Chapter 5

Variable Construction and File Development

5.1 Overview of the B&B:2000/01 Files

The B&B:2000/01 data files contain student level and institution level data collected from student interviews, institution records, and government financial aid databases. The primary analysis file, from which the study Data Analysis System (DAS) was constructed, contains data for a total of approximately 10,030 study respondents. The primary analysis file contains over 400 variables, developed from multiple B&B:2000/01 data sources.

Throughout the data collection period, data were processed and examined for quality control purposes. Editing of student data began shortly after the start of CATI data collection, when procedures and programs for this purpose were first developed. Anomalous values were investigated and resolved, where appropriate, through the use of data corrections and logical imputations. As shown in table 5.1, numerous interim data files were delivered to NCES for review, with each delivery including more of the study data.

Table 5.1. Interim file deliveries

Date	Description
10/04/2001	Delivery of about 7,900 completed interviews.—CATI
11/28/2001	Delivery of about 10,030 completed interviews. —CATI
12/17/2001	First interim delivery of student information file, school information file, CATI preload file coding file, and verbatim text file.
02/01/2002	Second interim delivery of student information file, school information file, CATI preload file coding file, and verbatim text file.
02/11/2002	Final delivery of student information file, school information file, CATI pre-load file coding file, and verbatim text file.

SOURCE: U.S. Department of Education, National Center for Education Statistics, 2000-2001 Baccalaureate and Beyond Longitudinal Study (B&B:2000/01).

Complete data obtained through the B&B:2000/01 study are on the restricted files and documented by the electronic codebook (ECB). These files and the ECB are available to researchers who have applied for and received authorization from NCES to access restricted research files. Authorization may be obtained by contacting the NCES Data Security Office.

The restricted use B&B:2000/01 ECB contains information about the following files:

- B&B:2000/01 analysis file—Contains analytic variables derived from all B&B data sources as well as selected direct CATI variables for the approximately 10,030 study respondents. [B01DER.DAT]

- B&B:2000/01 CATI student data file—Contains student level raw data collected from approximately 10,030 interview respondents. This file excludes any CATI "verbatim" variables, which are on the B&B:2000/01 Verbatim Data File described below. [B01STUD.DAT]

- B&B:2000/01 CATI school data file—Contains institution data obtained from the B&B:2000/01 student interview. It is a student level file; however, a student can have more than one record in the file. There is a separate record for each postsecondary institution that students reported they had attended since beginning their postsecondary education (up to 5 institutions collected during the NPSAS interview, up to 6 additional institutions collected in the follow up interview). [B01SCH.DAT]

- B&B:2000/01 coding results file—Contains the verbatim text and resulting code from B&B:2000/01 for post-baccalaureate major field of study, and for employed students, industry and occupation. Linkage to other data files is through the student ID. [B01COD.DAT]

- B&B:2000/01 verbatim data file—Contains item level records (i.e., one record per variable) for text variables collected in B&B:2000/01 CATI. It is possible to have multiple records per student or no records for a student. [B01VERB.DAT]

- B&B:2000/01 CATI preload file—Contains the data preloaded into the student interview for the approximately 10,030 CATI respondents. Preload data should not be used for analysis purposes, as they may have been updated during the interview. These data are provided for methodological purposes only. [B01PREL.DAT]

- B&B:2000/01 weights file—Contains all the sampling and analysis weights created for B&B:2000/01. There is a separate record for each of the approximately 10,030 B&B:2000/01 respondents. [B01WT.DAT]

- B&B:2000/01 nonresponse bias analysis file—Contains records for the approximately 11,700 members of the B&B:2000/01 sample. The variables included in this dataset allow nonresponse bias analysis and weight adjustment as detailed in chapter 6 of this report. [BB01SAMP.DAT]

- NPSAS:2000 analysis file—Contains analytic variables derived from all NPSAS data sources as well as selected direct CATI variables for the approximately 10,030 B&B:2000/01 respondents. [N2KDER.DAT]

- NPSAS:2000 CADE data file—Contains raw data collected from institutional records for the approximately 10,030 B&B:2000/01 study respondents. This includes about 9,610 respondents with sufficient data to be considered NPSAS CADE respondents, but also includes study respondents not considered CADE respondents. This file excludes any CADE "verbatim" variables such as responses to "Other, specify" items. [N2KCADE.DAT]

- NPSAS:2000 CATI student data file—Contains student level raw data collected from about 9,400 B&B:2000/01 respondents to the student interview during the base year study. This file excludes any CATI "verbatim" variables, which are located on the NPSAS:2000 verbatim data file described below. [N2KCATI.DAT].

- NPSAS:2000 CATI school data file—Contains institution data obtained from the student interview during the base year study. It is a student level file; however, a student can have more than one record in the file. There is a separate record for each postsecondary institution that students reported they had attended during the study year (up to five institutions). [N2KSCH.DAT]

- NPSAS:2000 coding results file—Contains the verbatim text and resulting code from NPSAS:2000 for post-baccalaureate major field of study, and for employed students, industry and occupation. Linkage to other data files is through the student ID. [N2KCODE.DAT]

- NPSAS:2000 verbatim data file—Contains item level records (i.e., one record per variable) for text variables collected either during CADE or NPSAS CATI. It is possible to have multiple records per student or no records for a student. [N2KVERB.DAT]

- NPSAS:2000 CATI preload file—Contains the data preloaded into the NPSAS student interview for the 9,400 B&B study respondents who were also NPSAS CATI respondents. It also contains records for the additional 630 B&B respondents who were NPSAS nonrespondents, for a total of 10,030 records. Preload data should not be used for analysis purposes, as they may have been updated during the interview. These data are provided for methodological purposes only. [N2KPREL.DAT]

- NPSAS:2000 Scholastic Aptitude Test (SAT) data file—Contains SAT data for the approximately 3,780 B&B study respondents who matched to Educational Testing Service (ETS) for the 1995–1999 test years. [N2KSAT.DAT]

- NPSAS:2000 American College Test (ACT) data file—Contains ACT data for about 4,000 B&B study respondents who matched to the ACT database for cohort years 1991–1992 through 1999–2000. [N2KACT.DAT]

- NPSAS:2000 institution data file—Contains selected institution level variables for about 690 NPSAS sampled institutions with B&B respondents. This file can be linked to the CATI Student Data File and CADE Data File by the IPEDS number. [N2KINST.DAT]

- CPS 2001/2002 data file—Contains data received from the central processing system (CPS) for approximately 1,480 study respondents who matched to the 2001–2002 financial aid application files. [CPS01.DAT]

- CPS 1999/2000 data file—Contains data received from the central processing system for the approximately 5,740 B&B study respondents who matched to the 1999–2000 financial aid application files. [CPS99.DAT]

- NSLDS file—Contains raw loan level data received from the National Student Loan Data System for the nearly 6,750 study respondents who received loans during the

2000–2001 year. This is a history file with separate records for each transaction in the loan files. [NSLDS.DAT]

- Pell data file—Contains raw grant level data received from the NSLDS for the B&B study respondents who received Pell Grants during the NPSAS year or prior years. This is a history file with separate records for each transaction in the Pell system. [PELL.DAT]

- Private school data file—Contains data about private schools in the United States. This file was used to extract selected information about the private schools at which B&B respondents taught. [PSS.DAT]

5.2 Data Coding and Editing

The B&B:2000/01 data were coded and edited using procedures developed and implemented for previous NCES-sponsored studies. The coding and editing procedures fell into two categories:

1. Online coding and editing performed during data collection, and
2. Post-data-collection data editing.

5.2.1 Online Coding and Editing

The B&B:2000/01 follow-up study had one major data collection system: CATI. The CATI system included edit checks to ensure that data collected were within valid ranges. To the extent feasible, this system incorporated across-item consistency edits. While more extensive consistency checks would have been technically possible, use of such edits was limited to prevent excessive respondent burden.

The CATI system included online coding systems used for the collection of industry, occupation, and major field of study data. Additionally, the CATI system included a coding module used to obtain IPEDS information for postsecondary institutions that the student attended (other than the NPSAS institution from which they were sampled). Below is a description of the online range and consistency checks and the online coding systems incorporated into the B&B:2000/01 CATI systems.

Data for the B&B:2000/01 sample from all NPSAS:2000 files were delivered along with B&B:2000/01 files. Users of the data files can find NPSAS:2000 coding and editing process reported in detail in the NPSAS:2000 Methodology Report.[19] Users of the data files from this study are encouraged to refer to that report for further information.

B&B:2000/01 CATI Range and Consistency Checks

- Range checks were applied to all numerical entries, such that only valid numeric responses could be entered.

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[19] Riccobono et al. 2001.

- Major field of study was entered by telephone interviewers as a text string. The coding software standardized and analyzed the text, and attempted to match the entry to a database. The interviewer was presented with one or more choices from which to select the appropriate entry in the coding dictionary.

- Student's occupation (if the student was employed) was coded by concatenating text strings entered for job title and job duties. The coding software then standardized and analyzed the text, and attempted to match the entry to the coding dictionary. The interviewer was presented with one or more choices, confirming entry with the student when multiple choices were presented.

- Student's industry (if the student was employed) was entered as a text string. The coding software then standardized and analyzed the text, and attempted to match the entry to the coding dictionary. The interviewer was presented with one or more choices, confirming entry with the student when multiple choices were presented.

- All postsecondary institutions in which the student had been enrolled since beginning his/her postsecondary education were selected from a list, based on the respondent's report and the interviewer's entry of the city and state in which the institution was located. Upon selection, the name of the institution, as well as selected IPEDS variables (institutional level, control, tuition) were inserted into the CATI database.

- If the respondent had taught since earning the bachelor's degree, the name of the elementary or secondary school in which the respondent taught was entered as a text string and coded in the elementary/secondary school user exit in a process similar to IPEDS (i.e., collect state, city, then school name). Additional variables such as county, district, lowest and highest grades offered, and whether the school is public or private, were obtained from the NCES Private School Survey (PSS) and Common Core of Data (CCD) data files.

- A verification check was triggered if the number of hours worked per week while enrolled exceeded 60 hours.

- A verification check was triggered if respondents stated that they worked more than 4 jobs.

- A verification check was triggered if earnings and income exceeded $1,000,000.

- A verification check was triggered if the respondent reported a mortgage payment over $4,000.

- A verification check was triggered if the respondent stated that they had 10 or more credit cards.

- A verification check was triggered if the respondent stated that they had become a teacher after completing their bachelor's degree, but reported that they started their job prior to July 1999.

5.2.2 Post-Data-Collection Editing

Following data collection, the information collected in CATI was subjected to various checks and examinations. These checks were intended to confirm that the database reflected appropriate skip-pattern relationships and different types of missing data by inserting special

codes. There are a variety of explanations for missing data within individual data elements. For example, an item may not have been applicable to certain students, a respondent may have refused to answer a particular item, or a respondent may not have known the answer to the question. Table 5.2 lists the set of consistency codes used to assist analysts in understanding the nature of missing data associated with B&B:2000/01 data elements.

Table 5.2. Description of missing data codes

Missing data code	Description
−1	Don't know (CATI variables)
	Data not available (CADE variables)
−2	Refused (CATI variables only)
−3	Not applicable—(CADE and CATI variables only)
−6	Bad data, out of range
−7	Item was not reached (abbreviated and partial CATI interviews)
−8	Item was not reached due to a CATI error
−9	Data missing, reason unknown (CATI variables)

SOURCE: U.S. Department of Education, National Center for Education Statistics, 2000–2001 Baccalaureate and Beyond Longitudinal Study (B&B:2000/2001).

Skip-pattern relationships in the database were examined by methodically running cross-tabulations between gate items and their associated nested items. In many instances, gate-nest relationships had multiple levels within the CADE or CATI instrument. That is, items nested within a gate question may themselves have been gate items for additional items. Therefore, validating the gate-nest relationships often required much iteration and many multiway cross-tabulations.

The data cleaning and editing process for the B&B:2000/01 data involved a multistage process that consisted of the following steps:

Step 1.   Blank or missing data were replaced with −9 for all variables in the CADE or CATI database. Also, a one-way frequency listing of every variable in the database was generated to confirm that no missing or blank values remained. These same one-way frequencies revealed any out-of-range or outlier data values, which were investigated and checked for reasonableness against other data values. Example: hourly wages of .10, rather than 10.

Some standard variable recodes were performed during this step. All Yes/No CATI variables were recoded from 1=Yes/2=No to 1=Yes/0=No. RTI's Telephone Survey Department standard is to use 1 for Yes and 2 for No. However, 1/0 for Yes/No works much better in the DAS and ECB, so the conversion was made in the editing process.

Step 2.   Using CADE or CATI source code as specifications, all gate-nest relationships were defined in SAS code. The format of the SAS statement should have been as follows: IF gate variable EQUAL gate value AND nest variable EQUAL −9 THEN nest variable EQUAL −3.

This code replaced –9's with –3's (the not applicable code) as appropriate or –1 when the response to the gate was indeterminate (don't know or refusal). Two-way cross-tabulations between each gate-nest combination revealed either numbers of nonreplaced –9 codes or "valid" responses in items that should have been skipped. Each such instance was investigated to ensure skip-pattern integrity. Typically, resolution involved reprogramming the gate-nest relationship to be consistent with the CADE or CATI instrument.

