Systematically Missing Data and Multiple Regression Analysis: An Empirical Comparison of Deletion and Imputation Techniques

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The purpose of this study was to investigate, within the context of a two-predictor multiple regression analysis with systematically missing data, the effectiveness of eight missing data treatments on the sample estimate of R^2 and each standardized regression coefficient. Furthermore, the study investigated whether sample size, proportion of systematically missing data above the mean of the regressor, and the percentage of missing data affected the effectiveness of the eight missing data treatments. One thousand samples of size 50, 100, and 200 were generated per data set. The percentages of missing data were 0%, 10%, 20%, 30%, 40%, 50%, and 60%, occurring either on one regressor or across both regressors. The proportions of missing data that were above the mean value of the regressors were 0.60, 0.70, 0.80, or 0.90. The data were analyzed by computing effect sizes obtained from the missing data treatment conditions relative to the complete sample condition (i.e., 0% missing data). The results suggest that the stochastic multiple regression imputation technique was the most effective treatment of the missing data. Listwise and pairwise deletion approaches were less effective than stochastic multiple regression imputation but were superior to the other techniques examined.

Empirical investigations frequently have missing data on one or more variables. Researchers have long recognized that missing data within a study may be detrimental to any subsequent data analyses, interpretations, and conclusions. Unfortunately, researchers' recommendations (Guertin, 1968; Beale & Little, 1975; Gleason & Staelin, 1975; Frane, 1976; Kim & Curry, 1977; Santos 1981; Basilevsky et al., 1985; Raymond & Roberts, 1987) for managing missing data are not in complete agreement. Anderson, Basilevsky, and Hum (cited in Rossi, Wright, & Anderson, 1983) observed that the results of many research studies on missing data treatments are not comparable due to the method used, stratification categories (number of variables, sample size, proportion of missing data, and degree of multicollinearity), and the criteria that measure effectiveness. Kromrey and Hines (1991) stated that in the multiple regression context, the criteria should be the accuracy of the sample estimate of R^2 (coefficient of determination) and the regression coefficients.

While numerous missing data treatments are available for use by the applied researcher to manage missing data, researchers have characteristically utilized only two classes of procedures. Applied researchers typically employ the deletion procedures or the deterministic imputation procedures. The deletion procedures only utilize cases with complete data (Glasser, 1964; Haitovsky, 1968). Listwise deletion discards all cases with incomplete information, whereas pairwise deletion constructs a correlation matrix utilizing all pairs of complete data. With the deterministic imputation procedures (Santos, 1981; Kalton & Kasprzyk, 1982), the applied researcher employs a statistical procedure (e.g., mean substitution, simple regression, or multiple regression) to estimate the missing values. The residual (error) term in the equation for this estimation is set to zero.

Stochastic imputation is not typically utilized by applied researchers. However, evidence suggests that stochastic imputation procedures might be a viable alternative in the treatment of missing data (Santos, 1981; Kalton & Kasprzyk, 1982; Jinn & Sedransk, 1989; Keawkungal & Benson, 1989; Brockmeier, Hines, & Kromrey, 1993; Brockmeier, Kromrey, & Hines, 1994, 1995, and 1996). As with the deterministic imputation procedures, a statistical procedure is employed to estimate the missing values. The residual term when employing stochastic imputation is a randomly appended value in the estimation equation instead of zero as occurs with deterministic imputation (an example of SAS code that provides stochastic imputation is included in Appendix A).

Applied researchers also do not usually employ maximum likelihood estimation and multiple imputation for managing missing data. Scholarly work on maximum likelihood estimation and multiple imputation are found in the technical statistical journals, not usually in the journals of applied researchers (Kromrey, 1989; Brockmeier,

1992). Maximum likelihood estimation is infrequently utilized due to the lack of software and mathematical complexity (Little, 1992).

In most of the previously conducted research, the key assumption is that data are missing at random. Researchers are often advised that if data are randomly missing, and the percentage of missing data is not too large, then any missing data treatment is effective. This assumption of randomly missing data is tenuous in many cases. Cohen and Cohen (1975, 1983) and Tabachnick and Fidell (1983) describe procedures to test the assumption of randomly missing data. Kromrey and Hines (1994) elucidate that the assumption of randomly missing data is rarely tested and that the applied researcher is hard pressed to find guidance if data are missing systematically.

Kromrey and Hines (1994) examined the effectiveness of the deletion procedures and deterministic imputation procedures with systematically missing data in the context of missing data on one of two predictor variables. The authors stated that with moderate amounts of missing data, the deletion procedures yielded results similar to those results obtained without missing data. Kromrey and Hines indicated that the deterministic imputation procedures generally did not work well when compared to the results obtained with complete data.

Brockmeier, Kromrey, and Hines (1996) investigated, within the context of a two-predictor multiple regression analysis with systematically missing data, the effectiveness of eight missing data treatments on the sample estimate of R^2 and each standardized regression coefficient. The stochastic multiple regression imputation technique was effective with as much as 60% of the data missing. With smaller proportions of missing data, both the listwise and pairwise deletion approaches were also effective in estimating R^2 and the regression weights.

The present study extends the previous work of Kromrey and Hines (1994) and Brockmeier et al. (1996). First, the study continues to investigate the effectiveness of the stochastic and deterministic imputation procedures and the deletion procedures with systematically missing data in data sets with different correlations between variables. Second, the number of levels of systematically missing data was increased to be more representative of authentic data sets.

Purpose

The purpose of this study was to investigate, within the context of a two-predictor multiple regression analysis with systematically missing data, the effectiveness of eight missing data treatments on the sample estimate of R^2 and each standardized regression coefficient. The study also examined whether the proportion of systematically missing data above the mean of each independent variable affected the effectiveness of the eight missing data treatments. Three types of missing data treatments were examined: deletion, deterministic imputation, and stochastic imputation. The missing data treatments examined in this study were: (a) listwise deletion, (b) pairwise deletion, (c) deterministic mean substitution, (d) deterministic simple regression, (e) deterministic multiple regression, (f) stochastic mean substitution, (g) stochastic simple regression, and (h) stochastic multiple regression.

Method

Data Source

Data selected for this investigation were chosen from the work of Skaalvik and Rankin (1995). Skaalvik and Rankin examined the relationship between math and verbal achievement and measures of motivation. One data set consisted of correlations between the measures of mathematics achievement, self-perceived ability to learn mathematics, and mathematics intrinsic motivation for grade six students. The second data set consisted of correlations between the same three measures, but for grade nine students. In the data obtained from the older students, the correlations between variables were higher.

Table 1. Summary Descriptive Statistics for the Population on the Grade Six Data

			Correlations	
	Mean	SD	(X_1)	(X_2)
(Y) Mathematics Achievement	12.2672	4.6380	0.33	0.25
(X_1) Mathematics Self-perceived Ability	13.1075	2.1900	- -	0.58
(X_2) Mathematics Intrinsic Motivation	50.3355	14.5836		

Table 2. Summary Descriptive Statistics for the Population on the Grade Nine Data

			Correlations	
	Mean	SD	(X_1)	(X_2)
(Y) Mathematics Achievement	9.3039	4.4363	0.58	0.59
(X_1) Mathematics Self-perceived Ability	12.2064	2.7616	- -	0.70
(X_2) Mathematics Intrinsic Motivation	45.0580	17.5328		

Table 3. Regression Models in the Study as Computed on the Population.

Data set	Dependent Variable	Independent Variables	Beta	R^2
Grade Six Data	Y	X_1	0.2779	0.1152
		X_2	0.0917	
Grade Nine Data	Y	X_1	0.3239	0.4027
		X_2	0.3638	

SAS/IML was employed to generate multivariate normal random variables given the correlation between variables and the mean and standard deviation of each variable. Tables 1 and 2 present the means and standard deviations of each variable and the correlation between variables by data set. Table 3 presents the regression model for each data set.

Experimental Design

The study employed a 2 x 3 x 4 x 13 x 8 experimental design. The design included two between-subjects variables (pseudopopulation and sample size) and three within-subjects variables (proportion of missing data above the mean, percentage of missing data, and missing data treatment). One thousand samples of size 50, 100, and 200 were generated per data set. The four proportions of systematically missing data above the mean of each independent variable were 0.60, 0.70, 0.80, and 0.90. The 13 percentages of missing data generated by predictor variable (X_1,X_2) were (0%,0%), (10%,0%), (20%,0%), (30%,0%), (40%,0%), (50%,0%), (60%,0%), (10%,10%), (20%,10%), (20%,20%), (30%,20%), (40%,20%), and (30%,30%). The eight missing data treatments examined were listwise deletion, pairwise deletion, deterministic mean substitution, deterministic simple regression, deterministic multiple regression, stochastic mean substitution, stochastic simple regression, and stochastic multiple regression.

The pseudopopulations were not manipulated within the experiment, but were generated to obtain the desired correlational differences between variables in each data set. The sample sizes and missing data treatments were chosen to replicate the earlier work of Kromrey and Hines (1994) and Brockmeier et al. (1996). The percentages of missing data were chosen to be representative of the research of Kromrey and Hines (1994) and Brockmeier et al. (1993, 1994, 1995, and 1996). The proportion of systematically missing data above the mean of the regressors was altered to create increasing degrees of distortion in the observed data. The probability of a missing value was established as proportional to the value of the variable. Kromrey and Hines (1994) indicated that this process reduces the variance and exaggerates the skewness in the observed distribution, and that the value of the observed mean is altered by the asymmetry.

Statistical Analysis

The dependent variables analyzed were the sample estimate of R^2 and the standardized regression coefficients. The data were analyzed by computing the effect sizes obtained from the missing data treatment conditions relative to the complete sample condition (i.e., 0% missing data).

Results

To conserve space, the results are presented as effect sizes representing the difference between the mean value of the sample statistic (R^2 or standardized regression weight) and the mean value obtained from the complete data condition. This difference in means was then divided by the standard deviation of the statistic obtained in the complete data condition. For more complete results, the raw means and standard deviations are available from the first author.

Sample estimates were considered to be reasonably unbiased and to present few practical problems to applied researchers if the absolute value of the effect size was less than 0.3 (Kromrey & Hines, 1991). The criterion of 0.3 was chosen because the regression coefficients and the sample estimate of R^2 are both subject to substantive interpretation and tests of statistical significance.

Effects of Missing Data on Sample Estimate of R^2

Effect sizes for the estimation of R^2 are presented in Tables 4 and 5. These data reveal that stochastic multiple regression generated fewer effect sizes greater than the criterion of 0.3 than any other missing data treatment. Stochastic multiple regression generated effect sizes greater than the criterion 4.3% (12 of 280 effect sizes) of the time. Of the 12 effect sizes greater than the criterion, 11 effect sizes occurred when the percentage of missing data was 60%. Ten of the twelve effect sizes greater than the criterion occurred for the grade six data set and the sample size of 50. Two other cases occurred with the sample size of 200 when the proportion of missing data above the mean was 0.90 and the proportion of missing data was 60%.

Pairwise deletion produced effect sizes greater than the criterion 8.9% (25 of 280 effect sizes) of the time, more than twice as frequently as that provided by stochastic multiple regression. Effect sizes greater than 0.3 occurred 19 of 25 times when the proportion of missing data above the mean was 0.80 or 0.90 and 22 of 25 times when the percentage of missing data was 50% or 60%. Listwise deletion yielded effect sizes greater than the criterion 22.5% (63 of 280 effect sizes) of the time. Across both data sets and sample sizes, 58 of 63 effect sizes greater than the criterion occurred when the percentage of missing data

was 50% or 60%. The other five effect sizes greater than the criterion occurred when the percentage of missing data was 40%.

Notably worse performance was observed for the other missing data treatments. Deterministic simple regression, deterministic mean substitution, deterministic multiple regression, stochastic simple regression, and stochastic mean substitution yielded effect sizes greater than the criterion from 45.7% (128 of 280 effect sizes) to 89.6% (251 of 280 effect sizes) of the time. For each of these missing data treatments, effect sizes greater than the criterion occurred about equally across the two data sets.

Effects of Missing Data on the First Standardized Regression Coefficient (X_1)

Tables 6 and 7 report the effect sizes for the first standardized regression coefficient. Stochastic multiple regression, listwise deletion, and pairwise deletion yielded the fewest effects sizes greater than the criterion for this coefficient. Stochastic multiple regression generated effect sizes greater than the criterion 9.6% (27 of 280 effect sizes) of the time. Eighteen of these 27 conditions occurred when the percentage of missing data was 60%, and 24 of the 27 conditions were when the proportion of missing data above the mean was 0.80 or 0.90. Listwise deletion generated effects sizes greater than the criterion 11.4% (32 of 280 effect sizes) of the time, only slightly more frequently than that of stochastic multiple regression. Twenty of the 32 conditions were those with 60% missing data, and 28 of the 32 conditions were those in which the proportion of missing data above the mean was 0.80 or 0.90. Pairwise deletion produced effect sizes greater than the criterion 18.2% (51 of 280 effect sizes) of the time.

As with the estimation of R^2, the effectiveness of deterministic simple regression, deterministic multiple regression, deterministic mean substitution, stochastic simple regression, and stochastic mean substitution were notably lower than that of stochastic multiple regression and the two deletion procedure. These techniques produced effect sizes greater than the criterion from 40.4% (113 of 280 effect sizes) to 85.7% (240 of 280 effect sizes) of the time.

