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MEMORANDUM FOR   ACS Research and Evaluation Advisory Group

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Subject: Variance Issues Related to Generalized Regression Estimation in
the Housing Unit Weighting Operation

Attached is the final American Community Survey Research and Evaluation report titled
"Variance Issues Related to Generalized Regression Estimation in the Housing Unit Weighting
Operation."

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Variance Issues Related to Generalized Regression Estimation in the Housing Unit Weighting Operation

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I.   EXECUTIVE SUMMARY

We discovered that variances of some 5-year estimates have issues related to the use of generalized regression modeling which is not used in the 1-year estimates. For example, the standard error (SE) of the 5-year estimate for total occupied housing units in the United States is larger than the corresponding 1-year estimate. This report presents results of an investigation to determine if there are any underlying causes of this. Another issue investigated is the question of whether the generalized regression process introduces bias into the American Community Survey (ACS) estimates.

The concern for variances of 5-year national level estimates larger than variances of the corresponding 1-year estimates was determined to be more properly expressed as a concern about **mean squared error (ratio estimation bias only)** of 5-year national level estimates that are larger than the **mean squared error** of the corresponding 1-year estimates. This concern only applies at the national level and appears to be caused by small ratio estimation biases due to generalized regression at the weighting area (tract) level aggregating to high levels where, although relatively small, they grow in relation to the sampling variance.

The small biases when summed to the county, state, and national level resulted in the conclusion that there is no evidence of meaningful systematic bias (not limited to ratio estimation bias). Systematic bias pushes error in the same direction over aggregation and would cause higher biases at the county, state, and national level than seen here.

II.   INTRODUCTION AND METHODOLOGICAL BACKGROUND

The American Community Survey multiyear housing unit (HU) weighting process includes a model-assisted step that uses a generalized regression model (GREG or g-weighting) to calibrate the HU weights using covariates derived from administrative records. Use of this process began with the weighting of the first set of ACS multiyear data (2005–2007). Prior to implementation, the GREG process was tested in the Multiyear Estimates Study (MYES), which used 1999–2005 data from 34 of the 36 ACS test counties (U.S. Census Bureau, 2007). The MYES demonstrated the effect of GREG on reducing variances of estimates in sub county areas, particularly census tracts (Starsinic, 2007). However, preliminary Census Bureau work discovered that variances of some 5-year estimates have issues that we believe are related to the GREG procedure, issues that remain unresolved. For example, the SE of the 5-year estimate for total occupied HUs in the United States is larger than the corresponding 1-year estimate. These variance estimates are calculated using the successive difference variance estimate calculated as follows:

$v(\hat{\theta}_0) = \frac{4}{80} \sum_{r=1}^{80} (\hat{\theta}_r - \hat{\theta}_0)^2$, where $\hat{\theta}_0$ is the ACS production estimate and $\hat{\theta}_r$ is the estimate using the weights from replicate r.

This report will attempt to determine if there are any underlying causes of these issues and if they can be eliminated or mitigated.

Another issue is the question of whether the GREG process introduces bias into the ACS estimates. Earlier analysis by Robert Fay (2007) indicated that there is some small amount of

bias. The only 5-year estimates available at that time were from the 34 ACS test counties that were produced as part of the MYES. This report reproduces part of Fay's bias analysis using all counties in the nation, as well as some additional analysis.

Some background useful to understanding the analysis follows.

Steps of the Implementation. The following five steps, outlined previously (Fay 2005a), form the basic elements of the GREG process for tract-level estimates:

1. Link administrative records to the ACS sampling frame the Master Address File (MAF), dropping administrative records that cannot be linked. If an ACS sample case does not match to administrative record data, then all GREG model covariates for that case, except for a frame count term are set to zero.
2. Form unweighted tract-level totals of the linked administrative record characteristics.
3. Apply ACS sampling weights at the housing-unit level to the linked administrative record data that fall into the ACS sample. The weighted estimates at this step represent unbiased (or essentially unbiased) estimates of the unweighted totals in step 2.
4. Using GREG, calibrate the ACS sample weights so that the weighted administrative totals from the sample match the unweighted totals from step 2.
5. Use the new housing-unit weights in subsequent stages of the ACS weighting, which includes ratio and raking/ratio estimation. Although the subsequent estimation steps adjust the new weights, the argument is that most of the variance reduction at the tract level will be retained in the final weights.

For GREG tract-level estimation seven age/sex categories and four race/ethnicity categories are used to define independent variables in the regression model.

The age/sex categories are as follows:

1. All persons age 0-17
2. All persons age 18-29
3. Males age 30-44
4. Females age 30-44
5. Males age 45-64
6. Females age 45-64
7. All persons age 65 and older

The race/ethnicity categories are as follows:

1. All Hispanics regardless of race
2. All Non-Hispanic Blacks
3. All Non-Hispanic Whites
4. All non-Hispanic Other races

The age/sex categories are potentially collapsed by checking two conditions without using race in the model: 1) is the regression equation solvable and 2) are all of the resulting weights greater

than 0.5. If either condition fails then the age/sex categories are collapsed and the regression is attempted again. Two levels of collapsing are attempted:

1. Collapsing across age/sex into three categories: all persons age 0-17, all persons age 18-44 and all persons 45 and older.
2. Collapse all categories into a single cell of total administrative persons.

If the conditions still fail after the second level of collapsing, then the administrative record data is not used. In this case, a one variable regression using only the frame count is attempted. If the conditions still fail then no GREG modeling is attempted.

If the regression passes using at least the single cell of total administrative persons, then an attempt is made to add race/ethnicity covariates as independent variables in the regression model. First, a collapsing procedure is run. The criteria for including a race/ethnicity category in the regression is that the administrative records universe count for the category being tested and the total for all other categories must be greater than 300 persons. This procedure is carried out first for the largest race/ethnicity category not including the non-Hispanic White category, then the next largest category and finally the smallest category. Three potential independent variables are added to the regression model based on the collapsing results:

1. Hispanics
2. Black non-Hispanics
3. Other Non-White Non-Hispanics

The following codes are used to indicate the model selection for each tract.

