THE NONRESPONSE PROBLEM

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This paper presents an outline of the nonresponse research which is carried out at the Netherlands Central Bureau of Statistics. The phenomenon of nonresponse is put into a general frame-work. The extent of nonresponse is indicated with figures from a number of CBS-surveys. The use of auxiliary variables is discussed as a means for obtaining information about nonrespondents. These variables can be used either to characterize nonrespondents or as stratification variables in adjustment procedures.

Adjustment for nonresponse bias by means of subgroup weighting is considered in more detail. Finally, the last section lists a number of other methods which also aim at reduction of the bias.

1. INTRODUCTION

Nonresponse is becoming a growing concern in survey research. The phenomenon of nonresponse, when people are not able or willing to answer questions asked by the interviewer, can appear in sample surveys as well as in censuses. It affects the quality of the survey in two ways: first of all, due to reduction of the available amount of data, estimates of population parameters will be less precise. Secondly, if a relationship exists between the variable under investigation and response behaviour, statements made on the basis of the response are not valid for the total population. For example if the housing demand of respondents is greater than the housing demand of nonrespondents, estimates of the housing demand in the total population will be significantly too high.

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The views expressed in this paper are those of the authors and do not necessarily reflect the policies of the Netherlands Central Bureau of Statistics.

It is obvious that the extent of the nonresponse must be kept as small as possible. If, in spite of these efforts, there still remains a considerable amount of nonresponse, measures have to be taken in order to prevent formulation of wrong statements about the population. Combination of adjustment procedures and usual estimation techniques is necessary to yield valid population estimates.

Two departments of the CBS (Netherlands Central Bureau of Statistics) are involved in nonresponse research. The Department for Social Surveys is responsible for the field work of the surveys. It is concerned with minimizing nonresponse during the process of collecting data. Research is carried out on the optimal number of recalls and the time of the interview. (See Widdershoven & Van den Berg (1980).) Experiments are set up to find the optimal way to approach persons and households with introductory letters. Attempts are made to measure the impact of interview fatigue and interview pressure. Ultimately, notwithstanding these efforts, there still remains an amount of nonresponse. The Department for Statistical Methods investigates the effect of nonresponse on the accuracy of the results of the survey. Methods are developed there to adjust population estimates for the bias due to nonresponse. The remainder of this paper is mainly concerned with the work of the latter department.

The next sections present an outline of the nonresponse analysis at the CBS. Section 2 introduces definitions and the accompanying problems. Nonresponse figures of a number of CBS-surveys are summarized. In section 3 graphical methods are discussed to select auxiliary variables. They provide insight into nonresponse and can be used in adjustment procedures. Section 4 presents adjustment methods which make use of subgroup weighting and section 5 lists a number of other methods.

2. THE PHENOMENON OF NONRESPONSE

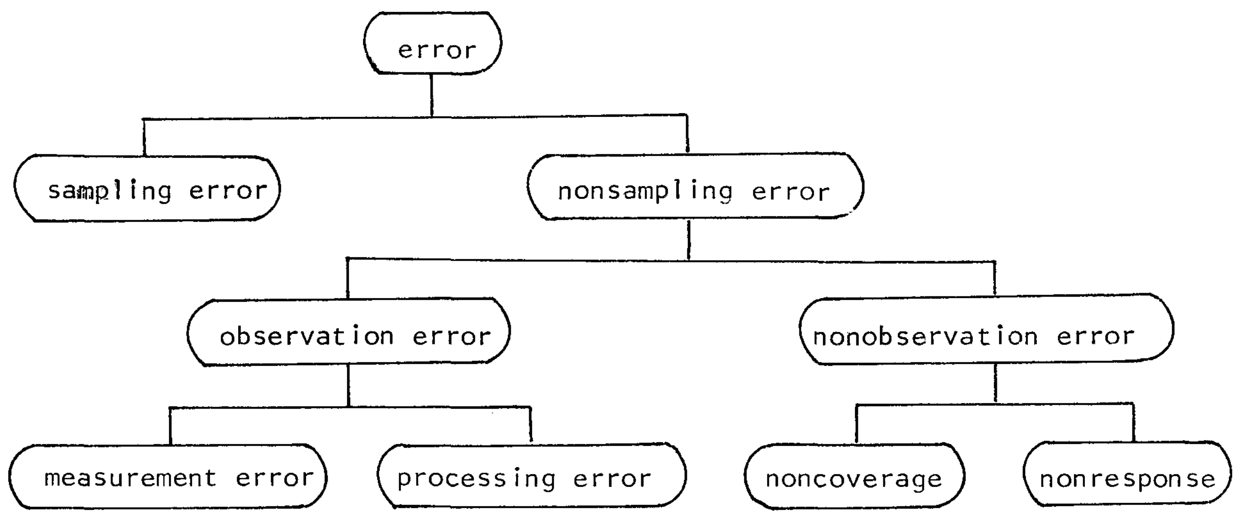
In this section the problem of nonresponse is placed in a general framework, in which also a number of other sampling problems play a role.

Nonresponse figures for a number of CBS surveys are given. Situations are described in which a relationship exists between the variable under investigation and the response behaviour. In the last part of the section two models for the general of nonresponse are considered.