Effects of Missing Data on the Second Standardized Regression Coefficient (X_2)

Examination of Tables 8 and 9 reveals that listwise deletion yielded no effect sizes greater than the criterion of 0.3 with the lower correlated data set (i.e., grade six data) and only six effect sizes (2.1%) greater than the criterion with the higher correlated data set (i.e., grade nine data). Five of these six effect sizes occurred when the proportion of missing data above the mean was 0.80, or 0.90 and the percentage of missing data was 50% or 60%. Stochastic multiple regression yielded effect sizes greater than the criterion 9.3% (26 of 280 effect sizes) of the time. These effect sizes occurred 23 of 26 times when the proportion of missing data above the mean was 0.80 or 0.90, and 18 of 26 times when the percentage of missing data was 60%. Deterministic simple regression yielded effect sizes greater than the criterion 16.4% (46 of 280 effect sizes) of the time and pairwise deletion yielded effect sizes greater than the criterion 22.1% (62 of 280 effect sizes) of the time.

Deterministic multiple regression, stochastic simple regression, deterministic mean substitution, and stochastic mean substitution yielded effect sizes greater than the criterion from 52.5% (147 of 280 effect sizes) to 78.9% (221 of 280 effect sizes) of the time.

Discussion

In the context of the current study, a two-predictor multiple regression analysis with systematically missing data, the results suggest large differences in the effectiveness of the eight missing data treatments. Stochastic multiple regression performed the best of the missing data treatments in yielding fewer sample estimates of R^2 that differed from the complete sample condition. Pairwise deletion, the second best performer of the missing data treatments, produced biased sample estimates of R^2 more than twice as frequently as stochastic multiple regression. The effect sizes greater than 0.3 that were generated by pairwise deletion occurred when the percentage of missing data was 50% or 60%. Listwise deletion yielded five times more effect sizes greater than the criterion when compared to stochastic multiple regression. Deterministic simple regression was the next most effective missing data treatment, but its performance was notably worse than those of the three best treatments. Deterministic mean substitution, deterministic multiple regression, stochastic simple regression, and stochastic mean substitution produced sample estimates of R^2 that differed from the complete sample condition at least 45.7% of the time. These four missing data treatments were simply ineffective in producing unbiased sample estimates of R^2.

Similar results were obtained for the estimation of regression weights in the presence of missing data. Stochastic multiple regression was the most effective at producing unbiased estimates of the first standardized regression coefficient but listwise deletion was more effective at generating unbiased estimates of the second. The conditions under which the estimates of the standardized regression coefficients differed from the complete sample condition, were the most extreme conditions examined (i.e., when the proportion of missing data above the mean was 0.80 or 0.90 and the percentage of missing data was 50% or 60%).

Table 4. Effect Sizes of the Sample Estimate of R-Square for the Grade Six Data by Sample Size, Proportion of Missing Data High, Percentage of Missing Data, and Missing Data Treatment

Sample Size	Proportion High	Percentage of Missing Data	L	P	MS	SR	MR	SMS	SSR	SMR
	.60	10%,0%	0.0316	0.0208	-0.0907	-0.0589	0.0983	-0.1480	-0.0947	0.0396
	.60	20%,0%	0.0783	0.0621	-0.1671	-0.1264	0.2198	-0.2556	-0.2054	0.0859
	.60	30%,0%	-0.1561	0.1199	-0.2322	-0.1832	0.3925	-0.3452	-0.2935	0.1189
	.60	40%,0%	-0.2511	0.1898	-0.2929	-0.2453	0.6098	-0.4063	-0.3719	0.1968
	.60	50%,0%	-0.4747	0.4125	-0.2998	-0.2634	1.0192	-0.4466	-0.3964	0.3747
	.60	60%,0%	-0.4832	0.3935	-0.4123	-0.3612	1.3667	-0.5001	-0.4876	0.4105
	.70	10%,0%	0.0000[a]							
	.70	20%,0%	0.0784	0.0668	-0.1600	-0.1170	0.2249	-0.2446	-0.1997	0.0777
	.70	30%,0%	0.1236	0.0823	-0.2546	-0.1935	0.3641	-0.3703	-0.3092	0.1337
	.70	40%,0%	0.1661	0.1353	-0.3076	-0.2492	0.5669	-0.4037	-0.3723	0.1773
	.70	50%,0%	0.2621	0.2209	-0.3693	-0.3023	0.8991	-0.4738	-0.4355	0.2724
50	.70	60%,0%	0.3924	0.3424	-0.4257	-0.3704	1.3806	-0.5150	-0.4813	0.3850
	.80	10%,0%	0.0371	0.0265	-0.0887	-0.0623	0.0992	-0.1429	-0.1134	0.0259
	.80	20%,0%	0.0883	0.0735	-0.1570	-0.1262	0.2187	-0.2491	-0.2075	0.0918
	.80	30%,0%	0.1338	0.1102	-0.2311	-0.1854	0.3775	-0.3595	-0.3102	0.1176
	.80	40%,0%	0.1881	0.1584	-0.2976	-0.2389	0.6096	-0.4139	-0.3694	0.2013
	.80	50%,0%	0.1121	0.0933	-0.4178	-0.3574	0.7386	-0.4775	-0.4638	0.1630
	.80	60%,0%	0.0386	0.0647	-0.4949	-0.4464	1.0187	-0.5253	-0.4954	0.2159
	.90	10%,0%	0.0000[a]							
	.90	20%,0%	0.0660	0.0516	-0.1835	-0.1292	0.2271	-0.2854	-0.2069	0.0662
	.90	30%,0%	0.0687	0.0655	-0.2598	-0.1997	0.3557	-0.3791	-0.2914	0.1200
	.90	40%,0%	0.0784	0.0699	-0.3426	-0.2674	0.5478	-0.4427	-0.3767	0.1917
	.90	50%,0%	-0.0758	0.0095	-0.4391	-0.3913	0.6428	-0.4879	-0.4804	0.1107
	.90	60%,0%	-0.1736	-0.0573	-0.5101	-0.4648	0.7441	-0.5477	-0.5358	0.1111
	.60	10%,10%	0.0668	0.0642	-0.1032	-0.0696	0.1614	-0.1823	-0.1231	0.0835
	.60	20%,10%	0.1825	0.1211	-0.1579	-0.1188	0.3004	-0.3043	-0.2057	0.1367
	.60	20%,20%	0.2525	0.1839	-0.1693	-0.1282	0.4036	-0.3397	-0.2312	0.2196
	.60	30%,20%	0.3912	0.2644	-0.2219	-0.1551	0.6706	-0.4229	-0.3362	0.2982
	.60	40%,20%	0.5757	0.3297	-0.3145	-0.2581	0.9462	-0.5471	-0.4105	0.4146
	.60	30%,30%	0.5596	0.3378	-0.2431	-0.1908	0.8362	-0.4589	-0.3260	0.4152
	.70	10%,10%	0.0000[a]							
	.70	20%,10%	0.1397	0.0870	-0.1857	-0.1337	0.2858	-0.3247	-0.2365	0.1523
	.70	20%,20%	0.2503	0.1796	-0.1624	-0.1311	0.3908	-0.3195	-0.2189	0.1999
	.70	30%,20%	0.2837	0.2257	-0.2306	-0.1848	0.5699	-0.4496	-0.3327	0.2444
	.70	40%,20%	0.4986	0.2942	-0.3018	-0.2588	0.8634	-0.5471	-0.3759	0.3573
50	.70	30%,30%	0.4928	0.3182	-0.2355	-0.1877	0.8204	-0.4691	-0.3174	0.4053
	.80	10%,10%	0.0784	0.0695	-0.0902	-0.0653	0.1530	-0.1703	-0.1163	0.0852
	.80	20%,10%	0.1690	0.1218	-0.1598	-0.1303	0.2893	-0.2934	-0.2253	0.1338
	.80	20%,20%	0.2363	0.1857	-0.1555	-0.1145	0.4178	-0.3264	-0.2300	0.2212
	.80	30%,20%	0.2973	0.2596	-0.2221	-0.1983	0.5685	-0.4153	-0.3207	0.2411
	.80	40%,20%	0.3558	0.2919	-0.2950	-0.2453	0.8117	-0.4976	-0.3692	0.3531
	.80	30%,30%	0.3642	0.3446	-0.2068	-0.1789	0.7251	-0.4288	-0.3142	0.3056
	.90	10%,10%	0.0000[a]							
	.90	20%,10%	0.1532	0.0992	-0.1730	-0.1274	0.2958	-0.3016	-0.2181	0.1364
	.90	20%,20%	0.1790	0.1734	-0.1590	-0.1323	0.3715	-0.3300	-0.2472	0.1918
	.90	30%,20%	0.1710	0.1761	-0.2527	-0.2224	0.5001	-0.4448	-0.3353	0.2168
	.90	40%,20%	0.2523	0.2907	-0.2792	-0.2577	0.7274	-0.4997	-0.4064	0.3049
	.90	30%,30%	0.1893	0.3533	-0.2068	-0.2088	0.5802	-0.4602	-0.3393	0.2635

(Table continues)

Table 4 (continued).

Sample Size	Proportion High	Percentage of Missing Data	L	P	MS	SR	MR	SMS	SSR	SMR
	.60	10%,0%	0.0122	0.0076	-0.1719	-0.1177	0.1385	-0.3146	-0.2137	0.0106
	.60	20%,0%	0.0311	0.0208	-0.3309	-0.2425	0.3107	-0.5390	-0.4345	0.0510
	.60	30%,0%	0.0535	0.0449	-0.4685	-0.3578	0.5391	-0.7191	-0.6083	0.0404
	.60	40%,0%	0.0854	0.0675	-0.6004	-0.4819	0.8254	-0.8479	-0.7762	0.0852
	.60	50%,0%	0.1278	0.0915	-0.7154	-0.5910	1.2319	-0.9612	-0.8658	0.1529
	.60	60%,0%	0.2099	0.1652	-0.8206	-0.7157	1.8387	-1.0430	-0.9857	0.1984
	.70	10%,0%	0.0217	0.0177	-0.1676	-0.1148	0.1492	-0.3077	-0.2213	0.0290
	.70	20%,0%	0.0205	0.0131	-0.3309	-0.2410	0.3044	-0.5452	-0.4208	0.0136
	.70	30%,0%	0.0162	0.0145	-0.4806	-0.3733	0.5032	-0.7247	-0.6202	0.0464
	.70	40%,0%	0.0313	0.0242	-0.6153	-0.4833	0.8179	-0.8423	-0.7503	0.0797
	.70	50%,0%	-0.0770	-0.0329	-0.7593	-0.6325	1.1078	-0.9856	-0.8926	0.0664
200	.70	60%,0%	-0.2324	-0.1434	-0.8993	-0.7893	1.4826	-1.0682	-1.0277	0.0194
	.80	10%,0%	0.0096	0.0105	-0.1719	-0.1204	0.1405	-0.3063	-0.2187	0.0194
	.80	20%,0%	0.0080	0.0015	-0.3437	-0.2508	0.2952	-0.5598	-0.4387	0.0160
	.80	30%,0%	-0.0028	0.0025	-0.4917	-0.3764	0.5189	-0.7447	-0.6108	0.0545
	.80	40%,0%	-0.1251	-0.0911	-0.6667	-0.5236	0.7137	-0.8937	-0.7924	0.0294
	.80	50%,0%	-0.3413	-0.2211	-0.8305	-0.6904	0.9385	-0.9975	-0.9341	-0.0146
	.80	60%,0%	-0.9049	-0.5265	-1.0072	-0.9076	0.8731	-1.1066	-1.0576	-0.2344
	.90	10%,0%	0.0007	-0.0017	-0.1834	-0.1292	0.1301	-0.2913	-0.2390	-0.0043
	.90	20%,0%	-0.0107	-0.0127	-0.3565	-0.2580	0.2983	-0.5573	-0.4564	0.0230
	.90	30%,0%	-0.1395	-0.0984	-0.5468	-0.4031	0.4478	-0.7640	-0.6320	0.0022
	.90	40%,0%	-0.3295	-0.2164	-0.7229	-0.5716	0.6058	-0.9102	-0.7991	-0.0423
	.90	50%,0%	-0.7429	-0.4629	-0.9122	-0.7765	0.6343	-1.0366	-0.9678	-0.2109
	.90	60%,0%	-1.2608	-0.7036	-1.0424	-0.9421	0.4194	-1.1131	-1.0620	-0.4166
	.60	10%,10%	0.0611	0.0371	-0.1853	-0.1331	0.1785	-0.3434	-0.2513	0.0329
	.60	20%,10%	0.0328	0.0243	-0.3686	-0.2744	0.3197	-0.6670	-0.4680	0.0377
	.60	20%,20%	0.1028	0.0841	-0.3538	-0.2689	0.3921	-0.6758	-0.4771	0.0719
	.60	30%,20%	0.2269	0.1357	-0.4737	-0.3677	0.6743	-0.9117	-0.6555	0.1561
	.60	40%,20%	0.2765	0.1301	-0.6176	-0.5077	0.9548	-1.1043	-0.8155	0.1773
	.60	30%,30%	0.1862	0.1358	-0.5197	-0.4165	0.7010	-1.0358	-0.7265	0.1476
	.70	10%,10%	0.0055	0.0256	-0.1961	-0.1302	0.1784	-0.3738	-0.2467	0.0367
	.70	20%,10%	0.0667	0.0494	-0.3443	-0.2614	0.3434	-0.6321	-0.4696	0.0545
	.70	20%,20%	0.0820	0.0872	-0.3432	-0.2720	0.3748	-0.7092	-0.4867	0.0772
	.70	30%,20%	0.0697	0.0769	-0.5058	-0.3863	0.6182	-0.9386	-0.6511	0.1252
	.70	40%,20%	-0.0032	0.1072	-0.6300	-0.5120	0.8961	-1.1317	-0.8237	0.1396
200	.70	30%,30%	0.1016	0.1564	-0.4803	-0.3931	0.7031	-1.0259	-0.6758	0.1637
	.80	10%,10%	0.0220	0.0297	-0.1884	-0.1304	0.1771	-0.3683	-0.2478	0.0358
	.80	20%,10%	0.0245	0.0504	-0.3382	-0.2447	0.3537	-0.6297	-0.4484	0.0542
	.80	20%,20%	0.0220	0.0646	-0.3642	-0.2751	0.3878	-0.7061	-0.4768	0.1053
	.80	30%,20%	-0.0646	0.0892	-0.4791	-0.3778	0.5804	-0.8920	-0.6548	0.1042
	.80	40%,20%	-0.1855	0.0639	-0.6158	-0.5293	0.7564	-1.1101	-0.8279	0.0724
	.80	30%,30%	-0.1998	0.1923	-0.4574	-0.3909	0.6485	-0.9951	-0.6928	0.1460
	.90	10%,10%	0.0331	0.0450	-0.1746	-0.1235	0.1853	-0.3604	-0.2477	0.0462
	.90	20%,10%	-0.0064	0.0525	-0.3296	-0.2340	0.3582	-0.6149	-0.4397	0.0710
	.90	20%,20%	-0.1236	0.0321	-0.3820	-0.2909	0.3498	-0.7376	-0.5033	0.0500
	.90	30%,20%	-0.2198	0.0610	-0.4850	-0.3993	0.5346	-0.9192	-0.6615	0.0620
	.90	40%,20%	-0.5107	0.1100	-0.5785	-0.5146	0.7081	-1.0827	-0.8029	0.0728
	.90	30%,30%	-0.5501	0.2709	-0.4148	-0.3865	0.5613	-0.9770	-0.6972	0.1042