Some logical imputations could occur during this step if nonnegative values were assigned to variables that were "missing" and whose values could have been implicitly determined (and were thereby skipped in CADE or CATI). For instance, if the student did not work while enrolled, then the amount earned should have been coded to $0 rather than –3 or –9. If a student indicated that he or she was not disabled, then the "nested" disability items under the gate question were logically imputed to "no." On certain occasions, values were filled in that were previously skipped because they had a preloaded value. For example, B&B:2001 respondents who were also NPSAS:2000 respondents were not asked about their 1999–2000 enrollment since that information was collected during the NPSAS interview. Enrollment data for the 1999–2000 school year were imputed from the base year data for these cases.

Another step that occurred at this stage involved merging to external databases—IPEDS, PSS, and CCD. During the CATI interview, both postsecondary institutions and elementary/secondary schools (for respondents who were teachers) were coded online. Subsequent to the interview, these files were merged by the school code to pick up additional information including level, control, district, county, etc. for delivery with the B&B:2000/01 data.

Step 3.   Based on the section completion indicators, and/or the abbreviated interview indicator, the code replaced –9 and –3 with –7 (item not administered). This code allows analysts to easily distinguish items not administered from items that were either skipped or left blank unintentionally.

Step 4.   One-way frequencies on all categorical variables were regenerated and examined. Variables with high counts of –9 were investigated. Frequencies were checked for out-of-range or outlier data items. Responses in the one-way frequencies were checked to confirm that they had corresponding entries in the VALCODES documentation file. If there were any remaining –9 codes, they were replaced with the appropriate data code.

Step 5.   Descriptive statistics were produced for all continuous variables using SAS PROC UNIVARIATE. The SAS program first temporarily recoded all values less than zero to missing. Minimum, median, maximum, and mean values were examined to assess reasonableness of responses. Anomalous data pattern values were investigated and corrected as necessary.

5.3   Composite and Derived Variable Construction

Analytic variables were created by examining the data available for each student from the various data sources, establishing relative priorities of the data sources—on an item-by-item basis—and reconciling discrepancies within and between sources. In some cases, the derived or composite variables were created by simply assigning a value from the available source of information given the highest priority. In other cases, raw interview items were recoded or otherwise summarized to create a derived variable. A listing of the set of analysis variables derived for B&B:2000/01 appears in appendix F. Specific details regarding the creation of each variable appear in the variable descriptions contained in the ECB and DAS.

Chapter 6

Weighting and Variance Estimation

This chapter describes the weighting and variance estimation methods used in B&B:2000/01. Since the B&B:2000/01 sample was obtained from a complex survey design, estimates based on the sample will usually be computed using statistical analysis weights. These analysis weights primarily account for the unequal probabilities of selection in the sample. However, they also contain adjustments to account for the potential bias due to nonresponse, and are poststratified to known population totals to improve overall efficiency. Weights can be developed for use with a variety of variance estimation approaches and here weights are provided for two approaches: Taylor series and balance repeated replication.

This chapter describes the development of the final study weights, starting with a description of how initial design-based sample weights were obtained, and continuing through later adjustments up to the construction of final weights for two different variance estimation approaches. Included is an evaluation of the adequacy of the weights and adjustments and a description of the two methods provided for obtaining variance estimates from the final weights. Aspects of the B&B:2000/01 statistical analysis not related to weight development are provided in the appendices: survey design effects are described in appendix G, and item nonresponse analysis is provided in appendix H. Instructions for the use of the final analysis weights are provided in appendix I.

Section 6.1 describes how initial B&B:2000/01 weights were obtained from NPSAS:2000 weights and the B&B:2000/01 sampling design. Section 6.2 provides a summary of the types of nonresponse observed in the B&B:2000/01 sample and compares response behavior of individuals in NPSAS:2000 and B&B:2000/01. Tests for nonresponse bias are reported in section 6.3. Nonresponse adjustment is the subject of section 6.4, including selection of model predictors, an overview of the adjustment model (see also appendix F), and summary statistics for the successive adjustments of location nonresponse, refusal nonresponse, nonrefusal nonresponse, and poststratification. Section 6.5 summarizes weight and adjustment factor distributions and applies a variety of methods to evaluate the performance of the adjustment methods. It also provides both a brief analysis of potential bias due to the use of abbreviated interviews and the overall estimated study response rates. Finally, section 6.6 describes the two supported methods of variance estimation (Taylor series and balanced repeated replication), as well as how weights and analysis strata were developed.

6.1 Obtaining Initial Weights

The B&B:2000/01 sample design includes the first two stages of the NPSAS:2000 sample design and an additional B&B:2000/01-specific stage in which a subsample was selected from confirmed and potential baccalaureate recipients identified at the end of the NPSAS:2000 sample. All confirmed baccalaureate recipients were selected into the B&B:2000/01 sample,

while (nonresponding) potential baccalaureate recipients were randomly selected according to probabilities based on a measure of size, which was the estimate of the NPSAS:2000 study weight at the time of sample selection. Once the B&B:2000/01 sample had been selected, initial B&B:2000/01 weights were obtained by adjusting the NPSAS:2000 study weights for both the B&B:2000/01 subsample design and the presence of study-ineligible individuals on the B&B:2000/01 sampling frame. These two adjustments are now described in more detail.

6.1.1 Subsampling Weight Adjustment

For the B&B:2000/01 study, the sampling frame contained about 10,400 NPSAS:2000 confirmed baccalaureates and about 3,520 CATI nonresponding potential baccalaureates who were CADE respondents. This represented the NPSAS:2000 second-stage sample restricted—to the extent possible—to the target population of baccalaureate recipients.

To adjust the NPSAS:2000 study weights for subsample selection, the about 13,920 individuals on the subsample frame are numbered from $i=1,\ldots, 13,920$, and w^*_{1i} is the final NPSAS:2000 study weight for individual i. From section 2.1.2, the selection probability π_i for individual i is as follows:

$$\pi_i = 1 \qquad \text{if individual } i \text{ is a confirmed baccalaureate or}$$
$$\text{certainty selection, and}$$

$$= \frac{n(A_i)S_i}{\sum_{j \in A_i} S_j} \qquad \text{otherwise.}$$

where A_i contains all non-certainty individuals in the stratum to which i belongs, and $n(A_i)$ is the number of certainty selections in that stratum. The measure of size for individual i is given by S_i.

The subsampling weight component a^*_{1i} for individual i is then the reciprocal of this probability $a^*_{1i}=\pi_i^{-1}$, and the weight w^*_{2i} for individual i which accounts for subsampling is then $w^*_{2i}=w^*_{1i}a^*_{1i}I_i$, where I_i is an indicator variable for the presence of individual i in the subsample:

$$I_i = 0 \qquad \text{if individual } i \text{ is not in the subsample,}$$
$$= 1 \qquad \text{if individual } i \text{ is in the subsample.}$$

Since each individual on the sampling frame has different sample weights w^*_{1i}, the estimate of the subpopulation total, $\sum_{i=1}^{13920} w^*_{1i}$, is not preserved by these adjusted weights; that is, $\sum_{i=1}^{13920} w^*_{2i} \neq \sum_{i=1}^{13920} w^*_{1i}$. A simple ratio adjustment was made to account for this total based on the full sample by rescaling the weights of sampled potential baccalaureate recipients so that the subpopulation total was preserved. Denote the set of all about 3,520 potential baccalaureate recipients *as B*. The ratio adjustment can be stated as follows:

$$a^*_{2i} = \frac{\sum_{j \in B} w^*_{1j}}{\sum_{j \in B} w^*_{2j}} \qquad \text{if } i \in B, \text{ and}$$

$$= 1 \qquad \text{otherwise.}$$

The new ratio-adjusted weight is then $w^*_{3i}=w^*_{2i}a^*_{2i}$. In the B&B:2000/01 study, the observed adjustment was, in fact, very small, $a^*_{2i}= 0.99993$ for all $i \in B$.

6.1.2 Eligibility Weight Adjustment

At the conclusion of B&B:2000/01 sampling, some of the potential baccalaureate recipients had unconfirmed eligibility due to nonresponse, so an additional weight adjustment was made in compensation. This adjustment was made within weighting classes defined by the five non-empty levels of institutional sector (the cross of institutional control and institutional level). Within each class, the proportion eligible was estimated using the observed proportions in the B&B:2000/01 respondents.

The estimated proportion eligible $\hat{p}_j$ in level j of institutional sector is as follows:

$$\hat{p}_j = \frac{\sum_{i \in A_j} w^*_{3i}I_i}{\sum_{i \in A_j} w^*_{3i}J_i} \qquad j = 1,...,5$$

where A_j, for j=1…,5, is a set of individuals in level j of institutional sector, I_i=1 if individual i is eligible, I_i= 0 otherwise,[20] and J_i=1 if the eligibility status of individual i is known, J_i=0 otherwise.[21] The adjustment factor a^*_{3i} for the eligibility of individual i is then

$$a^*_{3i} = 1 \qquad \text{if individual } i \text{ is known eligible,}$$
$$= 0 \qquad \text{if individual } i \text{ is known ineligible, or}$$
$$= \hat{p}_j \qquad \text{if } i \in A_j \text{ and individual } i \text{ is of unknown eligibility.}$$

The initial weight for individual i in the B&B:2000/01 study is then $w_{1i}=w^*_{3i}a^*_{3i}$.

6.2   Response Classification of the Collected Sample

The nonresponse that was observed in B&B:2000/01 can be classified into a variety of types, and this classification will be used later in fitting models for nonresponse adjustment. An overview of the distribution of the types of nonresponse in the B&B:2000/01 subsample is now provided. Overall, the B&B:2000/01 subsample had an unweighted 86 percent response rate; of the about 11,700 individuals selected in the B&B:2000/01 subsample, a total of about 10,030 were respondents.

Nonresponse was classified into three types for later use with weight adjustment models:
- *location nonresponse* (unable to locate),
- *refusal nonresponse*, and
- *nonrefusal nonresponse* (e.g., still attempting to schedule interview, language barriers).

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[20]Individuals were considered eligible if they were either NPSAS:2000 confirmed baccalaureate recipients who were B&B:2000/01 nonrespondents, or if they were B&B:2000/01 respondents who confirmed receiving a degree.
[21]Eligibility status was known if they were eligible as described above, or if they were revealed to be ineligible during the B&B:2000/01 CATI interview, or if they were deceased.

The distribution of these types of nonresponse among all sampled individuals is provided in table 6.1. Within the table, it can be seen that location was the most common type of nonresponse at 7 percent of the sample, followed by refusal at 5 percent, and nonrefusal at 3 percent.

Table 6.1. B&B 2000/01 respondent classifications and observed sample counts and percentages

Response status	Classification	Total	Percent	Cumulative classification	Cumulative total	Cumulative percent
Respondent	Respondent	10,030	86	Respondent	10,030	86
Nonrespondent	Nonrefusal	300	3	Nonrefusals	10,330	88
	Refusal	530	5	Located	10,860	93
	Location	760	7	Eligible	11,620	99
Excluded	Ineligible	80	1	Sampled	11,700	100

NOTE: Details may not sum to total due to rounding.
SOURCE: U.S. Department of Education, National Center for Education Statistics, 2000–-2001 Baccalaureate and Beyond Longitudinal Study (B&B:2000/01).

The five categories of response status are also grouped according to a "cumulative classification" that was used in fitting nonresponse models. Beginning with the approximately 10,030 respondents, this classification successively groups the response status categories of table 6.1, leading to cumulative classifications of respondents, nonrefusals (respondents plus nonrefusal nonrespondents), located (respondents and nonrespondents who were located), all eligible sample students, and finally, all 11,700 sampled students. From table 6.1, for example, it can be seen that there were a total of 10,330 nonrefusals, which is equal to 10,030 respondents plus 300 nonrefusal nonrespondents.

Since the B&B:2000/01 subsample was drawn from the NPSAS:2000 sample, individual response status can be compared across these two samples, and this comparison is made in table 6.2. The counts in the table show that individuals who were NPSAS:2000 CATI respondents had a 90 percent response rate in B&B:2000/01, while NPSAS:2000 CATI nonrespondents had a response rate of 48 percent. The counts also show that rankings of the various response types according to sample size are the same across the two groups.

Table 6.2. B&B:2000/01 respondent classification counts and percentages, by NPSAS:2000 CATI response status

B&B:2000/01 classification	NPSAS:2000 CATI respondents	Percent of NPSAS:2000 CATI respondents	NPSAS:2000 CATI nonrespondents	Percent of NPSAS:2000 CATI nonrespondents
All individuals	10,400	100	1,300	100
Respondents	9,400	90	630	48
Nonrespondents				
Nonrefusal	210	2	90	7
Refusal	350	3	180	14
Location	430	4	330	26
Ineligible	10	#	70	5

Rounds to zero.

NOTE: Individuals in the B&B:2000/01 sample were restricted NPSAS CADE respondents as discussed in section 2.1.4. Details may not sum to total due to rounding.

SOURCE: U.S. Department of Education, National Center for Education Statistics, 2000–2001 Baccalaureate and Beyond Longitudinal Study (B&B:2000/01).

In addition to types of nonrespondents, two types of respondents can also be considered: late respondents and refusal conversions. Late respondents should show similar behavior to location nonrespondents and refusal-conversion respondents should show similar behavior to refusal nonrespondents. With these comparisons in mind, these respondent types are discussed in section 6.3.3. Late respondents were defined as individuals who responded after October 15, 2001. There were about 1,430 late respondents in the B&B:2000/01 subsample, 14 percent of the total number of respondents. Refusal conversions were individuals who initially refused to participate in the interview, but later were convinced to respond. There were about 970 refusal conversions, 10 percent of the total number of respondents.

