TECHNICAL APPENDIX - January 11, 2017

My analyses are based on the Education Longitudinal Study of 2002 (ELS:2002). As described in project documentation, ELS:2002 "is conducted by RTI International—a nonprofit university-affiliated research organization—for the National Center for Education Statistics (NCES), a part of the Institute of Education Sciences in the U.S. Department of Education." While some portions of the ELS data are publicly available, the data I used are part of a restricted-use database that can be accessed only by obtaining a license from the Institute of Education Sciences (IES). ELS was "designed to provide trend data about critical transitions that students experience as they proceed through high school and into postsecondary education or their careers."[1]

In 2002, the initial year of the study, American tenth graders were sampled. A follow-up study took place in 2004, at which time a "freshening" sample was added to make the study representative of 2004 seniors nationwide. A second follow-up study (in 2006), a third follow-up study (in 2012), a high school transcript study, and a postsecondary transcript study were also conducted. A portion of the ELS data constitutes a nationally representative sample of students who were enrolled in the tenth grade in 2002. An overlapping portion of the data provides a nationally representative sample of students who were enrolled in twelfth grade in 2004.[2] It is these students that are the focus of my analyses.

This document contains the following sections:

- Sample Design, Weights, and Standard Error Computations
- Sample Sizes
- Senior Cohort, Applicants, and Enrollees
- Variables Used in the Analyses
- Imputation of Admissions Test Scores
- Construction of Composite Variables for Use in the Admissions Scenarios

- Admissions Procedures Based on Ranking
- Chapter-Specific Analysis Notes
- Compact Comparison Tables for All Admissions Models, Applicants, and Enrollees
- Reference Notes

Sample Design, Weights, and Standard Error Computations

In 2002, the ELS data were collected using a stratified two-stage probability sampling design in which schools with tenth grades were sampled first and then sophomores within these schools were selected. Students were sampled with unequal selection probabilities; one purpose was to obtain sufficiently large samples of Hispanic and Asian students. Because of this complex sampling design, sampling weights must be used in analyses of the data in order to allow generalization to US high school seniors of 2004. For the analyses in my study, which involve the first and third follow-ups and the high school and postsecondary transcripts, the appropriate weight is F3F1TSCPSWT.[3] All analyses described in the main text and in this appendix are weighted unless otherwise noted.

The complex sampling design also implies that standard error estimates based on simple random sampling assumptions are inappropriate for use with the ELS data. They will generally yield values that are too small because they do not take into account the clustering of students within schools. Resampling procedures or approaches based on Taylor series approximations can be used to obtain more appropriate standard error estimates. The design effect (DEFF), which is the ratio of the appropriately obtained variance of a statistic to the value that would be obtained under simple random sampling assumptions, provides a measure of the impact of the departure of the sample design from simple random sampling. ELS provides an extensive list of these design effects, which vary according to student groups, types of statistics, and the particular sampling weight used in the analyses. For analyses

involving F3F1TSCPSWT, the mean design effect (over key analysis groups) was 2.2; the mean root design effect (DEFT) was 1.5. These estimates can be used to obtain convenient estimates of standard errors. Standard errors reported below were approximated in this way: For weighted percentages *P*, the standard error was estimated as $1.5\sqrt{P(1-P)/N}$, where *N* is the sample size, and for weighted means, the standard error was estimated as $1.5s/\sqrt{N}$, where *s* is the weighted standard deviation.[4] Standard errors for regression coefficients (Chapter 3) were similarly adjusted.

Sample Sizes

Sample size information for key analyses appears in this appendix. IES data security regulations stipulate that sample sizes be rounded to the nearest ten in all analysis reports. Also, because results based on cells with fewer than three members may not be reported, results for Black, Hispanic, and American Indian students were, on occasion, combined into a group labeled "under-represented minorities." Results for the two Hispanic subgroups ("no race specified" and "race specified") were routinely combined.

Senior Cohort, Applicants, and Enrollees

Using F3F1TSCPSWT and then selecting students with G12COHRT equal to 1 or 2 yields the ELS senior cohort sample, which consists of 8,900 individuals who represent the 2.5 million high school seniors who were ever enrolled in a postsecondary institution.[5] My analyses focused on subsets of the senior cohort: applicants to elite postsecondary institutions and enrollees in those schools. These individuals were identified by linking the ELS data to two additional databases. One is the Integrated Postsecondary Education Data System (IPEDS), a publicly accessible data source that contains information on all US postsecondary institutions that participate in the federal financial aid system.[6]

The second is a restricted-use database, the Barron's admissions competitiveness index data files.[7] These files provide competitiveness ratings for American colleges and universities for 1972, 1982, 1992, 2004, and 2008. I used 2004 ratings and considered schools with the two top ratings: "most competitive" and "highly competitive," a total of 174 schools. The 2,190 students I refer to as applicants are those who applied to one or more of these schools (but may not have attended any of them). The 970 enrollees are those who initially enrolled in one of these schools.

Variables Used in the Analyses

The variables from the ELS database that I used in my analyses appear in Table A-1, along with definitions and information about missing data. The variables I constructed for use in the admissions scenarios are then described, following a description of imputation procedures used to complete the data on admissions test scores.

Table A-1

Variables from the ELS Database

Name of variable	Definition	Missing data
G12COHRT	Indicates whether individual is a senior cohort member	None
F3F1TSCPSWT	Sampling weight used in all analyses unless noted otherwise	None
F1SEX	Sex	None
F1RACE	Race. Original categories were: • Amer. Indian/Alaska Native, non-Hispanic • Asian, non-Hispanic • Black or African-American, non-Hispanic • Hispanic, no race specified • Hispanic, race specified • More than one race, non-Hispanic • Native Hawaii/Pac. Islander, non-Hispanic • White, non-Hispanic For all analyses, the two Hispanic groups were combined. Also, because of IES non-disclosure requirements, results for Black, Hispanic, and American Indian students were, on occasion, combined into a group labeled "Under-represented minorities."	None
STU_ID, F2PS1, F21ORDER, F2IIPED, MERGEID04	Variables used to link to IPEDS and Barron's databases to identify applicant and enrollee groups.	None
F1SES2QR	Socioeconomic quartile. The ELS socioeconomic status variable is a composite of mother's and father's education, mother's and father's occupation, and family income. This composite was then used to divide the ELS participants into four equal groups.	None
F1RAGP	High school grade-point average (GPA) for all academic courses	None among applicants. 10 cases missing in senior cohort.
TXEESATC	Admissions test (SAT or ACT) total/composite score, reported on the SAT scale (400 to 1600). For students who took the ACT, ELS uses a concordance table to obtain approximately equivalent SAT scores. If the student took both tests, the higher score is included here.	None among applicants after I imputed values for 160 individuals. See description below. 1770 cases missing in senior cohort.
F3TZYR1GPA	GPA for all courses taken by the student in the first year of undergraduate education	120 among applicants
F3TZPS2BA	Number of months elapsed between college entry and bachelor's degree	40 among applicants
F3TZHIGHDEG	Highest degree attained as of June 2013	10 among applicants
BYTXMSTD	Score on math test administered to ELS tenth graders in 2002	See imputation description below.
BYTXRSTD	Score on reading test administered to ELS tenth graders in 2002	See imputation description below.
F1TXMSTD	Score on math test administered to ELS twelfth graders in 2004	See imputation description below.
F1OCC30	Occupation the respondent expects/plans to have at age 30	10 among applicants
F1PSEPLN	Post-secondary plans right after high school	None
F1STEXP	How far in school respondent thinks he/she will get.	40 among applicants
F3TZBCH1CIP2	First known bachelor's degree major/field of study.	437 among applicants