Note. L: listwise deletion, P: pairwise deletion, MS: mean substitution, SR: simple regression, MR: multiple regression, SMS: stochastic mean substitution, SSR: stochastic simple regression, SMR: stochastic multiple regression. [a] Data were not computed for this combination of sample size, proportion of missing data high, and percentage of missing data.

Table 5. Effect Sizes of the Sample Estimate of R-Square for the Grade Nine Data by Sample Size, Proportion of Missing Data High, Percentage of Missing Data, and Missing Data Treatment

Sample Size	Proportion High	Percentage of Missing Data	L	P	MS	SR	MR	SMS	SSR	SMR
	.60	10%,0%	0.0225	0.0251	-0.0867	-0.0461	0.0853	-0.1487	-0.1048	0.0342
	.60	20%,0%	0.0311	0.0392	-0.1723	-0.1075	0.1765	-0.2539	-0.1796	0.0516
	.60	30%,0%	0.0409	0.0611	-0.2397	-0.1681	0.2707	-0.3402	-0.2793	0.0759
	.60	40%,0%	0.0902	0.1202	-0.2979	-0.2228	0.4520	-0.3884	-0.3377	0.1198
	.60	50%,0%	0.1163	0.1573	-0.3452	-0.2735	0.6156	-0.4425	-0.3922	0.1396
	.60	60%,0%	0.1533	0.2641	-0.3889	-0.3278	0.9518	-0.4677	-0.4338	0.2299
	.70	10%,0%	0.0000[a]							
	.70	20%,0%	0.0491	0.0536	-0.1556	-0.0942	0.1860	-0.2470	-0.1734	0.0680
	.70	30%,0%	0.0073	0.0573	-0.2565	-0.1666	0.2877	-0.3525	-0.2797	0.0700
	.70	40%,0%	0.0201	0.0847	-0.3104	-0.2167	0.4530	-0.4112	-0.3285	0.1248
	.70	50%,0%	-0.1186	0.0684	-0.3800	-0.2913	0.6189	-0.4453	-0.4065	0.1581
50	.70	60%,0%	-0.2708	0.1164	-0.4250	-0.3486	0.8867	-0.4721	-0.4497	0.2016
	.80	10%,0%	0.0214	0.0153	-0.0943	-0.0557	0.0741	-0.1616	-0.1069	0.0204
	.80	20%,0%	0.0275	0.0364	-0.1701	-0.1155	0.1630	-0.2574	-0.1880	0.0406
	.80	30%,0%	-0.0367	0.0396	-0.2602	-0.1695	0.2874	-0.3340	-0.2730	0.0777
	.80	40%,0%	-0.0753	0.0540	-0.3180	-0.2291	0.4322	-0.4130	-0.3257	0.0982
	.80	50%,0%	-0.3059	0.0200	-0.3943	-0.3083	0.5711	-0.4511	-0.4013	0.1279
	.80	60%,0%	-0.7960	-0.0397	-0.4639	-0.3988	0.6800	-0.4945	-0.4799	0.1295
	.90	10%,0%	0.0000[a]							
	.90	20%,0%	-0.0216	0.0147	-0.1856	-0.1184	0.1515	-0.2670	-0.1921	0.0231
	.90	30%,0%	-0.0858	0.0330	-0.2579	-0.1572	0.3041	-0.3371	-0.2515	0.0931
	.90	40%,0%	-0.2914	-0.0302	-0.3506	-0.2535	0.3725	-0.4294	-0.3481	0.0777
	.90	50%,0%	-0.8275	-0.1089	-0.4434	-0.3601	0.4342	-0.4771	-0.4249	0.0116
	.90	60%,0%	-1.1856	-0.1301	-0.4798	-0.4160	0.4876	-0.5019	-0.4587	0.0060
	.60	10%,10%	0.0700	0.0448	-0.2013	-0.1172	0.1554	-0.4308	-0.2247	0.0462
	.60	20%,10%	0.0496	0.0735	-0.3044	-0.1697	0.2504	-0.6226	-0.3165	0.0819
	.60	20%,20%	0.1256	0.1120	-0.3882	-0.2450	0.3524	-0.8244	-0.4480	0.1249
	.60	30%,20%	0.1449	0.1592	-0.4423	-0.2709	0.4822	-0.9791	-0.5223	0.1756
	.60	40%,20%	0.1463	0.2344	-0.5050	-0.3232	0.6690	-1.1814	-0.5983	0.2030
	.60	30%,30%	0.1251	0.2282	-0.5653	-0.3628	0.6297	-1.2934	-0.6529	0.1897
	.70	10%,10%	0.0000[a]							
	.70	20%,10%	0.0273	0.0617	-0.3027	-0.1696	0.2483	-0.6288	-0.3257	0.0763
	.70	20%,20%	0.0084	0.0933	-0.4020	-0.2569	0.3142	-0.8763	-0.4526	0.0916
	.70	30%,20%	0.0209	0.1798	-0.4328	-0.2825	0.4748	-1.0079	-0.5355	0.1528
	.70	40%,20%	-0.0484	0.2653	-0.4817	-0.3476	0.6329	-1.1538	-0.6445	0.1784
50	.70	30%,30%	-0.1473	0.2947	-0.5058	-0.3842	0.5906	-1.2845	-0.6659	0.1824
	.80	10%,10%	0.0284	0.0566	-0.1967	-0.1096	0.1696	-0.3867	-0.2047	0.0642
	.80	20%,10%	-0.0058	0.0724	-0.2800	-0.1613	0.2547	-0.5874	-0.3124	0.0821
	.80	20%,20%	-0.0316	0.1193	-0.3727	-0.2447	0.3329	-0.7880	-0.4605	0.1053
	.80	30%,20%	-0.1470	0.1989	-0.4295	-0.2992	0.4689	-0.9975	-0.5439	0.1307
	.80	40%,20%	-0.4512	0.2800	-0.4574	-0.3741	0.5466	-1.1321	-0.6342	0.1260
	.80	30%,30%	-0.3978	0.3997	-0.4380	-0.3653	0.5564	-1.2396	-0.6626	0.1472
	.90	10%,10%	0.0000[a]							
	.90	20%,10%	0.0186	0.0817	-0.2877	-0.1684	0.2684	-0.5675	-0.2973	0.0994
	.90	20%,20%	-0.2366	0.1093	-0.3848	-0.2596	0.3070	-0.8182	-0.4560	0.0650
	.90	30%,20%	-0.4642	0.2436	-0.3805	-0.3183	0.4009	-1.0173	-0.5446	0.0867
	.90	40%,20%	-0.8097	0.4404	-0.3643	-0.3655	0.5384	-1.0630	-0.6417	0.1400
	.90	30%,30%	-1.1361	0.5863	-0.3586	-0.4131	0.4015	-1.1560	-0.6953	0.0379

(Table continues)

Table 5. (continued)

Sample Size	Proportion High	Percentage of Missing Data	L	P	MS	SR	MR	SMS	SSR	SMR
	.60	10%,0%	0.0088	0.0048	-0.1783	-0.1012	0.1045	-0.3026	-0.1862	0.0052
	.60	20%,0%	0.0002	0.0103	-0.3282	-0.1957	0.2402	-0.5146	-0.3456	0.0177
	.60	30%,0%	0.0097	0.0239	-0.4479	-0.2919	0.4056	-0.6369	-0.4907	0.0380
	.60	40%,0%	0.0186	0.0436	-0.5449	-0.3828	0.6306	-0.7417	-0.6105	0.0566
	.60	50%,0%	-0.0320	0.0282	-0.6507	-0.4940	0.8763	-0.8155	-0.7259	0.0587
	.60	60%,0%	-0.1513	-0.0102	-0.7457	-0.6056	1.1857	-0.8851	-0.8131	0.0477
	.70	10%,0%	0.0019	0.0056	-0.1749	-0.0973	0.1081	-0.3034	-0.1865	0.0196
	.70	20%,0%	-0.0124	0.0109	-0.3253	-0.1934	0.2427	-0.4975	-0.3404	0.0404
	.70	30%,0%	-0.0251	0.0092	-0.4496	-0.2940	0.3976	-0.6545	-0.5041	0.0210
	.70	40%,0%	-0.0733	-0.0052	-0.5608	-0.4005	0.5881	-0.7467	-0.6275	0.0429
	.70	50%,0%	-0.3215	-0.0582	-0.6721	-0.4968	0.8593	-0.8279	-0.7227	0.0349
200	.70	60%,0%	-0.8557	-0.2373	-0.7895	-0.6454	1.0227	-0.8982	-0.8270	-0.0467
	.80	10%,0%	0.0039	0.0106	-0.1668	-0.0932	0.1096	-0.2970	-0.1729	0.0134
	.80	20%,0%	-0.0349	-0.0092	-0.3392	-0.2080	0.2237	-0.5224	-0.3620	0.0053
	.80	30%,0%	-0.1256	-0.0395	-0.4774	-0.3124	0.3670	-0.6779	-0.5095	0.0061
	.80	40%,0%	-0.3246	-0.1024	-0.6094	-0.4343	0.5377	-0.7736	-0.6435	-0.0098
	.80	50%,0%	-0.8434	-0.2470	-0.7304	-0.5588	0.6957	-0.8526	-0.7613	-0.0601
	.80	60%,0%	-2.0911	-0.5009	-0.8518	-0.7193	0.6845	-0.9211	-0.8607	-0.2185
	.90	10%,0%	-0.0289	-0.0073	-0.1865	-0.1018	0.0997	-0.3090	-0.1918	-0.0056
	.90	20%,0%	-0.1028	-0.0308	-0.3538	-0.2023	0.2222	-0.5253	-0.3524	0.0112
	.90	30%,0%	-0.2402	-0.0737	-0.4972	-0.3155	0.3668	-0.6818	-0.5065	-0.0135
	.90	40%,0%	-0.6653	-0.2103	-0.6480	-0.4472	0.4927	-0.7823	-0.6499	-0.0238
	.90	50%,0%	-1.6310	-0.4491	-0.7934	-0.6178	0.5080	-0.8865	-0.7948	-0.1651
	.90	60%,0%	-2.7342	-0.6396	-0.8767	-0.7458	0.3644	-0.9206	-0.8572	-0.3129
	.60	10%,10%	0.0187	0.0128	-0.4179	-0.2292	0.2164	-0.8489	-0.4477	0.0163
	.60	20%,10%	0.0020	0.0179	-0.5787	-0.3259	0.3239	-1.1697	-0.6206	0.0095
	.60	20%,20%	0.0358	0.0486	-0.7713	-0.4349	0.4769	-1.6598	-0.8437	0.0446
	.60	30%,20%	0.0030	0.0558	-0.9093	-0.5542	0.5719	-2.0329	-1.0384	0.0427
	.60	40%,20%	-0.0592	0.0870	-1.0251	-0.6417	0.7648	-2.3233	-1.1413	0.0669
	.60	30%,30%	-0.0962	0.0888	-1.0873	-0.6697	0.7398	-2.5399	-1.2424	0.0702
	.70	10%,10%	-0.0213	0.0060	-0.4260	-0.2272	0.2181	-0.8397	-0.4321	0.0285
	.70	20%,10%	-0.0475	0.0182	-0.5691	-0.3189	0.3272	-1.1807	-0.5993	0.0191
	.70	20%,20%	-0.0619	0.0536	-0.7487	-0.4352	0.4585	-1.6632	-0.8401	0.0390
	.70	30%,20%	-0.1976	0.0770	-0.8965	-0.5570	0.5701	-2.0138	-1.0381	0.0432
	.70	40%,20%	-0.4626	0.1337	-0.9598	-0.6517	0.7462	-2.2493	-1.1657	0.0460
200	.70	30%,30%	-0.5203	0.1825	-1.0096	-0.6996	0.6919	-2.4983	-1.2857	0.0315
	.80	10%,10%	0.0059	0.0247	-0.3989	-0.2235	0.2207	-0.8156	-0.4411	0.0215
	.80	20%,10%	-0.0921	0.0230	-0.5512	-0.3223	0.3234	-1.1501	-0.6135	0.0142
	.80	20%,20%	-0.2632	0.0396	-0.7615	-0.4726	0.4187	-1.6917	-0.8555	0.0175
	.80	30%,20%	-0.5341	0.1117	-0.8442	-0.5744	0.5377	-1.9998	-1.0314	0.0033
	.80	40%,20%	-1.1578	0.2250	-0.8749	-0.6776	0.6482	-2.2202	-1.1802	-0.0127
	.80	30%,30%	-1.2698	0.3677	-0.8887	-0.7154	0.6104	-2.4096	-1.2646	-0.0324
	.90	10%,10%	-0.0501	0.0226	-0.3953	-0.2185	0.2207	-0.8145	-0.4262	0.0125
	.90	20%,10%	-0.1844	0.0225	-0.5542	-0.3351	0.3148	-1.1721	-0.6347	0.0088
	.90	20%,20%	-0.4234	0.1062	-0.6870	-0.4523	0.4384	-1.6081	-0.8709	0.0212
	.90	30%,20%	-0.9301	0.2304	-0.7203	-0.5570	0.5346	-1.9020	-1.0174	0.0190
	.90	40%,20%	-2.2154	0.4767	-0.7293	-0.6999	0.5528	-2.0722	-1.2006	-0.0876
	.90	30%,30%	-2.4545	0.7049	-0.7391	-0.7797	0.4242	-2.3257	-1.3174	-0.2027