6.3   Assessing Nonresponse Bias

The substantial amount of unit nonresponse in the B&B:2000/01 sample of NPSAS:2000 CATI nonrespondents may lead to nonresponse bias in survey estimates. With outside knowledge from NPSAS:2000 of variable values for both B&B:2000/01 respondents and nonrespondents, however, tests for potential nonresponse bias can be performed to check if any bias can be detected. This section defines nonresponse bias and presents the results of such tests for the B&B:2000/01 sample.

6.3.1 Nonresponse Bias: Definition and Tests

Nonresponse bias can occur when survey respondents and nonrespondents differ in their response distributions for variables of interest. Unit nonresponse is considered here, the type that occurs when a sampled individual does not respond to any of the survey questions.[22] Another type of nonresponse, item nonresponse, occurs when otherwise responding individuals fail to respond to specific survey questions. Item nonresponse is considered separately in appendix H.

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[22]Unit nonresponse is referred to throughout this report as simply "nonresponse." Item nonresponse is referred to specifically as "item nonresponse."

Suppose that a design-unbiased estimator $\bar{y}$ is available to estimate population mean μ from the target population of interest. Estimator $\bar{y}$ may be a good estimator to use with no nonresponse, but in the presence of nonresponse it can easily become biased. To estimate and correct for this bias, a model for nonresponse is required.

Assume that the population can be divided into two groups: a group of responders and a group of nonresponders. Each of these groups may have a different distribution for y, the variable of interest, and as a result, the means can differ between the two groups: for the responders μ_R and for the nonresponders μ_{NR}. The proportion of nonresponders will be η (the nonresponse rate), and the proportion of responders therefore is $1 - \eta$. A mixture model structure for nonresponse is being assumed. A consequence of this mixture model is that the population mean μ can be expressed in terms of the subpopulation means and nonresponse rate as follows:

$$\mu = (1 - \eta)\mu_R + \eta\mu_{NR}.$$

The bias $B(\bar{y}_R)$ of the estimator $\bar{y}_R$ of mean response in the respondent group is defined as follows:

$$B(\bar{y}_R) = E[\bar{y}_R] - \mu$$

$$= \mu_R - \mu$$

because $\bar{y}_R$ is unbiased for μ_R, and the bias is the difference between the mean of the respondent group and the mean of the population as a whole.

This bias can be estimated for variables whose values are known for both respondents and nonrespondents. Substituting the mixture model population mean expression and replacing parameters with their estimates gives the following:

$$\hat{B}(\bar{y}_R) = \bar{y}_R - ((1 - \hat{\eta})\bar{y}_R + \hat{\eta}\bar{y}_{NR}) = \hat{\eta}(\bar{y}_R - \bar{y}_{NR}),$$

where $\hat{\eta}$ is the estimated nonresponse rate, and $\bar{y}_{NR}$ is the nonrespondent sample mean. Similar to a coefficient of variation, the bias can be adjusted by dividing through by the respondent mean. This gives the relative bias

$$\hat{RB}(\bar{y}_R) = \frac{\hat{B}(\bar{y}_R)}{\bar{y}_R}.$$

The variance of the bias can be estimated as:

$$\hat{Var}(\hat{B}(\bar{y}_R)) = \hat{\eta}^2\hat{Var}(\bar{y}_R - \bar{y}_{NR}).$$

This variance can be estimated in SUDAAN by Taylor series linearization, taking into account the covariance between $\bar{y}_R$ and $\bar{y}_{NR}$ induced by the multistage stratified sampling design.

6.3.2 Nonresponse Bias Analysis for Selected NPSAS:2000 Variables

Prior to making any adjustments for nonresponse bias, statistical tests were performed to test for the presence of nonresponse bias. Two tests of bias were performed: a test for bias at a specific level of a variable, and a test for bias over all levels of a variable. The first test is a *t*-test based on the difference in proportions in the responding and nonresponding groups at a given variable level; the second is a chi-square test of heterogeneity of the distributions of respondents and nonrespondents over all levels of a given variable. Both of these tests are conducted in SUDAAN, which takes account of the complex survey design as well as potential cluster correlation in the data.

Nonresponse bias was tested in variables that were available for both respondents and nonrespondents in the B&B:2000/01 sample. Since all individuals in the B&B:2000/01 sampling frame were NPSAS:2000 CADE respondents, the NPSAS:2000 CADE variables were available for the nonresponse analysis. Of these variables, the ones that were selected are as follows:

- Type of institution,
- Type of institution crossed with enrollment category,
- Institution region,
- Gender,
- Age,
- Race,
- Hispanic,
- Citizenship,
- Attendance status,
- Income,
- Applied for aid,
- Received federal aid,
- Received Pell Grant,
- Received Stafford Loan,
- Received state aid,
- Received institution aid, and
- Received any aid.

For compatibility with later nonresponse modeling, only categorical variables were used in the nonresponse analysis. Some of the above variables, such as age, are therefore collapsed versions of initially continuous variables.

Since these variables are all categorical, the response associated with each individual is simply the category to which the individual belongs, and so the mean parameters being estimated for respondents and nonrespondents are vectors of proportions.

The results of the nonresponse bias *t*-tests are given in table 6.3. From this table it can be seen that many levels of the tested variables had significant nonresponse bias. The only variables that did not show any levels of significant nonresponse bias were the two institution level variables—institutional sector and the cross of institutional control and enrollment category—and the individual level variables indicating recipient of Pell grant or state aid. All other variables had at least one significant *t*-test. Note that in cases of two-level variables, if one *t*-test is significant, the other is as well. This consistency occurs because the test is a two sample test of proportions, and is invariant to the labeling of the levels. For example, the test of bias comparing percent male respondents against percent male nonrespondents is the same as the test of bias comparing percent female respondents (100 percent minus percent male respondents) to percent female nonrespondents (100 percent minus percent male nonrespondents).

The results of the nonresponse bias chi-squared tests are given in table 6.4 and are consistent with the results of the *t*-tests. Most variables with at least one significant *t*-test had a significant chi-square test, and significant chi-square tests typically had at least one significant *t*-test.

6.3.3 Analysis of Selected B&B:2000/01 Variables for Potential Nonresponse Bias

In addition to testing for nonresponse bias directly by comparing distributions of respondents and nonrespondents on levels of variables known for both, behavior suggestive of nonresponse can be tested using variables with values known only for B&B:2000/01 CATI interview respondents. To do this, respondents are divided into two groups, one of which has nonresponse-like behavior. Two comparisons are considered: late respondents versus other (not late) respondents, and refusal conversions versus other (never-refused) respondents.

For the comparison of late respondents versus other (not late) respondents, significant differences in means would be suggestive of potential nonresponse bias due to inability to locate sampled individuals. The results of *t*-tests among means of these two groups for selected B&B:2000/01 CATI interview variables are given in table 6.5. The table shows that there are significant differences for levels of ever married, supports children, and military status. Enrollment in 2000–2001 and previous teaching experience show no significant differences among their levels.

Table 6.3. Nonrespondents versus respondents: Percentages and bias tests for selected NPSAS:2000 variables

Variable description	Number of respondents	Number of non-respondents	Percent respondent distribution	Percent nonrespondent distribution	Non-response bias	Percent relative bias	P-value
Institutional sector							
Public 4-year	6,460	1,030	65	66	−0.0008	−0.1	0.78
Non-doctorate-granting	2,060	300	19	18	−0.0023	1.2	0.37
Doctorate granting	4,400	730	46	48	−0.0031	−0.7	0.30
Private not-for-profit 4-year	3,450	540	34	33	0.0010	0.3	0.74
Non-doctorate-granting	1,920	260	20	17	0.0053	2.7	0.03
Doctorate-granting	1,530	280	14	16	−0.0043	−3.1	0.03
Private for-profit 4-year	120	30	1	1	−0.0001	−1.2	0.77
Institutional control and enrollment category							
Public							
Fewer than 1,000	10	0	#	0	#	#	0.16
1,000–2,499	120	10	1	1	0.0005	6.0	0.21
2,500–4,999	360	60	4	3	0.0007	2.0	0.62
5,000–9,999	1,090	150	9	8	0.0021	2.4	0.09
10,000–19,999	1,780	260	18	17	0.0007	0.4	0.77
20,000 or more	3,110	560	34	37	−0.0049	−1.4	0.09
Private not-for-profit							
Fewer than 1,000	270	30	2	2	0.0009	4.1	0.25
1,000–2,499	840	110	8	7	0.0028	3.4	0.04
2,500–4,999	880	130	9	9	0.0003	0.3	0.86
5,000–9,999	590	100	6	6	−0.0006	−1.0	0.67
10,000 or more	870	160	9	10	−0.0026	−3.0	0.14
Private for-profit							
Fewer than 999	20	10	#	#	0.0001	4.0	0.39
1,000 or more	100	20	1	1	−0.0003	−2.9	0.54
Institution region							
New England	600	130	7	9	−0.0034	−5.1	0.04
Mid East	1,860	280	18	17	0.0015	0.8	0.44
Great Lakes	1,670	250	16	16	0.0010	0.6	0.63
Plains	860	130	9	8	0.0020	2.3	0.26
South East	2,410	310	23	18	0.0072	3.2	0.00*
South West	990	180	10	12	−0.0034	−3.5	0.09
Rocky Mountains	400	50	4	3	0.0015	4.0	0.22
Far West	1,130	250	13	17	−0.0068	−5.2	0.00*
Outlying Area	110	20	1	1	0.0004	2.9	0.64
Gender							
Male	3,850	710	41	46	−0.0091	−2.2	0.00*
Female	6,180	890	59	54	0.0091	1.5	0.00*
Age							
21 or younger	2,660	360	26	22	0.0077	2.9	0.00*
22	2,510	380	24	22	0.0042	1.8	0.09
23	1,340	230	13	14	−0.0005	−0.4	0.82
24 to 27	1,580	330	16	22	−0.0103	−6.3	0.00*
28 or older	1,950	310	20	21	−0.0012	−0.6	0.63
Race							
White	8,170	1,180	80	73	0.0127	1.6	0.00*
Black or African American	790	140	8	9	−0.0016	−1.9	0.34
Asian	460	170	5	12	−0.0116	−22.4	0.00*
American Indian/Alaska Native	80	10	1	1	−0.0001	−1.3	0.85
Native Hawaiian/Other Pacific Islander	60	20	1	1	−0.0012	−17.4	0.06
Other	480	70	5	4	0.0019	3.8	0.13
Hispanic							
Yes	700	160	8	11	−0.0042	−5.0	0.04*
No	9,330	1,440	92	89	0.0042	0.5	0.04*
Citizenship							
U.S. citizen	9,610	1,400	95	86	0.0166	1.7	0.00*
Resident alien	290	70	3	5	−0.0032	−9.4	0.02*
Foreign/international student	130	120	2	9	−0.0134	−85.4	0.00*

See notes at end of table.

Table 6.3. Nonrespondents versus respondents: Percentages and bias tests for selected NPSAS:2000 variables—Continued

Variable description	Number of respondents	Number of non-respondents	Percent respondent distribution	Percent nonrespondent distribution	Nonresponse bias	Percent relative bias	P-value
Attendance status							
Full-time/full year, 1 institution	4,900	740	47	44	0.0059	1.3	0.04
Full-time/full year, more than 1 institution	380	40	3	2	0.0015	5.0	0.07
Full-time/part year	2,100	310	21	18	0.0056	2.7	0.02
Part-time/full year, 1 institution	1,150	210	13	15	−0.0034	−2.6	0.10
Part-time/full year, more than 1 institution	150	10	1	1	0.0008	8.0	0.09
Part-time/part year	1,360	280	15	21	−0.0106	−7.1	0.00*
Parents' income (for dependent students)							
Less than $10,000	190	30	2	2	−0.0001	−0.5	0.92
$10,000–$19,999	300	50	3	3	−0.0005	−1.7	0.61
$20,000–$29,999	520	80	5	5	0.0005	1.0	0.67
$30,000–$39,999	500	80	5	5	−0.0009	−1.8	0.43
$40,000–$49,999	590	90	6	5	0.0006	1.0	0.62
$50,000–$59,999	580	90	6	6	0.0007	1.2	0.56
$60,000–$69,999	580	90	6	5	0.0001	0.2	0.93
$70,000–$79,999	500	70	5	4	0.0009	1.8	0.45
$80,000–$99,999	820	110	8	6	0.0041	5.1	0.00
$100,000 or more	1,260	170	13	9	0.0068	5.2	0.00*
Student's income (for independent students)							
Less than $5,000	680	130	6	8	−0.0027	−4.5	0.10
$5,000–$9,999	600	110	6	7	−0.0024	−4.0	0.12
$10,000–$19,999	840	140	9	9	−0.0005	−0.6	0.75
$20,000–$29,999	560	120	6	8	−0.0033	−5.5	0.06
$30,000–$49,999	740	130	7	10	−0.0039	−5.6	0.03
$50,000 or more	770	120	9	8	0.0006	0.7	0.72
Applied for aid							
Yes	5,930	810	57	50	0.0137	2.4	0.00*
No	4,100	780	43	50	−0.0137	−3.2	0.00*
Receipt of federal aid							
Yes	5,220	710	51	43	0.0141	2.8	0.00*
No	4,810	880	49	57	−0.0141	−2.9	0.00*
Receipt of Pell grant							
Yes	2,350	340	22	21	0.0022	1.0	0.34
No	7,680	1,250	78	79	−0.0022	−0.3	0.34
Receipt of Stafford loan							
Yes	4,510	620	45	38	0.0115	2.6	0.00*
No	5,520	970	56	62	−0.0115	−2.1	0.00*
Receipt of state aid							
Yes	1,950	260	17	15	0.0035	2.1	0.08
No	8,080	1,340	83	85	−0.0035	−0.4	0.08
Receipt of institution aid							
Yes	3,360	470	31	28	0.0067	2.2	0.01*
No	6,670	1,120	69	73	−0.0067	−1.0	0.01*
Receipt of any aid							
Yes	7,080	970	69	60	0.0163	2.4	0.00*
No	2,950	620	31	40	−0.0163	−5.3	0.00*

\# Rounds to zero. All zeros provided in this table are actual values.