2.1 Terminology

The objective of every survey is the determination of certain population characteristics. Due to all kinds of errors, the true value will generally never be obtained. A typology of sources of error is presented in fig. 1. The scheme is due to Kish (1967).

FIG. 1. TYPOLOGY OF ERRORS IN SURVEYS



The two sources of error in surveys are sampling errors and nonsampling errors. Sampling errors consist of that part of the error which is due to the fact that only a sample of values is observed rather than the total population. The sampling error has an expected frequency distribution generated by the totality of sampling errors in all possible samples of the same size. This distribution is used to estimate the population characteristic.

Nonsampling errors are those errors in sample estimates which can not be attributed to sampling fluctuations. Nonsampling errors are often a more serious problem than sampling errors. Nonsampling errors can be divided in observation errors and nonobservation errors.

Observation errors are caused by obtaining and recording observations incorrectly. They may be further subdivided into measurement errors and processing errors.

Measurement errors are caused either by the interviewer or by the respondent. The interviewer himself can be a source of error. He can influence the response by his mere presence, by his (or her) sex, skin colour, age, or dress. Also the way in which he asks questions and clarifies statements affects results. The answer of a person may depend on the type of question (whether a question measures a fact such as year of birth, or an opinion). Errors can also be introduced by factors such as whether the person understands the question, whether he knows the answer or not, whether he wishes to conceal the answer, or whether he wishes to present a certain image. Moreover, memory is not always free of errors, and data may be incorrectly recorded.

Processing errors arise during the processing of the data at the office. They occur during the stage of coding, tabulating and computing.

Nonobservation errors are due to the failure to obtain observations on certain parts of the population. They may be subdivided in noncoverage and nonresponse.

Let the target population be the population the survey is intended to cover. Practical difficulties in handling parts of the population may result in their elimination from the scope of the survey. It is also possible that the actually sampled population contains elements which do not belong to the scope of the survey.

Noncoverage refers to all errors which result from differences between target population and sampled population. Elements which belong to the target population as well as to the sampled population are correct elements. The situation in which elements in the target population do not appear in the sampled population is called undercoverage. These elements have zero probability of selection in the sample. The situation in which elements in the sampled population do not appear in the target population is called overcoverage. Elements, classified as overcoverage, are called duds. They have to be excluded from the sample before analysis takes place. If there is unexpected overcoverage the ultimate sample size may be less than the planned sample size.

Nonresponse refers to failure to obtain observations on some elements selected and designated for the sample. A good classification of nonresponse errors depends on the survey situation. The classification given below focuses on problems in face-to-face interviews. A similar treatment may be applicable in other survey situations. The following categories of nonresponse can be distinguished:

(1) Not at home. To reduce the extent of this category recalls can be made. Research should be carried out on the optimal number of recalls. The term temporarily unavailable would be a useful generalization for this category, denoting a delay rather than a denial of the interview. The respondent may be too busy, tired, or ill at the time, but will be cooperative on another call.

(2) Refusal. Some of the factors causing refusal are temporary and changeable. A person may refuse because he is ill-disposed or approached at the wrong hour. Another try, or another approach may find him cooperative. Since quite a number of refusals can, however be considered permanent, a better term for this category is unobtainable,, denoting a denial rather than a delay of observation. Repeated attempts will not bring success. From this view, respondents known to be away during the entire survey period belong in this category, rather than among the not-at-homes.

(3) Incapacity or inability. This type of nonresponse may refer to mental or physical illness which prevents response during the entire survey period. A language barrier belongs also to this category. If generalized this category could fit in the previously defined unobtainables. It can, however, be useful in some situations to distinguish between the unwilling and the willing, but incapable, respondent.

(4) Not found. This category can e.g. be large for movers. Such respondents are either not identified or followed because this would be too expensive. Cases of not attempted interviews belong to the same general category. They could be caused by inaccessibility (lighthouse keeper, shepherd), or dangerous surroundings (watchdog, slum).

(5) Lost information. Information may get lost after a field attempt. Some questionnaires may be unusable because of poor quality or cheating. Other may remain unfilled because they were lost or forgotten.

The typology as described above is applicable in most survey situations, but care must be taken in case of complex sampling designs. When e.g. sampling takes place in more stages the typology can be used in each separate stage. The same source of error can be classified differently in different stage. This is illustrated in an example. In a household survey first a sample of households is selected. The interviewer enumerates all persons in a particular selected household and after that selects a sample from this list. In such an enumeration the student living in an attic is often concealed. In the first stage of the sampling procedure this situation would be classified as measurement error, and in the second stage as undercoverage.

For some sources of error classification may depend on other factors and appropriate rules to cover them must be adopted. For example, if a person to be interviewed died before the interview could take place, classification depends on the time of death. If death occurred before the day the sample was selected this could be classified as overcoverage, but if death occurred between the day the sample was selected and the day of the interview, the correct classification may be nonresponse.

Before selecting the sample, the population must be divided into sampling units. To every element in the population there must correspond one and only one sampling unit. The construction of the physical list of sampling units, called the sampling frame, is often a major practical problem. The nature of the available sampling frames is an important consideration in sample design. Relevant factors include the type of sampling unit, extent of coverage, accuracy and completeness of the list, and the amount and quality of auxiliary information in the list.