Note. L: listwise deletion, P: pairwise deletion, MS: mean substitution, SR: simple regression, MR: multiple regression, SMS: stochastic mean substitution, SSR: stochastic simple regression, SMR: stochastic multiple regression. [a] Data were not computed for this combination of sample size, proportion of missing data high, and percentage of missing data.

Table 6. Effect Sizes of the First Standardized Regression Coefficient (X_1) for the Grade Six Data by Sample Size, Proportion of Missing Data High, Percentage of Missing Data, and Missing Data Treatment

Sample Size	Proportion High	Percentage of Missing Data	L	P	MS	SR	MR	SMS	SSR	SMR
	.60	10%,0%	0.0012	-0.0044	-0.1720	-0.0568	0.1136	-0.2985	-0.1595	-0.0102
	.60	20%,0%	-0.0267	-0.0149	-0.3430	-0.1404	0.2216	-0.5528	-0.3496	-0.0176
	.60	30%,0%	0.0005	0.0145	-0.4704	-0.1749	0.4172	-0.7577	-0.5079	-0.0180
	.60	40%,0%	-0.0223	-0.0044	-0.6214	-0.2630	0.5878	-0.9338	-0.6869	-0.0272
	.60	50%,0%	0.0313	0.1356	-0.6839	-0.2745	0.8829	-1.0613	-0.8026	0.0260
	.60	60%,0%	-0.0985	-0.1456	-0.9517	-0.4406	0.9745	-1.2245	-1.0789	-0.0852
	.70	10%,0%	0.0000[a]							
	.70	20%,0%	-0.0080	-0.0131	-0.3377	-0.1233	0.2387	-0.5294	-0.3496	-0.0316
	.70	30%,0%	-0.0070	-0.0228	-0.4929	-0.1791	0.4096	-0.7757	-0.5105	0.0232
	.70	40%,0%	-0.0431	-0.0885	-0.6643	-0.2723	0.5596	-0.9277	-0.6781	-0.0416
	.70	50%,0%	-0.1064	-0.1629	-0.8285	-0.3909	0.7015	-1.1133	-0.9174	-0.1010
50	.70	60%,0%	-0.2444	-0.3544	-1.0307	-0.5754	0.7853	-1.2830	-1.0695	-0.2024
	.80	10%,0%	0.0026	0.0065	-0.1661	-0.0545	0.1169	-0.2899	-0.1781	-0.0106
	.80	20%,0%	0.0059	0.0251	-0.3120	-0.1082	0.2638	-0.5291	-0.3140	0.0419
	.80	30%,0%	-0.0341	-0.0443	-0.5007	-0.2031	0.3717	-0.7903	-0.5333	-0.0391
	.80	40%,0%	-0.0509	-0.1029	-0.6720	-0.2792	0.5582	-0.9583	-0.6945	-0.0547
	.80	50%,0%	-0.2707	-0.4184	-0.9573	-0.5299	0.4825	-1.1988	-0.9860	-0.2289
	.80	60%,0%	-0.5365	-0.7498	-1.1769	-0.8084	0.3357	-1.3907	-1.2023	-0.4654
	.90	10%,0%	0.0000[a]							
	.90	20%,0%	-0.0162	-0.0300	-0.3642	-0.1277	0.2514	-0.5852	-0.3245	-0.0211
	.90	30%,0%	-0.0779	-0.1114	-0.5571	-0.2397	0.3422	-0.8213	-0.5237	-0.0284
	.90	40%,0%	-0.1450	-0.2564	-0.7552	-0.3605	0.4262	-0.9872	-0.7263	-0.0849
	.90	50%,0%	-0.4779	-0.7050	-1.0750	-0.7049	0.1883	-1.2344	-1.0965	-0.4430
	.90	60%,0%	-0.6693	-0.9448	-1.2350	-0.9045	0.0246	-1.4042	-1.2092	-0.5652
	.60	10%,10%	-0.0276	-0.0010	-0.1257	-0.0715	0.0688	-0.2054	-0.1498	-0.0097
	.60	20%,10%	0.0102	0.0056	-0.2540	-0.1134	0.2180	-0.4110	-0.3006	-0.0391
	.60	20%,20%	0.0192	0.0263	-0.2022	-0.1054	0.2110	-0.3688	-0.2482	0.0421
	.60	30%,20%	0.0759	0.0563	-0.3260	-0.1090	0.4804	-0.5101	-0.4405	0.0496
	.60	40%,20%	-0.1082	-0.0058	-0.5047	-0.3017	0.4553	-0.7507	-0.6444	-0.0749
	.60	30%,30%	-0.0195	0.0131	-0.2916	-0.1518	0.4147	-0.4324	-0.4033	0.0317
	.70	10%,10%	0.0000[a]							
	.70	20%,10%	-0.0196	-0.0098	-0.2780	-0.1164	0.2270	-0.4556	-0.3081	0.0424
	.70	20%,20%	-0.0441	-0.0424	-0.2440	-0.1665	0.1239	-0.3977	-0.3140	-0.0433
	.70	30%,20%	-0.0452	-0.0672	-0.3814	-0.2144	0.3148	-0.5753	-0.4739	-0.0351
	.70	40%,20%	-0.0484	-0.0747	-0.5118	-0.2800	0.5424	-0.7560	-0.5953	-0.0352
50	.70	30%,30%	-0.1038	-0.0965	-0.3326	-0.2185	0.2554	-0.5031	-0.4090	-0.0422
	.80	10%,10%	0.0004	0.0096	-0.1103	-0.0521	0.0907	-0.1795	-0.1526	0.0066
	.80	20%,10%	-0.0332	-0.0097	-0.2773	-0.1524	0.1745	-0.4397	-0.3415	-0.0467
	.80	20%,20%	-0.0051	-0.0107	-0.2182	-0.1177	0.1943	-0.3601	-0.2807	0.0000
	.80	30%,20%	-0.0707	-0.0772	-0.3910	-0.2375	0.2887	-0.5579	-0.4493	-0.0633
	.80	40%,20%	-0.0808	-0.1362	-0.5433	-0.3263	0.4422	-0.7481	-0.6321	-0.0250
	.80	30%,30%	-0.0406	-0.1167	-0.3296	-0.1932	0.3173	-0.4785	-0.3871	-0.0252
	.90	10%,10%	0.0000[a]							
	.90	20%,10%	-0.0147	-0.0541	-0.3141	-0.1434	0.1980	-0.4698	-0.3287	-0.0263
	.90	20%,20%	-0.0304	-0.0590	-0.2548	-0.1452	0.1665	-0.3917	-0.2802	-0.0052
	.90	30%,20%	-0.1275	-0.2289	-0.4788	-0.3416	0.1706	-0.6425	-0.5376	-0.1246
	.90	40%,20%	-0.1347	-0.2766	-0.6011	-0.4046	0.3446	-0.8020	-0.7091	-0.1223
	.90	30%,30%	-0.1005	-0.2021	-0.3868	-0.2528	0.2170	-0.5601	-0.4502	-0.0826

(Table continues)

Table 6 (continued).

Sample Size	Proportion High	Percentage of Missing Data	L	P	MS	SR	MR	SMS	SSR	SMR
	.60	10%,0%	-0.0024	-0.0079	-0.3493	-0.1208	0.2364	-0.6485	-0.3426	-0.0118
	.60	20%,0%	-0.0150	-0.0178	-0.6859	-0.2554	0.5237	-1.1479	-0.7291	0.0159
	.60	30%,0%	-0.0060	-0.0103	-0.9836	-0.3761	0.8989	-1.5784	-1.0902	-0.0142
	.60	40%,0%	-0.0386	-0.0511	-1.3066	-0.5348	1.3247	-1.9465	-1.4660	-0.0244
	.60	50%,0%	-0.0449	-0.0861	-1.5866	-0.6788	1.8978	-2.2854	-1.7637	-0.0132
	.60	60%,0%	-0.0667	-0.1007	-1.8626	-0.8456	2.6981	-2.5775	-2.1450	-0.0451
	.70	10%,0%	0.0082	0.0090	-0.3416	-0.1105	0.2580	-0.6381	-0.3466	0.0181
	.70	20%,0%	-0.0168	-0.0356	-0.6924	-0.2575	0.5126	-1.1663	-0.7034	-0.0366
	.70	30%,0%	-0.0532	-0.0742	-1.0205	-0.4155	0.8363	-1.5909	-1.1172	-0.0291
	.70	40%,0%	-0.0691	-0.1241	-1.3360	-0.5598	1.2866	-1.9270	-1.4423	-0.0455
	.70	50%,0%	-0.2148	-0.3498	-1.7047	-0.8221	1.6594	-2.3532	-1.8427	-0.1771
200	.70	60%,0%	-0.4562	-0.6802	-2.0781	-1.1678	2.0551	-2.6978	-2.3204	-0.3695
	.80	10%,0%	-0.0081	-0.0141	-0.3592	-0.1268	0.2372	-0.6448	-0.3481	0.0021
	.80	20%,0%	-0.0295	-0.0465	-0.7059	-0.2692	0.5049	-1.1889	-0.7335	-0.0327
	.80	30%,0%	-0.0651	-0.1095	-1.0481	-0.4266	0.8465	-1.6300	-1.1141	-0.0289
	.80	40%,0%	-0.1934	-0.3260	-1.4417	-0.6676	1.1220	-2.0502	-1.5470	-0.1539
	.80	50%,0%	-0.4498	-0.7127	-1.8801	-1.0156	1.3559	-2.4127	-1.9950	-0.3324
	.80	60%,0%	-1.1026	-1.5660	-2.4345	-1.7067	0.9128	-2.8839	-2.5623	-0.9232
	.90	10%,0%	-0.0239	-0.0309	-0.3753	-0.1414	0.2202	-0.6274	-0.3832	-0.0369
	.90	20%,0%	-0.0533	-0.0810	-0.7399	-0.2892	0.4990	-1.2032	-0.7708	-0.0346
	.90	30%,0%	-0.1399	-0.2739	-1.1567	-0.4894	0.7471	-1.7049	-1.1481	-0.1237
	.90	40%,0%	-0.3769	-0.6126	-1.6041	-0.8239	0.9016	-2.1277	-1.5764	-0.2992
	.90	50%,0%	-0.8213	-1.2375	-2.1183	-1.3391	0.7883	-2.5702	-2.1538	-0.7129
	.90	60%,0%	-1.4187	-1.9514	-2.5564	-1.9316	0.1251	-2.9109	-2.5651	-1.2907
	.60	10%,10%	-0.0076	-0.0273	-0.2662	-0.1427	0.1588	-0.4268	-0.2954	-0.0461
	.60	20%,10%	-0.0691	-0.0201	-0.5707	-0.2865	0.4356	-0.9292	-0.6667	-0.0334
	.60	20%,20%	-0.0401	0.0107	-0.4282	-0.2612	0.3935	-0.6895	-0.5788	-0.0324
	.60	30%,20%	-0.1472	-0.3800	-0.8904	-0.5913	0.5228	-1.2245	-1.0570	-0.1864
	.60	40%,20%	-0.0463	-0.0871	-0.9904	-0.5830	1.2253	-1.5132	-1.3127	-0.0534
	.60	30%,30%	-0.0350	-0.0326	-0.6026	-0.3983	0.7406	-0.9836	-0.8860	0.0107
	.70	10%,10%	-0.0116	0.0104	-0.2291	-0.1095	0.1907	-0.4174	-0.2824	-0.0011
	.70	20%,10%	-0.0254	-0.0340	-0.5706	-0.2732	0.4555	-0.9354	-0.6628	-0.0285
	.70	20%,20%	-0.0398	-0.0449	-0.4555	-0.2900	0.3424	-0.7431	-0.6232	-0.0591
	.70	30%,20%	-0.0242	-0.0973	-0.7573	-0.4103	0.7805	-1.1709	-0.9298	-0.0051
	.70	40%,20%	-0.1286	-0.1618	-1.0144	-0.6027	1.1845	-1.5522	-1.2859	-0.0497
200	.70	30%,30%	-0.0376	-0.1142	-0.6147	-0.4193	0.6948	-0.9938	-0.8498	-0.0062
	.80	10%,10%	-0.0045	-0.0089	-0.2493	-0.1222	0.1807	-0.4264	-0.2956	0.0201
	.80	20%,10%	-0.0173	-0.0393	-0.5732	-0.2610	0.4621	-0.9272	-0.6617	-0.0262
	.80	20%,20%	-0.0648	-0.0647	-0.4747	-0.2986	0.3614	-0.7499	-0.5965	-0.0215
	.80	30%,20%	-0.1105	-0.1964	-0.7899	-0.5016	0.6142	-1.1580	-0.9883	-0.1073
	.80	40%,20%	-0.2315	-0.4575	-1.1488	-0.8111	0.8179	-1.6120	-1.4101	-0.2634
	.80	30%,30%	-0.1317	-0.2697	-0.6731	-0.4963	0.5411	-1.0438	-0.9152	-0.0878
	.90	10%,10%	-0.0099	-0.0201	-0.2517	-0.1332	0.1634	-0.4268	-0.3138	-0.0124
	.90	20%,10%	-0.0178	-0.0709	-0.5915	-0.2690	0.4517	-0.9443	-0.6785	-0.0211
	.90	20%,20%	-0.1087	-0.1995	-0.5628	-0.3578	0.2949	-0.8185	-0.6421	-0.0986
	.90	30%,20%	-0.1472	-0.3800	-0.8904	-0.5913	0.5228	-1.2245	-1.0570	-0.1864
	.90	40%,20%	-0.3494	-0.6288	-1.2274	-0.8975	0.6420	-1.6996	-1.4292	-0.3022
	.90	30%,30%	-0.2251	-0.3989	-0.7368	-0.5438	0.3995	-1.0763	-0.9203	-0.1514