Table II-1 Codes for GREG Modelling

AGE/SEX Independent Variables		Ethnicity Independent Variables	
Choice Code	Model Choice	Origin Cell Code	Covariate in model
4	All seven categories	1	Hispanic
3	Three collapsed categories	2	Black Non-Hispanics
2	One total population category	3	Other Non-White Non-Hispanics
1	Only a frame count	0	No Ethnicity variable in model
0	No GREG modelling		

For ethnicity, the code for each variable included in the model selected for the tract is used to create a one, two, or three digit code indicating the ethnicity variables in the model. For example, 23 indicates that only the Black Non-Hispanics and Other Non-White Non-Hispanic independent variables were used (Hispanic variable omitted). Code 123, indicates all three potential ethnicity independent variables were used in the model.

The calibrated GREG weights are then further adjusted with HU and person post-stratification adjustments to obtain final weights. Section II describes the research questions documented in Albright (2013) and presents results and analysis for each question. Section III summarizes the analysis of the major issues and presents some potential future research.

III. RESEARCH QUESTIONS, METHODOLOGY, RESULTS AND ANALYSIS

The specific research questions presented in this section were motivated by things Decennial Statistical Studies Division (DSSD) staff observed regarding the variances of 5-year estimates, as well as the GREG adjustments that were applied to individual sample records. For example, the 5-year estimate of occupied HUs in the United States has a variance that is larger than the corresponding 1-year estimate, and its replicate estimates are all larger than the point estimate. These two results have also been observed in other estimates. We also observed that some sample cases get GREG adjustment factors that are far outside the range of what is typical for other weighting adjustment factors. This report will attempt to determine what causes the issues that we have observed and if there are connections between them. Answers to these questions may give insight into changes that could be made to the GREG process and variance computation to mitigate or eliminate these issues.

Our analysis uses the 2006–2010 ACS data. All the data in all the tables and text of this report uses the production 2006-2010 ACS data. Much of the methodology involves comparing estimates produced using GREG (the original estimates) with estimates produced without GREG. The estimates we use are from the data profile tables (DP02–DP05), with duplicate lines removed (e.g., multiple lines show total households). Although a significant portion of the analysis focuses on census tracts, we also include other summary levels as well. Throughout this section, the term "summary levels" refers to national, state, county, Minor Civil Division (MCD), place, and tract, unless otherwise specified.

A. For what estimates are variances of 5-year national level estimates larger than variances of the corresponding 1-year estimates?

We noted earlier that this was observed for the estimate of occupied housing units in the United States. This phenomenon was also observed, to a lesser extent, at the state level. Staff in DSSD looked at this estimate using the 2006–2010 data that was weighted without GREG and using the original weights with a modified variance formula. In both cases, the SE for this estimate was much lower than the published SE. This portion of the research is intended to find out the extent that this issue exists for other estimates and summary levels and whether it is more likely to occur with the use of GREG.

A profile line refers to a specific ACS estimate at a summary level. For example at the state level one profile line is "Male householder, no wife present, family". This is the state level estimate of the number of families with a male householder with no wife living with the family. First, we have identified 5-year profile lines where the SE is at least 90 percent of the corresponding 1-year SE. Frequency distributions have been run to determine if there are specific types of estimates where this tends to occur and at what summary levels.

We have also recalculated SEs using a slightly different alternative variance formula.

$$Var(Y) = \frac{4}{80}\sum_{i=1}^{80}\left(Y_i - Y_{avg}\right)^2 \quad (1a)$$

where Y_i is the ith replicate estimate and Y_{avg} is the average of the 80 replicate estimates. This variance estimator differs slightly from the variance formula currently used by the ACS, in which the squared term uses the point estimate Y_0 (also called the full sample estimate) instead of Y_{avg}:

$$Var(Y) = \frac{4}{80}\Sigma_{i=1}^{80}(Y_i - Y_0)^2 \quad (1b)$$

We then compared the recalculated SEs to the original values. Typically, Y_0 and Y_{avg} are close and there is little difference between (1a) and (1b). However, for the situation addressed in this research question, it could be that $(Y_i - Y_{avg})$ is smaller than $(Y_i - Y_0)$ in absolute value for most, if not all, replicate estimates. This would cause a large difference between (1a) and (1b).

1.   Results

Tables 1–10 in Appendix 1 provide results for each of 51 topic categories. Odd numbered tables use the production variance estimator (1b) and even number tables use the alternative variance estimator (1a). Each table is for one of the following geographic areas: nation, state, county, MCD, and place. For both 5-year estimates using GREG and 5-year estimates computed without using GREG (NOGREG), the number of estimates for each topic and the number of those estimates with a Y flag (SE ratio of 5-year to 1-year > 0.9) is provided. The average coefficient of variation (CV) ratio of the 5-year estimate to the 1-year estimate over these estimates is also given. Note that based only on sample size considerations the sampling error only CV ratio would be expected to be close to $\sqrt{0.2} = 0.447$ so that those ratios larger than 0.9 are clearly a concern.

For example, Table 1 is for national-level estimates using the production variance estimate. There is one estimate of total households and the SE ratio is greater than 0.9 for GREG (CV ratio = 1.524) but not for NOGREG (CV ratio = 0.425). Table 2 is also for national level estimates but using the alternative variance estimate. The SE ratio for total households is less than 0.9 for both GREG (CV ratio = 0.48) and NOGREG (CV ratio = 0.45). Table 3 is for state level estimates using the production variance estimate. There are 51 estimates of total households (TOTHLD) and the SE ratio is greater than 0.9 for three of these estimates using GREG (average CV ratio = 0.588) but for zero of the estimates for NOGREG (average CV ratio = 0.431). Table 4 is also for state level estimates but using the alternative variance estimate. The SE ratio for TOTHLD is less than 0.9 for all 51 estimates for both GREG (average CV ratio = 0.392) and NOGREG (average CV ratio = 0.423).

Tables A1 (Production variance estimate) and A2 (Alternative variance estimate) provide the proportion of estimates with a SE ratio greater than 0.9 and the unweighted average CV ratio over topics for both GREG and NOGREG. **These tables make it very clear that the concern about a high CV ratio for GREG estimates is limited to the national geographic level using the production variance estimate.**

From Table A1 (Production variance estimate), using GREG, 23.28 percent (88/378) of national estimates have a SE ratio greater than 0.9. The unweighted average CV ratio (5yr/1yr) over topics is 0.773. For NOGREG estimation, 0.26 percent (1/378) national estimates have a SE ratio greater than 0.9 and the unweighted average CV ratio (5yr/1yr) over topics is 0.465. The

other geographic areas show small differences between GREG and NOGREG with less than 1 percent of the SE ratios greater than 0.9 and an unweighted average CV ratio between 0.460 and 0.491.