For sampling frames in which the sampling unit is a person the CBS has to restrict itself to administrative records of local authorities (municipalities). For household surveys the CBS manages its own frame, but at the moment the use of the list of delivery points of the Post Office is considred as a sampling frame.

2.2 The Extent of Nonresponse

It is rather difficult to compare nonresponse figures of different surveys. The percentage of nonresponse depends on a number of circumstances: aim of the survey, type of sampling unit, the sampling design, efficiency of the field work, performance of the interviewers, nonresponse reducing measures, perdiod in which the survey is held, the target population, the length of the questionnaire, wording of questions, etc. Even the definition of nonresponse may differ. It is necessary to create a frame-work which enables proper comparison of surveys. By controlling the factors which influence nonresponse figures, judgement can be passed on the quality of the different surveys. Such a frame work also offers opportunities for comparing surveys from different countries.

Table 1 presents nonresponse figures of a number of CBS-surveys. A clear trend of increasing nonresponse percentages can be seen in this table.

Table 1: <u>Nonresponse percentages of some CBS-surveys</u>

year	LFS		SSC		SLC		NTS		HS	
	tn	rn	tn	rn	tn	rn	tn	rn	tn	rn
1973	13.2									
1974					28.2	15.6				
1975	15.8	9.0	30.1	18.3					14.5	
1976			28.1	18.6	23.0[1)]	15.6			12.9	
1977	13.1	6.6	30.9	20.5	29.7	16.9			17.6	9.3
1978			36.1	23.9			33.0	26.2	21.9	12.5
1979	19.7		36.6	24.4	33.7[2)]		30.6	23.9	25.5	
1980			36.8	24.7	35.6	19.7	32.1	24.5		

1) = elderly people only

2) = young people only

tn = percentage of total nonresponse

rn = percentage of refusals

LFS = Labour Force Survey

SSC = Survey of Consumer Sentiments

SLC = Survey of Living Conditions

NTS = National Travel Survey

HS = Holiday Survey

As mentioned before a relationship between the variable under investigation and the response behaviour reduces the value of the conclusions of the survey. The existence of such relationships is not rare, as will be illustrated in the following examples. If the aim of the survey is to measure in which way people spend their spare time, then the reason of nonresponse "not at home" is rather annoying since these people are probably spending their (spare) time somewhere else. The same applies for the survey on the number of hours people watch television: the not-at-homes (in the evening) are probably not watching television. One of the aims of the Housing

Demand Survey is to measure the frequency with which people move to other houses. As there is a considerable amount of nonresponse due to moving (the sampling unit is a person), the estimate for the total population will be biased. A number of surveys show that unmarried people have a smaller response rate. If there is a relationship between marital status and the variable under investigation then estimates will be wrong in this case too.

2.3 Response Models

The first requirement in the development of theories for the treatment of nonresponse is the formulation of a mathematical model, which describes the way in which nonresponse is generated. Two models appear frequently in the literature. They are denoted here by "random response model" and "fixed response model".

According to the random response model every element in the population has a certain (unknown) probability of response. These response probabilities are not necessarily the same for every element. When the interviewer contacts the person to be questioned the probability mechanism is activated and determines whether or not the person responds.

The fixed response model assumes the existence of two strata in the population: a stratum of potential respondents and a stratum of potential non-respondents. Size and content of each stratum is not known beforehand. They are determined by the specification of the survey (aim, type of questions, interviewing techniques, interviewers, period of field work, etc.). Disregarding the two strata a sample is selected from the population. Consequently the number of respondents is a random variable in both the random response model and the fixed response model.

If instead of sampling complete enumeration would take place then in the case of random response model the determination of respondents would still be a random process whereas in the case of the fixed response model this would be fixed. There is, however, a certain resemblance between the two models. Assuming the existence of two stochastic meachanisms, the sampling mechanism and the response mechanism, both models differ only in the order in which the mechanisms are applied: In the fixed response model first the response mechanism is activated for each element in the population. This determines the two strata. Then the sample is selected. In the random response model first the sample is selected. Then the response mechanism is activated for each selected element.

The random response model offers the opportunity to estimate response probabilities. These estimated response probabilities can be used in adjustment procedures, or they can be connected to personal characteristics. The fixed response models generally results in easier formulae. The theory, developed within this model, is conditional on the realized response and non-response strata. Consequently the accuracy of the estimates can be computed, but the accuracy of the estimation method can not be determined. Due to this last argument research is focussed on the random response model.

3. SELECTION OF AUXILIARY VARIABLES

3.1 Auxiliary Variables

It is important to discover a possibly existing relationship between the variable under investigation and the response behaviour. It is, however, not possible to determine such a relationship using the sample data, since the values of the variable under investigation are not known for the nonrespondents. To be able to say something about nonrespondents there must be information available about them. One source of information about the non-response is formed by auxiliary variables. Auxiliary variables are defined as variables which can be measured for both respondents and nonrespondents. Two types of auxiliary information can be distinguished:

(1) Information which can be collected by the interviewer without a face-to-face interview. Among the information, obtained in this way, are type of town, type of housing, (approximate) year of construction of the housing and social status of the neighbourhood.

(2) Information which can be obtained from administrative records. Typical examples are age, sex and marital status.