*Difference between respondents and nonrespondents is significant at the .05/(c−1) level, where c is the number of categories within the primary variable.

NOTE: Details may not sum to total due to rounding.

SOURCE: U.S. Department of Education, National Center for Education Statistics, 2000–2001 Baccalaureate and Beyond Longitudinal Study (B&B:2000/01).

Table 6.4. Nonrespondents versus respondents: Chi-square tests for selected NPSAS:2000 variables

Variable description	Chi-square	Degrees of freedom	P-value
Institutional sector	9.9	4	0.05*
Institutional control and enrollment category	17.2	12	0.15
Institution region	26.2	8	0.00*
Gender	8.4	1	0.00*
Age	23.4	4	0.00*
Race	40.6	5	0.00*
Hispanic	4.3	1	0.04*
Citizenship	72.7	2	0.00*
Attendance status	29.9	5	0.00*
Income of independent students and parents of dependent students	39.2	15	0.00*
Applied for aid	21.8	1	0.00*
Receipt of federal aid	24.4	1	0.00*
Receipt of Pell grant	0.9	1	0.34
Receipt of Stafford loan	17.2	1	0.00*
Receipt of state aid	3.1	1	0.08
Receipt of institution aid	6.0	1	0.01*
Receipt of any aid	31.5	1	0.00*

* Significant at the α=.05 level.

SOURCE: U.S. Department of Education, National Center for Education Statistics, 2000–2001 Baccalaureate and Beyond Longitudinal Study (B&B:2000/01).

Table 6.5. Late respondents versus other respondents: Percentages and bias tests for selected B&B:2000/01 variables

Variable description	Number of other respondents	Number of late respondents	Percent other respondents distribution	Percent late respondents distribution	Late respondent bias	Percent relative bias	P-value
Ever married							
Yes	3,170	460	36	31	0.0078	2.2	0.01*
No	5,400	970	64	69	−0.0078	−1.2	0.01*
Have children							
Yes	1,640	180	19	16	0.0045	2.4	0.02*
No	6,860	940	81	84	−0.0045	−0.6	0.02*
Military status							
Veteran	270	30	3	3	0.0007	2.1	0.56
Active duty	90	20	1	2	−0.0016	−15.0	0.14
Reserves	80	10	1	#	0.0008	8.7	0.00*
None	7,900	1,040	92	93	−0.0006	−0.1	0.76
Non-citizen	190	30	3	2	0.0006	2.3	0.48
Enrolled in 2000–01							
Yes	3,130	440	35	36	0.0000	0.0	1.00
No	5,410	740	65	65	0.0000	0.0	1.00
Teacher							
Yes	1,800	210	17	16	0.0020	1.1	0.29
No	6,700	910	83	84	−0.0020	−0.2	0.29

Rounds to zero.

*Difference between converted refusals and other respondents is significant at the .05/(c–1) level, where c is the number of categories within the primary variable.

NOTE: Details may not sum to total due to rounding.

SOURCE: U.S. Department of Education, National Center for Education Statistics, 2000–2001 Baccalaureate and Beyond Longitudinal Study (B&B:2000/01).

The chi-square tests of heterogeneity for late-respondents versus other respondents are given in table 6.6. Ever married, supports children, and military status have significant heterogeneity, while enrollment in 2000–2001 and previous teaching experience do not. These results are consistent with those of the *t*-tests, and suggest the potential for location nonresponse bias associated with variable levels with significant tests.

Table 6.6. **Late respondents versus other respondents: Chi-square tests of heterogeneity for selected B&B:2000/01 variables**

Variable description	Chi-square	Degrees of freedom	P-value
Ever married	7.6	1	0.00*
Have children	5.2	1	0.02*
Military status	12.5	4	0.02*
Enrolled in 2000–01	0.0	1	0.99
Teacher	1.1	1	0.29

* Significant at the α=.05 level.

SOURCE: U.S. Department of Education, National Center for Education Statistics, 2000–2001 Baccalaureate and Beyond Longitudinal Study (B&B:2000/01).

For the comparison between groups of converted refusals versus other respondents who never refused, significant differences in means would suggest potential refusal bias among the true nonrespondents. Converted refusals are respondents who initially refused to be surveyed but later agreed. Results of *t*-tests and chi-square tests for converted refusals versus other respondents for selected B&B:2000/01 CATI variables are given in tables 6.7 and 6.8. These tables show that no significance was detected on either *t*-tests or chi-square tests for any of the selected variables. These analyses do not suggest any potential refusal nonresponse bias related to these variables.

Table 6.7. **Converted refusals versus other respondents: Percentages and bias tests for selected B&B:2000/01 variables**

Variable description	Number of nonrefusals	Number of converted refusals	Percent nonrefusal distribution	Percent converted refusal distribution	Converted refusal bias	Percent relative bias	P-value
Ever married							
Yes	3,210	420	35	38	−0.0040	−1.2	0.12
No	5,820	550	65	62	0.0040	0.6	0.12
Have children							
Yes	1,630	200	18	21	−0.0032	−1.8	0.27
No	7,110	700	82	79	0.0032	0.4	0.27
Military status							
Veteran	270	20	3	2	0.0010	3.0	0.11
Active duty	90	10	1	3	−0.0016	−15.0	0.14
Reserves	80	10	1	1	0.0001	1.2	0.86
None	8,110	830	92	91	0.0016	0.2	0.31
Non-citizen	200	20	2	4	−0.0011	−4.4	0.27
Enrolled in 2000–01							
Yes	3,270	300	35	32	0.0036	1.0	0.21
No	5,540	610	65	68	−0.0036	−0.6	0.21
Teacher							
Yes	1,830	180	17	15	0.0024	1.4	0.16
No	6,890	710	83	85	−0.0024	−0.3	0.16

NOTE: None of the p-values in this table were significant at the .05(c-1) level, where c is the number of categories within the primary variable. Details may not sum to total due to rounding.

SOURCE: U.S. Department of Education, National Center for Education Statistics, 2000–2001 Baccalaureate and Beyond Longitudinal Study (B&B:2000/01).

Table 6.8. Converted refusals versus other respondents: Chi-square tests of heterogeneity for selected B&B:2000/01 variables

Variable description	Chi-square	Degrees of freedom	P-value
Ever married	2.52	1	0.11
Have children	1.19	1	0.28
Military status	5.61	4	0.23
Enrolled in 2000–01	1.57	1	0.21
Teacher	1.94	1	0.16

NOTE: None of the p-values in this table were significant at the .05 level.

SOURCE: U.S. Department of Education, National Center for Education Statistics, 2000–2001 Baccalaureate and Beyond Longitudinal Study (B&B:2000/01).

All of the above tests were restricted to individuals who were item respondents in the CATI interview. There should not be any substantial effect of item nonresponse, as none of the selected variables had more than an estimated 2 percent item nonresponse rate.

6.4   Adjusting for Nonresponse Bias and Poststratification

The analysis of the previous section suggests some nonresponse bias in a number of the NPSAS:2000 variables. This nonresponse bias can be reduced by adjusting individual weights using variables whose values are known for both respondents and nonrespondents. Further adjustment can be accomplished by poststratification to make the weights consistent with known population totals.

In this section, methods used to perform weight adjustments are described, as well as their application to the B&B:2000/01 initial weights. The results and performance of these adjustment methods also are discussed. Weight adjustment proceeds in the following stages: identification of model predictors, generalized exponential model (GEM) adjustment for nonresponse, and finally GEM poststratification adjustment.

6.4.1 Identification of Model Predictors

Predictors used in the nonresponse modeling included all variables identified for nonresponse analysis in section 6.3.2, as well as certain potentially important interactions. To identify these interactions without attempting a methodologically challenging step-wise regression procedure, the Chi-square automatic interaction detection (CHAID) algorithm (Kass, 1980)[23] was used. CHAID is a hierarchical clustering algorithm that successively partitions individuals according to categorical predictors for a categorical dependent variable. The algorithm begins with all study individuals as a whole, and cycles over each predictor, finding for each predictor an optimal partition of the individuals according to its levels. The most significant optimal partition is then retained, and the CHAID algorithm is again applied to the members of that partition to find further partitions using the remaining predictors. The algorithm is stopped after a specified number of partitioning steps or if none of the partitions at a given step is found to be significant.

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[23]Kass, G.V. (1980). An exploratory technique for investigating large quantities of data. *Applied Statistics*, 119–127.

Application of the CHAID algorithm provided interaction terms for each of the three nonresponse adjustment models: location, refusal, and other. For each model, CHAID was run for up to three segments, resulting in identification of two-way and three-way interactions. Segments were retained if they were both statistically and practically significant.

6.4.2 GEM Nonresponse and Poststratification Adjustments

Four adjustment steps were successively applied to the initial B&B:2000/01 weights to adjust for nonresponse bias and known population totals. There were three adjustment steps for nonresponse bias: adjustment for inability to locate, adjustment for refusal to respond, and adjustment for nonrefusal nonresponse. Since population totals for some variables were available through the IPEDS institutional census, there was also a fourth poststratification adjustment to make the sample weights consistent with the known postsecondary totals. All adjustments were made by successive application of a GEM.

The RTI-proprietary GEM (Folsom and Singh, 2000[24]; Chen, Penne, and Singh, 2000[25]) is a generalization of a logit model. It has several desirable features for weight adjustments, including the following:

1. It is a generalization of the commonly used, well known, and accepted adjustment approaches: the raking ratio method and the logit method (see e.g., Deville and Särndal, 1992).[26] For this reason, initial weights are perturbed minimally, bounds can be specified, and poststratification control totals met.

2. It allows for individual-specific bounds on the weight adjustment factors, allowing for the application of special adjustments to those weights identified as having extreme values.

The application of GEM to each adjustment step of the B&B:2000/01 study is described in appendix J.

[24]Folsom, R.E. and Singh A.C. (2000). The generalized exponential model for sampling weight calibration for extreme values, nonresponse, and poststratification. *Proceedings of the American Statistical Association Section on Survey Research Method,* 598–603.

[25]Chen, P., Penne, M.A., and Singh, A.C. (2000). Experience with the generalized exponential model for weight calibration for the national household survey on drug abuse. *Proceedings of the American Statistical Association Section on Survey Research Methods,* 604–609.

[26]Deville, J.C. and Särndal, C.E. (1992). Calibration estimation in survey sampling. *Journal of the American Statistical Association,* 87: 376–382.

Indexing the eligible individuals in the selected B&B:2000/01 sample from about $i = 1,\ldots, 11620$, the four weight adjustments were as follows:

a_{1i}	location nonresponse adjustment
a_{2i}	refusal nonresponse adjustment
a_{3i}	nonrefusal nonresponse adjustment
a_{4i}	poststratification adjustment.

These weight adjustment factors provide us with successive adjusted weights:

$w_{2i} = a_{1i}w_{1i}$	location nonresponse adjusted
$w_{3i} = a_{2i}w_{2i}$	refusal nonresponse adjusted
$w_{4i} = a_{3i}w_{3i}$	nonrefusal nonresponse adjusted
$w_{5i} = a_{4i}w_{4i}$	poststratification adjusted.

Summary statistics for the GEM for each nonresponse adjustment stage are provided in tables 6.9, 6.10, and 6.11. Each table lists in its left-most column the levels of predictor variables used in the model. The main-effects predictors are the same as those used for the nonresponse bias analysis of section 6.3.2. Interaction terms were obtained from the CHAID algorithm as described in section 6.4.1 and are listed at the bottom of the tables. For each interaction, the variables and their levels are listed in the order of CHAID partitioning.

For all individuals and by predictor level, the tables provide the number of individuals with nonzero weight, number of individuals in the nonresponse category, and the mean weight adjustment. These tables again show the general trend, whereby the largest adjustments occur at earlier adjustment stages.

Table 6.9. Location nonresponse sample sizes and mean location weight adjustments at all levels of GEM predictor variables

Variable description	Number located	Number not located	Mean weight adjustment
All individuals	11,620	760	1.15
Institutional control			
Public	7,490	500	1.11
Private not-for-profit	3,990	250	1.21
Private for-profit	150	20	1.24
Institutional control and enrollment category			
Public			
Fewer than 2,500	130	10	1.10
2,500–4,999	420	30	1.25
5,000–9,999	1,230	60	1.09
10,000–19,999	2,040	120	1.11
20,000 or more	3,670	280	1.11
Private not-for-profit			
Fewer than 1,000	300	20	1.18
1,000–2,499	950	60	1.15
2,500–4,999	1,020	60	1.14
5,000–9,999	690	50	1.18
10,000 or more	1,030	70	1.35
Private for-profit			
Fewer than 1,000	30	#	1.11
1,000 or more	120	10	1.27
Institution region			
New England	740	50	1.17
Mid East	2,140	110	1.12
Great Lakes	1,920	130	1.14
Plains	980	50	1.13
South East	2,720	160	1.13
South West	1,170	100	1.16
Rocky Mountains	450	20	1.10
Far West	1,370	130	1.22
Outlying Area	130	10	1.37
Gender			
Male	4,560	350	1.17
Female	7,070	410	1.13
Age			
21 or younger	3,010	170	1.15
22	2,890	180	1.12
23	1,560	120	1.13
24 to 27	1,910	160	1.17
28 or older	2,260	140	1.18
Race			
White	9,350	530	1.12
Black or African American	930	90	1.23
Asian	630	90	1.29
American Indian/Alaska Native	90	10	1.28
Native Hawaiian/Other Pacific Islander	80	10	1.17
Other	550	40	1.21
Hispanic			
Yes	860	100	1.30
No	10,760	660	1.13
Citizenship			
U.S. citizen	11,010	660	1.14
Resident alien	360	40	1.26
Foreign/international student	250	70	1.58

See notes at end of table.