From Table A2 (Alternative variance estimate), there is little difference between GREG and NOGREG for all geographic areas including the nation. At the national level there were zero estimates out of 378 with a SE ratio greater than 0.9 for both GREG (average CV ratio = 0.43) and NOGREG (average CV ratio = 0.44). The other geographic areas show small differences between GREG and NOGREG with less than 1 percent of the SE ratios greater than 0.9 and an unweighted average CV ratio between 0.438 and 0.493.

Table A1 Production Variance Estimation

Summary Level	% SE Ratio >.9 GREG	Mean CV Ratio GREG	% SE Ratio >.9 NOGREG	Mean CV Ratio NOGREG
Nation	23.28%	0.773	0.26%	0.465
State	0.44%	0.473	0.27%	0.460
County	0.81%	0.475	0.84%	0.483
Minor Civil Division	0.84%	0.469	0.83%	0.489
Place	0.81%	0.473	0.82%	0.491

Table A2 Alternative Variance Estimation

Summary Level	% CV Ratio >.9 GREG	Mean CV Ratio GREG	% CV Ratio >.9 NOGREG	Mean CV Ratio NOGREG
Nation	0.00%	0.43	0.00%	0.440
State	0.24%	0.438	0.26%	0.450
County	0.80%	0.477	0.83%	0.487
Minor Civil Division	0.87%	0.467	0.86%	0.487
Place	0.83%	0.473	0.83%	0.493

2.   Analysis

According to Fay (2007), the ACS use of GREG at the tract-level results in "indirectly estimating characteristics at higher levels through summation. Thus, small biases at the weighting area level potentially can aggregate to high levels where, although relatively small, they grow in relation to the sampling variance." This could well be a major contributor to the concern for observed results at the national level when comparing ACS 5-year estimates with 1-year estimates. The successive difference variance estimator used for ACS (see Fay and Train 1995) is a replication variance estimator. Replication variance estimation is further discussed in Fay (1984). An instructive paper providing simulations of replication variance estimation is given by Judkins (1990).

None of these references suggests a variance estimator limited to the sum of squared differences about the replicate mean. They are based on "taking the mean square difference among the replicate estimates as the variance estimate" (Judkins 1990). The mean square difference

is estimated by summing the squared differences between the replicate estimates and the full sample estimate. Thus the full sample estimate is treated as the "true value target" for obtaining the mean square error. The successive difference variance estimate can be written as follows:

$$v(\hat{\theta}_0) = \frac{4}{80} \sum_{r=1}^{80} (\hat{\theta}_r - \hat{\theta}_0)^2 = \frac{4}{80} [\sum_{r=1}^{80} (\hat{\theta}_r - \overline{\theta}_r)^2 + 80(\overline{\theta}_r - \hat{\theta}_0)^2], \text{ where } \hat{\theta}_0 \text{ is the ACS production}$$

estimate and $\hat{\theta}_r$ is the estimate using the weights from replicate r.

This variance estimate is thus constructed as the sum of a term for the variance among the replicates and a term for the squared difference between the mean of the replicate estimates and the full sample estimate. This second term is a first order approximation of the bias due to ratio estimation (verified via personal correspondence with Robert Fay who developed the successive difference variance estimator). Variance estimation using replication and in particular the ACS successive difference variance estimator is better described as a mean squared error estimator. However only the ratio estimation bias is measured, other forms of bias such as response bias and missing data are not measured by the successive difference estimator. This makes it seem that forming the variance estimator as only the variance of replicate estimates about their mean provides estimates of sampling variance but not mean squared error. If the squared bias second term is meaningful then it may be best to include it in an estimate of mean squared error. This is done by using the production variance estimate.

The results described above indicate that the concern for variances of 5-year national level estimates larger than variances of the corresponding 1-year estimates is more properly expressed as a concern about **mean squared error (sampling error and ratio estimation bias only)** of 5-year national level estimates that are larger than the **mean squared error** of the corresponding 1-year estimates. This concern only applies at the national level and appears to be caused by small biases due to GREG at the weighting area (tract) level aggregating to high levels where, although relatively small, they grow in relation to the sampling variance. Estimates formed without using GREG do not share this national level concern. Thus, this phenomenon at the national level is the result of ratio estimation bias and not sampling variance.

For both GREG and NOGREG estimates the production variance estimator, which actually is an estimate of mean squared error (ratio estimation bias only), is appropriate. The NOGREG estimate likely has less ratio estimation bias but is not unbiased.

B.   Do some geographies have a disproportionate effect on national level variances?

This question ties into Question A, regarding the increased 5-year variances, and may provide an explanation for that issue. We will identify profile lines where the SE of the national level estimate is higher than the corresponding standard error that results from not using GREG. Then we will try to determine if these higher variances are being driven by higher variances at lower levels of geography or if the problem is systematic. For instance, for a particular profile line, estimates in some tracts may have much higher variance resulting from the use of GREG than they would otherwise (we noted earlier that the GREG process produced lower variances for tract-level estimates, but this is only in a general sense, not universally true for all estimates in all tracts).

1. Results

Table 11 (Appendix 1) shows the mean SE ratio (GREG/NOGREG) over profile lines for each topic for each of the geographic areas (summary level): nation, state, county, MCD, place, and tract. The overall mean over all profile lines is on the first row of the table.

Table B1 provides the overall mean SE ratios as well as the number of profile lines (N), standard deviation (SD), minimum, 99th percentile and maximum for each geographic area summary level.

Table B1 Summary Statistics for Distribution of Standard Error Ratios (GREG/NOGREG)

Summary Level	N	Mean	SD	Minimum	99th Percentile	Maximum
Nation	380	1.681	0.983	0.776	5.820	7.404
State	19,280	1.022	0.193	0.319	1.627	14.589
County	1,098,260	0.994	0.540	0	1.368	152.542
Minor civil division	5,401,908	0.991	0.153	0.092	1.454	10.366
Place	5,447,605	1.011	0.170	0	1.586	17.217
Tract	21,710,011	0.944	0.213	0	1.544	17.217

Histograms (Graphs 1 to 6 in Appendix 2) provide additional information on the distribution of these standard error ratios for each of the six geographic summary levels.

Table B2 provides the topic for the profile line with the maximum standard error ratio shown in Table B1 for each geographic summary level. The mean of the standard error ratio over the profile lines for that topic and the national summary level mean for that topic are also provided. This information is used in section B.2 below to analyze the effect of outliers on aggregated national-level estimates.