Analysis of the relationship between auxiliary variables and the response behaviour provides insight in the group of people which do not respond. It may give additional information about the relationship between the variable under investigation and the response behaviour. Auxiliary variables showing a clear relationship with the response behaviour play an important role in adjustment procedures, to be discussed later.

It is assumed that auxiliary variables are nominal variables, i.e. different values have no other meaning than to distinguish between different groups. Arithmetic operations on these values, which in fact are only labels, are not allowed. The assumption that the variables are nominal is in practice not a restriction. Many variables are nominal and other types of variables can easily be re-expressed in terms of nominal variables. As an example of the available amount of auxiliary information, the auxiliary variables of the Housing Demand Survey 1977/1978 is listed below.

(1) year of birth
(2) sex
(3) marital status
(4) size of the family
(5) structure of the family
(6) type of housing
(7) number of floors in the housing
(8) year of construction of the housing
(9) municipality
(10) quarter of town
(11) degree of urbanization

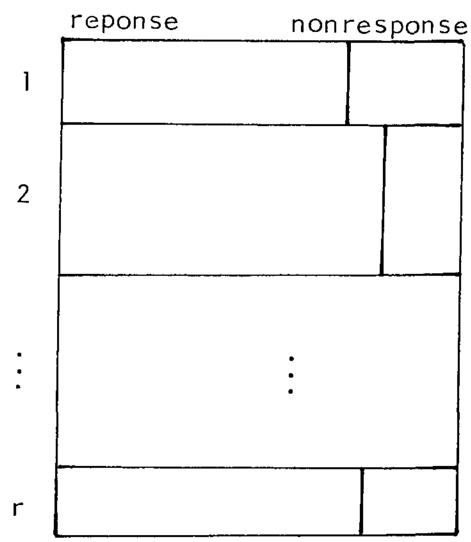
3.2 Graphical Methods

As a preliminary tool in the selection of auxiliary variables graphical methods have been developed. The advantage of graphical methods is clear. They bring out hidden facts and relationships and can stimulate as well as aid the analysis. They often offer a more complete and better balanced understanding then could be obtained from tabular or textual forms of presentation. Furthermore the visual relationships in the plots are more clearly grasped and more easily remembered. (See Schmid (1954).) Two simple graphical devices are presented in the next sections: the box-plot and the windmill-plot.

3.2.1 The box-plot

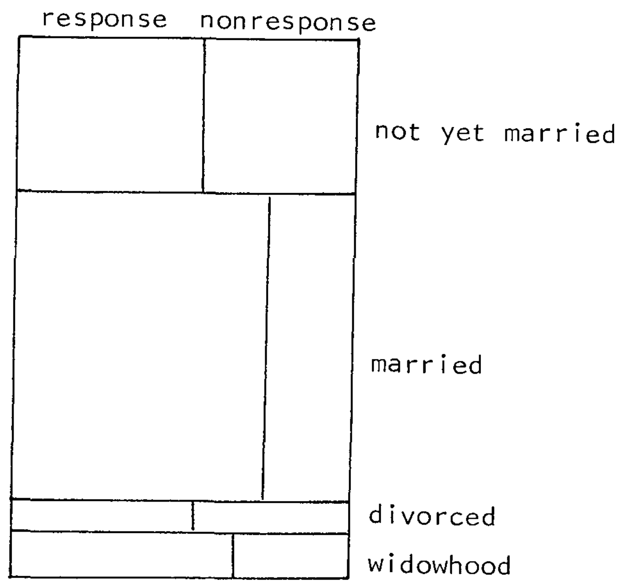
The box-plot can be seen as a generalization of a histogram or bar chart. The name of the box plot is derived from its form (see fig. 2).

FIGURE 2. THE BOX-PLOT



A rectangle of standard width and a height proportional to the sample size represents the sample. The rectangle is divided in a number of layers (the categories of the auxiliary variable). The height of a particular layer is proportional to the number of sample elements in the corresponding category. Each layer is divided by a vertical line in a left-hand part (the response) and a right-hand part (the nonresponse). The areas of these two parts are proportional to the amounts of response and nonresponse in the particular category. Fig. 3 contains an example of a box-plot. The data originate from the Housing Demand Survey 1977/1978 as far as it concerns Amsterdam. The auxiliary variable is the marital status of the person in the sample.

FIGURE 3. BOX-PLOT OF MARITAL STATUS IN AMSTERDAM IN THE HOUSING DEMAND SURVEY 1977/1978.



A number of aspects may be worth paying attention to:

(1) The heights of the layers indicate to what extent categories contribute to the sample. Clearly a large part of the people is married. The smallest category is the category of people who are divorced.

(2) The extent of the nonresponse can be read from the distance of the vertical dividing lines to the right-hand side of the box. In this example there obviously is a considerable amount of nonresponse.

(3) If all dividing lines form approximately a straight line there is no relationship between response behaviour and the auxiliary

variable. Clearly, in this situation there exists a relationship: Married people respond better than other people. Response is bad in the group of unmarried and divorced people.

More about the box plot can be found in Bethlehm & Kersten (1981).