Table 6.9. Location nonresponse sample sizes and mean location weight adjustments at all levels of GEM predictor variables—Continued

Variable description	Number located	Number not located	Mean weight adjustment
Attendance status			
Full-time/full year, 1 institution	5,650	340	1.12
Full-time/full year, more than 1 institution	420	10	1.23
Full-time/part year	2,410	150	1.13
Part-time/full year, 1 institution	1,360	110	1.17
Part-time/full year, more than 1 institution	160	#	1.15
Part-time/part year	1,640	140	1.20
Parents' income (for dependent students)			
Less than $10,000	220	20	1.15
$10,000–$19,999	350	30	1.16
$20,000–$29,999	600	40	1.14
$30,000–$39,999	590	50	1.13
$40,000–$49,999	670	40	1.13
$50,000–$59,999	670	40	1.13
$60,000–$69,999	670	40	1.11
$70,000–$79,999	570	30	1.12
$80,000–$99,999	930	40	1.12
$100,000 or more	1,420	70	1.13
Student's income (for independent students)			
Less than $5,000	800	60	1.17
$5,000–$9,999	710	60	1.15
$10,000–$19,999	980	80	1.16
$20,000–$29,999	680	60	1.18
$30,000–$49,999	870	60	1.18
$50,000 or more	890	50	1.18
Applied for aid			
Yes	6,740	410	1.14
No	4,880	350	1.15
Receipt of federal aid			
Yes	5,930	360	1.14
No	5,690	400	1.15
Receipt of Pell grant			
Yes	2,690	180	1.14
No	8,930	580	1.15
Receipt of Stafford loan			
Yes	5,130	320	1.14
No	6,490	440	1.15
Receipt of state aid			
Yes	2,200	130	1.11
No	9,420	630	1.15
Receipt of institution aid			
Yes	3,830	220	1.13
No	7,790	540	1.15
Receipt of any aid			
Yes	8,050	480	1.14
No	3,580	280	1.16
NPSAS response status			
CADE only	1,230	330	1.40
CATI only	470	30	1.33
CADE and CATI	9,930	400	1.11
Telephone numbers available			
0 or 1 number	700	110	1.31
2 numbers	1,730	120	1.15
3 numbers	2,580	140	1.14
4 numbers	2,500	120	1.12
5 numbers	2,030	90	1.12
6 numbers	1,130	60	1.11
7 or more numbers	950	130	1.24

See notes at end of table.

Table 6.9. Location nonresponse sample sizes and mean location weight adjustments at all levels of GEM predictor variables—Continued

Variable description	Number located	Number not located	Mean weight adjustment
Number of times answering machine was encountered			
None	2,350	210	1.19
Once	1,540	70	1.14
More than once	7,730	480	1.14
Student was in field cluster area			
Yes	6,220	390	1.15
No	5,400	380	1.15
Interaction segments			
1=CADE respondent, Zero answering machine contacts, In field cluster area	170	50	1.52
2=CADE respondent, Zero answering machine contacts, Not in field cluster area	130	70	2.16
3=CADE respondent, One or more answering machine contacts, Zero or one phone numbers available	120	20	1.26
4=CADE respondent, One or more answering machine contacts, Two or more phone numbers available	820	190	1.33
5=CATI or CADE&CATI respondent, Zero or one phone numbers available, US citizen or resident alien	460	20	1.21
6=CATI or CADE&CATI respondent, Zero or one phone numbers available, Foreign/International student	20	#	1.15
7=CATI or CADE&CATI respondent, Two or more phone numbers available, Age 21 or less	2,660	90	1.12
8=CATI or CADE&CATI respondent, Two or more phone numbers available, Age 22 or more	7,250	310	1.12

Rounds to zero.

NOTE: Details may not sum to total due to rounding.

SOURCE: U.S. Department of Education, National Center for Education Statistics, 2000–2001 Baccalaureate and Beyond Longitudinal Study (B&B:2000/01).

Table 6.10. Refusal nonresponse sample sizes and mean refusal weight adjustments at all levels of GEM predictor variables

Variable description	Number nonrefusals	Number refusals	Mean weight adjustment
All individuals	10,860	530	1.06
Institutional control			
Public	6,990	340	1.06
Private not-for-profit	3,740	180	1.06
Private for-profit	130	10	1.02
Institutional control and enrollment category			
Public			
Fewer than 2,500	130	#	1.01
2,500–4,999	390	30	1.10
5,000–9,999	1,170	50	1.05
10,000–19,999	1,920	90	1.05
20,000 or more	3,390	170	1.06
Private not-for-profit			
Fewer than 1,000	290	10	1.05
1,000–2,499	900	30	1.04
2,500–4,999	960	60	1.06
5,000–9,999	640	30	1.06
10,000 or more	950	50	1.05
Private-for-profit			
Fewer than 1000	20	#	1.03
1,000 or more	110	10	1.02
Institution region			
New England	690	50	1.09
Mid East	2,030	120	1.06
Great Lakes	1,790	90	1.05
Plains	930	50	1.06
South East	2,570	100	1.04
South West	1,070	50	1.07
Rocky Mountains	430	20	1.06
Far West	1,240	60	1.05
Outlying Area	120	#	1.02
Gender			
Male	4,200	230	1.06
Female	6,660	300	1.05
Age			
21 or younger	2,850	100	1.04
22	2,710	130	1.04
23	1,450	80	1.07
24 to 27	1,740	110	1.08
28 or older	2,120	120	1.06
Race			
White	8,820	440	1.05
Black or African American	840	30	1.05
Asian	540	40	1.07
American Indian/Alaska Native	80	#	1.09
Native Hawaiian/Other Pacific Islander	70	10	1.22
Other	510	20	1.04
Hispanic			
Yes	760	30	1.04
No	10,100	500	1.06
Citizenship			
U.S. citizen	10,360	490	1.05
Resident alien	330	20	1.06
Foreign/international student	180	20	1.14

See notes at end of table.

Table 6.10. Refusal nonresponse sample sizes and mean refusal weight adjustments at all levels of GEM predictor variables—Continued

Variable description	Number nonrefusals	Number refusals	Mean weight adjustment
Attendance status			
Full-time/full year, 1 institution	5,300	240	1.05
Full-time/full year, more than 1 institution	400	10	1.02
Full-time/part year	2,260	110	1.05
Part-time/full year, 1 institution	1,250	80	1.08
Part-time/full year, more than 1 institution	150	#	1.03
Part-time/part year	1,490	100	1.08
Parents' income (for dependent students)			
Less than $10,000	200	10	1.03
$10,000–$19,999	320	20	1.06
$20,000–$29,999	560	20	1.04
$30,000–$39,999	540	20	1.04
$40,000–$49,999	630	30	1.05
$50,000–$59,999	630	30	1.05
$60,000–$69,999	630	30	1.06
$70,000–$79,999	540	20	1.04
$80,000–$99,999	890	40	1.04
$100,000 or more	1,350	60	1.05
Student's income (for independent students)			
Less than $5,000	740	40	1.06
$5,000–$9,999	660	30	1.06
$10,000–$19,999	900	40	1.05
$20,000–$29,999	620	40	1.09
$30,000–$49,999	810	60	1.10
$50,000 or more	840	50	1.05
Applied for aid			
Yes	6,330	250	1.05
No	4,530	280	1.07
Receipt of federal aid			
Yes	5,570	220	1.04
No	5,290	310	1.07
Receipt of Pell grant			
Yes	2,510	100	1.04
No	8,350	430	1.06
Receipt of Stafford loan			
Yes	4,810	190	1.04
No	6,050	350	1.07
Receipt of state aid			
Yes	2,070	80	1.05
No	8,790	450	1.06
Receipt of institution aid			
Yes	3,610	140	1.04
No	7,260	390	1.06
Receipt of any aid			
Yes	7,570	300	1.05
No	3,300	230	1.08
NPSAS response status			
CADE only	900	180	1.29
CATI only	440	10	1.03
CADE and CATI	9,520	340	1.04

See notes at end of table.

Table 6.10. Refusal nonresponse sample sizes and mean refusal weight adjustments at all levels of GEM predictor variables—Continued

Variable description	Number nonrefusals	Number refusals	Mean weight adjustment
Telephone numbers available			
0 or 1 number	600	70	1.14
2 numbers	1,610	100	1.07
3 numbers	2,440	100	1.05
4 numbers	2,390	90	1.04
5 numbers	1,940	60	1.03
6 numbers	1,070	40	1.04
7 or more numbers	820	80	1.11
Number of times answering machine was encountered			
None	2,140	70	1.06
Once	1,480	40	1.03
More than once	7,250	420	1.06
Student was in field cluster area			
Yes	5,840	300	1.06
No	5,020	230	1.05
Interaction segments			
1=CADE only respondent, Age 27 or less, Receipt of federal aid in base year	360	50	1.20
2=CADE only respondent, Age 27 or less, No receipt of federal aid in base year	400	80	1.31
3= CADE only respondent, Age 28 or more, Receipt of aid in base year	60	10	1.27
4=CADE only respondent, Age 28 or more, No receipt of aid in base year	80	30	1.78
5=CATI only or CADE&CATI respondent, Less than two or more than six phone numbers available, Age 23 or less	810	50	1.06
6=CATI only or CADE&CATI respondent, Less than two or more than six phone numbers available, Age 24 or more	420	50	1.15
7=CATI only or CADE&CATI respondent, More than 1 but less than 7 phone numbers available	8,730	250	1.03

Rounds to zero.

NOTE: Details may not sum to total due to rounding.

SOURCE: U.S. Department of Education, National Center for Education Statistics, 2000–2001 Baccalaureate and Beyond Longitudinal Study (B&B:2000/01).

Table 6.11. Nonrefusal nonresponse sample sizes and mean nonrefusal weight adjustments at all levels of GEM predictor variables

Variable description	Number respondents and nonrefusal nonrespondents	Number other nonrespondents	Mean weight adjustment
All individuals	10,330	300	1.03
Institutional control			
Public	6,650	190	1.03
Private not-for-profit	3,560	110	1.03
Private for-profit	120	10	1.08
Institutional control and enrollment category			
Public			
Fewer than 2,500	130	#	1.01
2,500–4,999	360	#	1.02
5,000–9,999	1,120	30	1.02
10,000–19,999	1,830	50	1.03
20,000 or more	3,220	110	1.04
Private not-for-profit			
Fewer than 1,000	280	10	1.04
1,000–2,499	870	30	1.04
2,500–4,999	910	20	1.03
5,000–9,999	610	20	1.03
10,000 or more	900	30	1.03
Private for-profit			
Fewer than 1,000	20	#	1.12
1,000 or more	100	10	1.07
Institution region			
New England	640	30	1.05
Mid East	1,910	60	1.03
Great Lakes	1,700	30	1.02
Plains	880	20	1.03
South East	2,470	60	1.03
South West	1,020	30	1.04
Rocky Mountains	410	10	1.03
Far West	1,180	60	1.06
Outlying Area	120	#	1.00
Gender			
Male	3,980	130	1.04
Female	6,360	180	1.03
Age			
21 or younger	2,750	90	1.03
22	2,580	80	1.02
23	1,360	30	1.03
24 to 27	1,640	60	1.05
28 or older	2,000	50	1.04
Race			
White	8,390	220	1.03
Black or African American	810	20	1.03
Asian	500	40	1.12
American Indian/Alaska Native	80	#	1.02
Native Hawaiian/Other Pacific Islander	60	#	1.04
Other	500	20	1.04
Hispanic			
Yes	730	30	1.04
No	9,600	270	1.03
Citizenship			
U.S. citizen	9,860	250	1.03
Resident alien	310	20	1.18
Foreign/international student	160	30	1.25

See notes at end of table.

Table 6.11. **Nonrefusal nonresponse sample sizes and mean nonrefusal weight adjustments at all levels of GEM predictor variables—Continued**

Variable description	Number respondents and nonrefusal nonrespondents	Number other nonrespondents	Mean weight adjustment
Attendance status			
Full-time/full year, 1 institution	5,070	170	1.03
Full-time/full year, more than 1 institution	390	10	1.05
Full-time/part year	2,160	60	1.03
Part-time/full year, 1 institution	1,170	20	1.02
Part-time/full year, more than 1 institution	150	#	1.05
Part-time/part year	1,400	40	1.03
Parents' income (for dependent students)			
Less than $10,000	200	#	1.02
$10,000–$19,999	310	10	1.04
$20,000–$29,999	540	20	1.03
$30,000–$39,999	520	20	1.03
$40,000–$49,999	600	10	1.02
$50,000–$59,999	600	20	1.03
$60,000–$69,999	600	20	1.04
$70,000–$79,999	520	20	1.03
$80,000–$99,999	850	30	1.03
$100,000 or more	1,290	30	1.02
Student's income (for independent students)			
Less than $5,000	700	20	1.04
$5,000–$9,999	630	20	1.06
$10,000–$19,999	860	30	1.03
$20,000–$29,999	580	20	1.04
$30,000–$49,999	760	20	1.04
$50,000 or more	790	20	1.03
Applied for aid			
Yes	6,080	150	1.02
No	4,250	150	1.04
Receipt of federal aid			
Yes	5,350	130	1.02
No	4,980	170	1.04
Receipt of Pell grant			
Yes	2,410	60	1.03
No	7,920	240	1.03
Receipt of Stafford loan			
Yes	4,630	120	1.02
No	5,700	190	1.04
Receipt of state aid			
Yes	1,990	40	1.03
No	8,340	260	1.03
Receipt of institution aid			
Yes	3,470	110	1.03
No	6,860	190	1.03
Receipt of any aid			
Yes	7,260	190	1.03
No	3,070	120	1.04
NPSAS response status			
CADE only	720	90	1.03
CATI only	430	10	1.04
CADE and CATI	9,180	200	1.03
Telephone numbers available			
0 or 1 number	530	40	1.10
2 numbers	1,510	50	1.04
3 numbers	2,340	60	1.02
4 numbers	2,300	50	1.02
5 numbers	1,880	40	1.02
6 numbers	1,030	30	1.03
7 or more numbers	740	50	1.07

See notes at end of table.