Note. L: listwise deletion, P: pairwise deletion, MS: mean substitution, SR: simple regression, MR: multiple regression, SMS: stochastic mean substitution, SSR: stochastic simple regression, SMR: stochastic multiple regression. [a] Data were not computed for this combination of sample size, proportion of missing data high, and percentage of missing data.

Table 7. Effect Sizes of the First Standardized Regression Coefficient (X_1) for the Grade Nine Data by Sample Size, Proportion of Missing Data High, Percentage of Missing Data, and Missing Data Treatment

Sample Size	Proportion High	Percentage of Missing Data	L	P	MS	SR	MR	SMS	SSR	SMR
	.60	10%,0%	0.0131	0.0138	-0.2761	-0.0435	0.1677	-0.4660	-0.2285	0.0260
	.60	20%,0%	-0.0069	-0.0002	-0.5497	-0.1125	0.3482	-0.8228	-0.4123	-0.0031
	.60	30%,0%	-0.0266	-0.0102	-0.7773	-0.1911	0.5422	-1.1236	-0.6547	-0.0279
	.60	40%,0%	-0.0239	0.0465	-0.9492	-0.2495	0.8340	-1.3272	-0.8824	0.0273
	.60	50%,0%	-0.0388	-0.0085	-1.1361	-0.3244	1.1149	-1.4995	-1.0769	-0.0604
	.60	60%,0%	-0.0723	-0.0380	-1.3218	-0.4155	1.5024	-1.6637	-1.2814	-0.0526
	.70	10%,0%	0.0000[a]							
	.70	20%,0%	0.0284	0.0304	-0.5080	-0.0831	0.3717	-0.8079	-0.4053	0.0392
	.70	30%,0%	-0.0196	-0.0188	-0.7966	-0.1900	0.5558	-1.1378	-0.6636	-0.0034
	.70	40%,0%	-0.0446	-0.0553	-1.0025	-0.2595	0.8175	-1.3677	-0.8424	-0.0025
	.70	50%,0%	-0.1664	-0.2596	-1.2420	-0.4201	1.0326	-1.5566	-1.1250	-0.0438
50	.70	60%,0%	-0.3181	-0.5020	-1.4609	-0.6084	1.1746	-1.7353	-1.3966	-0.1958
	.80	10%,0%	-0.0061	-0.0009	-0.2921	-0.0618	0.1515	-0.5015	-0.2177	0.0050
	.80	20%,0%	-0.0220	0.0004	-0.5428	-0.1302	0.3285	-0.8282	-0.4162	-0.0089
	.80	30%,0%	-0.0564	-0.0927	-0.8301	-0.2136	0.5299	-1.1139	-0.6663	-0.0264
	.80	40%,0%	-0.1076	-0.1508	-1.0368	-0.3080	0.7639	-1.3904	-0.8640	-0.0654
	.80	50%,0%	-0.2864	-0.4574	-1.3029	-0.5171	0.8512	-1.5948	-1.1485	-0.1718
	.80	60%,0%	-0.6482	-1.0008	-1.5957	-0.8856	0.6884	-1.7984	-1.5403	-0.4545
	.90	10%,0%	0.0000[a]							
	.90	20%,0%	-0.0391	-0.0525	-0.5862	-0.1436	0.3034	-0.8684	-0.4290	-0.0420
	.90	30%,0%	-0.0843	-0.1549	-0.8566	-0.2322	0.5082	-1.1624	-0.6265	-0.0387
	.90	40%,0%	-0.2574	-0.4258	-1.1611	-0.4290	0.5785	-1.4491	-0.9656	-0.1694
	.90	50%,0%	-0.6277	-0.9750	-1.5154	-0.8141	0.4012	-1.7413	-1.3351	-0.5021
	.90	60%,0%	-0.9072	-1.3876	-1.7052	-1.0967	0.1642	-1.8526	-1.5675	-0.7215
	.60	10%,10%	-0.0167	-0.0111	0.0071	-0.0830	-0.0321	-0.0368	-0.0657	-0.0329
	.60	20%,10%	-0.0585	-0.0176	-0.2451	-0.1419	0.1405	-0.4377	-0.2721	-0.0332
	.60	20%,20%	0.0263	0.0393	0.0736	-0.0937	-0.0012	0.0328	-0.0739	0.0004
	.60	30%,20%	0.0056	-0.0501	-0.1705	-0.1944	0.1610	-0.3495	-0.3575	0.0008
	.60	40%,20%	0.0014	-0.0246	-0.3223	-0.2321	0.4735	-0.6160	-0.5426	0.0020
	.60	30%,30%	-0.0209	-0.0561	0.0781	-0.1236	0.0127	-0.0960	-0.1276	0.0276
	.70	10%,10%	0.0000[a]							
	.70	20%,10%	0.0142	0.0119	-0.2160	-0.0875	0.2001	-0.3841	-0.2726	0.0106
	.70	20%,20%	-0.0096	0.0018	0.0312	-0.0960	0.0115	-0.0434	-0.1024	0.0099
	.70	30%,20%	0.0104	-0.0478	-0.1809	-0.1724	0.2233	-0.3746	-0.3020	0.0210
	.70	40%,20%	-0.0260	-0.0540	-0.3364	-0.2202	0.4652	-0.6414	-0.5655	0.0335
50	.70	30%,30%	-0.0120	0.0145	0.1166	-0.0389	0.1088	-0.0751	-0.0763	0.0631
	.80	10%,10%	-0.0182	-0.0037	0.0118	-0.0627	-0.0109	0.0019	-0.0481	0.0107
	.80	20%,10%	-0.0018	-0.0455	-0.2525	-0.1097	0.1746	-0.3834	-0.2408	0.0205
	.80	20%,20%	-0.0245	-0.0246	0.0214	-0.1025	0.0049	-0.0211	-0.1372	0.0168
	.80	30%,20%	-0.0696	-0.0678	-0.1855	-0.1777	0.2010	-0.3594	-0.3051	0.0040
	.80	40%,20%	-0.2091	-0.2155	-0.4195	-0.2713	0.3371	-0.7196	-0.5772	-0.1347
	.80	30%,30%	0.0052	0.0504	0.1140	0.0963	0.2580	-0.0983	-0.0281	0.1995
	.90	10%,10%	0.0000[a]							
	.90	20%,10%	-0.0293	-0.0121	-0.2421	-0.1208	0.1769	-0.4030	-0.2358	0.0065
	.90	20%,20%	-0.0740	-0.0548	0.0054	-0.1116	-0.0186	-0.0571	-0.1310	-0.0056
	.90	30%,20%	-0.1215	-0.1658	-0.2454	-0.1790	0.2026	-0.4005	-0.3605	-0.0507
	.90	40%,20%	-0.2424	-0.2973	-0.5198	-0.2412	0.3572	-0.7747	-0.5342	-0.0876
	.90	30%,30%	-0.1600	0.0632	0.0476	0.2112	0.4088	-0.1360	0.0208	0.2139

(Table continues)

Table 7 (continued).