* "None" means that data in the ELS database were complete for all individuals in my study. In some cases, ELS imputes missing values in order to provide complete data.[8]

Imputation of Admissions Test Scores

For the admissions scenarios described below, it was important that all 2,190 individuals in the applicant group be included, in order to maintain national representativeness. While data on high school GPA (F1RAGP) were complete, 160 applicants were missing admissions test scores (TXEESATC). Therefore, TXEESATC values were imputed using a stochastic regression imputation procedure with BYTXMSTD, BYTXRSTD, F1TXMSTD, and F1RAGP as predictors (see Table A-1). For the 2,020 applicants who did have TXEESATC values and complete data on the predictors, a regression model was estimated. Prediction accuracy was excellent: The multiple *R* value was 0.850. The resulting regression equation was used to predict TXEESATC for individuals with missing values. (Three of those individuals were also missing data on BYTXMSTD and BYTXRSTD. The mean was substituted.) To avoid artificially shrinking the variance of TXEESATC or inflating its covariances with other variables, a random draw from a normal distribution with a mean of zero and a variance equal to the residual variance from the regression analysis was added to the initial predicted TXEESATC values. The final values were checked to verify that they fell in the interval [400, 1600] and were then rounded to the nearest ten, like the non-imputed values of TXEESATC.

Construction of Composite Variables for Use in the Admissions Scenarios

GPA-test score composite. To create this composite, I first converted each of the two variables, F1RAGP and TXEESATC, to standard-score form by subtracting the mean and dividing by the standard deviation (*SD*). The reference group was the applicant population. For F1RAGP, the mean and *SD* were 3.25 and 0.59; for TXEESATC, the mean and *SD* were 1146.2 and 193.8. For each student, these two standard scores were then added together. This composite served as the starting point for the three other composites used in the analyses.

Race-based affirmative action composite. For individuals who were Black, Hispanic, or American Indian, the GPA-test score composite was augmented by an amount (i.e., 1.032) equivalent to 200 SAT points.

SES-based affirmative action composite. For individuals who were in the two lower SES quartiles, the GPA-test score composite was augmented by an amount (i.e., 1.032) equivalent to 200 SAT points.

Noncognitive composite. The GPA-test score composite for all individuals was augmented by adding a combination of three aspirational variables: F1OCC30, F1PSEPLN, and F1STEXP (see Table A-1). In F1OCC30, the student's planned occupation, the original ELS codes did not reflect the prestige of the occupation. Subsequent ELS documentation provided a useful recoding that reflected occupational prestige; I used this recoding.[9] For missing values (for each of the three variables), I assigned the median of the legitimate values for that variable (7.5 for F1OCC30, 3.5 for F1PSEPLN, and 4.5 for F1STEXP). For F1OCC30, I also assigned the median value of 7.5 to "I don't know" responses. Each of the three variables was then converted to standard-score form. The three were then added together, and the resulting variable was converted to standard-score form and added to the GPA-test score composite. Thus, GPA, test score, and the combination of aspirational variables had nominally equal weights. (The effective weight of each element in a composite is also influenced by the covariances among the components.)

Admissions Procedures Based On Ranking

Twelve of the sixteen admissions rules I studied involved ranking individuals on F1RAGP, TXEESATC, or one of the four composites described above. For each of these six ranking criteria, there were two rules: a "broad" rule and a "narrow" rule. For the broad rules, the target selection rate was 0.40728, which is equal to the (weighted) ratio of enrollees (members of the ELS senior cohort who

actually enrolled in the selective schools) to applicants. For the narrow rules, the target selection rate was 0.10. Since the sum of the weights for the 2,190 applicants was 513,757.67, the target sum of weights was 209,245.49 for the broad rules and 51,375.77 for the narrow rules. Students were "accepted" until the sum of the weights was as close to the target as possible. Suppose the sum of weights for the top n students was $T - a$ and the sum of weights for the top $n + 1$ students was $T + b$, where T is the target and a and b are positive numbers. Then if $a < b$, n students would be admitted and if $a > b$, $n + 1$ students would be admitted. Departures from the target for the twelve rules were small. If individuals near the cut-point were tied on the criterion variable, randomization was used to determine which one(s) would be "accepted."

A risk of this ranking procedure is that a minor reordering of candidates could have a substantial effect if an individual with a large weight was near a cut-point. To check for this situation, we examined the individuals near the cut-points and also conducted unweighted analyses to verify that no anomalous situations of this kind were occurring.

Chapter-Specific Analysis Notes

Analyses Details for Introduction Chapter

The following sections provide details about the analyses reported in the main text. Where appropriate, the pertinent table numbers from the main text are provided.

Group Differences in High School GPA and Admissions Test Scores. To compute the difference between the highest and lowest socioeconomic groups in high school GPA in standard deviation units, the difference between the means for the two groups was divided by the pooled within-group standard deviation (*SD*). The difference in means was 3.02-2.48=0.54. The pooled within-group standard deviation was obtained by multiplying the (weighted) proportion of students in each SES

quartile (see Table *I*-6 in the main text) by the standard deviation in that quartile (Table A-5) and then summing, as follows:

Pooled within-group *SD* = (0.311)(0.68) + (0.265)(0.71) + (0.234)(0.76) + (0.190)(0.73)=0.72.

Therefore, the standardized difference was equal to 0.54/0.72=0.75.

A similar computation was performed for admission test score, where the difference in means was 1091.6-887.2=204.4 and the pooled within-group *SD* was (0.311)(193) + (0.265)(185) + (0.234)(189) + (0.190)(178)=187.1. The standardized difference was equal to 204.4/187.1=1.09. Analogous computations were performed to obtain the standardized ethnic group differences.