Table 6.11. Nonrefusal nonresponse sample sizes and mean nonrefusal weight adjustments at all levels of GEM predictor variables—Continued

Variable description	Number respondents and nonrefusal nonrespondents	Number other nonrespondents	Mean weight adjustment
Number of times answering machine was encountered			
None	2,070	50	1.04
Once	1,430	30	1.02
More than once	6,830	220	1.03
Student was in field cluster area			
Yes	5,530	190	1.03
No	4,800	110	1.03
Interaction segments			
1= CADE only respondent, Zero or one phone numbers available	110	30	1.41
2= CADE only respondent, Two or more phone numbers available, US citizen	560	50	1.12
3= CADE only respondent, Two or more phone numbers available, resident alien or foreign/international student	50	10	1.39
4= CATI only or CADE&CATI respondent, US citizen or resident alien	9,480	190	1.02
5=CATI only or CADE&CATI respondent, Foreign/International student	130	20	1.23

Rounds to zero.

NOTE: Details may not sum to total due to rounding.

SOURCE: U.S. Department of Education, National Center for Education Statistics, 2000–2001 Baccalaureate and Beyond Longitudinal Study (B&B:2000/01).

Summary statistics for the poststratification adjustment step can be found in table 6.12. The table gives the poststratification categories together with their control totals from IPEDS and sample totals from the B&B:2000/01 nonresponse adjusted weights. The population level variables that had control totals obtained from IPEDS were institutional control, gender, and degree major. Sample totals were additionally poststratified for U.S. citizenship and receipt of any aid to preserve those weight totals. The mean of the poststratification weight adjustments a_{4i} within each category is also provided, and it shows substantially more adjustment than the later stages of the nonresponse adjustment.

Table 6.12.   GEM poststratification mean weight adjustments

Variable description	Number of individuals	IPEDS control total	B&B sample total	Mean weight adjustment
Institutional control				
Public	6,460	814,846	844,959	1.00
Private not-for-profit	3,440	415,444	431,923	0.98
Private for-profit	120	20,227	17,336	1.26
Gender				
Male	3,850	533,057	545,113	1.01
Female	6,180	717,460	749,105	0.98
Major				
Humanities	1,400	205,832	174,280	1.24
Social/behavioral sciences	1,860	229,266	219,219	1.08
Life sciences	830	74,697	103,913	0.75
Physical sciences	170	21,104	19,301	1.12
Math	120	12,039	14,211	0.88
Computer/Information Science	350	36,805	53,241	0.74
Engineering	510	72,993	68,869	1.10
Education	1,370	110,759	129,697	0.88
Business/management	1,190	263,532	250,571	1.09
Health	1,100	99,155	123,493	0.83
Vocational/technical	230	29,408	24,243	1.23
Other Technical/professional	910	94,927	113,181	0.87
Citizenship				
U.S. Citizen	9,610	1,167,476	1,208,275	0.99
Noncitizen	420	83,041	85,943	1.07
Receipt of any aid				
Yes	7,080	839,736	869,081	0.98
No	2,950	410,782	425,137	1.02

SOURCE: U.S. Department of Education, National Center for Education Statistics, 2000–2001 Baccalaureate and Beyond Longitudinal Study (B&B:2000/01).

6.5   Weighting Adjustment Performance

The performance of the weight adjustment process is examined in this section. Subsections include discussion of distributions of weights and adjustment factors, unequal weighting effects, nonresponse bias reduction, receiver operating characteristic (ROC) curves, abbreviated interview bias, and overall study response rates. An additional analysis of design effects is provided in appendix G.

6.5.1 Study Weight Distributions

Table 6.13 provides percentiles and extreme values, for the initial weights. In addition, the weights obtained after each step in the adjustment process are provided ending with the poststratification adjusted weight. The table shows that the greatest adjustment occurred after the first GEM adjustment, in which the maximum was greatly reduced, and the median weight shifted by about 10.

Table 6.13. Percentiles and extremes of study weight distributions

| Weight | Min | Percentile | | | | | | | | | Max |
		1%	5%	10%	25%	Median	75%	90%	95%	99%	
Initial	7	17	31	33	42	89	119	240	307	467	2,750
Location adjusted	8	19	33	36	47	101	133	275	347	435	855
Location and refusal adjusted	8	20	34	37	48	102	136	299	368	532	725
All nonresponse adjusted	8	20	34	37	49	103	139	308	386	569	852
Poststratification adjusted	8	19	30	34	49	99	148	287	373	441	593

SOURCE: U.S. Department of Education, National Center for Education Statistics, 2000–2001 Baccalaureate and Beyond Longitudinal Study (B&B:2000/01).

The percentiles and extreme values of the adjustment distributions are provided in table 6.14. Again, this table illustrates that the first GEM produced the most adjustment, with many of the individual adjustments near unity. The later GEM nonresponse adjustments were not as large.

Table 6.14. Percentiles and extremes of weight adjustment distributions

| Weight adjustment | Min | Percentile | | | | | | | | | Max |
		1%	5%	10%	25%	Median	75%	90%	95%	99%	
Nonresponse											
Nonrefusal	0.1	0.6	0.9	1.0	1.0	1.1	1.2	1.4	1.6	2.2	2.8
Refusal	0.6	1.0	1.0	1.0	1.0	1.0	1.1	1.1	1.2	1.6	2.0
Location	0.7	1.0	1.0	1.0	1.0	1.0	1.0	1.1	1.2	1.4	2.2
Poststratification	0.3	0.6	0.7	0.8	0.8	1.0	1.1	1.3	1.3	1.3	1.3

SOURCE: U.S. Department of Education, National Center for Education Statistics, 2000–2001 Baccalaureate and Beyond Longitudinal Study (B&B:2000/01).

6.5.2 Unequal Weighting Effects

To assess the effect of the various weight adjustment steps on variance estimates, unequal weighting effects were computed at each stage of the weighting process. The unequal weighting effect UWE_j at step j is defined as follows:

$$UWE_j = n_j \frac{\sum_{i=1}^{n} w_{ji}^2}{\left(\sum_{i=1}^{n} w_{ji}\right)^2} \qquad j=1,\dots,5$$

where n_j is the number of individuals of nonzero weight at step j, and n is the total number of respondents. The larger the unequal weighting effect, the greater the variation among the weights and so the greater the potential for extreme weights to inflate variances.

Table 6.15 provides the unequal weighting effects (UWE) obtained at each stage of the adjustment process. From the table it can be seen that there was an initial decrease in the unequal weighting effect after location nonresponse adjustment, followed by a gradual increase in the unequal weighting effect up to the poststratification step, which again decreased the UWE.

Table 6.15. Unequal weighting effects by stage of weight adjustment

Weight	Number of individuals	Unequal weighting effect
Initial	11,620	1.88
Location adjusted	10,860	1.67
Location and refusal adjusted	10,330	1.74
All nonresponse adjusted	10,030	1.81
Poststratification adjusted	10,030	1.66

SOURCE: U.S. Department of Education, National Center for Education Statistics, 2000–2001 Baccalaureate and Beyond Longitudinal Study (B&B:2000/01).

6.5.3 Assessing Bias Reduction

To evaluate the performance of GEM in adjusting for nonresponse bias, significance tests were performed on estimates of population means using both initial (pre-adjustment) and final weights. The final weights are zero for nonrespondents, so if the GEM has properly transferred the nonrespondent weights to the respondents, estimates based on the final weights should be close to estimates based on initial weights for variables known for both respondents and nonrespondents.

For each variable level tested in section 6.3.2, the test of weight adjustment performance was as follows:

$$H_0 : \mu_F - \mu_I = 0$$

$$H_1 : \mu_F - \mu_I \neq 0$$

where μ_F is a group mean based on the final weights, and μ_I is the group mean based on the initial weights. Mean μ_F is estimated using the final weights, while μ_I is estimated using the initial weights. These means are over all eligible B&B:2000/01 sample members, but the final weights are zero for nonrespondents.

If the GEM adjustments have successfully reduced the bias, then variable levels that previously showed significance in section 6.3.2 should not show significance. Table 6.16 gives the results of these significance tests for each of the variable levels. The table shows few significant findings, suggesting that much of the nonresponse bias has been successfully accounted for. The only predictor with remaining significant mean differences was citizenship, for which both levels of non-U.S. citizens were significant. This predictor was also the only variable with a significant chi-square test (not shown in tables).

Table 6.16.   Comparison of before-adjustment and after-adjustment weighted means for selected NPSAS:2000 variables

Variable description	Unweighted respondents	Unweighted non-respondents	Before nonresponse adjustment			After weight adjustment	
			Respondent percentage, original weights	Nonrespondent percentage, original weights	Difference (respondent minus nonrespondent)	Percentage, final adjusted weights	Difference (original minus final)[1]
Institutional sector							
Public 4-year	6,460	1,030	65.0	65.5	–0.5	65.2	–0.1
Non-doctorate-granting	2,060	300	19.2	17.9	0.2	19.3	–0.4
Doctorate-granting	4,400	730	45.8	47.6	0.3	45.8	0.3
Private not-for-profit 4-year	3,450	540	33.7	33.2	0.5	33.2	0.4
Non-doctorate-granting	1,920	260	19.9	16.9	0.5	19.4	#
Doctorate-granting	1,530	280	13.8	16.3	0.4	13.8	0.4
Private for-profit 4-year	120	30	1.3	1.3	–0.1	1.6	–0.3
Institutional control and enrollment category							
Public							
Fewer than 1,000	10	0	#	#	#	#	#
1,000–2,499	120	10	0.8	0.6	0.3	0.8	#
2,500–4,999	360	60	3.6	3.2	0.4	3.6	–0.1
5,000–9,999	1,090	150	8.8	7.6	1.2	8.7	–0.1
10,000–19,999	1,780	260	17.9	17.4	0.4	17.9	–0.1
20,000 or more	3,110	560	34.0	36.7	-2.8	34.2	0.2
Private not-for-profit							
Fewer than 1,000	270	30	2.2	1.6	0.5	2.1	#
1,000–2,499	840	110	8.3	6.8	1.6	8.1	#
2,500–4,999	880	130	8.8	8.6	0.2	8.6	0.2
5,000–9,999	590	100	5.8	6.2	–0.3	5.7	0.2
10,000 or more	870	160	8.5	10.0	–1.5	8.9	–0.1
Private for-profit							
Fewer than 999	20	10	0.3	0.2	0.1	0.3	–0.1
1,000 or more	100	20	1.0	1.2	–0.2	1.3	–0.3
Institution region							
New England	610	130	6.6	8.6	–1.9	6.9	0.1
Mid East	1,860	280	17.9	17.1	0.8	17.8	–0.1
Great Lakes	1,670	250	16.2	15.6	0.6	16.1	#
Plains	860	130	8.9	7.8	1.1	8.5	0.2
South East	2,410	310	22.5	18.4	4.1*	21.8	–0.1
South West	990	180	9.8	11.7	–1.9	10.1	#
Rocky Mountains	400	50	3.7	2.9	0.8	3.6	#
Far West	1,130	250	13.1	16.9	-3.8*	13.9	–0.2
Outlying Area	110	20	1.4	1.2	0.2	1.3	#
Gender							
Male	3,850	710	41.2	46.4	–5.2*	42.6	–0.5
Female	6,180	890	58.8	53.6	5.2*	57.4	0.5
Age							
21 or younger	2,660	360	26.1	21.8	4.4*	25.5	–0.2
22	2,510	380	23.9	21.5	2.4	23.7	–0.2
23	1,340	230	13.4	13.6	–0.3	13.3	0.1
24 to 27	1,580	330	16.3	22.1	–5.8*	17.0	0.3
28 or older	1,950	310	20.3	21.0	–0.7	20.5	#
Race							
White	8,170	1,180	79.9	72.7	7.2*	78.5	0.1
Black or African American	790	140	8.4	9.3	–0.9	8.6	#
Asian	460	170	5.2	11.7	–6.6*	6.1	0.2
American Indian/Alaska Native	80	10	0.8	0.8	–0.1	0.8	#
Native Hawaiian/Other Pacific Islander	60	20	0.7	1.4	–0.7	0.8	#
Other	480	70	5.1	4.0	1.1	5.2	–0.3
Hispanic							
Yes	700	160	8.3	10.7	–2.4*	8.9	–0.2
No	9,330	1,440	91.7	89.3	2.4*	91.1	0.2
Citizenship							
U.S. citizen	9,610	1,400	95.0	85.6	9.4*	93.4	#
Resident alien	290	70	3.4	5.2	–1.8*	4.2	–0.5*
Foreign/international student	130	120	1.6	9.2	–7.6*	2.4	0.5*

See notes at end of table.