3.2.2 The Windmill-Plot

The windmill-plot is a graphical representation of the results of correspondence analysis. Correspondence analysis is a technique for the analysis of associations in two-way tables. (See e.g. Benzecri (1976).). A geometrical representation of the rows (the categories of the vertically tabulated variable) and the columns (the categories of the horizontally tabulated variable) is constructed. This geometrical representation contains all the information concerning the associations in the table. By means of a scaling procedure rows and columns are assigned values in such a way that the correlation coefficient, computed by using these values, is maximized. To each cell in the table there correspond two scale values: a row-value and a column-value. When these values are conceived as coordinates, a plot of the table can be constructed. In this plot all points form an unequally spaced grid. Such a plot may not be easy to interpret. To simplify interpretation regression lines are plotted instead of the points themselves. Due to the special properties of the scale values the regression line to explain y-values from the x-values in the plot has the simple form

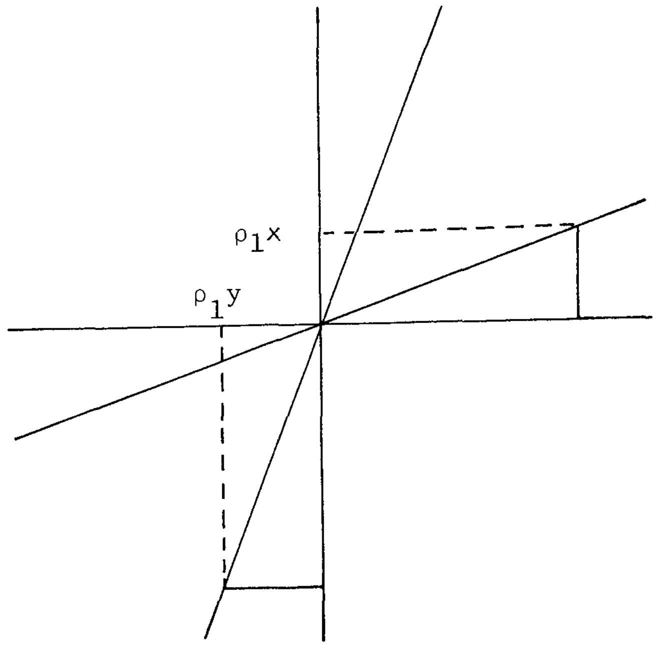
$$y = \rho_1 x \quad (1)$$

and the regression line to explain the x-values from the y-values has the form

$$x = \rho_1 t \quad (2)$$

were ρ_1 is the maximized correlation coefficient. By plotting both regression lines the result is the windmill-plot, see fig. 4.

FIGURE 4. THE WINDMILL-PLOT



A number of aspects may be worth noting:

(1) The origin represents both marginal distributions of the table

(2) Scale values close to the origin point at categories which resemble the marginal distribution and thus have a regular behaviour. Far out scale values indicate differently behaving categories.

(3) The relationship between the two variables is strong if the two regression lines are near the 45^o -line.

(4) Projection of a differently behaving category of one variable via the regression line on the axis of the other variable provides a clue about the dependencies of the categories of the variables.

The plot as described above can not account for all the information in the table. It explains as much as is possible in a two-dimensional plot. Conditionally on the first plot a second plot can be constructed, which accounts for as much as is possible of the information not yet explained. If necessary even more plots can be constructed, but preferably one plot is sufficient to explain the major part of the associations.

A total of s of such plots can be made, in which s is one less than the minimum of the number of rows and the number of columns. Let $\rho_1, \rho_2, .., \rho_s$ be the maximized correlation coefficients. Since

$$\sum_{i=1}^{s} \rho_i = X^2/N, \tag{3}$$

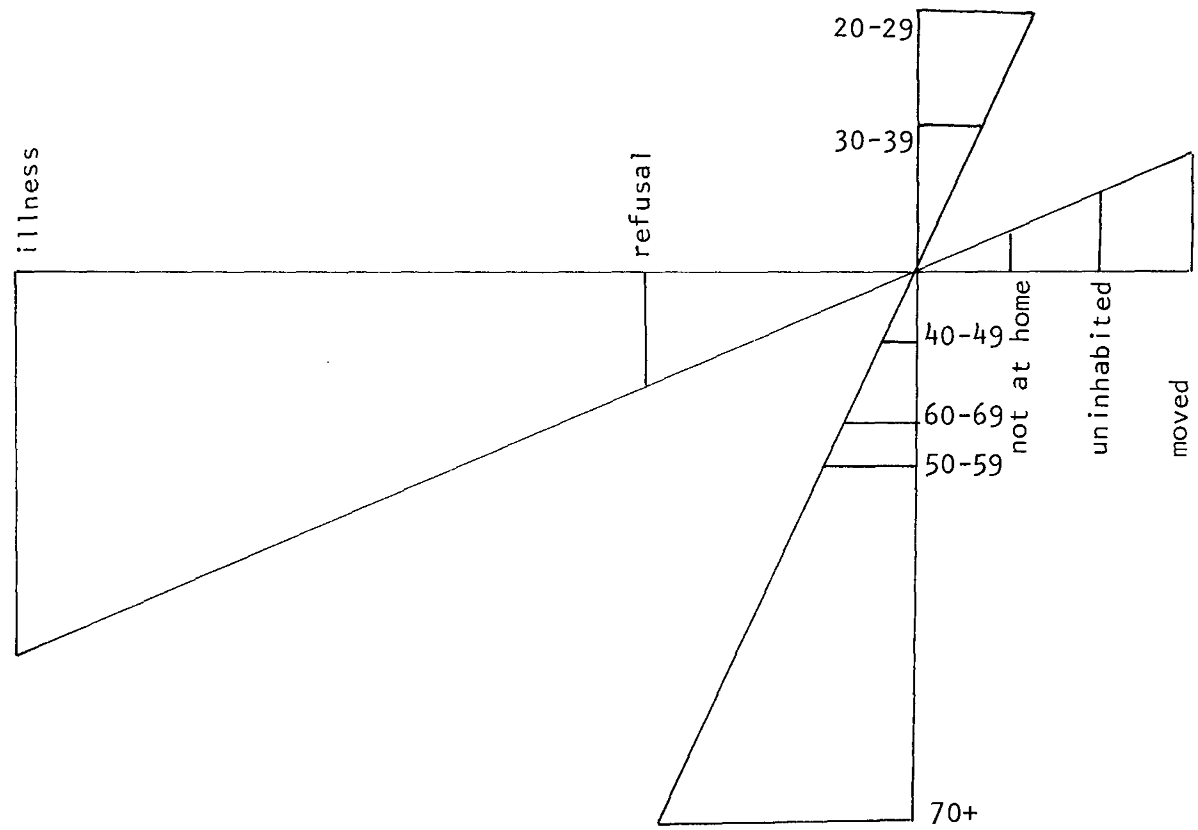
where X^2 is the chi-square test statistics for the table and N the general total,