Table A-2
Rounded Sample Sizes for Women and Men (Tables *I*-1 and *I*-4)

	Senior Cohort	**Applicants**	**Enrollees**
Women	4870	1180	540
Men	4030	1010	440

Table A-3
Rounded Sample Sizes for Socioeconomic Quartiles (Table *I*-6)

	Senior Cohort	**Applicants**	**Enrollees**
Highest SES	3190	1280	660
Second highest SES	2320	480	180
Second lowest SES	1920	270	90
Lowest SES	1470	170	50

Table A-4
Rounded Sample Sizes for Ethnic Groups (Tables *I*-2, *I*-3, and *I*-5)

	Senior Cohort	**Applicants**	**Enrollees**
American Indian	50	10	*
Asian	980	420	220
Black	980	180	*
Hispanic	1060	210	*
More than one race	370	90	40
White	5460	1290	600

* The rounded sample size for under-represented minorities is 120.

Table A-5
Weighted Standard Deviations of High School GPA and Admission Test Score for the Senior Cohort (Tables *I*-1, *I*-2, and *I*-3)

	High School GPA	**Admission Test Score**
Ethnic Group		
American Indian	0.76	166
Asian	0.71	224
Black	0.66	170
Hispanic	0.74	193
More than one race	0.72	189
White	0.69	184
Socioeconomic Quartile		
Highest SES	0.68	193
Second highest SES	0.71	185
Second lowest SES	0.76	189
Lowest SES	0.73	178
Sex		
Women	0.73	200
Men	0.74	202
Total	0.74	202

Table A-6
Standard Errors of Average High School GPA and Average Test Score for Women and Men in the ELS Senior Cohort (Table *I*-1)

	GPA	**Test Score**
Women	0.02	4.8
Men	0.02	5.4
Total Group	0.01	3.6

Table A-7
Standard Errors of Average High School GPA for Socioeconomic and Ethnic Groups in the ELS Senior Cohort (Table *I*-2)

	Socioeconomic Status (SES)				
Ethnic Group	**Lowest SES**	**Second Lowest SES**	**Second Highest SES**	**Highest SES**	**Total Group**
American Indian	*	*	*	*	0.16
Asian	0.08	0.08	0.07	0.05	0.03
Black	0.06	0.06	0.06	0.07	0.03
Hispanic	0.06	0.07	0.08	0.08	0.03
More than one race	0.15	0.12	0.10	0.09	0.06
White	0.05	0.03	0.03	0.02	0.01
Total Group	0.03	0.03	0.02	0.02	0.01

* Results for these cells were suppressed because of small sample size.

Table A-8
Standard Errors of Average Test Score for Socioeconomic and Ethnic Groups in the ELS Senior Cohort (Table *I*-3)

	Socioeconomic Status (SES)				
Ethnic Group	**Lowest SES**	**Second Lowest SES**	**Second Highest SES**	**Highest SES**	**Total Group**
American Indian	*	*	*	*	44.0
Asian	23.0	23.8	24.1	17.6	11.8
Black	17.0	16.3	19.6	19.0	9.4
Hispanic	18.8	22.5	21.9	23.3	11.4
More than one race	47.3	40.3	22.8	25.5	16.5
White	13.1	9.0	7.1	6.0	4.1
Total Group	8.8	7.5	6.4	5.4	3.6

* Results for these cells were suppressed because of small sample size.

Table A-9
Standard Errors of Percentages of Women and Men (Table *I*-4)

Gender	Senior Cohort	Applicants	Enrollees
Women	0.79	1.60	2.40
Men	0.79	1.60	2.40

Table A-10
Standard Errors of Percentages of Students in Each Ethnic Group (Table *I*-5)

Ethnic Group	Senior Cohort	Applicants	Enrollees
Asian	0.34	0.95	1.57
Under-represented minority	0.72	1.29	1.59
More than one race	0.30	0.61	0.92
White	0.77	1.52	2.17

Table A-11
Standard Errors of Percentages in Each of Four Socioeconomic Categories (Table *I*-6)

Socioeconomic Status (SES)	Senior Cohort	Applicants	Enrollees
Highest SES	0.74	1.60	2.31
Second highest SES	0.70	1.37	1.95
Second lowest SES	0.67	1.11	1.53
Lowest SES	0.62	0.88	0.97

Analysis Details for Chapter 2

Table A-12
Standard Errors of Percentages of Women and Men for Enrollees and Six Admissions Models (Table 2-1)

Gender	Enrollees	Broad Selection Rule			Narrow Selection Rule		
		Test Score	High School GPA	GPA-Test Score Composite	Test Score	High School GPA	GPA-Test Score Composite
Women	2.40	2.41	2.44	2.39	4.71	4.99	4.78
Men	2.40	2.41	2.44	2.39	4.71	4.99	4.78

Table A-13
Standard Errors of Percentages of Students in Each Ethnic Group for Enrollees and Six Admissions Models (Table 2-2)

Ethnic Group	Enrollees	Broad Selection Rule			Narrow Selection Rule		
		Test Score	High School GPA	GPA-Test Score Composite	Test Score	High School GPA	GPA-Test Score Composite
Asian	1.57	1.61	1.54	1.59	3.51	2.63	3.48
Under-represented minority	1.59	1.26	1.52	1.30	1.48	2.96	1.50
More than one race	0.92	0.77	0.77	0.68	1.19	2.02	1.16
White	2.17	2.02	2.11	2.01	3.83	4.13	3.80

Table A-14
Standard Errors of Percentages in Each of Four Socioeconomic Categories for Enrollees and Six Admissions Models (Table 2-3)

Socioeconomic Status (SES)	Enrollees	Broad Selection Rule			Narrow Selection Rule		
		Test Score	High School GPA	GPA-Test Score Composite	Test Score	High School GPA	GPA-Test Score Composite
Highest SES	2.31	2.30	2.48	2.32	3.98	5.10	4.37
Second highest SES	1.95	2.02	2.10	2.01	3.51	4.35	3.96
Second lowest SES	1.53	1.37	1.69	1.42	1.83	3.62	2.03
Lowest SES	0.97	0.87	1.19	0.96	1.53	1.72	1.63

Table A-15
Standard Errors of High School GPA and Test Score Averages for Enrollees and Six Admissions Models (Table 2-4)

	Enrollees	Broad Selection Rule			Narrow Selection Rule		
		Test Score	High School GPA	GPA-Test Score Composite	Test Score	High School GPA	GPA-Test Score Composite
SE of Average High school GPA	0.02	0.02	0.01	0.01	0.03	0.00	0.01
SE of Average Test score	7.2	4.3	7.3	5.4	5.1	13.9	6.5