Table B2 Topics with highest Standard Error Ratios (GREG/NOGREG)

Summary Level	Topic with Maximum Ratio	Mean Ratio for this Topic	National-Level Mean Ratio for Topic
Nation	Household Type	3.641	3.641
State	Hispanic Origin Status	1.104	1.096
County	Hispanic Origin Status	1.108	1.096
Minor civil division	Year of Entry	1.005	1.446
Place	Class of worker	0.943	1.425
Tract	Class of worker	1.019	1.425

2. Analysis

We want to determine if some geographic summary levels have a disproportionate effect on national estimates. Do outliers at some summary level aggregate to the national-level producing the large variance estimates for some 5-year estimates? How do the extreme outliers compare to the 99th percentile outliers? Table B1 shows that the maximum SE ratios are extreme. For states

and MCDs the maximum is about 9 times larger than the 99th percentile ratio. For places and tracts the maximum is about 11 times larger. For counties, the maximum is exceptionally extreme at over 100 times larger than the 99th percentile ratio. As shown in Table B2 there are some differences across summary levels in the topic producing the maximum ratio. Household Type is the topic with the highest ratio at the national-level. However, for the state and county levels, the topic Hispanic had the highest ratio, the highest ratio for MCDs is the topic Year of Entry, and the highest ratio for places and tracts is for the topic Class of Worker. For each of these summary levels (excluding national), the mean ratio over all the profile lines for that topic was not far from one indicating that the topic in general does not produce extreme standard errors using GREG. In addition at the national level, these same topics did not have particularly large ratios. For example, the topic Class of Worker for tracts has a maximum ratio of 17.217. However, the mean ratio for this topic at the tract level is 1.019 and the mean ratio at the national level for topic Class of Worker is 1.425 compared with the average mean ratio of 1.786 over topics at the national-level. If topic class of worker had a disproportionate effect on national level variances, the mean ratio at the tract level would be large and the national level mean ratio would be significantly larger than the average mean ratio over topics. Thus, there is no indication from this data that any particular profile lines, topics, or geographies are having a disproportionate effect on national-level variances.

These SE ratios use the production variance estimator and are more properly called **root mean squared error ratios (ratio estimation bias only)**. The number of profile lines for counties, MCDs, places and tracts is in the millions. The mean reduction in root mean squared error ratio using GREG is 0.6 percent for counties, 0.9 percent for minor civil divisions, -1.1 percent (an average increase) for places, and 5.6 percent for tracts. For states, there is a mean increase of 2.2 percent and the mean increase for the nation is 68.1 percent. As discussed in section A.2, small biases due to GREG at the tract-level can aggregate to high levels where, although relatively small, they grow in relation to the sampling variance. This is the likely reason for these ratios averaging an increase in root mean squared error for larger geographic summary levels. The sampling variance portion of the mean squared error is likely similar for GREG and NOGREG for larger summary levels. Since GREG improves estimation at the tract level and it is necessary for production purposes to only have one set of weights, it is not feasible to use GREG based weights for smaller levels of geography and NOGREG weights for larger geographic areas.

C.   What characteristics have a point estimate that is higher (lower) than all its replicate estimates?

In any estimate, the average of the 80 replicate estimates should be close to the full sample estimate (the same is true for replicate weights of sample cases). However, we have found instances where all replicate estimates are either higher or lower than the full sample estimate. This situation may have a detrimental effect on estimated variances and be related to the issue that is the subject of Question A. Based on the decomposition of the production variance estimate discussed in Section III.A.2, this is an indication that the bias is more of a concern than the variance for an estimate. All replicates either higher or lower than the full sample estimate will make $\bar{\theta}_r$ more different than $\hat{\theta}_0$ increasing the bias portion of the decomposition; higher replicate differences are not cancelled by lower replicate differences. We wish to determine which characteristics this happens with and at what summary levels and then determine if there

are any patterns or trends that may indicate why it happens. We also will determine if it happens more often when using GREG than without GREG.

First we identify 5-year profile lines where all the replicate estimates are higher (lower) than the full sample estimate. Then run frequency distributions to find what types of estimates this tends to occur and at what summary levels. The same frequency distributions will then be run using the non-GREG versions of these estimates and the results will be compared.

1.   Results

Table 12 (Appendix 1) shows the number of estimates and the number of these estimates for which the point estimate is higher or lower than all its replicate estimates for each topic for each of the geographic areas (summary level): nation, state, county, minor civil division, place, and tract. Table C1 provides summary results across topics at the summary area level.

Table C1 Point Estimates Higher or Lower than all Replicate Estimates

Summary Area	Number Of Estimates	All Reps		Percent all reps	
		Hi or Low		Hi or Low	
		GREG	NOGREG	GREG	NOGREG
Nation	378	75	1	19.841%	0.265%
State	19245	25	3	0.130%	0.016%
County	1092179	189	161	0.017%	0.015%
Minor civil division	5360077	711	645	0.013%	0.012%
Place	5408782	259	213	0.005%	0.004%
Tract	21566182	269	227	0.001%	0.001%

2.   Analysis

From Table C1, for the national level estimates using GREG, about 20 percent of estimates have all replicate estimates higher or lower than the point estimate. All the NOGREG estimates as well as the GREG estimates for subnational levels have well less than 1 percent of estimates with all replicate estimates higher or lower than the point estimate. Thus all replicate estimates higher or lower than the point estimate is only notable for GREG estimates at the nation-level.

Looking at Table 12 at the nation-level, Table C2 shows topics that are notable in terms of the number of profile lines with all the replicate estimates higher or lower than the point estimate.

Table C2 Some Topics with Large Proportion of All high or low Replicate Estimates

Topic Description	Number of Profile Lines	Number of Profile Lines with all Replicates Hi or Low
Mortgage	2	2
Occupied Housing Units	1	1
Only One Race	1	1
Tenure	2	2
Total Households	1	1
Total Housing Units	1	1
Educational Attainment	7	7
Household Type	13	8
Migration	7	4
Relationship	7	3
Housing Value	8	5

The correlation between the topic proportion of all profile lines with replicate estimates higher or lower than the point estimate and the topic mean SE ratio GREG/NOGREG from Table 11 is 0.482 so that a simple regression with the SE ratio as the dependent variable (y) and the proportion of all replicate estimates higher or lower than the point estimate as the independent variable (x) has a R^2 of 0.232 (estimated regression equation $y = 1.466 + 1.145x$). A correlation of 0.482 indicates a modest or moderate positive relationship (Taylor 1990).

