are missing for others constitute wave nonresponse, this causes attrition when respondents who miss one wave do not return to subsequent waves, nonattrition nonrespondents return to the panel after missing a particular wave. Partial nonresponse which may be seen as item nonresponse occurs when the survey is divided into components which may or may not require separate contacts with the chosen sample and one or some of the components is missing resulting to a large portion of the survey data being missing.

D. Compensating for Panel nonresponse.

The problems of nonresponse in panel surveys are not new. Until the 1970s, missing values were handled by editing (Schafer and Graham 2002). Nonresponse in panel surveys depends on the panel length, interval between waves, types of respondents to be interviewed, e.t.c. Comprehensive literatures exist in dealing with nonresponse with focus on imputation, weighting, available and complete cases; unfortunately the use of rotation in adjusting or dealing with nonresponse rarely appears in survey textbooks or journals. Little (1988) distinguishes three broad general strategies for dealing with nonresponse as: direct analysis of the incomplete data due to nonresponse, imputation and weighting complete cases.

Direct analysis of the incomplete data involves complete case analysis and available case analysis. In complete case analysis (also called case or listwise deletion), analysis is done on items with complete set of observations and items with missing responses are discarded. Attention is focused on items or units that have observed values for all variables under consideration thereby losing information by discarding incomplete cases. This method is inefficient since the complete cases may no longer be representative of the target population and thus estimates derived from them are subject to bias

In available case methods all the available values with variables of interest are used. i.e. including cases where the variable of interest is present for analysis, while modifications are required to estimate measures of covariation (Little and Rubin 1987). Schafer and Graham (2002) see the method to be more efficient than complete case but can yield correlation outside [-1, 1] and difficulty to compute standard errors and measures of covariation.

E. Imputation Methods

A situation where the missing data are filled in to restore the completeness of the data for analysis i.e. assigning values for missing item responses. Sande (1982) defines imputation as the estimation of individual items missing in a survey response. The imputed values are derived using the responses to other items available for the respondent (and any other auxiliary information that is relevant) as predictors of the missing values. Kalton and Kasprzyk (1986) note that most of the methods developed for imputation fall within a general multiple regression framework. Lekpkowski (1989) notes that when the amount of wave nonresponse is substantial, imputation procedure such as the carryover method has some advantages. Imputation can be single or multiple. Laaksonen (1991) groups imputation into five various groups as deductive imputation, mean imputation, random imputation, hot deck and cold deck imputation and imputation using modeling (e.g ordinary, weighted , censored regression imputation and log linear models). Little and Rubin (1987) identify three commonly used procedures as Hot deck, where

recorded units in the sample are substituted i.e. filling in nonrespondents' data with values from actual respondents. This only works when data is in sequential order. Second is mean imputation where means from sets of recorded values are substituted i.e. replacing each missing values for a variable with the average of the observed values. Third is regression imputation where the missing variables for a unit are estimated by predicted values from the regression on the known variables for that unit.

Schafer and Graham (2002) see mean and hot deck procedures to bias estimates for many parameters under any form of missingness. The deterministic nature of the methods distorts the distribution (e.g variances, correlations) of the variables.

F. Weighting

Adjustments by weighting are assigned to respondents' records to compensate for unequal selection probabilities and nonresponse, estimates and make the sample a representation of the population as closely as possible. Usually, nonrespondents in the first wave of data collection are not followed for subsequent waves because they are not yet clearly identified and because no data is available for tracing them, and are thus seen as total nonrespondents (see Lepkowski and Couper 2002) e.g US Census Bureau's Survey of income and program participation (SIPP). In adjusting for nonresponse, the base weight is adjusted so that there is conformity between the respondents distribution and the total sample distribution. Kalton and Flores-Cervantes (2003) describe six methods of weighting as Cell weighting, Raking/rim weighting linear weighting. Generalized regression estimator (GREG) weighting, Logistic regression weighting, and mixture of cell weighting and another method. They further give two other methods that constrain the range of the nonresponse adjustment as logit weighting and truncated linear weighting.