Table A-16
Standard Errors of College First-Year Grade-Point Average (FGPA), Graduation Rate, and Post-Baccalaureate Attainment Rate for Enrollees and Six Admissions Models (Table 2-5)

	Enrollees	Broad Selection Rule			Narrow Selection Rule		
		Test Score	High School GPA	GPA-Test Score Composite	Test Score	High School GPA	GPA-Test Score Composite
SE of Average College FGPA	0.03	0.03	0.03	0.02	0.05	0.04	0.04
SE of 4-year graduation rate	2.31	2.36	2.40	2.31	4.60	5.02	4.41
SE of 6-year graduation rate	1.78	1.86	1.71	1.70	3.33	3.56	3.09
SE of post-baccalaureate attainment rate	2.16	2.22	2.40	2.27	4.34	5.15	4.53

Table A-17

Rounded Sample Sizes and Weighted Sample Sizes for the Six Admission Rules of Chapter 2 (Tables 2-1 through 2-5)

	Broad Selection Rule			**Narrow Selection Rule**		
	Test Score	**High School GPA**	**GPA-Test Score Composite**	**Test Score**	**High School GPA**	**GPA-Test Score Composite**
Rounded Sample Size	970	890	970	250	210	250
Weighted Sample Size	209,523.4	209,244.4	209,099.0	51,465.9	51,402.9	51,433.5

College Competitiveness Analysis. To investigate college competitiveness, the variable F2PS1 was used to identify the student's first postsecondary institution, and the variable MERGEID04 was used to link to the restricted-use NCES-Barron's admissions competitiveness index data files.[10] There are six Barron's levels of competitiveness, as well as a seventh category of specialized schools, such as art or music schools. For the enrollees and the six admissions rules of Chapter 2, Table A-18 shows the percentages of students in the top four levels. Nearly all students were in these categories.

Table A-18

Percentages of Students Attending Colleges in Each Barron's Category, with Standard Errors in Parentheses

	Enrollees	**Broad Selection Rule**			**Narrow Selection Rule**		
		Test Score	**High School GPA**	**GPA-Test Score Composite**	**Test Score**	**High School GPA**	**GPA-Test Score Composite**
Most competitive	38.6 (2.34)	31.8 (2.30)	31.7 (2.41)	32.3 (2.31)	50.9 (4.83)	38.6 (5.20)	57.2 (4.83)
Highly competitive	61.4 (2.34)	33.8 (2.34)	30.9 (2.40)	31.8 (2.30)	23.8 (4.11)	26.4 (4.71)	20.8 (3.96)
Very competitive	0	21.3 (2.03)	24.2 (2.22)	23.1 (2.08)	15.5 (3.50)	20.4 (4.31)	15.5 (3.53)
Competitive	0	12.0 (1.61)	11.2 (1.64)	11.6 (1.58)	9.5 (2.83)	11.0 (3.34)	5.8 (2.28)
Other	0	1.1 (0.52)	2.0 (0.73)	1.2 (0.54)	0.3 (0.53)	3.6 (1.99)	0.7 (0.81)

Note: Within each of the admissions rules, about 5% of students could not be matched with their first college. These students are omitted from this table.

Field of Study Analysis. The variable used to identify field of study, F3TZBCH1CIP2, gathered from students' college transcripts, gives a 2-digit code for the "first known bachelor's degree major/field of study." I further collapsed the 35 categories into 15, using the mapping in Table A-19. There were some slight differences among the narrow rules of Chapter 2 in the distributions of field of study, but only two were as large as five percentage points: Those selected by the composite rule were more likely than those selected by the GPA rule to study engineering (17% versus 11%) and those selected using test scores were more likely than those chosen using GPA to major in English (7% versus 2%).

Table A-19

Mapping of ELS variable F3TZBCH1CIP2 from 35 into 15 Categories

My label	**F3TZBCH1CIP2 categories included**
Biological and biomedical sciences	Biological and biomedical sciences
Business/management/marketing/related	Business/management/marketing/related
Communication, journalism, related	Communication, journalism, related
Education	Education
Engineering	Engineering, Engineering technologies/technicians
English language and literature/letters	English language and literature/letters
Health/related clinical sciences	Health/related clinical sciences
Liberal arts/sci/gen studies/humanities	Liberal arts/sci/gen studies/humanities, Foreign languages /literature /linguistics, History
Multi/interdisciplinary studies	Multi/interdisciplinary studies
Physical Sciences	Physical Sciences, Mathematics and statistics
Psychology	Psychology
Public administration/social service	Public administration/social service, Security and protective services
Social Sciences	Social Sciences, Family/consumer sciences/human sciences
Visual and performing arts	Visual and performing arts
Other	Agriculture/operations/related sciences, Natural resources and conservation, Architecture and related services, Area/ethnic/cultural/gender studies, Communication technology and support, Computer/information science/support, Legal professions and studies, Military science/leadership/op art, Military technologies, Parks /recreation /leisure /fitness studies, Philosophy and religious studies, Theology and religious vocations, Transportation and materials moving

Analysis Details for Chapter 3

Three regression models were fit for each pair of groups (URM/White and Men/Women): (1) a model in which the GPA-test score composite was the sole predictor of GPA, (2) a model that included the composite, as well as a group membership variable, and (3) a model that included the composite, the group membership variable, and their interaction. All regressions used sampling weights. The *t*-values in Table A-20 were computed by adjusting the standard errors of the regression coefficients, assuming a root design effect of 1.5. (This has the effect of

reducing the *t*-values and increasing the corresponding *p*-values.) For both pairs of groups, the composite and group membership indicator were statistically significant at $\alpha = 0.05$, but the interaction term was not. More specifically, in the case of the URM/White comparison, the group membership indicator in Model 2 had a two-sided *p*-value of 0.026 after adjustment. For the corresponding coefficient in the comparison of men and women, the two sided *p*-value was less than 0.001. R^2 values for the regressions ranged from 0.3050 to 0.3265.

The residuals discussed in the text of Chapter 3 correspond to Model 1. They illustrate the systematic prediction errors that would occur if Model 1 were applied. Table A-21 shows the average residuals for each group in each analysis, along with the weighted proportion of candidates in each group. In each analysis, the weighted average of the residuals is zero, a property of least squares regression.