All replicates estimates higher or lower than the point estimate is an indication of ratio estimation bias. These results are consistent with the previous results and indicate that it is only at the national level using GREG that there is a substantial bias component likely caused by aggregation.

The alternative variance estimator is a measure of sampling error and does not include ratio estimation bias. Ratio estimation bias exists for both the GREG and NOGREG estimates and is likely larger for GREG estimates. The production variance estimator measures the sum of the sampling variance and the square of the ratio estimation bias. Denote production variance estimate as $\hat{V}_P$ and the alternative variance estimate as $\hat{V}_A$. Also denote the absolute value of the ratio estimation bias of an estimate as B. Then $\hat{V}_P = \hat{V}_A + B^2$ and $B = \sqrt{\hat{V}_p - \hat{V}_A}$. We use this equation for each profile line for each topic at the national level (378 profile lines). There are a total of 50 profiles lines for the topics in Table C2 with a high number of profile lines with all replicates higher or lower than the point estimate. Table C3 shows average coefficients of variation for GREG and NOGREG estimates using the alternative variance estimator and the production variance estimator for all 378 profile lines and for the 50 profile lines for the topics in Table C2. The relative absolute ratio estimation bias using $B = \sqrt{\hat{V}_p - \hat{V}_A}$ is also shown.

Table C3 Average Statistics Over 378 Profile Lines and Over 50 Profile Lines

Statistic	Averages Over all 378 Profile Lines	Averages Over 50 Profile Lines from Table C2
Alternative Variance Estimator GREG CV	0.226	0.0958
Alternative Variance Estimator NOGREG CV	0.235	0.0996
Production Variance Estimator GREG CV	0.317	0.293
Production Variance Estimator NOGREG CV	0.243	0.117
Relative Absolute Ratio Estimation Bias GREG	0.00178	0.00265
Relative Absolute Ratio Estimation Bias NOGREG	0.000436	0.000528

Looking at Table C3, the average CV based on the alternative variance estimator, which measures sampling error, is about the same for GREG and NOGREG over all 378 profile lines and over the 50 profile lines representing the topics from Table C2 with a high proportion of all high or low profile lines. The average CV based on the production variance estimator, which measures a mean squared error (ratio estimation bias only), is greater for GREG than NOGREG using all 378 profile lines as well as the 50 profile lines. GREG estimates have more ratio estimation bias, as measured by $B = \sqrt{\hat{V}_p - \hat{V}_A}$, than NOGREG estimates.

Comparing the 50 profile lines column with the 378 profile line column, the topics with a high proportion of all high or low profile lines have lower sampling error as measured by the alternative variance estimator. They also have slightly larger average relative absolute ratio estimation bias. The level of sampling error is not related to the bias of estimates. Using $B = \sqrt{\hat{V}_p - \hat{V}_A}$ to estimate ratio bias may have limitations. The second term of the production variance estimator is a first order approximation of the bias due to ratio estimation. This does not mean that it is an unbiased or stable estimator of ratio estimations bias. This second term is $4(\bar{\theta}_r - \hat{\theta}_0)^2$. When an estimate for a profile estimate line has all replicate estimates higher or lower than the point estimate this second term is greater since all θ_r in $\bar{\theta}_r$ are higher (or lower) than the point estimate. There is no positive difference compensated by a negative difference in calculating $\bar{\theta}_r$. This fact combined with limitations in the first order approximation estimator could well be a contributor to the increased estimated average absolute relative ratio bias for the topics with a high proportion of profile lines with all replicate estimates higher or lower than the point estimate.

The variance at the national level is very small for both GREG and NOGREG but the bias, although small in a relative sense, is larger for GREG than NOGREG.

D. Are there factors associated with unusually large (small) GREG factors or a large range of GREG replicate factors?

We have seen before that GREG adjustment factors can exhibit a much wider range of values than is typical for other HU weighting adjustments. Cutoffs for what will be considered large and small will be determined by examining distributions of the factors.

We will attempt to determine if there are factors that make it more likely that a HU record will exhibit either of these characteristics. This will be done with the use of frequency tabulations and logistic regression modeling. Factors to try in the model may include, but are not limited to:

Tenure/Status (owner/renter/vacant); Mode of data collection; Urban/rural; Geography; Type of household (married couple with/without kids, single person, other nonfamily)

There are also two other aspects of the GREG methodology itself that may contribute to this issue. We discuss them in this section since, intuitively, they are most directly related to this question. However, they may also be connected to the other questions. One is large discrepancies between the values of the area level covariate totals and the sample estimates (which are unbiased) of those totals. The differences between these two quantities are a component of the GREG model. We will attempt to determine if extreme GREG factors are associated with the size of these differences.

The second additional aspect is the application of the selected GREG model to each replicate. Currently, the form of the GREG model is determined using the full sample weights and then that same model is applied to each replicate so that all replicate weights are calibrated to the same covariates. We hope to reweight the 2006-2010 data, allowing the GREG process to select models for each replicate independently. The ranges of replicate GREG factors among observations can then be compared to the ranges that were observed with the original data. We could also compare variance estimates from this method to the original variances to assess if variances are negatively affected. This is a concern because different replicates will be calibrated to different sets of covariates, which may affect variance estimates.

1. Results

In the Appendix, Tables 13 and 14 show the tract distribution of the ethnicity and age/sex covariate selections respectively and Table 15 is a cross-tabulation of these codes.

Table 16 provides the distribution information of the average g-weight over tract for all GREG models and for each type of model selected by the combination of the age/sex Choice Code and the Origin Cell Code.

Graph 7 in Appendix 2 is a histogram of the average tract-level g-weight adjustment factor. This factor is multiplied times the adjusted housing unit weight after the mode bias factor adjustment to produce the g-weight.

The differences between the values of the tract covariate total from administrative records and the unbiased sample estimates were computed for each tract for each independent variable used for the tract. Table 17 in Appendix 1 describes these differences and shows their distribution.

Table D.1 shows the Pearson correlation coefficient between (1) the differences between the values of the tract covariate total from administrative records and the unbiased sample estimates and (2) the average tract g-weight adjustment factor (gwft).