Sample Size	Proportion High	Percentage of Missing Data	L	P	MS	SR	MR	SMS	SSR	SMR
	.60	10%,0%	-0.0059	0.0058	-0.5746	-0.1129	0.3145	-0.9948	-0.4220	-0.0079
	.60	20%,0%	-0.0050	-0.0077	-1.0785	-0.2210	0.6971	-1.7258	-0.8331	-0.0077
	.60	30%,0%	-0.0014	0.0017	-1.4967	-0.3332	1.1722	-2.1964	-1.2497	0.0141
	.60	40%,0%	-0.0025	-0.0054	-1.8614	-0.4439	1.7640	-2.6200	-1.6561	-0.0088
	.60	50%,0%	-0.0570	-0.0904	-2.2536	-0.6120	2.4624	-2.9886	-2.1129	-0.0478
	.60	60%,0%	-0.1967	-0.2914	-2.6257	-0.8497	3.2920	-3.3139	-2.5705	-0.1423
	.70	10%,0%	-0.0085	-0.0073	-0.5847	-0.1126	0.3132	-1.0183	-0.4299	0.0184
	.70	20%,0%	-0.0104	-0.0209	-1.0906	-0.2245	0.6951	-1.7000	-0.8298	0.0310
	.70	30%,0%	-0.0392	-0.0592	-1.5230	-0.3612	1.1261	-2.2686	-1.3120	-0.0329
	.70	40%,0%	-0.0872	-0.1358	-1.9199	-0.5111	1.6731	-2.6624	-1.7214	-0.0254
	.70	50%,0%	-0.1748	-0.3873	-2.3535	-0.6947	2.3401	-3.0534	-2.1461	-0.1409
200	.70	60%,0%	-0.6356	-1.0727	-2.8479	-1.1908	2.6882	-3.4274	-2.6916	-0.4917
	.80	10%,0%	0.0007	-0.0031	-0.5689	-0.1066	0.3104	-0.9997	-0.3974	0.0024
	.80	20%,0%	-0.0531	-0.0663	-1.1196	-0.2635	0.6511	-1.7626	-0.8812	-0.0332
	.80	30%,0%	-0.1036	-0.1754	-1.5988	-0.4110	1.0708	-2.3388	-1.3308	-0.0744
	.80	40%,0%	-0.2615	-0.4227	-2.0909	-0.6512	1.5276	-2.7648	-1.8055	-0.1649
	.80	50%,0%	-0.5722	-0.9932	-2.5808	-1.0196	1.8545	-3.1429	-2.3695	-0.4254
	.80	60%,0%	-1.3159	-2.1213	-3.1616	-1.7865	1.5394	-3.5579	-2.9700	-1.1140
	.90	10%,0%	-0.0192	-0.0389	-0.6123	-0.1235	0.2950	-1.0266	-0.4517	-0.0291
	.90	20%,0%	-0.0558	-0.1307	-1.1708	-0.2622	0.6396	-1.7808	-0.8723	-0.0313
	.90	30%,0%	-0.1541	-0.3028	-1.6812	-0.4483	1.0310	-2.3726	-1.3366	-0.1400
	.90	40%,0%	-0.4150	-0.7812	-2.2408	-0.7720	1.3360	-2.8235	-1.8840	-0.2634
	.90	50%,0%	-1.0185	-1.7119	-2.8500	-1.4062	1.2405	-3.3215	-2.5826	-0.7847
	.90	60%,0%	-1.6916	-2.5967	-3.2668	-2.0845	0.6154	-3.6220	-3.0131	-1.3553
	.60	10%,10%	-0.0153	-0.0192	0.0140	-0.1286	-0.0303	-0.0150	-0.1199	-0.0088
	.60	20%,10%	-0.0062	-0.0183	-0.4451	-0.2292	0.3439	-0.7511	-0.5325	-0.0276
	.60	20%,20%	0.0450	0.0401	0.1221	-0.1779	0.0079	-0.0008	-0.1831	0.0672
	.60	30%,20%	-0.0303	-0.0489	-0.3077	-0.3702	0.3935	-0.7175	-0.6172	-0.0498
	.60	40%,20%	-0.0317	-0.0111	-0.5894	-0.4639	1.0407	-1.1742	-0.9943	0.0050
	.60	30%,30%	-0.0600	0.0352	0.2277	-0.2829	-0.0416	-0.0990	-0.3074	0.0165
	.70	10%,10%	-0.0267	0.0099	0.0568	-0.1101	-0.0225	0.0097	-0.0922	-0.0136
	.70	20%,10%	-0.0655	-0.0593	-0.4760	-0.2643	0.3126	-0.7974	-0.5326	-0.0478
	.70	20%,20%	0.0127	-0.0364	0.0758	-0.2150	-0.0361	-0.0562	-0.1661	0.0105
	.70	30%,20%	-0.0727	-0.1136	-0.3258	-0.3511	0.3846	-0.7030	-0.5781	-0.0514
	.70	40%,20%	-0.0533	-0.2082	-0.6500	-0.4562	0.9607	-1.2431	-1.0012	-0.0477
200	.70	30%,30%	-0.0469	-0.0687	0.1982	-0.2206	0.0112	-0.1498	-0.2307	0.0293
	.80	10%,10%	-0.0195	-0.0077	0.0368	-0.1232	-0.0316	0.0223	-0.1156	0.0090
	.80	20%,10%	-0.0304	-0.1077	-0.5108	-0.2581	0.3194	-0.8438	-0.5193	-0.0096
	.80	20%,20%	-0.0510	-0.0602	0.0617	-0.2113	-0.0326	-0.0721	-0.1423	0.0122
	.80	30%,20%	-0.1112	-0.2063	-0.3669	-0.3324	0.3808	-0.7406	-0.6186	-0.0639
	.80	40%,20%	-0.2377	-0.3691	-0.7356	-0.4675	0.8549	-1.3129	-1.0400	-0.0818
	.80	30%,30%	-0.1329	-0.0045	0.2236	0.0361	0.2921	-0.1193	-0.1260	0.1663
	.90	10%,10%	-0.0213	-0.0384	0.0092	-0.1194	-0.0329	-0.0180	-0.0835	-0.0058
	.90	20%,10%	-0.0778	-0.1175	-0.5054	-0.2746	0.2986	-0.8310	-0.5356	-0.0591
	.90	20%,20%	-0.0382	-0.0888	0.0582	-0.1679	0.0074	-0.0578	-0.1896	0.0381
	.90	30%,20%	-0.1486	-0.2569	-0.3614	-0.2784	0.3943	-0.7047	-0.6067	-0.0091
	.90	40%,20%	-0.4503	-0.4708	-0.8584	-0.4037	0.7856	-1.3911	-0.9864	-0.1467
	.90	30%,30%	-0.1995	0.1407	0.2294	0.4789	0.8062	-0.1592	0.1240	0.4457

Note. L: listwise deletion, P: pairwise deletion, MS: mean substitution, SR: simple regression, MR: multiple regression, SMS: stochastic mean substitution, SSR: stochastic simple regression, SMR: stochastic multiple regression. [a] Data were not computed for this combination of sample size, proportion of missing data high, and percentage of missing data.

Table 8. Effect Sizes of the Second Standardized Regression Coefficient (X_2) for the Grade Six Data by Sample Size, Proportion of Missing Data High, Percentage of Missing Data, and Missing Data Treatment

Sample Size	Proportion High	Percentage of Missing Data	L	P	MS	SR	MR	SMS	SSR	SMR
	.60	10%,0%	-0.0139	0.0017	0.1389	0.0020	-0.0924	0.2376	0.0862	0.0042
	.60	20%,0%	0.0091	0.0024	0.2698	0.0125	-0.1937	0.4280	0.1902	0.0114
	.60	30%,0%	-0.0059	-0.0212	0.3694	-0.0090	-0.3561	0.5677	0.2726	0.0079
	.60	40%,0%	0.0105	-0.0035	0.4800	0.0172	-0.4947	0.6770	0.3788	0.0348
	.60	50%,0%	0.0471	-0.0904	0.5504	-0.0213	-0.7293	0.7632	0.4405	-0.0038
	.60	60%,0%	-0.0507	0.0758	0.6927	0.0485	-0.8601	0.8292	0.5919	0.0451
	.70	10%,0%	0.0000[a]							
	.70	20%,0%	-0.0088	0.0045	0.2687	0.0038	-0.2021	0.4175	0.1898	0.0152
	.70	30%,0%	-0.0340	0.0059	0.3859	-0.0030	-0.3524	0.5842	0.2797	-0.0204
	.70	40%,0%	-0.0263	0.0583	0.5147	0.0266	-0.4751	0.6878	0.3795	0.0352
	.70	50%,0%	-0.0484	0.1251	0.6321	0.0848	-0.5864	0.7874	0.5304	0.0880
50	.70	60%,0%	-0.0501	0.2589	0.7420	0.1897	-0.6592	0.8533	0.6117	0.1746
	.80	10%,0%	-0.0078	-0.0081	0.1344	-0.0042	-0.0984	0.2389	0.0955	0.0020
	.80	20%,0%	0.0049	-0.0196	0.2571	-0.0076	-0.2187	0.4168	0.1664	-0.0263
	.80	30%,0%	0.0054	0.0264	0.3977	0.0178	-0.3194	0.5909	0.2901	0.0234
	.80	40%,0%	-0.0399	0.0708	0.5208	0.0352	-0.4686	0.7045	0.3900	0.0450
	.80	50%,0%	-0.0317	0.2851	0.6885	0.1891	-0.4293	0.8092	0.5714	0.1674
	.80	60%,0%	-0.0419	0.5436	0.8148	0.3989	-0.2797	0.8846	0.7168	0.3616
	.90	10%,0%	0.0000[a]							
	.90	20%,0%	-0.0215	0.0134	0.2845	0.0013	-0.2156	0.4408	0.1699	0.0011
	.90	30%,0%	-0.0137	0.0797	0.4377	0.0511	-0.2892	0.6114	0.2960	0.0242
	.90	40%,0%	-0.0518	0.1852	0.5749	0.1078	-0.3594	0.7208	0.4136	0.0786
	.90	50%,0%	-0.0414	0.4991	0.7591	0.3482	-0.1705	0.8405	0.6465	0.3243
	.90	60%,0%	-0.0178	0.6760	0.8450	0.4993	-0.0250	0.8909	0.7314	0.4388
	.60	10%,10%	0.0063	-0.0057	0.0924	-0.0071	-0.0509	0.1207	0.0553	0.0042
	.60	20%,10%	-0.0067	-0.0061	0.2052	-0.0225	-0.1777	0.2791	0.1318	0.0231
	.60	20%,20%	-0.0022	-0.0102	0.1756	-0.0366	-0.1567	0.2245	0.0612	-0.0290
	.60	30%,20%	-0.0968	-0.0466	0.2779	-0.0928	-0.4033	0.3109	0.1596	-0.0547
	.60	40%,20%	0.0452	0.0210	0.4346	0.0296	-0.3726	0.4698	0.2932	0.0628
	.60	30%,30%	-0.0715	0.0208	0.2786	-0.0608	-0.3405	0.2387	0.1258	-0.0199
	.70	10%,10%	0.0000[a]							
	.70	20%,10%	-0.0267	-0.0016	0.2179	-0.0197	-0.1930	0.3086	0.1312	-0.0307
	.70	20%,20%	0.0557	0.0558	0.2177	0.0188	-0.0735	0.2744	0.1299	0.0510
	.70	30%,20%	-0.0281	0.0800	0.3423	0.0154	-0.2480	0.3549	0.2085	0.0395
	.70	40%,20%	0.0131	0.1266	0.4754	0.0308	-0.4221	0.4777	0.2893	0.0616
50	.70	30%,30%	0.0405	0.1809	0.3519	0.0259	-0.1465	0.2947	0.1626	0.0706
	.80	10%,10%	-0.0183	-0.0190	0.0747	-0.0284	-0.0809	0.1129	0.0546	-0.0166
	.80	20%,10%	0.0559	0.0224	0.2386	0.0198	-0.1301	0.3313	0.1735	0.0539
	.80	20%,20%	0.0003	0.0413	0.2106	-0.0082	-0.1246	0.2443	0.1027	0.0219
	.80	30%,20%	0.0226	0.1217	0.3707	0.0461	-0.2087	0.4052	0.2033	0.0670
	.80	40%,20%	-0.0400	0.2192	0.5177	0.1006	-0.3357	0.5238	0.3402	0.0631
	.80	30%,30%	-0.0713	0.2523	0.3741	0.0302	-0.1940	0.3293	0.1506	0.0543
	.90	10%,10%	0.0000[a]							
	.90	20%,10%	-0.0109	0.0578	0.2689	0.0117	-0.1549	0.3491	0.1642	0.0228
	.90	20%,20%	0.0068	0.0839	0.2430	0.0018	-0.1252	0.2691	0.0987	0.0025
	.90	30%,20%	0.0536	0.2924	0.4704	0.1596	-0.0854	0.4643	0.2868	0.1406
	.90	40%,20%	-0.0325	0.4460	0.6205	0.2296	-0.1736	0.5922	0.4434	0.1641
	.90	30%,30%	-0.0160	0.4876	0.4949	0.1568	-0.0452	0.4475	0.2599	0.1542

(Table continues)

Table 8 (continued).