$$\tau_i = N\rho_i^2/X^2 \tag{4}$$

is a measure of the amount of information explained by the i-th plot (i=1, 2, .., s).

Fig. 5 contains the first windmill-plot for the variables age (six categories) and type of nonresponse (five categories) of the Housing Demand Survey 1977/1978 as far as it concerns Amsterdam.

FIGURE 5: WINDMILL-PLOT OF AGE BY TYPE OF NONRESPONSE IN AMSTERDAM IN THE HOUSING DEMAND SURVEY 1977/78



It contains about 88% of the information about associations in the table (τ_1 = 0.88). The main reasons for nonresponse of the old people are refusal and illness. In case of young people the nonresponse is the result of the impossibility of making contact: uninhabited, not at home and moved. More about the application of correspondence analysis can be found in Bethlehem & Kersten (1980).

3.3 Other selection methods

There are many other, mainly nongraphical, method to determine the association between auxiliary vairables and the response behaviour. Much about association in contingency tables can e.g. be found in Bishop, Fienberg & Holland (1975).

A popular method for the selection of the most important auxiliary variables is AID (Automatic Interaction Detection), described by Morgan & Sonquist (1963). In a stepwise process those auxiliary variables are determined which can explain as much as possible of the variance of the binary response variable. There are disadvantages which make reliable application of this method doubtful. As the selection process proceeds in a stepwise fashion there is no guarantee that the optimal solution will be found. Because there is no stopping rule based on a statistical model this sense the result is rather arbitrary. Further research in this field is necessary (see e.g. Kass (1980)).

4. REDUCTION OF NONRESPONSE BIAS BY SUBGROUP WEIGHTING

When a relationship is found or suspected between the variable under investigation (Y) and the response behaviour (R) measures have to be taken in order to reduce the nonresponse bias. In this section a number of adjustment procedures are discussed which are based on subgroup weighting. Attention is focussed on estimating the population mean of Y.

It can be shown that the bias, introduced by only using response values, is proportional to the covariance between Y and R. If it would be possible to divide the population in a number of subgroups in each of which the covariance is neglectable, then (nearly unbiased) estimates of the subgroup means can be combined into a (nearly unbiased) estimate of the population mean.

Let the finite population consist of N elements U_1, U_2, .., U_N with Y-values Y_1, Y_2, .., Y_N. From this population a simple random sample $\underline{u}_1$, $\underline{u}_2$, ..,$\underline{u}_n$

(stochastic variables are underlined) of size n is selected without replacement. The corresponding y-values are $\underline{y}_1, \underline{y}_2, .., \underline{y}_n$ and the response behaviour is indicated by $\underline{r}_1, \underline{r}_2, ..,$ ($\underline{r}_i = 1$ indicating response and $\underline{r}_i = 0$ nonresponse). In fact $\underline{y}_i$ can only be observed for those sample elements $\underline{u}_i$ for which $\underline{r}_i = 1$. The $\underline{m}$ responding elements are denoted by $\underline{u}^*_1, \underline{u}^*_2, ..., \underline{u}^*_{\underline{m}}$ ($\underline{m} = \underline{r}_1 + \underline{r}_2 + .. + \underline{r}_n$), with y-values $\underline{y}^*_1, \underline{y}^*_2, .., \underline{y}^*_{\underline{m}}$.