Table D.1 Pearson Correlation between Difference (Frame - Estimate) and Average g Weight

Variable	Pearson Correlation
Frame Count	0.819
Male/Female 0-17	0.298
Male/Female 18-29	0.283
Male 30-44	0.280
Female 30-44	0.282
Male 45-64	0.309
Female 45-64	0.323
Male/Female 65+	0.244
Male/Female 0-17	0.243
Male/Female 18-44	0.346
Male/Female 45-64	0.323
Total Persons	0.282
Hispanic	0.297
Black Non-Hispanics	0.329
Other Non-White Non-Hispanics	0.257

Logistic Regression models were fit using a random sample of 10,000 records for final High and final low g-weights for GREG and NOGREG estimates for housing units and persons. Only occupied housing units were used in the housing unit modeling.

The dependent variable for final high was 1 if final weight was in the 90 percentile or higher of final weights in the sample and 0 otherwise.

The dependent variable for final low was 1 if final weight was in the 10 percentile or lower of final weights in the sample and 0 otherwise.

The independent variables for the housing unit models are as follows:

1. Household Type (HHT)
   1 = Family household married couple
   2 = Family household male reference person
   3 = Family household female reference person
   4 = Nonfamily household male reference person lives alone
   5 = Nonfamily household male reference person does not live alone
   6 = Nonfamily household female reference person lives alone
   7 = Nonfamily household female reference person does not live alone

2. Mode (1 = Mail, 2 = Computer Assisted Telephone Interview (CATI), 3 = Computer Assisted Personal Interview (CAPI))

3. Tenure (1 = Owner, 2 = Renter)
4. Urban/Rural (UR) (1 = Urban, 2 = Rural)

The independent variables for the person models are as follows:

1. Age in Years = Treated as continuous variable
2. Sex (1 = Male, 2 = Female)
3. Hispanic or Non-Hispanic (1 = Hispanic, 2 = Non-Hispanic)
    Race: (1 = White, 2 = Black, 3 = American Indian, 4 = Asian, 5 = Non-Hispanic Non-White Other Pacific Islander

Tables D.2 through D.9 below show the estimated odds ratios using reference coding for logistic regression modeling for the eight combinations of housing or person weights, GREG or NOGREG estimation, and high or low weight. The 95 percent confidence intervals for each odds ratio point estimate are also shown.

Graphs 8 through 15 are the Receiver Operation Characteristic (ROC) curves from logistic regression modeling for these same combinations.

Table D.2 Odds Ratios and Confidence Limits: High GREG Final Housing Unit Weight Model

Effect	Point Estimate	95% Wald Confidence Limits	
hht 1 vs 7	1.133	0.673	1.907
hht 2 vs 7	0.921	0.490	1.731
hht 3 vs 7	1.382	0.770	2.483
hht 4 vs 7	0.916	0.527	1.595
hht 5 vs 7	0.940	0.454	1.949
hht 6 vs 7	0.846	0.491	1.456
mode 1 vs 3	0.171	0.121	0.240
mode 2 vs 3	0.123	0.085	0.178
tenure 1 vs 2	0.867	0.708	1.061
ur 1 vs 2	0.089	0.075	0.107

Table D.3 Odds Ratios and Confidence Limits: Low GREG Final Housing Unit Weight Model

Effect	Point Estimate	95% Wald Confidence Limits	
hht 1 vs 7	1.512	0.836	2.737
hht 2 vs 7	1.007	0.509	1.991
hht 3 vs 7	1.252	0.674	2.324
hht 4 vs 7	1.352	0.722	2.532
hht 5 vs 7	1.168	0.569	2.399
hht 6 vs 7	1.855	0.983	3.503
mode 1 vs 3	141.809	97.370	206.529
mode 2 vs 3	90.189	46.215	176.007
tenure 1 vs 2	1.148	0.924	1.425
ur 1 vs 2	2.498	2.001	3.118

Table D.4 Odds Ratios and Confidence Limits: High NOGREG Final Housing Unit Weight Model

Effect	Point Estimate	95% Wald Confidence Limits	
hht 1 vs 7	1.085	0.634	1.855
hht 2 vs 7	0.805	0.424	1.529
hht 3 vs 7	1.336	0.731	2.441
hht 4 vs 7	0.800	0.453	1.411
hht 5 vs 7	1.104	0.510	2.391
hht 6 vs 7	0.798	0.456	1.396
mode 1 vs 3	0.149	0.104	0.213
mode 2 vs 3	0.113	0.077	0.167
tenure 1 vs 2	0.719	0.582	0.887
ur 1 vs 2	0.077	0.064	0.093

Table D.5 Odds Ratios and Confidence Limits: Low NOGREG Final Housing Unit Weight Model

Effect	Point Estimate	95% Wald Confidence Limits	
hht 1 vs 7	1.052	0.557	1.984
hht 2 vs 7	0.946	0.458	1.955
hht 3 vs 7	0.829	0.428	1.604
hht 4 vs 7	0.908	0.465	1.774
hht 5 vs 7	0.960	0.448	2.058
hht 6 vs 7	1.346	0.683	2.650
mode 1 vs 3	>999.999	<0.001	>999.999
mode 2 vs 3	>999.999	<0.001	>999.999
ur 1 vs 2	3.201	2.540	4.034
tenure 1 vs 2	1.018	0.811	1.278

Table D.6 Odds Ratios and Confidence Limits: High GREG Final Person Weight Model

Effect	Point Estimate	95% Wald Confidence Limits	
AGE	0.988	0.985	0.991
SEX 1 vs 2	1.071	0.936	1.225
HISP 1 vs 2	0.333	0.282	0.393
SRACE 1 vs 5	1.374	0.315	5.997
SRACE 2 vs 5	3.922	0.892	17.248
SRACE 3 vs 5	2.209	0.475	10.270
SRACE 4 vs 5	2.412	0.540	10.782

Table D.7 Odds Ratios and Confidence Limits: Low GREG Final Person Weight Model

Effect	Point Estimate	95% Wald Confidence Limits	
AGE	1.006	1.003	1.009
SEX 1 vs 2	1.100	0.963	1.256
HISP 1 vs 2	5.940	3.968	8.891
SRACE 1 vs 5	>999.999	<0.001	>999.999
SRACE 2 vs 5	>999.999	<0.001	>999.999
SRACE 3 vs 5	>999.999	<0.001	>999.999
SRACE 4 vs 5	>999.999	<0.001	>999.999

Table D.8 Odds Ratios and Confidence Limits: High NOGREG Final Person Weight Model