Sample Size	Proportion High	Percentage of Missing Data	L	P	MS	SR	MR	SMS	SSR	SMR
	.60	10%,0%	-0.0028	0.0046	0.2971	0.0007	-0.2066	0.5362	0.1954	0.0067
	.60	20%,0%	-0.0052	0.0070	0.5678	0.0050	-0.4635	0.9275	0.4176	-0.0106
	.60	30%,0%	-0.0115	0.0059	0.8084	0.0044	-0.7889	1.2448	0.6226	0.0019
	.60	40%,0%	-0.0091	0.0300	1.0467	0.0189	-1.1847	1.4824	0.8335	0.0184
	.60	50%,0%	-0.0078	0.0698	1.2588	0.0343	-1.6969	1.6760	1.0200	0.0188
	.60	60%,0%	0.0013	0.0938	1.4472	0.0602	-2.4132	1.8178	1.2420	0.0667
	.70	10%,0%	-0.0114	-0.0056	0.2923	-0.0055	-0.2195	0.5364	0.1988	-0.0116
	.70	20%,0%	-0.0027	0.0257	0.5784	0.0129	-0.4488	0.9440	0.4052	0.0237
	.70	30%,0%	0.0159	0.0544	0.8387	0.0355	-0.7412	1.2591	0.6467	0.0224
	.70	40%,0%	-0.0244	0.0986	1.0792	0.0533	-1.1363	1.4888	0.8392	0.0458
	.70	50%,0%	-0.0002	0.2752	1.3371	0.1671	-1.4808	1.7161	1.0843	0.1586
200	.70	60%,0%	0.0289	0.5387	1.5737	0.3601	-1.8281	1.8576	1.3785	0.3252
	.80	10%,0%	-0.0039	0.0085	0.3019	0.0048	-0.2058	0.5323	0.1973	-0.0002
	.80	20%,0%	-0.0033	0.0291	0.5831	0.0180	-0.4472	0.9576	0.4199	0.0191
	.80	30%,0%	-0.0030	0.0943	0.8666	0.0569	-0.7286	1.2774	0.6556	0.0433
	.80	40%,0%	-0.0054	0.2540	1.1536	0.1508	-0.9928	1.5423	0.9177	0.1348
	.80	50%,0%	-0.0067	0.5399	1.4415	0.3360	-1.2168	1.7501	1.1931	0.2804
	.80	60%,0%	0.0183	1.1692	1.7557	0.8534	-0.8070	1.9244	1.5678	0.7728
	.90	10%,0%	0.0060	0.0196	0.3131	0.0139	-0.1958	0.5278	0.2180	0.0199
	.90	20%,0%	0.0011	0.0646	0.6169	0.0407	-0.4314	0.9768	0.4507	0.0332
	.90	30%,0%	-0.0523	0.2013	0.9323	0.1029	-0.6638	1.3189	0.6814	0.0989
	.90	40%,0%	-0.0034	0.4658	1.2585	0.2846	-0.8040	1.5911	0.9534	0.2516
	.90	50%,0%	0.0013	0.9400	1.5926	0.6396	-0.6905	1.8147	1.3333	0.5924
	.90	60%,0%	-0.0053	1.4292	1.8129	1.0991	-0.1098	1.9343	1.6115	1.0380
	.60	10%,10%	0.0240	0.0363	0.2214	-0.0134	-0.1127	0.3119	0.0934	0.0496
	.60	20%,10%	0.0369	0.0041	0.4605	-0.0114	-0.3777	0.6491	0.3036	0.0179
	.60	20%,20%	0.0270	-0.0152	0.3501	-0.0684	-0.3185	0.4139	0.1773	0.0215
	.60	30%,20%	0.0234	0.0224	0.6316	-0.0647	-0.6901	0.7296	0.3816	0.0335
	.60	40%,20%	0.0770	0.1036	0.8961	0.0012	-1.0638	0.9816	0.6257	0.0605
	.60	30%,30%	-0.0051	0.0406	0.5648	-0.1027	-0.6371	0.5013	0.2709	-0.0231
	.70	10%,10%	-0.0233	-0.0180	0.1681	-0.0497	-0.1506	0.2663	0.0881	-0.0008
	.70	20%,10%	0.0146	0.0366	0.4772	-0.0142	-0.3812	0.6705	0.3065	0.0263
	.70	20%,20%	0.0500	0.0631	0.4074	-0.0332	-0.2642	0.4553	0.2353	0.0618
	.70	30%,20%	-0.0505	0.1075	0.6758	-0.0392	-0.6798	0.7631	0.3959	-0.0001
	.70	40%,20%	-0.0493	0.2037	0.9315	0.0348	-1.0381	0.9864	0.6108	0.0322
200	.70	30%,30%	0.0123	0.2103	0.6536	-0.0440	-0.5581	0.5467	0.2868	0.0328
	.80	10%,10%	-0.0116	0.0103	0.2009	-0.0331	-0.1386	0.2943	0.1004	-0.0245
	.80	20%,10%	-0.0038	0.0524	0.4978	-0.0093	-0.3773	0.6942	0.3241	0.0313
	.80	20%,20%	0.0393	0.1005	0.4409	-0.0165	-0.2745	0.4890	0.2116	0.0424
	.80	30%,20%	0.0433	0.2726	0.7761	0.0899	-0.4809	0.8178	0.4760	0.1319
	.80	40%,20%	0.0884	0.5830	1.1276	0.2856	-0.6430	1.1165	0.7532	0.2661
	.80	30%,30%	0.0201	0.5173	0.8051	0.0986	-0.3557	0.6931	0.4006	0.1534
	.90	10%,10%	0.0067	0.0337	0.2162	-0.0184	-0.1151	0.2998	0.1203	0.0143
	.90	20%,10%	-0.0186	0.0949	0.5313	0.0093	-0.3598	0.7144	0.3503	0.0371
	.90	20%,20%	-0.0399	0.2331	0.5309	0.0394	-0.2268	0.5420	0.2459	0.0832
	.90	30%,20%	-0.0064	0.5093	0.9166	0.2011	-0.3722	0.9053	0.5646	0.2111
	.90	40%,20%	0.0128	0.9071	1.2911	0.4507	-0.4007	1.2430	0.8498	0.3781
	.90	30%,30%	-0.0405	0.8685	0.9817	0.2386	-0.1616	0.7968	0.4493	0.2552

Note. L: listwise deletion, P: pairwise deletion, MS: mean substitution, SR: simple regression, MR: multiple regression, SMS: stochastic mean substitution, SSR: stochastic simple regression, SMR: stochastic multiple regression. [a] Data were not computed for this combination of sample size, proportion of missing data high, and percentage of missing data.

Table 9. Effect Sizes of the Second Standardized Regression Coefficient (X_2) for the Grade Nine Data by Sample Size, Proportion of Missing Data High, Percentage of Missing Data, and Missing Data Treatment

Sample Size	Proportion High	Percentage of Missing Data	L	P	MS	SR	MR	SMS	SSR	SMR
	.60	10%,0%	-0.0102	-0.0109	0.2560	-0.0081	-0.1518	0.4244	0.1564	-0.0170
	.60	20%,0%	-0.0046	-0.0029	0.5015	-0.0036	-0.3235	0.7445	0.2811	-0.0001
	.60	30%,0%	0.0093	0.0039	0.6975	0.0138	-0.5094	0.9792	0.4478	0.0209
	.60	40%,0%	0.0122	-0.0446	0.8459	0.0153	-0.7739	1.1385	0.6058	-0.0124
	.60	50%,0%	0.0162	-0.0072	0.9927	0.0249	-1.0548	1.2406	0.7405	0.0389
	.60	60%,0%	0.0095	0.0210	1.1344	0.0558	-1.4003	1.3468	0.8791	0.0613
	.70	10%,0%	0.0000[a]							
	.70	20%,0%	-0.0152	-0.0230	0.4730	-0.0224	-0.3374	0.7366	0.2783	-0.0264
	.70	30%,0%	-0.0320	0.0104	0.7058	0.0179	-0.5155	0.9848	0.4565	0.0010
	.70	40%,0%	-0.0448	0.0473	0.8866	0.0279	-0.7585	1.1552	0.5805	0.0145
	.70	50%,0%	-0.0257	0.2213	1.0749	0.1233	-0.9571	1.2768	0.7852	0.0714
50	.70	60%,0%	-0.0555	0.4345	1.2301	0.2503	-1.0851	1.3780	0.9843	0.2012
	.80	10%,0%	0.0038	-0.0011	0.2666	0.0040	-0.1408	0.4531	0.1468	-0.0049
	.80	20%,0%	0.0263	0.0029	0.5022	0.0175	-0.3002	0.7523	0.2875	0.0110
	.80	30%,0%	-0.0017	0.0850	0.7486	0.0448	-0.4822	0.9885	0.4642	0.0306
	.80	40%,0%	-0.0041	0.1322	0.9227	0.0741	-0.7058	1.1752	0.6053	0.0596
	.80	50%,0%	0.0088	0.3904	1.1232	0.2164	-0.7886	1.3087	0.8088	0.1736
	.80	60%,0%	-0.0147	0.8394	1.3081	0.5185	-0.6355	1.4013	1.1093	0.4172
	.90	10%,0%	0.0000[a]							
	.90	20%,0%	0.0031	0.0403	0.5292	0.0261	-0.2857	0.7767	0.2961	0.0318
	.90	30%,0%	-0.0124	0.1487	0.7818	0.0710	-0.4527	1.0299	0.4460	0.0547
	.90	40%,0%	0.0040	0.3548	1.0091	0.1819	-0.5471	1.2124	0.6851	0.1501
	.90	50%,0%	-0.0048	0.8044	1.2515	0.4952	-0.3803	1.3649	0.9722	0.4345
	.90	60%,0%	0.0178	1.1298	1.3618	0.7310	-0.1692	1.4149	1.1406	0.6196
	.60	10%,10%	0.0346	0.0143	-0.0246	-0.0363	0.0483	-0.0481	-0.0769	0.0310
	.60	20%,10%	0.0220	0.0172	0.2056	-0.0317	-0.1093	0.2673	0.0707	0.0358
	.60	20%,20%	-0.0151	-0.0270	-0.0735	-0.1452	0.0410	-0.1932	-0.1992	0.0050
	.60	30%,20%	0.0232	0.0721	0.2156	-0.0910	-0.1092	0.1526	0.0295	0.0149
	.60	40%,20%	-0.0249	0.0740	0.4108	-0.0985	-0.3910	0.3248	0.1587	0.0184
	.60	30%,30%	-0.0786	0.0878	0.0050	-0.2333	0.0325	-0.2048	-0.2826	-0.0337
	.70	10%,10%	0.0000[a]							
	.70	20%,10%	-0.0422	-0.0104	0.1876	-0.0835	-0.1681	0.2354	0.0639	-0.0074
	.70	20%,20%	-0.0154	0.0043	-0.0258	-0.1455	0.0162	-0.1406	-0.1743	-0.0119
	.70	30%,20%	-0.0254	0.0877	0.2441	-0.1154	-0.1753	0.1605	-0.0353	-0.0044
	.70	40%,20%	-0.0093	0.1543	0.4558	-0.1055	-0.3841	0.3615	0.1710	-0.0216
50	.70	30%,30%	-0.0420	0.1554	0.0704	-0.2799	-0.0285	-0.1726	-0.2933	-0.0404
	.80	10%,10%	0.0085	0.0104	-0.0278	-0.0501	0.0348	-0.0711	-0.0774	-0.0012
	.80	20%,10%	-0.0205	0.0550	0.2432	-0.0559	-0.1371	0.2617	0.0415	-0.0108
	.80	20%,20%	-0.0026	0.0563	0.0128	-0.1300	0.0317	-0.1114	-0.1463	-0.0068
	.80	30%,20%	0.0069	0.1437	0.2730	-0.1008	-0.1446	0.1752	-0.0228	-0.0057
	.80	40%,20%	0.0570	0.3941	0.5727	-0.0330	-0.2679	0.4610	0.2017	0.1275
	.80	30%,30%	-0.0576	0.2376	0.1389	-0.3629	-0.1545	-0.0977	-0.3082	-0.1621
	.90	10%,10%	0.0000[a]							
	.90	20%,10%	0.0070	0.0381	0.2371	-0.0415	-0.1275	0.2947	0.0607	0.0164
	.90	20%,20%	-0.0190	0.1084	0.0515	-0.1151	0.0494	-0.0628	-0.1364	-0.0073
	.90	30%,20%	0.0135	0.3288	0.4028	-0.0737	-0.1394	0.2432	0.0596	0.0542
	.90	40%,20%	0.0800	0.6490	0.7457	0.0215	-0.2071	0.5936	0.2276	0.1504
	.90	30%,30%	-0.0161	0.4937	0.3155	-0.3691	-0.2361	0.0613	-0.2707	-0.1300

(Table continues)

Table 9 (continued).

Sample Size	Proportion High	Percentage of Missing Data	L	P	MS	SR	MR	SMS	SSR	SMR
	.60	10%,0%	-0.0024	-0.0079	-0.3493	-0.1208	0.2364	-0.6485	-0.3426	-0.0118
	.60	20%,0%	-0.0150	-0.0178	-0.6859	-0.2554	0.5237	-1.1479	-0.7291	0.0159
	.60	30%,0%	-0.0060	-0.0103	-0.9836	-0.3761	0.8989	-1.5784	-1.0902	-0.0142
	.60	40%,0%	-0.0386	-0.0511	-1.3066	-0.5348	1.3247	-1.9465	-1.4660	-0.0244
	.60	50%,0%	-0.0449	-0.0861	-1.5866	-0.6788	1.8978	-2.2854	-1.7637	-0.0132
	.60	60%,0%	-0.0667	-0.1007	-1.8626	-0.8456	2.6981	-2.5775	-2.1450	-0.0451
	.70	10%,0%	0.0082	0.0090	-0.3416	-0.1105	0.2580	-0.6381	-0.3466	0.0181
	.70	20%,0%	-0.0168	-0.0356	-0.6924	-0.2575	0.5126	-1.1663	-0.7034	-0.0366
	.70	30%,0%	-0.0532	-0.0742	-1.0205	-0.4155	0.8363	-1.5909	-1.1172	-0.0291
	.70	40%,0%	-0.0691	-0.1241	-1.3360	-0.5598	1.2866	-1.9270	-1.4423	-0.0455
	.70	50%,0%	-0.2148	-0.3498	-1.7047	-0.8221	1.6594	-2.3532	-1.8427	-0.1771
200	.70	60%,0%	-0.4562	-0.6802	-2.0781	-1.1678	2.0551	-2.6978	-2.3204	-0.3695
	.80	10%,0%	-0.0081	-0.0141	-0.3592	-0.1268	0.2372	-0.6448	-0.3481	0.0021
	.80	20%,0%	-0.0295	-0.0465	-0.7059	-0.2692	0.5049	-1.1889	-0.7335	-0.0327
	.80	30%,0%	-0.0651	-0.1095	-1.0481	-0.4266	0.8465	-1.6300	-1.1141	-0.0289
	.80	40%,0%	-0.1934	-0.3260	-1.4417	-0.6676	1.1220	-2.0502	-1.5470	-0.1539
	.80	50%,0%	-0.4498	-0.7127	-1.8801	-1.0156	1.3559	-2.4127	-1.9950	-0.3324
	.80	60%,0%	-1.1026	-1.5660	-2.4345	-1.7067	0.9128	-2.8839	-2.5623	-0.9232
	.90	10%,0%	-0.0239	-0.0309	-0.3753	-0.1414	0.2202	-0.6274	-0.3832	-0.0369
	.90	20%,0%	-0.0533	-0.0810	-0.7399	-0.2892	0.4990	-1.2032	-0.7708	-0.0346
	.90	30%,0%	-0.1399	-0.2739	-1.1567	-0.4894	0.7471	-1.7049	-1.1481	-0.1237
	.90	40%,0%	-0.3769	-0.6126	-1.6041	-0.8239	0.9016	-2.1277	-1.5764	-0.2992
	.90	50%,0%	-0.8213	-1.2375	-2.1183	-1.3391	0.7883	-2.5702	-2.1538	-0.7129
	.90	60%,0%	-1.4187	-1.9514	-2.5564	-1.9316	0.1251	-2.9109	-2.5651	-1.2907
	.60	10%,10%	0.0133	0.0175	-0.0709	-0.1096	0.0631	-0.1591	-0.1607	0.0090
	.60	20%,10%	-0.0045	0.0073	0.3931	-0.1224	-0.3153	0.5089	0.1294	0.0106
	.60	20%,20%	-0.0333	-0.0289	-0.1298	-0.2920	0.0644	-0.3571	-0.3576	-0.0701
	.60	30%,20%	0.0373	0.0562	0.3626	-0.2232	-0.3344	0.2393	-0.0582	0.0489
	.60	40%,20%	-0.0176	0.0275	0.7287	-0.2418	-0.9908	0.5868	0.2374	-0.0199
	.60	30%,30%	-0.0313	-0.0069	-0.0605	-0.4376	0.1228	-0.5388	-0.5061	-0.0285
	.70	10%,10%	0.0054	-0.0107	-0.1086	-0.1249	0.0583	-0.1767	-0.1793	0.0240
	.70	20%,10%	0.0454	0.0597	0.4441	-0.0790	-0.2769	0.5523	0.1508	0.0373
	.70	20%,20%	-0.0016	0.0640	-0.0517	-0.2487	0.1044	-0.2829	-0.3695	-0.0104
	.70	30%,20%	0.0176	0.1579	0.4193	-0.2353	-0.3238	0.2648	-0.0869	0.0486
	.70	40%,20%	-0.0220	0.3173	0.8853	-0.2271	-0.8923	0.7274	0.2561	0.0404
200	.70	30%,30%	-0.0283	0.2274	0.0963	-0.4826	0.0825	-0.3996	-0.5788	-0.0307
	.80	10%,10%	0.0260	0.0154	-0.0754	-0.1125	0.0666	-0.1681	-0.1647	-0.0073
	.80	20%,10%	0.0187	0.1182	0.5010	-0.0840	-0.2827	0.6158	0.1320	-0.0002
	.80	20%,20%	-0.0131	0.0991	-0.0159	-0.2654	0.0865	-0.2617	-0.3938	-0.0143
	.80	30%,20%	-0.0023	0.3146	0.5455	-0.2465	-0.3268	0.3502	-0.0262	0.0445
	.80	40%,20%	0.0268	0.6331	1.0894	-0.1832	-0.7925	0.8487	0.3169	0.0704
	.80	30%,30%	0.0422	0.4105	0.2529	-0.6799	-0.1822	-0.2856	-0.6122	-0.1551
	.90	10%,10%	0.0102	0.0506	-0.0350	-0.1108	0.0696	-0.1260	-0.1817	-0.0004
	.90	20%,10%	0.0188	0.1378	0.5098	-0.0721	-0.2642	0.6068	0.1357	0.0481
	.90	20%,20%	-0.0196	0.1895	0.0761	-0.2913	0.0579	-0.1941	-0.3504	-0.0410
	.90	30%,20%	0.0647	0.5042	0.6985	-0.2582	-0.3129	0.4448	-0.0044	0.0151
	.90	40%,20%	0.1155	1.0825	1.3977	-0.1361	-0.6577	1.0901	0.3462	0.1869
	.90	30%,30%	0.0228	0.7197	0.4850	-1.0172	-0.6737	-0.1019	-0.7715	-0.4352