Table A-20

Regression Coefficients and *t*-values from Regression Analyses

	Intercept		**Composite**		**Group Membership**		**Interaction**		
URM/White (*N*=870)	**Coefficient**	***t*-value**	**Coefficient**	***t*-value**	**Coefficient**	***t*-value**	**Coefficient**	***t*-value**	**Adjusted R^2**
Model 1	2.9904	123.9**	0.2465	18.4**	-	-	-	-	.3206
Model 2	3.0232	107.2**	0.2324	15.7**	-.1400	-2.23*	-	-	.3249
Model 3	3.0283	106.4**	0.2198	12.3**	-.1071	-1.57	0.0397	1.25	.3259
Men/Women (*N*=2190)									
Model 1	2.9879	137.9**	.2459	20.1**	-	-	-	-	.3050
Model 2	2.8691	93.3**	.2390	19.8**	.2307	5.4**	-	-	.3257
Model 3	2.8716	93.3**	.2528	15.3**	.2314	5.4**	-0.0297	-1.23	.3265

Note: *t*-values were computed assuming a root design effect of 1.5. A double asterisk indicates that the two-sided *p*-value is below 0.001. The single asterisk denotes a two-sided *p*-value of 0.026. White students and men were coded "0" on the group membership variable; URMs and women were coded "1."

Table A-21

Descriptive Statistics for Residuals from Regression Analysis, Model 1

	Weighted Average of Residuals (Observed Minus Predicted)	**Weighted Proportion of Analysis Sample**
URM/White Analysis		
URM	-0.0873	.2372
White	0.0270	.7627
Weighted Average of Residuals	-0.0000	
Men/Women Analysis		
Men	-0.1176	.4817
Women	0.1105	.5183
Weighted Average of Residuals	0.0000	

Analysis Details for Chapter 4

Table A-22
Standard Errors of Percentages of Students in Each Ethnic Group for Enrollees and Six Admissions Models (Table 4-1)

Ethnic Group	Enrollees	Broad Selection Rule			Narrow Selection Rule		
		GPA-Test Score Composite	Composite with Race-Based Affirmative Action	Composite with SES-Based Affirmative Action	GPA-Test Score Composite	Composite with Race-Based Affirmative Action	Composite with SES-Based Affirmative Action
Asian	1.57	1.59	1.53	1.67	3.48	3.25	3.53
Under-represented minority	1.59	1.30	1.73	1.43	1.50	3.57	2.29
More than one race	0.92	0.68	0.63	0.67	1.16	1.14	1.49
White	2.17	2.01	2.17	2.11	3.80	4.48	4.17

Table A-23

Standard Errors of Percentages in Each of Four Socioeconomic Categories for Enrollees and Six Admissions Models (Table 4-2)

Socioeconomic Status (SES)	Enrollees	Broad Selection Rule			Narrow Selection Rule		
		GPA-Test Score Composite	Composite with Race-Based Affirmative Action	Composite with SES-Based Affirmative Action	GPA-Test Score Composite	Composite with Race-Based Affirmative Action	Composite with SES-Based Affirmative Action
Highest SES	2.31	2.32	2.33	2.42	4.37	4.55	4.91
Second highest SES	1.95	2.01	2.00	1.93	3.96	3.92	3.45
Second lowest SES	1.53	1.42	1.44	1.80	2.03	2.46	4.02
Lowest SES	0.97	0.96	1.09	1.32	1.63	2.07	2.62

Table A-24

Standard Errors of Percentages of Women and Men for Enrollees and Six Admissions Models (Table 4-3)

Gender	Enrollees	Broad Selection Rule			Narrow Selection Rule		
		GPA-Test Score Composite	Composite with Race-Based Affirmative Action	Composite with SES-Based Affirmative Action	GPA-Test Score Composite	Composite with Race-Based Affirmative Action	Composite with SES-Based Affirmative Action
Women	2.40	2.39	2.38	2.41	4.78	4.88	4.93
Men	2.40	2.39	2.38	2.41	4.78	4.88	4.93

Table A-25
Standard Errors of High School GPA and Test Score Averages for Enrollees and Six Admissions Models (Table 4-4)

	Enrollees	Broad Selection Rule			Narrow Selection Rule		
		GPA-Test Score Composite	Composite with Race-Based Affirmative Action	Composite with SES-Based Affirmative Action	GPA-Test Score Composite	Composite with Race-Based Affirmative Action	Composite with SES-Based Affirmative Action
SE of Average High school GPA	0.02	0.01	0.01	0.01	0.01	0.01	0.01
SE of Average Test score	7.2	5.4	5.6	5.9	6.5	8.3	9.1

Table A-26
Standard Errors of College First-Year Grade-Point Average (FGPA), Graduation Rate, and Post-Baccalaureate Attainment Rate for Enrollees and Six Admissions Models (Table 4-5)

	Enrollees	Broad Selection Rule			Narrow Selection Rule		
		GPA-Test Score Composite	Composite with Race-Based Affirmative Action	Composite with SES-Based Affirmative Action	GPA-Test Score Composite	Composite with Race-Based Affirmative Action	Composite with SES-Based Affirmative Action
SE of Average College FGPA	0.03	0.02	0.03	0.03	0.04	0.04	0.04
SE of 4-year graduation rate	2.31	2.31	2.31	2.35	4.41	4.23	4.53
SE of 6-year graduation rate	1.78	1.70	1.72	1.79	3.09	2.91	3.39
SE of post-baccalaureate attainment rate	2.16	2.27	2.27	2.29	4.53	4.68	4.67

Table A-27

Rounded Sample Sizes and Weighted Sample Sizes for the Four Affirmative Action Rules of Chapter 4 (Tables 4-1 through 4-5)

	Broad Selection Rule		**Narrow Selection Rule**	
	Composite with Race-Based Affirmative Action	**Composite with SES-Based Affirmative Action**	**Composite with Race-Based Affirmative Action**	**Composite with SES-Based Affirmative Action**
Rounded Sample Size	970	940	230	230
Weighted Sample Size	209,211.7	209,095.3	51,385.5	51,391.9

Correlations between SES and URM Status. The following tables of weighted percentages were used in computing the phi correlations in Chapter 4.