Effect	Point Estimate	95% Wald Confidence Limits	
AGE	0.988	0.985	0.991
SEX 1 vs 2	1.080	0.943	1.236
HISP 1 vs 2	0.309	0.262	0.364
SRACE 1 vs 5	1.411	0.322	6.182
SRACE 2 vs 5	3.977	0.901	17.557
SRACE 3 vs 5	1.686	0.356	7.978
SRACE 4 vs 5	2.539	0.566	11.390

Table D.9 Odds Ratios and Confidence Limits: Low NOGREG Final Person Weight Model

Effect	Point Estimate	95% Wald Confidence Limits	
AGE	1.007	1.005	1.010
SEX 1 vs 2	1.072	0.938	1.224
HISP 1 vs 2	7.530	4.809	11.792
SRACE 1 vs 5	>999.999	<0.001	>999.999
SRACE 2 vs 5	>999.999	<0.001	>999.999
SRACE 3 vs 5	>999.999	<0.001	>999.999
SRACE 4 vs 5	>999.999	<0.001	>999.999

Table D.10 shows the amount of area under the ROC curve for each logistic regression model.

Table D.10 Area under the ROC Curve for Logistic Regression Models

Logistic Regression Model			Area Under ROC Curve
Type of Weight	Type of Estimation	High or Low Decline Dependent Variable	
Housing	GREG	High	0.8008
Housing	GREG	Low	0.9334
Housing	NOGREG	High	0.8171
Housing	NOGREG	Low	0.9651
Person	GREG	High	0.6781
Person	GREG	Low	0.6339
Person	NOGREG	High	0.6823
Person	NOGREG	Low	0.6539

A rough guide for classifying the accuracy of a diagnostic test using logistic regression ROC area under the curve is 0.9-1 excellent, 0.8-0.9 good, 0.7-0.8 fair, 0.6-0.7 poor, 0.5-0.6 fail. Looking at Table D. 10, the housing weight models for low weights were excellent (about 0.93 for GREG and 0.97 for NOGREG) and the HU weight models for high weights were good (about 0.80 for GREG and 0.82 for NOGREG). All the models for person weights were poor with areas between about 0.63 and 0.68.

From Table 13, about 52 percent of tracts used no ethnicity independent variables, about 12 percent used only the Hispanic variable, about 14 percent used only the Black Non-Hispanic variable, and about 5 percent used only the Other Non-White Non-Hispanic variable. About 13 percent used two of the three possible ethnicity variables and about 5 percent used all three ethnicity independent variables.

From Table 14, about 78 percent of tracts used all seven age/sex categories as independent variables, about 17 percent used three collapsed categories, and about 4 percent used only a total population independent variable. Less than 1 percent of tracts either used GREG with only a housing unit frame count as an independent variable or used no GREG modeling due to failing the conditions.

From Table 15, as designed there are no ethnicity categories in the model when there are no age/sex variables selected (choice = 0) or only a frame count is selected (choice=1). When at least the total population category is used (Choice = 2, 3, or 4), only one ethnicity independent variable (Origin Cell = 1, 2, or 3) is selected about 31 percent of the time, two ethnicity variables (Origin Cell = 12, 13, or 23) are selected about 13 percent of the time, and all three ethnicity variables (Origin Cell=123) are selected about 5 percent of the time.

From Table 16, over all tracts the mean g weight factor is 1.021 with a minimum of 0.608, a maximum of 6.004, and a standard deviation of 0.079. The histogram that is Graph 7 shows that almost all the tracts have an average g weight factor between 0.8 and 1.2. The variation of the average g-weight factor over model choice is not large. The minimum average is 0.997 for age/sex Choice 2 and Origin Cell 32. The maximum average is 1.034 for age/sex Choice 2 and Origin Cell 0.

2.   Analysis

From logistic regression modeling, odds ratios greater than 2 or less than 0.5 are particularly worth mentioning indicating that one level of the independent variable has more than double the odds of a high (or low) final weight than another level of the independent variable.

Note that mode 3, CAPI, is expected to have more high weights since the CAPI subsampling results in higher initial weights.

For HU weighting, high GREG model (Table D.2), mode 1 (mail) and mode 2 (CATI) had low odds ratios of 0.171 and 0.123 respectively for a high weight when compared with mode 3 (CAPI). Rural also had a very low odds ratio of 0.089 compared with Urban. Results were similar for the high NOGREG model (Table D.4). Mode 1 (mail) and mode 2 (CATI) had low odds ratios of 0.149 and 0.113 respectively for a high weight when compared with mode 3 (CAPI). Rural also had a very low odds ratio of 0.077 compared with Urban.

For the HU weighting, low GREG model (Table D.3), mode 1 (mail) and mode 2 (CATI) had very high odds ratios of about 142 and 90 respectively for a low weight when compared with mode 3 (CAPI). Rural also had a very high odds ratio of about 2.5 compared with Urban. Results were similar for the low NOGREG model (Table D.5) for Rural, which had a very high odds ratio for a low weight of about 3.2. The estimate for mode was not accurate as indicated by the 95 percent Wald Confidence limits.

For the person unit weighting, high GREG model (Table D.6), Hispanic had a low odds ratio of 0.333 compared with Non-Hispanic. Odds ratios for the race categories of White, Black, American Indian and Asian were high, ranging from 1.374 to 3.922 when compared with Non-Hispanic Non-White Pacific Islander. Results were similar for the high NOGREG model (Table D.8). Hispanic had a low odds ratio of 0.309 compared with Non-Hispanic. Odds ratios for the race categories of White, Black, American Indian and Asian were high, ranging from 1.411 to 3.977 when compared with Non-Hispanic Non-White Pacific Islander.

For the person unit weighting, low GREG model (Table D.7), Hispanic had a very high odds ratio of 5.94 compared with Non-Hispanic. The estimates for race were not accurate as indicated by the 95 percent Wald Confidence limits. Results were similar for the low NOGREG model (Table D.9). Hispanic had a very high odds ratio of 7.53 compared with Non-Hispanic. The estimates for race were also not accurate as indicated by the 95 percent Wald Confidence limits.

The logistic regression modeling described in this section identified mode of data collection and urban/rural status as important predictors of extreme g weight factors for housing units. The models for housing units were generally good or excellent based on the ROC area under the curve. For persons, Hispanic Origin status and race were important predictors. However, the person level models were poor based on the ROC area under the curve.