Note. L: listwise deletion, P: pairwise deletion, MS: mean substitution, SR: simple regression, MR: multiple regression, SMS: stochastic mean substitution, SSR: stochastic simple regression, SMR: stochastic multiple regression. [a] Data were not computed for this combination of sample size, proportion of missing data high, and percentage of missing data.

Pairwise deletion was the third most effective missing data treatment estimating the regression weights for the first data set, but was less effective than deterministic simple regression for the second data set (in which higher zero-order correlations were present). Deterministic mean substitution, deterministic multiple regression, stochastic simple regression, and stochastic mean substitution were generally ineffective in generating unbiased estimates of the regression coefficients.

Overall, these results suggest that applied researchers can be reasonably confident in utilizing stochastic multiple regression and the deletion procedures to generate unbiased parameter estimates of the standardized regression coefficients even when the proportion of missing data is as high as 50%. As the proportion of missing data increases, and as the probability of missingness becomes more highly related to the values of the regressors, however, we can be more confident in employing the stochastic multiple regression or listwise deletion procedures than the pairwise deletion technique.

The relative effectiveness of the missing data treatments in this study with systematically missing data were similar to the results obtained with randomly missing data in previous studies (Brockmeier, Hines, & Kromrey, 1993; Brockmeier, Kromrey, & Hines, 1994; Brockmeier, Kromrey, & Hines, 1995). Stochastic multiple regression and pairwise deletion were the most effective procedures in estimating the sample estimate of R^2. Listwise deletion was the next closest procedure in yielding parameter estimates that did not differ from the complete sample condition. The pattern of effectiveness for the missing data treatments also was similar for the standardized regression coefficients. Across the studies, deterministic mean substitution, deterministic simple regression, deterministic multiple regression, and stochastic mean substitution generally did not perform well in producing unbiased estimates of the sample estimate of R^2 and standardized regression coefficients.

Similarly, the effectiveness of the missing data treatments with systematically missing data in this study and in Kromrey and Hines (1994) was consistent. The deletion procedures were more effective than the deterministic imputation procedures in generating unbiased estimates of the sample estimate of R^2 and standardized regression coefficients. Pairwise deletion was more effective than listwise deletion for the estimation of R^2, but listwise deletion was more effective than pairwise deletion in estimating the regression weights.

Finally, the effectiveness of the missing data treatments with systematically missing data in this study and in Brockmeier et al. (1996) was also congruent. Stochastic multiple regression and pairwise deletion were the most effective missing data treatments for estimating R^2, with listwise deletion being the third most effective method. Stochastic multiple regression and listwise deletion were the most effective missing data treatments for estimating the regression weights in both studies, with pairwise deletion being the third most effective. Across the studies, deterministic mean substitution, deterministic multiple regression, and stochastic mean substitution did not perform well in generating unbiased estimates of the sample estimate of R^2 and standardized regression coefficients.

Three limitations should be considered when interpreting the results of the present investigation. First, generalizability of the results to other data sets is a limitation. The data sets were selected based on the type of data and the correlational differences between variables in each data set. The data sets were not randomly selected from all possible data sets. Second, the outcomes are limited to a two-predictor regression model. The outcomes of regression models with additional predictor variables require examination. Finally, variations in the missing data mechanism need further investigation.

Given these limitations, however, the consistency of the results across several years of research suggest that the choice of a missing data treatment is an important one for researchers. Many of the procedures yield large degrees of bias in the resulting sample estimates, even in the presence of small proportions of missing data. In contrast, stochastic multiple regression and the deletion procedures appear to maintain the integrity of the data matrix and provide relatively unbiased estimates in the presence of large proportions of missing data.

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Appendix A
Example SAS Code for Three Stochastic Imputation Procedures

```
*-------------------------------------------------------*;
* STOCHASTIC MEAN SUBSTITUTION*;
*-------------------------------------------------------*;;

PROC MEANS DATA=SAM50MD NOPRINT;
  VAR X1 X2;
  BY SAMPLE;
  OUTPUT OUT=SMS MEAN=MX1 MX2
              STD=STDX1 STDX2;

DATA SMSUB; MERGE SAM50MD SMS;
  BY SAMPLE;
  IF X1=. OR X2=.  THEN DO;
    RX1=STDX1*RANNOR(0);
    RX2=STDX2*RANNOR(0);
    IF X1=. THEN X1=MX1+RX1;
    IF X2=. THEN X2=MX2+RX2;
    OUTPUT;
  END;
  ELSE OUTPUT;
  KEEP SAMPLE Y X1 X2;

PROC MEANS DATA=SMSUB NOPRINT;
  VAR Y X1 X2 ;
  BY SAMPLE;
 OUTPUT OUT=SMES STD=STDY STDX1 STDX2;

DATA SMSUBS; SET SMES;
  BY SAMPLE;
  KEEP SAMPLE STDY STDX1 STDX2;
PROC REG DATA=SMSUB OUTEST=SMEAS
         NOPRINT;
 MODEL Y=X1 X2/SELECTION=RSQUARE
         START=2 B;
 BY SAMPLE;

DATA SMEANSUB; MERGE SMSUBS SMEAS;
 BY SAMPLE;
 STBX1=X1*(STDX1/STDY);
 STBX2=X2*(STDX2/STDY);
 KEEP SAMPLE _RSQ_ STBX1 STBX2;
 RENAME _RSQ_=SMSRSQ STBX1=SMSX1
                     STBX2=SMSX2;
```

```
*-------------------------------------------------------*;
* STOCHASTIC SIMPLE REGRESSION *;
*-------------------------------------------------------*;
PROC REG DATA=SAM50MD OUTEST=A
         NOPRINT;
  MODEL X1=X2/SELECTION=RSQUARE
             START=1 B;
  BY SAMPLE;
  OUTPUT OUT=SSR1 P=X1PV1;
DATA A1; SET A;
  BY SAMPLE;
  KEEP SAMPLE _RMSE_;
  RENAME _RMSE_=RMSE1;
DATA SSIM;  MERGE SAM50MD A1 SSR1;
          * B1 SSR2;
  BY SAMPLE;
  IF X1=. OR X2=. THEN DO;
    RX1=RMSE1*RANNOR(0);
*     RX2=RMSE2*RANNOR(0);
    IF X1=. AND X1PV1 NE . THEN
X1=X1PV1+RX1;
    OUTPUT;
    END;
  ELSE OUTPUT;
  KEEP SAMPLE Y X1 X2;
PROC MEANS DATA=SSIM NOPRINT;
  VAR Y X1 X2;
  BY SAMPLE;
  OUTPUT OUT=SSIMP
             STD=STDY STDX1
STDX2;
DATA F2;  SET SSIMP;
 BY SAMPLE;
 KEEP SAMPLE STDY STDX1 STDX2;
PROC REG DATA=SSIM OUTEST=SSIMPL
NOPRINT;
 MODEL Y=X1 X2/SELECTION=RSQUARE
START=2 B;
 BY SAMPLE;
DATA SSIMR;  SET SSIMPL;
 BY SAMPLE;
 KEEP SAMPLE _RSQ_ X1 X2;
DATA SSIMREG;  MERGE F2 SSIMR;
 BY SAMPLE;
 STBX1=X1*(STDX1/STDY);
 STBX2=X2*(STDX2/STDY);
 KEEP SAMPLE _RSQ_ STBX1 STBX2;
 RENAME _RSQ_=SSRRSQ STBX1=SSRX1
STBX2=SSRX2;
```

```
*-------------------------------------------------------------*;
* STOCHASTIC MULTIPLE REGRESSION *;
*-------------------------------------------------------------*;
PROC REG DATA=SAM50MD OUTEST=AB
     NOPRINT;
  MODEL X1=Y X2/SELECTION=RSQUARE
START=2 B;
  BY SAMPLE;
  OUTPUT OUT=SMR1 P=X1PV1;
DATA AB1; SET AB;
  BY SAMPLE;
  KEEP SAMPLE _RMSE_;
  RENAME _RMSE_=RMSE1;
PROC REG DATA=SAM50MD OUTEST=AC
NOPRINT;
  MODEL X2=Y X1/SELECTION=RSQUARE
START=2 B;
  BY SAMPLE;
  OUTPUT OUT=SMR2 P=X2PV1;

DATA AC1; SET AC;
  BY SAMPLE;
  KEEP SAMPLE _RMSE_;
  RENAME _RMSE_=RMSE2;

DATA GR1A; MERGE SMR1 AB1 SMR2 AC1;
  BY SAMPLE;
DATA SMUL; MERGE SAM50MD GR1A;
   BY SAMPLE;
    IF X1=. OR X2=. THEN DO;
      RX1=RMSE1*RANNOR(0);
      RX2=RMSE2*RANNOR(0);
          IF X1=. AND X1PV1 NE .
             THEN X1=X1PV1+RX1;
          IF X2=. AND X2PV1 NE . THEN
                X2=X2PV1+RX2;
          OUTPUT;
          END;
   ELSE OUTPUT;
   KEEP SAMPLE Y X1 X2;

PROC MEANS DATA=SMUL NOPRINT;
   VAR Y X1 X2;
   BY SAMPLE;
   OUTPUT OUT=SMULT
             STD=STDY STDX1 STDX2;
DATA F3;  SET SMULT;
  BY SAMPLE;
  KEEP SAMPLE STDY STDX1 STDX2;
PROC REG DATA=SMUL OUTEST=SMULTI
NOPRINT;
  MODEL Y=X1 X2/SELECTION=RSQUARE
START=2 B;
  BY SAMPLE;
DATA SMULTR;  SET SMULTI;
  BY SAMPLE;
  KEEP SAMPLE _RSQ_ X1 X2;
DATA SMREGRES;  MERGE F3 SMULTR;
  BY SAMPLE;
  STBX1=X1*(STDX1/STDY);
  STBX2=X2*(STDX2/STDY);
  KEEP SAMPLE _RSQ_ STBX1 STBX2;
  RENAME _RSQ_=SMRRSQ STBX1=SMRX1
          STBX2=SMRX2;
```