Table A-28
Weighted Percentages for Applicants; Phi=0.3218

	Low SES	**High SES**	**Total**
URM	9.98	10.55	20.53
Not URM	12.29	67.18	79.47
Total	22.27	77.73	100

Table A-29
Weighted Percentages for Applicants with Admissions Test Scores of at least 1200; Phi=0.1786

	Low SES	**High SES**	**Total**
URM	2.08	3.86	5.94
Not URM	9.88	84.18	94.06
Total	11.96	88.04	100

Table A-30
Weighted Percentages for Applicants with Admissions Test Scores of at least 1400; Phi=0.0737

	Low SES	**High SES**	**Total**
URM	0.38	1.93	2.31
Not URM	5.13	92.56	97.69
Total	5.51	94.49	100

Analysis Details for Chapter 6

Table A-31
Standard Errors of Percentages of Women and Men for Enrollees and Four Admissions Models (Table 6-1)

Gender	Enrollees	Broad Selection Rule		Narrow Selection Rule	
		GPA-Test Score Composite	Composite Plus Noncognitive	GPA-Test Score Composite	Composite Plus Noncognitive
Women	2.40	2.39	2.41	4.78	4.64
Men	2.40	2.39	2.41	4.78	4.64

Table A-32
Standard Errors of Percentages of Students in Each Ethnic Group for Enrollees and Four Admissions Models (Table 6-2)

Ethnic Group	Enrollees	Broad Selection Rule		Narrow Selection Rule	
		GPA-Test Score Composite	Composite Plus Noncognitive	GPA-Test Score Composite	Composite Plus Noncognitive
Asian	1.57	1.59	1.55	3.48	3.50
Under-represented minority	1.59	1.30	1.45	1.50	2.29
More than one race	0.92	0.68	0.80	1.16	1.25
White	2.17	2.01	2.08	3.80	4.06

Table A-33

Standard Errors of Percentages in Each of Four Socioeconomic Categories for Enrollees and Four Admissions Models (Table 6-3)

Socioeconomic Status (SES)	Enrollees	Broad Selection Rule		Narrow Selection Rule	
		GPA-Test Score Composite	Composite Plus Noncognitive	GPA-Test Score Composite	Composite Plus Noncognitive
Highest SES	2.31	2.32	2.35	4.37	4.29
Second highest SES	1.95	2.01	2.00	3.96	3.61
Second lowest SES	1.53	1.42	1.49	2.03	2.65
Lowest SES	0.97	0.96	1.03	1.63	1.54

Table A-34
Standard Errors of High School GPA and Test Score Data for Enrollees and Four Admissions Models (Table 6-4)

	Enrollees	**Broad Selection Rule**		**Narrow Selection Rule**	
		GPA-Test Score Composite	**Composite Plus Noncognitive**	**GPA-Test Score Composite**	**Composite Plus Noncognitive**
Standard Error of Average High school GPA	0.02	0.01	0.01	0.01	0.02
Standard Error of Average Test Score	7.2	5.4	6.0	6.5	8.6

Table A-35
Standard Errors of College First-Year Grade-Point Average (FGPA), Graduation Rates, and Post-Baccalaureate Attainment Rate for Enrollees and Four Admissions Models (Table 6-5)

	Enrollees	Broad Selection Rule		Narrow Selection Rule	
		GPA-Test Score Composite	Composite Plus Noncognitive	GPA-Test Score Composite	Composite Plus Noncognitive
SE of Average College FGPA	0.03	0.02	0.03	0.04	0.05
SE of 4-year graduation rate	2.31	2.31	2.35	4.41	4.33
SE of 6-year graduation rate	1.78	1.70	1.77	3.09	3.05
SE of post-baccalaureate attainment rate	2.16	2.27	2.32	4.53	4.64

Table A-36

Rounded Sample Sizes and Weighted Sample Sizes for the Two Noncognitive Rules of Chapter 6 (Tables 6-1 through 6-5)

	Broad Selection Rule	**Narrow Selection Rule**
Rounded Sample Size	950	250
Weighted Sample Size	209,344.1	51,267.57

Analyses Details for Chapter 7

Table A-37
Standard Errors of Percentages of Women and Men for Enrollees and Two Lottery Models (Table 7-1)

	Enrollees	Lottery-Test Score Threshold of 1000	Lottery-High School GPA Threshold of 2.8
Women	2.40	1.77	1.75
Men	2.40	1.77	1.75

Table A-38
Standard Errors of Percentages of Students in Each Ethnic Group for Enrollees and Two Lottery Models (Table 7-2)

Ethnic Group	Enrollees	Lottery-Test Score Threshold of 1000	Lottery-High School GPA Threshold of 2.8
Asian	1.57	1.10	1.09
Under-represented minority	1.59	1.16	1.24
More than one race	0.92	0.69	0.65
White	2.17	1.57	1.59

Table A-39

Standard Errors of Percentages in Each of Four Socioeconomic Categories for Enrollees and Two Lottery Models (Table 7-3)

Socioeconomic Status (SES)	Enrollees	Lottery-Test Score Threshold of 1000	Lottery-High School GPA Threshold of 2.8
Highest SES	2.31	1.74	1.75
Second highest SES	1.95	1.51	1.51
Second lowest SES	1.53	1.12	1.16
Lowest SES	0.97	0.80	0.90

Table A-40

Standard Errors of High School GPA and Test Score Data for Enrollees and Two Lottery Models (Table 7-4)

	Enrollees	Lottery-Test Score Threshold of 1000	Lottery-High School GPA Threshold of 2.8
Standard Error of Average High school GPA	0.02	0.02	0.01
Standard Error of Average Test Score	7.2	4.6	5.6

Table A-41

Standard Errors of College First-Year Grade-Point Average (FGPA), Graduation Rates, and Post-Baccalaureate Attainment Rate for Enrollees and Two Lottery Models (Table 7-5)

	Enrollees	**Lottery-Test Score Threshold of 1000**	**Lottery-High School GPA Threshold of 2.8**
SE of Average College FGPA	0.03	0.02	0.02
SE of 4-year graduation rate	2.31	1.76	1.75
SE of 6-year graduation rate	1.78	1.44	1.40
SE of post-baccalaureate attainment rate	2.16	1.56	1.58

Table A-42

Rounded Sample Sizes and Weighted Sample Sizes for the Two Lottery Rules of Chapter 7 (Tables 7-1 through 7-5)

	Lottery-Test Score Threshold of 1000	**Lottery-High School GPA Threshold of 2.8**
Rounded Sample Size	1,790	1,810
Weighted Sample Size	405,398.6	406,141.1

Analyses Details for Chapter 8

Application of constrained optimization techniques to the unweighted ELS data involves standard integer programming techniques. First consider the "Match diversity" analysis: Out of our 2,190 applicants, we wish to admit 970 individuals—the number of students who were, in fact, enrolled. We want at least 12.6% of them to be URMs—the percentage that were actually enrolled. Given these constraints, we want to maximize the GPA-test score composite. This problem can be formalized as follows: Let **x** be a 2,190-element vector of scores on the composite. Let **y** be a vector of zeroes and ones indicating URM status (1=URM; 0 otherwise), and let **z** be a 2,190-element vector of zeroes and ones that will contain the solution. We want to maximize the sum, **x'z**, (or equivalently, the average) of composite scores for the selected students under the following constraints:

- All elements of **z** are either 0 or 1, indicating whether each student is accepted (1) or not (0).
- Exactly 970 students are to be accepted: $\mathbf{1}'\mathbf{z} = 970$.
- At least 12.6% of the selected students should be URMs: $\mathbf{y}'\mathbf{z} \geq .126(970)$.