Let X be an auxiliary variable inducing a division of the population in H subgroups with sizes $N_1, N_2, .., N_H$. In subgroup weighting first of all in each subgroup h an estimator $\bar{\underline{y}}^*_h$ for the subgroup mean is computed:

$$\bar{\underline{y}}^*_h = \frac{1}{\underline{m}_h} \sum_{i=1}^{\underline{m}_h} \underline{y}^*_{hi}, \qquad (h = 1, 2, .., H) \tag{5}$$

where $\underline{y}^*_{h1}, \underline{y}^*_{h2}, ..., \underline{y}^*_{h\underline{m}_h}$ are the values of the $\underline{m}_h$ responding elements in subgroup h. The subgroup estimators $\bar{\underline{y}}^*_1, \bar{\underline{y}}^*_2, .., \bar{\underline{y}}^*_H$ are combined into a population estimators $\bar{\underline{y}}^*$.

$$\bar{\underline{y}}^* = \sum_{h=1}^{H} \underline{w}_h \bar{\underline{y}}^*_h \tag{6}$$

The type of estimator is determined by the available amount of information about the weights $\underline{w}_1, \underline{w}_2, .., \underline{w}_H$.

If the sizes $N_1, N_2, .., N_H$ of the subgroups are known the situation is equivalent to poststratification. (See e.g. Holt & Smith (1979).) The weights are not random but fixed quantities:

$$\underline{w}_h = \frac{N_h}{N} \qquad (h = 1, 2, .., H) \tag{7}$$

If these sizes are not known they can be estimated by

$$\underline{w}_h = \frac{\underline{n}_h}{n}, \qquad (h = 1,2,..,H) \qquad (8)$$

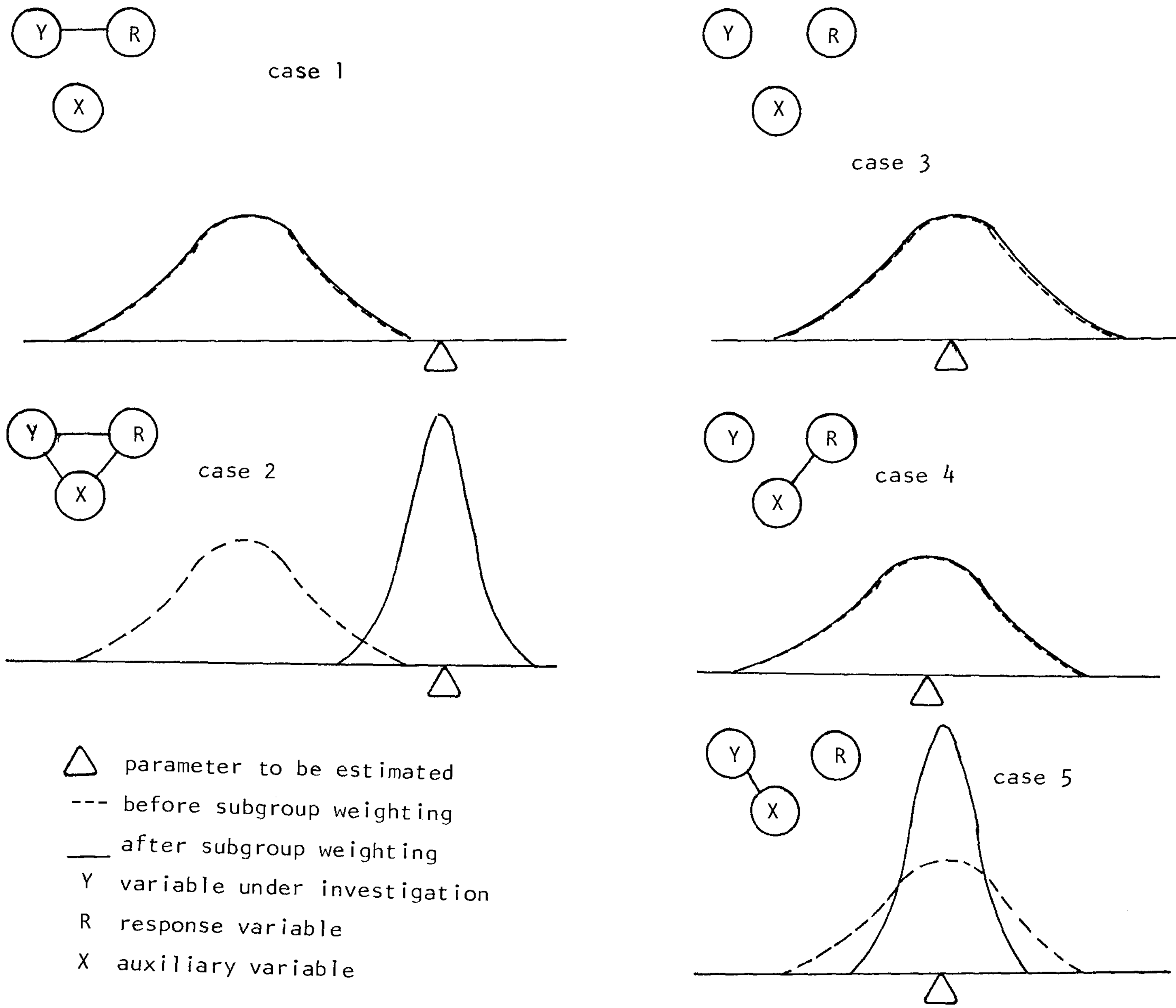
where $\underline{n}_h$ is the number of sample elements in subgroup h $(n=\underline{n}_1 + \underline{n}_2 + .. + \underline{n}_H)$.