Duncan and Kalton (1987) see the form of compensation for wave nonresponse as debatable. Nonresponse in panel survey can either be in the pattern of attrition whereby respondents or units that drop out in an earlier wave do not return in subsequent waves, or nonattrition whereby a nonrespondent in an earlier wave return in subsequent wave. While some contributors prefer imputation for adjusting wave nonresponse, others prefer weighting (see for example Kalton 1986 and Little 1988). In the nonattrition wave with k waves say, there will be 2k -1 sets of weights. The proliferation of weights in this case becomes highly problematic and weighting becomes unattractive for general purpose analysis of combinations of waves. To deal with this problem, weights are developed for the set of respondents who provide data for all waves involved in the analysis or by converting nonattrition nonresponse to attrition. Converting the nonattrition case to attrition to reduce the 2k-1 sets of weights to k is seen to be problematic and inconsistent when key analyses involve specific waves, and when the panel has significant number of waves, a large amount of data is discarded. It also discards a good deal of data for units with only one or two missing waves interspersed with responding waves. Nonresponse bias can arise in panel surveys, and in compensating with weighting, Chapman et al., (1986) show that weighting can attenuate the effect of the bias. Since individual's responses between waves tend to be correlated, procedures that use all the available data for each respondent should be preferred, because missing information can then be partially recovered from earlier waves.

G. The use of Rotation.

In compensating for nonresponse by the use of rotation panel which is our major focus of interest in this paper, a given proportion of units drop from the panel after a given time points and new units are rotated into the sample to replace those dropped (Fuller1999). A longitudinal survey with no rotation usually has the largest nonresponse problems (Bailar1989).

The goal of a statistical procedure should be to make valid and efficient inferences about a population of interest – not to estimate, predict or recover missing observations, since attempts to recover missing data may impair inference. In panel surveys, each panel must represent the population it was sampled from; this objective is achieved by introducing new panel members and dropping uncooperating members. In longitudinal study of medical sciences, panel rotation is incorporated as new respondents present themselves.

The rotational structure compensates for panel attrition, makes cross–sectional sample more representative, corrects for time in sample bias, minimizes the high respondent burden in pure panels and reflects the changing population composition. Biorn (1981) considers the case of a rotating panel to maintain household sample size by replacing households that drop from the sample in the second period by new members.

With rotation, instead of using variables from the recorded units to impute for nonrespondents or discarding data from earlier respondents for weighting, based on the information from the previous wave, the specific area of the panel with high nonresponse rate is targeted and the rotated sample is chosen to ensure appropriate representation of the population and responses obtained from the rotated sample reflects the characteristics of interest at that particular time without bias. Instead of using variables from the recorded units for imputation, Titterington and Sedransk (1986) evaluate an imputation technique that replaces each missing response, Y with response from a donor respondent that matches the nonrespondent on a continuous background covariate, X available for all units and conclude from their simulation study that replacing missing responses with donor responses generally works well in terms of expected bias and mean squared error of the estimated population mean provided the donors are well matched to the nonrespondents; in the same vein for panel rotation , information from earlier wave on the nonresponding units can be used to choose matched replacements that will be rotated into the panel.

When the auxiliary variables are only weakly related to the variables with the missing values, imputation gives rise to serious problems of fabrication of data and attenuation of covariances (Kalton 1986). Imputation becomes inconsistent and out of scope when responses are due to seasonal effect and variables are unstable, this problem is tackled by rotation when a different sample is rotated into the panel to represent the nonrespondents.

II. DISCUSSION

As notated above, the use of panel rotation in compensating for nonresponse rarely appears in the statistical journal of panel surveys. Other methods often considered assume resemblance and use variables from the recorded units to deal with nonresponse, this may not always be the case. The situation with rotation is different, based on the available record from earlier wave, the rotated panel can be chosen to resemble the nonrespondents and those rotated out due to unsatisfactory response or fatigue, the data obtained from the rotated sample thus replace that of nonrespondents and the resulting dataset is treated as a complete response, this is different from the guesses of imputed values.

As this discussion has shown, weighting adjustment for nonresponse is complicated by the fact that the nonrespondents have varying amounts of data from earlier wave. This can lead to many different sets of weights that depend on the particular patterns of nonresponse with obvious cost implications associated with developing separate weights for every possible combination. In analysis, this different sets of weights can be extremely large, erroneous and operationally awkward. Moreover, the cumulative effect of nonresponse on panel surveys threatens the representativeness of the panel and makes complete cases practically inapplicable.