In the second CO analysis ("Exceed diversity"), we modify the constraint on URMs to require that 20% of the entering class be URMs and we add a further constraint that 20% of the class be from the bottom two SES quartiles. So, letting **w** be a vector of zeroes and ones indicating membership in the bottom two quartiles (1=bottom two quartiles; 0 otherwise), we have the following constraints:

- All elements of **z** are either 0 or 1, indicating whether each student is accepted (1) or not (0).
- Exactly 970 students are to be accepted: $\mathbf{1}'\mathbf{z} = 970$.
- At least 20% of the selected students should be URMs: $\mathbf{y}'\mathbf{z} \geq .2(970)$.
- At least 20% of the selected students should be from the bottom two SES quartiles: $\mathbf{w}'\mathbf{z} \geq .2(970)$.

In both these problems, the quantity to be optimized is linear, as are all the constraints, other than the integer constraint. This problem can be solved using linear programming routines. We used lpSolve, a free routine in R. For integer programs, lpSolve uses a branch-and-bound algorithm.[11]

If sampling weights are incorporated, the problem changes in a fundamental way. We cannot optimize the weighted sum of the composite scores, because this sum can become arbitrarily large simply through the inclusion of applicants with large sampling weights. We therefore must maximize the weighted mean, $\sum_i w_i x_i z_i / \sum_i w_i z_i$, where the w_i are the sampling weights. The denominator is not a constant here; it is a function of the z_i's. Therefore, this expression is nonlinear in the z_i's. Nonlinear integer programs are notoriously difficult, and even locating appropriate software is a challenge. We therefore conducted only the unweighted analysis and compared the results to the unweighted results for the enrollees and to the unweighted results of unconstrained optimization. These unweighted results cannot be used to generalize to the ELS senior cohort. Real-world applications in the admissions context would not involve sampling weights, however, and would therefore circumvent the problems of nonlinear integer programming.

Table A-43

Standard Errors of Unweighted Percentages of Women and Men for Enrollees and Two Constrained Optimization (CO) Models, and Unconstrained Optimization (Table 8-1)

Gender	Enrollees	CO (Match diversity)	CO (Exceed diversity)	Unconstrained Optimization
Women	2.39	2.38	2.38	2.38
Men	2.39	2.38	2.38	2.38

Because sampling weights are not incorporated, results for enrollees differ from those in previous tables.

Table A-44

Standard Errors of Unweighted Percentages of Students in Each Ethnic Group for Enrollees and Two Constrained Optimization (CO) Models, and Unconstrained Optimization (Table 8-2)

Ethnic Group	Enrollees	CO (Match diversity)	CO (Exceed diversity)	Unconstrained Optimization
Asian	2.00	1.98	1.97	2.01
Under-represented Minorities	1.60	1.60	1.93	1.27
More than one race	0.93	0.77	0.72	0.79
White	2.35	2.32	2.39	2.26

Note. Because sampling weights are not incorporated, results for enrollees differ from those in previous tables.

Table A-45

Standard Errors of Unweighted Percentages in Each of Four Socioeconomic Categories for Enrollees and Two Constrained Optimization (CO) Models, and Unconstrained Optimization (Table 8-3)

Socioeconomic Status (SES)	**Enrollees**	**CO (Match diversity)**	**CO (Exceed diversity)**	**Unconstrained Optimization**
Highest SES	2.24	2.25	2.32	2.24
Second highest SES	1.86	1.87	1.81	1.90
Second lowest SES	1.37	1.34	1.60	1.33
Lowest SES	1.01	1.04	1.26	0.97

Note. Because sampling weights are not incorporated, results for enrollees differ from those in previous tables.

Table A-46

Standard Errors of Unweighted High School GPA and Test Score Data for Enrollees and Two Constrained Optimization (CO) Models, and Unconstrained Optimization (Table 8-4)

	Enrollees	**CO (Match diversity)**	**CO (Exceed diversity)**	**Unconstrained Optimization**
Standard Error of Average High school GPA	0.02	0.01	0.01	0.01
Standard Error of Average Test Score	7.4	5.6	6.6	5.4

Note. Because sampling weights are not incorporated, results for enrollees differ from those in previous tables.

Table A-47

Standard Errors of College First-Year Grade-Point Average (FGPA), Graduation Rates, and Post-Baccalaureate Attainment Rate for Enrollees and Two Constrained Optimization (CO) Models, and Unconstrained Optimization (Table 8-5)

	Enrollees	**CO (Match diversity)**	**CO (Exceed diversity)**	**Unconstrained Optimization**
SE of Average College FGPA	0.03	0.03	0.03	0.03
SE of 4-year graduation rate	2.44	2.41	2.44	2.27
SE of 6-year graduation rate	1.88	1.79	1.84	1.70
SE of post-baccalaureate attainment rate	2.14	2.35	2.35	2.28

Note. Because sampling weights are not incorporated, results for enrollees differ from those in previous tables.

Compact Comparison Tables for All Admissions Models, Applicants, and Enrollees

Tables A-48 and A-49 below provide summary information, in compact form, for the classes that result from the admissions rules evaluated in *Who Gets In?* as well as for the applicant and enrollee groups. Further detail, including sample sizes, weighted sample sizes, and standard errors, appears elsewhere in this document. Further detail about the applicant and enrollee populations, as well as the admissions rules themselves, appears in the main text.

Table A-48. Descriptive Data for Applicants, Enrollees, and Classes Admitted Using Broad Ranking Rules and Lotteries (Chapter references in parentheses)