Table 6.16.   Comparison of before-adjustment and after-adjustment weighted means for selected NPSAS:2000 variables—Continued

Variable description	Unweighted respondents	Unweighted non-respondents	Before nonresponse adjustment			After weight adjustment	
			Respondent percentage, original weights	Nonrespondent percentage, original weights	Difference (respondent minus nonrespondent)	Percentage, final adjusted weights	Difference (original minus final)[1]
Attendance status							
Full-time/full year, 1 institution	4,900	740	47.2	43.8	3.4	46.9	−0.3
Full-time/full year, more than 1 institution	380	40	3.0	2.1	0.9	3.0	-0.2
Full-time/part year	2,100	310	20.9	17.7	3.2	20.5	−0.2
Part-time/full year, 1 institution	1,150	210	12.8	14.7	−1.9	12.9	0.2
Part-time/full year, more than 1 institution	150	10	1.1	0.6	0.5	1.0	−0.1
Part-time/part year	1,360	280	15.1	21.1	−6.0*	15.6	0.5
Parent's income (for dependent students)							
Less than $10,000	190	30	1.7	1.8	#	1.7	#
$10,000–$19,999	300	50	2.8	3.1	−0.3	3.0	−0.1
$20,000–$29,999	520	80	5.0	4.7	0.3	5.0	#
$30,000–$39,999	500	80	4.8	5.3	−0.5	4.7	0.2
$40,000–$49,999	590	90	5.6	5.2	0.3	5.6	−0.1
$50,000–$59,999	580	90	6.0	5.6	0.4	5.8	0.1
$60,000–$69,999	580	90	5.5	5.4	0.1	5.4	0.1
$70,000–$79,999	500	70	4.9	4.4	0.5	4.8	#
$80,000–$99,999	820	110	8.2	5.9	2.3	7.9	−0.1
$100,000 or more	1,260	170	12.8	8.9	3.8*	12.5	−0.4
Student's income (for independent students)							
Less than $5,000	680	130	6.3	7.8	−1.5	6.5	#
$5,000–$9,999	600	110	6.0	7.4	−1.4	6.0	0.2
$10,000–$19,999	840	140	8.6	8.9	−0.3	8.6	0.1
$20,000–$29,999	560	120	6.1	7.9	−1.8	6.1	0.3
$30,000–$49,999	740	130	7.3	9.5	−2.2	7.8	−0.2
$50,000 or more	770	120	8.6	8.2	0.4	8.6	−0.1
Applied for aid							
Yes	5,930	810	57.4	49.7	7.7*	56.0	#
No	4,100	780	42.6	50.4	−7.7*	44.0	#
Receipt of federal aid							
Yes	5,220	710	51.2	43.2	8.0*	49.7	#
No	4,810	880	48.8	56.8	−8.0*	50.3	#
Receipt of Pell grant							
Yes	2,350	340	21.8	20.6	1.2	21.5	0.1
No	7,680	1,250	78.2	79.4	−1.2	78.5	−0.1
Receipt of Stafford loan							
Yes	4,510	620	44.5	38.0	6.5*	43.2	0.2
No	5,520	970	55.5	62.0	−6.5*	56.8	−0.2
Receipt of state aid							
Yes	1,950	260	17.1	15.1	2.0	16.7	0.1
No	8,080	1,340	82.9	84.9	−2.0	83.3	−0.1
Receipt of institution aid							
Yes	3,360	470	31.3	27.5	3.8*	30.4	0.2
No	6,670	1,120	68.7	72.5	−3.8*	69.6	−0.2
Receipt of any aid							
Yes	7,080	970	68.8	59.6	9.2*	67.2	#
No	2,950	620	31.2	40.4	−9.2*	32.9	#

Rounds to zero. All zeros provided in this table are actual values.

*Difference between respondents and nonrespondents is significant at the .05/(c–1) level, where c is the number of categories within the primary variable.

[1]"Original" is the weighted average of respondent percentage and nonrespondent percentage.

NOTE: Details may not sum to total due to rounding.

SOURCE: U.S. Department of Education, National Center for Education Statistics, 2000–2001 Baccalaureate and Beyond Longitudinal Study (B&B:2000/01).

6.5.4 ROC Curve Analysis

The predictive performance of the GEM can be evaluated using an receiver operating characteristic curve (Hanley and McNeil, 1982).[27] The receiver operating curve (ROC) provides a measure of how well a model can correctly classify individuals of known response type.[28]

An ROC curve was used to evaluate how well the GEM models used for B&B:2000/01 nonresponse adjustments predict the B&B:2000/01 study response propensities. The ROC curve was developed in the following manner. For any specified probability, c, two proportions were calculated:

- the proportion of respondents with a predicted probability of response greater than c, and

- the proportion of nonrespondents with a predicted probability of response greater than c.

These predicted probabilities were obtained as the product of the predicted response probabilities obtained at each of the three GEM adjustment steps. For each GEM step, the predicted response probability was equal to the inverse of the estimated adjustment factor. Note that for the last two GEM steps, predicted probabilities were not directly available for students who had already been dropped from the model due to nonresponse in an earlier step. For these students, their predicted probability was set equal to the mean of the predicted probabilities of students still in the model.

The plot of the first probability against the second, for c from 0 to 1, resulted in the ROC curve shown in figure 6.1. Numerical integration provided the area under the curve, and this area equals the probability that the fitted model will correctly classify two randomly chosen individuals—one of which is a true respondent and the other a true nonrespondent—where the individual with the higher predicted probability of response is classified as the respondent. An area of 0.5 under an ROC curve indicates that a correct classification is a 50:50 proposition, with the model providing no predictive benefit. An area of 1 indicates that the true respondent always has the higher predicted probability of response, and so the model always classifies the two individuals correctly. The area under the ROC curve of figure 6.3 is 0.65, and so 65 percent of the time (or for about two of every three pairings) the predicted probabilities give the correct classification. Predictive probabilities from ROC curves can also be interpreted in terms of the non-parametric Wilcoxon test statistic, where the ROC area of 0.65 equals the value of the Wilcoxon test statistic. Viewed in this way, the Wilcoxon test provides a highly significant rejection of the null hypothesis of no predictive ability.

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[27]Hanley, J.A. and McNeil, B.J. (1982). The meaning and use of the area under a receiver operating characteristic curve. *Diagnostic Radiology*, 143: 29–36.

[28] For a more detailed example of ROC curve use in nonresponse modeling see Iannacchione, V. (2003). Sequential weight adjustments for location and cooperation propensity for the 1995 national survey of family growth. *Journal of Official Statistics*, 16:31-43.

Figure 6.1. **ROC curve for overall response propensity**
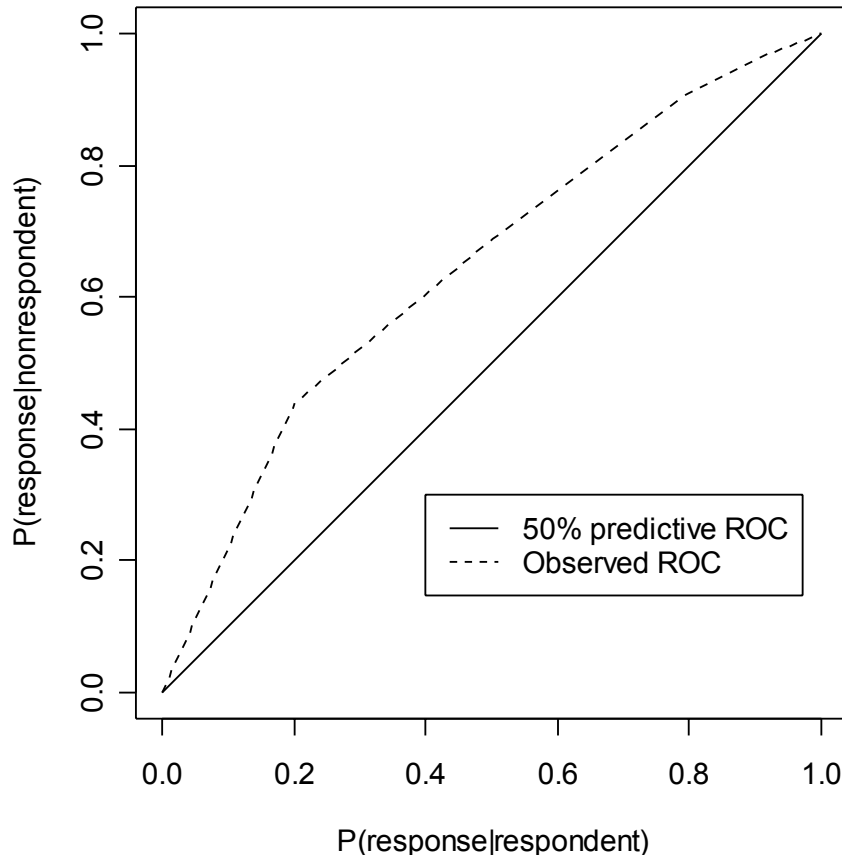
SOURCE: U.S. Department of Education, National Center for Education Statistics, 2000–2001 Baccalaureate and Beyond Longitudinal Study (B&B:2000/01).

6.5.5 Analysis of Abbreviated Respondent Bias

The B&B:2000/01 survey design allowed individuals who could not complete the full CATI interview the option of completing an abbreviated interview. Questions present on the abbreviated interview were those considered key items about the respondent's post-baccalaureate enrollment and work experiences. Of the about 10,030 B&B:2000/01 study respondents, there were about 9,650 full interview respondents, about 370 abbreviated interview respondents, and about 10 partial interview respondents.[29]

Nonresponse bias can occur if abbreviated interview respondents and full interview respondents differ in their response distributions for questions only on the full interview. Nonresponse bias associated with questions only on the full interview can be tested as was done for respondents and nonrespondents in section 6.3.2.

Results of significance tests for abbreviated-interview response bias are given in table 6.17. These tests reveal significant bias associated with the levels of six variables:

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[29]Partial respondents were individuals who only partially completed the full interview.

institution region, Hispanic origin, attendance status, receipt of Stafford loan, receipt of institution aid, and receipt of any aid. These biases were also supported by chi-squared tests.

The bias suggested by these tests could be adjusted for either by an additional weight adjustment, or by imputation. In the case of a weight adjustment, two final sets of analysis weights would be obtained: the current set of analysis weights for questions in both the full and abbreviated interview, and a new set of weights for questions only in the full interview. This additional weight adjustment was not implemented because the statistical gains in bias reduction would be more than offset by the additional complexity of having item-specific weights. Imputations would require specification of a statistical model for each outcome that is only in the full interview. They were not implemented because the B&B:2000/01 contract did not provide for imputations.

6.5.6 Overall Study Response Rates

The overall weighted response rate is an estimate of the proportion of the study population that would have responded if a census had been conducted. Because the B&B:2000/01 study includes a subsample of NPSAS:2000 nonrespondents, the overall study response rate is the product of the NPSAS:2000 institution level response rate and the B&B:2000/01 student level response rate. Therefore, the overall B&B:2000/01 study response rates can be estimated directly only for domains defined by institutional characteristics.

Both weighted and unweighted overall study response rates are shown in table 6.18, along with their institution and student response rate components. The institution level response rates shown in this table are the percentages of institutions that provided sufficient data to select the NPSAS:2000 student level sample. Only the weighted response rates can be interpreted as estimates of the proportions of the B&B:2000/01 study population that are represented by the study respondents. Hence, this table shows that approximately 74 percent of the B&B:2000/01 study population is represented by the B&B:2000/01 respondents. Moreover, it shows that the rate of population coverage does not vary greatly by institutional control, although it is slightly higher for public institutions than for non-public institutions. Weighted rates are somewhat lower due to the undersampling of NPSAS:2000 nonrespondents within the B&B:2000/01 sample. This undersampling led to higher weights for NPSAS:2000 nonrespondents in the final B&B:2000/01 sample and subsequent lower overall response rates due to a tendency of NPSAS:2000 nonrespondents to remain nonrespondents in the B&B:2000/01 sample (see table 6.2).