Sande (1982) notes that imputation obviously affects the quality of the estimates and does not solve any specific estimation problem more satisfactorily than classical estimation techniques for incomplete data, and it may do a lot worse.

However, the most commonly cited criticism of rotation is higher cost (see Sharot1991), this is also applicable to other methods and more so, rather than distorting association of items with imputation and dropping cases with nonresponse resulting to a major loss of data with weighting, compensating for nonresponse with rotation is at advantage.

REFERENCES

[1] Bailar, B.A. (1989). Information Needs, Surveys, and Measurement Errors. In Panel Surveys. (D. Kasprzyk, G.J. Duncan, G. Kalton, and M.P Singh eds).New York:Wiley 1-24

[2] Binder, D.A. (1998). Longitudinal Surveys: Why Are These Surveys Different from All Other Surveys? Survey Methodology, 24:101-108

[3] Biorn, E. (1981). Estimating Economic Relations from Incomplete Cross Section/ Time Series Data. Journal of Econometrics, 16: 221-236.

[4] Chapman, D.W, Bailey, L, and Kasprzyk, D. (1986). Nonresponse Adjustment Procedure at the US Bureau of the Census: Survey Methodology, 12: 161-180

[5] Crider, D, M, Willits, F.K. and Bealer, R.C. (1971). Tracking Respondents in

[6] Longitudinal Surveys. Public Opinion Quarterly, 35: 613-620.

[7] Douglas, J.W.B. (1964). The Home and the School. MacGibbon and Kee, London.

[8] Duncan, G.J. and Kalton, G. (1987). Issues of Design and Analysis of Surveys Across Time. International Statistical Review 55, 1, 97-117.

[9] Eckland, B.K. (1968). Retrieving Mobile Cases in Longitudinal Surveys. Public Opinion Quarterly, 32: 51-64.

[10] Fuller, W.A. (1999). Environmental Surveys Over Time. Journal of Agricultural, Biological and Environmental Statistics vol. 4, No 4 Sampling Overtime 331-345

[11] Kalton, G. (1986). Handling Wave Nonresponse in Panel Surveys. Journal of Official Statistics, Vol 2, No3, 303-314.

[12] Kalton, G. and Flores-Cervantes, I. (2003). Weighting Methods. Journal of Official Statistics, Vol. 19, No 2, 81-97.

[13] Kalton, G. and Kasprzyk, D. (1986). The Treatment of Missing Survey Data. Survey Methodology, 12, 1-16.

[14] Laaksonen, S.S. (1991). Adjustment for Nonresponse in Two-Year Panel Data: Applications to Problems of Household Income Distribution. The Statistician, Vol. 40, No2, Special Issue: Survey Design, Methodology and Analysis, 153-168.

[15] Lepkowski, J.M and Couper, M.P. (2002). Nonresponse in the Second Wave of Longitudinal Household Surveys, In Survey Nonresponse.(R.M. Groves, D.A.Dillman, J.L. Eltinge, and R.J.A. Little eds). New York: Wiley. 259-272.

[16] Little, R. J.A. (1988). Missing Data Adjustments in Large Surveys. Journal of Business and Economic Statistics, Vol 6, no 3, 287-296.

[17] Little, J.A. and Rubin, D.B (1987). Statistical Analysis with Missing Data. New York: John Wiley and Sons.

[18] Sande, I.G. (1982). Imputation in Surveys: Coping with Reality. The American Statistician, Vol. 36, No 3, Part 1, 145-152.

[19] Schafer, J.L. and Graham, J.W. (2002). Missing Data: Our view of the State of

[20] the Art. American Psychological Association. 147-177

[21] Sharot,T. (1991).Attrition and Rotation in Panel Surveys. The Statistician, 40:325-331

[22] Titterington, D.M. and Sedransk, J. (1986). Matching and Linear Regression Adjustment in Imputation and Observational Studies. Sankhya, The Indian Journal of Statistics,Series B, 48: 347-367.