	Appli-cants (Intro)	Enrol-lees (Intro)	Top 41% Test score (Ch, 2)	Top 41% GPA (Ch. 2)	Top 41% composite (Ch. 2)	Top 41% Race AA (Ch. 4)	Top 41% SES AA (Ch. 4)	Top 41% Noncog-nitive (Ch. 6)	Lottery-Min SAT (Ch. 7)	Lottery-Min GPA (Ch. 7)
	RACE									
Asian	9.8	12.1	12.7	10.4	12.3	11.4	13.6	11.5	10.7	10.6
URM	20.5	12.4	7.3	10.1	7.9	15.3	9.5	9.8	12.3	14.5
.> 1 Race	3.8	3.8	2.6	2.4	2.0	1.8	1.9	2.8	3.9	3.5
White	66.0	71.7	77.5	77.1	77.8	71.6	75.0	76.0	73.1	71.4
	SOCIOECONOMIC STATUS									
Highest	53.6	63.6	64.9	58.7	64.0	62.6	56.6	63.2	59.7	56.7
Second	24.2	20.8	22.8	22.5	22.4	22.2	19.3	21.6	23.8	24.0
Third	14.0	11.4	8.9	12.9	9.5	9.9	16.1	10.5	11.2	12.3
Lowest	8.3	4.2	3.4	5.9	4.1	5.4	7.9	4.7	5.4	7.0
	GENDER									
Female	51.8	53.4	50.0	62.0	57.2	57.8	57.3	57.8	51.6	56.1
Male	48.2	46.6	50.0	38.0	42.8	42.2	42.7	42.2	48.4	43.9
	HIGH SCHOOL GRADES									
GPA mean	3.25	3.5	3.5	3.8	3.7	3.7	3.7	3.7	3.4	3.5
GPA SD	0.59	0.4	0.4	0.2	0.2	0.3	0.3	0.3	0.5	0.3
	TEST SCORES									
SAT mean	1146	1245	1325	1249	1303	1299	1295	1289	1222	1197
SAT SD	194	150	89	144	111	117	121	122	130	158
	COLLEGE AND BEYOND									
FGPA mean	2.99	3.2	3.3	3.4	3.4	3.4	3.4	3.4	3.1	3.2
FGPA SD	0.79	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.7	0.6
4 yr grad	47.6	64.3 %	60.8 %	65.2 %	64.7 %	64.1%	63.5%	63.4%	55.1	55.8
6 yr grad	71.1	83.7 %	81.8 %	86.6 %	85.4 %	85.1%	84.1%	84.3%	79.3	80.3
Post-BA	23.2	28.0 %	30.2 %	35.2 %	33.2 %	32.9%	32.8%	34.9%	26.5	27.5

Note: All table entries are weighted.

Table A-49. Descriptive Data for Enrollees and Classes Admitted Using Narrow Ranking Rules and Constrained Optimization (Chapter references in parentheses)

	Enrol-lees (Intro)	Top 10% Test score (Ch. 2)	Top 10% GPA (Ch. 2)	Top 10% composite (Ch. 2)	Top 10% Race AA (Ch. 4)	Top 10% SES AA (Ch. 4)	Top 10% Noncog-nitive (Ch. 6)	*CO: Match Diversity (Ch. 8)	*CO: Exceed Diversity (Ch. 8)	*Enrol-lees (Ch. 8)
		RACE								
Asian	12.1	16.5	6.8	15.6	12.5	14.9	16.5	21.5	21.2	22.3
URM	12.4	2.5	8.8	2.5	15.6	5.6	6.3	12.6	20.1	12.6
.> 1 Race	3.8	1.6	3.9	1.5	1.4	2.3	1.8	2.6	2.3	3.9
White	71.7	79.4	80.6	80.4	70.5	77.2	75.4	63.4	56.5	61.1
		SOCIOECONOMIC STATUS								
Highest	63.6	77.0	61.0	70.4	68.8	57.8	70.7	67.9	63.0	68.2
Second	20.8	16.5	22.3	21.8	19.8	14.1	17.9	18.6	17.0	18.3
Third	11.4	3.9	13.9	4.7	6.7	20.6	8.7	8.5	12.7	8.9
Lowest	4.2	2.7	2.8	3.0	4.6	7.5	2.8	4.9	7.4	4.6
		GENDER								
Female	53.4	44.7	64.8	53.5	55.9	56.2	58.8	57.2	57.4	55.1
Male	46.6	55.3	35.2	46.5	44.1	43.8	41.2	42.8	42.6	44.9
		HIGH SCHOOL GRADES								
GPA mean	3.5	3.7	4.0	3.9	3.9	3.9	3.8	3.7	3.7	3.5
GPA SD	0.4	0.3	0.0	0.1	0.1	0.1	0.2	0.3	0.3	0.4
		TEST SCORES								
SAT mean	1245	1452	1297	1431	1418	1411	1395	1307	1291	1250
SAT SD	150	54	133	68	85	91	92	116	137	153
		COLLEGE AND BEYOND								
FGPA mean	3.2	3.5	3.6	3.6	3.6	3.6	3.5	3.4	3.3	3.2
FGPA SD	0.6	0.5	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.6
4 yr grad	64.3 %	61.6 %	64.0 %	69.6 %	75.4%	70.4%	69.8	66.4	65.0	65.6
6 yr grad	83.7 %	85.5 %	86.6 %	88.2 %	90.3%	86.5%	88.1	85.6	84.7	84.2
Post-BA	28.0 %	30.0 %	41.8 %	33.8 %	34.9%	32.9%	41.3	34.6	34.0	24.3

Note: An asterisk indicates that the column contains unweighted results. All other table entries are weighted.

Reference Notes

[1] See pp. 1, 5 in S. J. Ingels, D. J. Pratt, C. P. Alexander, M. Bryan, D. M. Jewell, E. Lauff, T. L. Mattox, & D. Wilson (2015). *Education Longitudinal Study of 2002 (ELS:2002) Postsecondary Education Transcript Study Data File Documentation* (NCES 2015-033). Washington, DC: National Center for Education Statistics. Retrieved from http://nces.ed.gov/pubsearch; see also http://nces.ed.gov/surveys/els2002/.

[2] Ingels et al., 2015, p. 5.

[3] Ingels et al., 2015, pp. 49, 103.

[4] Ingels et al., 2015, p. 90, 95.

[5] Email from Elise Christopher, project officer, July 15, 2015.

[6] See https://nces.ed.gov/ipeds/about/ .

[7] See C. M. Schmitt, (2009). *Documentation for the restricted-use NCES-Barron's admissions competiveness index data files.* (NCES 2010-330). Washington DC: National Center for Education Statistics.

[8] See Ingels et al., 2015, pp. 36, 130.

[9] See p. F4 in S. J. Ingels, D. J. Pratt, D. Wilson, L. J. Burns, D. Currivan, J. E. Rogers, & S. Hubbard-Bednasz (2007). *Education Longitudinal Study of 2002: Base-Year to Second Follow-up Data File Documentation* (NCES 2008-347). Washington, DC: National Center for Education Statistics.

[10] Schmitt, 2009.

[11] See M. Berkelaar, *Package lpSolve* (2014). Retrieved from https://cran.r-project.org/ and *lp_solve reference guide*. (n.d.) Retrieved from http://web.mit.edu/lpsolve/doc/. Branch-and-bound algorithms are described on pp. 277-289 in B. Kolman & R. E. Beck, *Elementary Linear Programming with Applications, 2nd Edition* (San Diego, CA: Academic Press, 1995).