Table 6.17. Full respondents versus abbreviated respondents: Distributions and bias tests for selected NPSAS:2000 variables

Variable description	Number of full respondents	Number of abbreviated respondents	Percent full respondent distribution	Percent abbreviated respondent distribution	Abbreviated response bias	Percent relative bias	P-value
Institutional sector							
Public 4-year	6,240	220	66	59	0.0033	0.5	0.05
Non-doctorate-granting	1,990	60	20	15	0.0020	1.0	0.10
Doctorate-granting	4,250	150	46	43	0.0013	0.3	0.42
Private not-for-profit 4-year	3,300	140	33	39	−0.0028	−0.8	0.10
Non-doctorate-granting	1,830	90	19	25	−0.0028	−0.1	0.07
Doctorate-granting	1,470	60	14	14	0.0001	0.1	0.94
Private for-profit 4-year	110	10	2	3	−0.0006	−3.8	0.34
Institutional control and enrollment category							
Public							
Fewer than 1,000	10	0	#	0	0.0000	0.0	0.16
1,000–2,499	120	#	1	#	0.0003	3.7	0.03
2,500 – 4,999	350	10	4	2	0.0008	2.2	0.08
5,000–9,999	1,050	40	9	8	0.0002	0.2	0.73
10,000–19,999	1,720	60	18	15	0.0015	0.8	0.27
20,000 or more	2,990	110	34	33	0.0004	0.1	0.77
Private not-for-profit							
Fewer than 1,000	260	10	2	1	0.0003	1.4	0.58
1,000–2,499	810	30	8	9	−0.0003	−0.4	0.84
2,500–4,999	850	40	9	9	−0.0004	−0.5	0.61
5,000–9,999	550	40	5	11	−0.0025	−4.6	0.09
10,000 or more	830	40	9	9	0.0001	0.1	0.91
Private for-profit							
Fewer than 999	20	0	#	0	0.0002	6.1	0.05
1,000 or more	90	10	1	3	−0.0007	−5.7	0.22
Institution region							
New England	590	30	7	8	−0.0006	−0.9	0.52
Mid East	1,740	110	17	28	−0.0049	−2.8	0.00*
Great Lakes	1,630	40	16	11	0.0028	1.7	0.01*
Plains	830	30	9	8	0.0003	0.4	0.68
South East	2,350	50	22	13	0.0044	2.0	0.00*
South West	960	30	10	9	0.0004	0.4	0.70
Rocky Mountains	390	10	4	1	0.0011	3.0	0.01
Far West	1,100	30	14	9	0.0027	1.9	0.01
Outlying Area	60	60	1	14	−0.0062	−88.6	0.00*
Gender							
Male	3,710	140	43	39	0.0018	0.4	0.24
Female	5,940	230	57	61	−0.0018	−0.3	0.24
Age							
21 or younger	2,560	90	25	27	−0.0009	−0.4	0.57
22	2,410	100	24	27	−0.0014	−0.6	0.31
23	1,280	50	13	12	0.0009	0.7	0.40
24 to 27	1,510	70	17	14	0.0015	0.9	0.15
28 or older	1,880	70	21	21	−0.0001	0.0	0.94
Race							
White	7,880	270	79	74	0.0021	0.3	0.14
Black or African American	760	30	9	8	0.0003	0.3	0.72
Asian	440	20	6	8	−0.0008	−1.3	0.36
American Indian/Alaska Native	70	#	1	1	−0.0002	−2.6	0.60
Native Hawaiian/Other Pacific Islander	60	#	1	#	0.0003	3.6	0.02
Other	440	40	5	9	−0.0017	−3.4	0.04
Hispanic							
Yes	620	80	8	20	−0.0053	−6.3	0.00*
No	9,030	290	92	81	0.0053	0.6	0.00*
Citizenship							
U.S. citizen	9,250	350	93	94	−0.0004	0.0	0.61
Resident alien	280	10	4	5	−0.0002	−0.5	0.82
Foreign/international student	120	#	3	1	0.0006	2.4	0.14

See notes at end of table.

Table 6.17. Full respondents versus abbreviated respondents: Distributions and bias tests for selected NPSAS:2000 variables—Continued

Variable description	Number of full respondents	Number of abbreviated respondents	Percent full respondent distribution	Percent abbreviated respondent distribution	Abbreviated response bias	Percent relative bias	P-value
Attendance status							
Full-time/full year, 1 institution	4,720	170	47	47	0.0000	0.0	0.99
Full-time/full year, more than 1 institution	370	#	3	1	0.0013	4.2	0.00*
Full-time/part year	2,020	80	21	18	0.0013	0.6	0.29
Part-time/full year, 1 institution	1,100	50	13	16	−0.0014	−1.1	0.25
Part–time/full year, more than 1 institution	150	0	1	0	0.0005	4.7	0.00*
Part–time/part year	1,290	60	16	19	−0.0016	−1.0	0.22
Parents' income (for dependent students)							
Less than $10,000	180	10	2	2	−0.0002	−1.2	0.62
$10,000–$19,999	280	20	3	4	−0.0007	−2.4	0.26
$20,000–$29,999	500	20	5	4	0.0006	1.2	0.21
$30,000–$39,999	480	20	5	5	0.0000	0.0	0.93
$40,000–$49,999	570	20	6	5	0.0002	0.4	0.77
$50,000–$59,999	560	20	6	8	−0.0010	−1.8	0.28
$60,000–$69,999	570	20	6	5	0.0005	0.9	0.50
$70,000–$79,999	480	20	5	6	−0.0007	−1.5	0.45
$80,000–$99,999	800	20	8	6	0.0009	1.1	0.20
$100,000 or more	1,210	50	13	13	−0.0001	−0.1	0.95
Student's income (for independent students)							
Less than $5,000	640	30	7	8	−0.0006	−0.9	0.51
$5,000–$9,999	590	20	6	4	0.0009	1.5	0.17
$10,000–$19,999	800	40	9	10	−0.0005	−0.6	0.57
$20,000–$29,999	540	20	6	8	−0.0008	−1.3	0.35
$30,000–$49,999	720	20	8	6	0.0011	1.4	0.18
$50,000 or more	740	30	9	8	0.0003	0.3	0.73
Applied for aid							
Yes	5,710	210	56	52	0.0021	0.4	0.20
No	3,940	160	44	48	−0.0021	−0.5	0.20
Receipt of federal aid							
Yes	5,020	190	50	47	0.0014	0.3	0.41
No	4,630	180	50	53	−0.0014	−0.3	0.41
Receipt of Pell grant							
Yes	2,240	110	21	24	−0.0012	−0.6	0.48
No	7,410	260	79	76	0.0012	0.2	0.48
Receipt of Stafford loan							
Yes	4,370	130	44	34	0.0046	1.1	0.00*
No	5,280	230	56	66	−0.0046	−0.8	0.00*
Receipt of state aid							
Yes	1,880	60	17	14	0.0012	0.7	0.32
No	7,770	300	83	86	−0.0012	−0.1	0.32
Receipt of institution aid							
Yes	3,250	100	31	24	0.0030	1.0	0.02*
No	6,400	260	69	76	−0.0030	−0.4	0.02*
Receipt of any aid							
Yes	6,830	240	68	59	0.0043	0.6	0.01*
No	2,820	130	32	42	−0.0043	−1.3	0.01*

Rounds to zero. All zeros provided in this table are actual values.

*Difference between respondents and nonrespondents is significant at the .05/(c–1) level, where c is the number of categories within the primary variable.

NOTE: Details may not sum to total due to rounding.

SOURCE: U.S. Department of Education, National Center for Education Statistics, 2000–2001 Baccalaureate and Beyond Longitudinal Study (B&B:2000/01).

Table 6.18. Overall B&B:2000/01 study response rates

Type of institution	Institutions[1]				Students				Overall response rate	
	Number eligible	Number respondents	Response rate unweighted	Response rate weighted	Number eligible	Number respondents	Response rate unweighted	Response rate weighted	Unweighted	Weighted
All 4-year institutions	710	660	93	90	11,620	10,030	86	82	80	74
Public 4-year	350	330	95	95	7,490	6,460	86	82	82	78
Non-doctorate-granting	130	120	97	94	2,360	2,060	87	83	80	78
Doctorate-granting	220	210	95	95	5,130	4,400	86	82	80	78
Private not-for-profit 4-year	340	310	91	87	3,990	3,450	87	83	79	72
Non-doctorate-granting	170	150	90	82	2,180	1,920	88	85	80	69
Doctorate-granting	170	160	93	97	1,810	1,530	85	80	80	77
Private for-profit 4-year	20	20	96	98	150	120	80	81	80	80

[1]Includes all eligible NPSAS:2000 4-year doctorate and non-doctorate granting institutions. Less than 4-year institutions do not provide baccalaureate degrees and have been excluded.

NOTE: Details may not sum to total due to rounding.

SOURCE: U.S. Department of Education, National Center for Education Statistics, 2000–2001 Baccalaureate and Beyond Longitudinal Study (B&B:2000/01).

6.6   Variance Estimation

Since most survey statistics computed from weighted data are nonlinear, it is generally not possible to find closed form expressions for their variance estimators. For this reason, RTI provides the information needed for two alternative variance estimation methods: Taylor series and balanced repeated replication (BRR). This section provides background on how analysis strata and weights for each method were created.

6.6.1 Taylor Series

The standard method of the variance estimation for nonlinear statistics is Taylor series expansion (see, e.g., Wolter, 1985).[30] This method obtains a variance estimate for a statistic of interest by substituting its first order Taylor series expansion into the appropriate sampling design variance formula.

Since the B&B:2000/01 sample was obtained through a stratified multistage design, a file of analysis strata and analysis primary sampling units (PSUs) is needed for application of the appropriate sampling design variance formula with Taylor series methods. Starting with the NPSAS:2000 institution level sampling strata, institutions were assigned to analysis strata and analysis primary sampling units (PSUs) such that each analysis stratum contained at least 2 analysis PSUs, and each analysis PSU contained at least four B&B:2000/01 respondents. The partitioning was done according to the ordering of institutions on the sampling frame and preserves much of the implicit stratification induced by the serpentine frame ordering (see appendix G of the NPSAS:2000 methodology report). The final analysis file contains 389 analysis strata and 812 analysis PSUs.

Software that is currently available for Taylor series variance estimation (e.g., STATA, SUDAAN or the NCES DAS) does not accommodate estimating the additional variation due to use of sample-based weight adjustment factors because of the complexity of those estimates. However, the methodology has been developed[31] and may be accommodated by the next generation of survey analysis software.

Instructions for Taylor series variance estimation using the B&B:2000/01 weights are found in appendix I, which also specifies the names of the 66 B&B:2000/01 weight variables and the files in which they are located.

6.6.2 Balanced Repeated Replication

In addition to the Taylor series approximations noted above, another method of variance estimation is the balanced repeated replications (BRR) method (Wolter, 1985).[32] This approach is useful for estimating variances of survey quantile estimates (e.g., medians, quartiles, etc.), and works by computing the statistic of interest $\bar{y}_j$ once for each of k replicate sets of BRR weights, and then estimating the variance of the full sample stratified estimate $\bar{y}_{strat}$ as follows:

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[30]Wolter, K.N. (1985). *Introduction to variance estimation*. New York: Springer-Verlag.

[31]Vaish, A.K., Gordek, H., and Singh, A.C. (2000).   Variance estimation for weight calibration via the generalized exponential model with applications to the National Household Survey on Drug Abuse. *ASA Proceedings of the Section on Survey Research Methods,* 67–55.

[32]Wolter. Op cit.

$$\hat{Var}_{BRR}[\bar{y}_{strat}] = \sum_{j=1}^{k} \frac{\left(\bar{y}_j - \bar{y}_{strat}\right)^2}{k} \ .$$

The BRR approach is based on the idea of partitioning the sample respondents into L analysis strata such that there are two analysis PSUs per stratum. A half-sample replicate is defined as a sample containing one analysis PSU selected from each analysis stratum. There are then 2^L different half-sample replicates that can be drawn from the L analysis strata. If all 2^L possible half-samples are considered, and if $\bar{y}_j$ is the sample mean from the jth half-sample, and

$\bar{y}_{strat}$ the stratified mean from the full sample, then it can be shown that $\sum_{j=1}^{2^L}(\bar{y}_j - \bar{y}_{strat})^2 / 2^L$ is equal to the stratified variance estimator. The BRR approach provides a method to find $k < 2^L$ "balanced" half-sample replicates where this same property holds.

Obtaining the $k < 2^L$ BRR replicates is accomplished by finding a k-dimensional Hadamard matrix, which is a kxk orthogonal matrix **H** containing only -1s and $+1$s with the property that $\mathbf{H}^T\mathbf{H}=k\mathbf{I}$. These matrices have been verified to exist where k is a multiple of 4 up to $k=428$. In the B&B:2000/01 study, a $k=64$ dimensional Hadamard matrix was used to define 64 BRR replicates.

To obtain the needed 64 BRR analysis strata, the 389 Taylor series analysis strata were collapsed. The first step was to reduce the number of strata to a multiple of 6 by collapsing 10 strata into 5 strata. The 10 strata of the 389 with the smallest NPSAS:2000 institutional weight were randomly paired to produce 5 strata, resulting in 384 (64*6) strata. The collapsing of the resulting 384 strata to 64 strata was accomplished by first sorting by stratum ID, labeling the sorted strata with repeated sequences of 1 to 6, and then defining the strata into six groups according to these labels. Each of the 64 BRR strata was created by merging one stratum selected at random without replacement from each of the 6 groups.

The collapsing of PSUs within strata to obtain the two analysis PSUs per BRR analysis stratum started with the 389 Taylor analysis strata. Any analysis stratum with 3 PSUs had 2 PSUs chosen at random to merge, and any analysis stratum with 4 PSUs was converted to 2 PSUs by random pairing. This led to all strata having 2 PSUs, as none of the Taylor analysis strata contained more than 4 PSUs. When the 389 Taylor analysis strata were collapsed to the final 64 BRR analysis strata, all first-replicate PSUs were merged to form the first-replicate PSU in each collapsed stratum, and all second-replicate PSUs were similarly merged to form the second-replicate PSU.

Given the 64 collapsed BRR analysis strata, the 64 BRR replicates are obtained by using the Hadamard matrix. The columns of the Hadamard matrix identify the replicates, while the rows identify the strata. If the element of column k, row j of **H** was equal to -1, then for replicate k, stratum j, the weights of individuals in the first PSU were doubled and the weights of individuals in the second PSU were set to zero. If instead the element equaled $+1$, then the individual weights in the first PSU were set to zero, and the individual weights in the second PSU were doubled.

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The weights used to produce the BRR replicates were the w_{4i}, the weights after nonresponse adjustment but before poststratification. Each BRR replicate was then poststratified to the IPEDS control totals, providing the final BRR replicate. In theory, all steps of the GEM adjustment should be repeated, although this was determined to not be a cost-effective approach.

Instructions for BRR variance estimation using the B&B:2000/01 weights are found in appendix I, which also specifies the names of the 66 B&B:2000/01 weight variables and the files in which they are located.