In an intermediate situation where two auxiliary variables X_1 and X_2 are used and only the marginal totals of the two variables are known, a raking procedure can be applied to estimate the weights (see e.g. Chapman (1976)). Suppose X_1 induces G groups and X_2 induces H groups. Crossing X_1 and X_2 results in a subdivision into G x H groups. If only the marginal totals N_{g+} (g=1,2,..,G) of X_1 and N_{+h} (h=1,2,..,H) of X_2 are known then by using the sample information good estimates $\underline{N}_{gh}$ of N_{gh} can be computed. The weights are then equal to

$$\underline{w}_{gh} = \frac{\underline{N}_{gh}}{N} \qquad (g=1,2,..,G;\ h=1,2,..,H) \qquad (9)$$

All three estimators have, when used in the same grouping situation, the same bias, but the greater the amount of available information on the subgroup sizes the smaller the variance of the estimate. Subgroup weighting has two advantages: reduction of the variance of the estimate and reduction of the response bias. The most extreme possibilities are illustrated in fig. 6. If two variables are connected it means that they have a strong correlation.

FIG. 6. VARIANCE AND BIAS OF ESTIMATORS BEFORE AND AFTER SUBGROUP WEIGHTING



A number of conclusions can be drawn:

(1) If nonresponse bias exists subgroup weighting is significant when X and R are correlated (case 2). Both bias and variance are reduced.

(2) If no nonresponse bias exists a correlation between X and R has no effect (case 4). Only correlation between X and Y reduces the variance (case 5).

Because the data on the nonrespondents are missing, it is impossible to use the remaining data to find an auxiliary variable X which is highly correlated with Y. It is, however, possible to use this data to look for auxiliary variables which are highly correlated with the response variable R. If such a variable has been found, application of it in subgroup weighting will reduce the nonresponse bias (if it exists), but not always the variance.

5. Other adjustment methods

Several other adjustment methods appear in the literature. Several of them will be discussed in this section. Some of them need further research to establish their merits.

5.1 No adjustment

In some situations no adjustment is necessary. If it appears that no relationship exists between the variable under investigation and the response behaviour the response can be considered as a random sample from the population. Also if statements are restricted to the population of potential respondents no correction is necessary. In all other situations no adjustment is only justified if the category "nonresponse" is included in all tables in publications.

5.2. Imputation

Imputation procedures solve the problem of missing observations due to nonresponse by substitution of values in the records of the nonrespondents. In "hot deck" imputation data are taken from respondents of the current survey, while in "cold deck" imputation data are taken from a previous survey. If the response structure of previous and current survey resemble each other the results of cold deck imputation and hot deck imputation will roughly be the same. Imputation can be carried out in several ways. Some of them are:

(1) imputation of a random respondent
(2) imputation of the mean respondent
(3) imputation of a random respondent within the same subgroup
(4) imputation of the mean respondent within the same subgroup
(5) imputation of a value obtained by fitting a model
(6) imputation of upper or lower bounds

Procedures (1) and (2) do not reduce the bias. Procedures (3) and (4) resemble subgroup weighting. The effect of procedure (5) depends strongly on the fit of the model and the reasonableness of the model assumptions. Procedure (6) gives insight in how bad things could be if no adjustment would take place.

5.3. Adjustment for not-at-homes

The well-known method of Politz & Simmons (1949) tries to adjust for not-at-home bias by estimating the probability to find a person at home. This is performed by asking respondents e.g. how often they were at home at the time of the interview during the previous days. The at-home-probability, constructed in this way, can be used as a stratification variable. It is also worth trying to find a model which explains the relationship between the variable under investigation and the at-home-probability. Extrapolation of this model to the group of not-at-homes may provide more information about this group.

5.4. Adjustment for refusers

It is possible to measure the willingness of people to co-operate in the survey (see Van Tulder (1977)). Using this information a procedure analogous to adjustment for not-at-homes can be carried out. Furthermore the willingness to co-operate is a measure for the survey climate. The construction of a scale to obtain this information will probably be somewhat more difficult then in the case of not-at-home adjustment.

5.5 Double sampling

In order to get more information about nonrespondents Hansen & Hurwitz (1946) propose selecting a sample from the nonrespondents. Specially trained interviewers try as yet to obtain (part of) the missing information. Time and money constraints often prevent application of double sampling.

5.6. The principal question

If the method of Hansen & Hurwitz is too expensive the principal question procedure may offer a substitute. In many surveys there often is one important basic question around which the survey has been constructed. If during the field work problems are met with completing the whole questionnaire, the interviewer may try to get an answer on only the principal question. This may even be tried afterwards by letter or by telephone. This technique will shortly be tried out in one of the surveys of the CBS.

6. Conclusions

In view of the rise in nonresponse rates during the past years it is important to carry out thorough research on the impact of nonresponse on the quality of the survey.

Quite a few adjustment procedures appear in literature, which all aim at reduction of the nonresponse bias. A comparative study of these procedures has to provide decisive answers about their merits.

The large differences which exist with regard to objective, design and execution of surveys prevent correct interpretation of differences in nonresponse figures. It is therefore necessary to create a theoretical framework which allows proper comparison.

Of course reduction of nonresponse during the field work will remain an important topic.

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