For all results presented here the form of the GREG model is determined using the full sample weight and that same model is used for each replicate for variance estimation. As discussed above we had planned to reweight allowing the GREG model to be selected independently for each replicate. Due to resource limitations, we have not done this for this report. This may be done in the future, if after reviewing all the results presented, we think that doing so would

provide useful information and resources are available. The model choice for the ethnicity independent variables is based on unweighted totals from our administrative records so that replicate weights do not affect model choice for ethnicity. The age/sex category independent variable selection choice depends on the regression equation being solvable and all resulting weights being greater than 0.5. Given that the mean weight from not using GREG is about 14 and the 1 percentile weight is 2.084, it seems likely that the additional variance due to model selection would be small. The expectation is that about 50 percent of the replicate factors will be 1, and the other 50 percent of replicate factors will be evenly split between 1.7 and 0.3. It does not seem likely that applying these replicate factors would make a solvable regression model unsolvable. We are interested in records that have a weight prior to GREG for production greater than 0.5 but have a replicate weight after GREG less than 0.5. These records would change a production decision on age/sex collapsing from pass to fail. This would seem to require a weight prior to GREG of greater than 0.5 and less than 1.67 and a replicate factor of 0.3 (0.3 x 1.67 = 0.5). Less than 1 percent of records are likely to have a weight prior to GREG between 0.5 and 1.67. Thus, it might crudely be expected that less than about 0.25 percent (1% x 25% replicate factor 0.3) of records would have a replicate weight after GREG less than 0.5 when their production weight prior to GREG was greater than 0.5. However, this only has to happen once for all the HU records in the tract.

The Pearson correlation coefficient between (1) the differences between the values of the tract covariate total from administrative records and the unbiased sample estimates and (2) the average tract g weight (Table D.1) was 0.819 for the frame count indicating a strong positive correlation. All the other covariates had a moderate positive correlation ranging from a high of 0.346 for male/female 18-44 to a low of 0.243 for male/female 0-17. The conclusion is that extreme GREG factors are associated with these differences.

E. What is the effect of the GREG adjustment on weighting adjustments that take place after GREG?

Here we will look at the weighting adjustments that take place after the GREG process: the Housing Post stratification Factor (HPF), the Person Post stratification Factor (PPSF), and the Householder Factor (HHF). HHF applies to occupied housing units and is equal to the PPSF of the householder. We will compare the original values of these factors to those that result from the reweighting that does not use GREG to determine if the GREG process has a substantial effect on the values of these adjustments.

We will also look at estimates from selected profile lines, comparing the GREG and NOGREG based estimates, which are derived from different weights:

   Weight through Mode Bias Factor (GREG or NOGREG before HU controls are applied)

   Weight through HPF and PPSF (GREG or NOGREG after HU controls are applied)

This may also provide insight into any interaction between GREG and other weighting adjustments.

1.   Results

Table E.1 provides distributional information for the HPF and PPSF factors with GREG and with NOGREG. For each statistic the ratio of the GREG value to the NOGREG value is also shown.

Table E.1 Distribution of HPF and PPSF factors with GREG and NOGREG

	Mean	Std Dev	Minimum	Maximum	N
HPF GREG	1.023	0.071	0.497	2.520	13842
HPF NOGREG	1.026	0.080	0.514	2.340	13842
Ratio	0.996	0.892	0.968	1.077	1
PPSF GREG	1.071	0.325	0.000	126.468	1718793
PPSF NOGREG	1.074	0.330	0.000	112.252	1722108
Ratio	0.997	0.983		1.127	0.998

Tables E.2 and E.3 show the distribution of the ratio of the NOGREG estimate to the GREG estimate for state level profile lines before (Table E.2) and after (Table E.3) application of the HU controls. The housing unit controls is the first weighting operation after applying the GREG model if it is used.

Table E.2 Distribution of NOGREG/GREG Ratio Before HU Controls

Mean	Std Dev	Minimum	Maximum	N	1st Pctl	5th Pctl
0.998	0.045	0.535	5.585	19374	0.933	0.975
10th Pctl	Lower Quartile	Median	Upper Quartile	90th Pctl	95th Pctl	99th Pctl
0.983	0.990	0.996	1.004	1.013	1.023	1.074

Table E.3 Distribution of NOGREG/GREG Ratio After HU Controls

Mean	Std Dev	Minimum	Maximum	N	1st Pctl	5th Pctl
1.000	0.043	0.541	5.461	19374	0.936	0.977
10th Pctl	Lower Quartile	Median	Upper Quartile	90th Pctl	95th Pctl	99th Pctl
0.986	0.993	0.998	1.005	1.014	1.024	1.073

Graphs 16 and 17 are histograms of the average ratio of the estimates with no GREG estimation to the estimates with GREG estimation by topic group before (Graph 16) and after (Graph 17) application of the housing unit controls.

Tables 18 and 19 each show results with NOGREG and GREG for a sample of 30 profile lines before (Table 18) and after (Table 19) application of the HU controls. The two samples are independent due to processing limitations.

2. Analysis

Looking at Table E.1, neither the HPF nor PPSF factors seem to be affected very much by GREG. The ratio of the GREG mean to the NOGREG mean is close to one for both factors and the standard deviations for GREG are slightly smaller. However the maximum for GREG is about 8 percent higher than for NOGREG for HPF and about 13 percent higher for PPSF.

Tables E.2 and E.3 seem to indicate that the distribution of the ratio of the NOGREG estimate to the GREG estimate does not change much from before to after application of the HU controls. The mean ratio over 19,374 state level profile lines before applying the controls is 0.998 with a minimum of 0.535 and a maximum of 5.585. After application of the HU controls, the mean is 1.000 with a minimum of 0.541 and a maximum of 5.461.

The histogram in Graphs 16 (before HU controls) and Graph 17 (after HU controls) of the average ratio of the NOGREG estimate to the GREG estimate over summary topic categories also shows that the estimates themselves are not much effected by GREG.

The random sample of 30 profile lines before HU controls (Table 18) had a minimum ratio of 0.854 for Kentucky for "Sioux tribal grouping," an average ratio of 0.998, and a maximum ratio of 1.066 for the District of Columbia for "Less than 9th grade". The random sample of 30 profile lines after HU controls (Table 19) had a minimum ratio of 0.978 for Kansas for "$200,000 or more," an average ratio of 0.998, and a maximum ratio of 1.041 for Wyoming for "Guamanian or Chamorro."

Overall the application of GREG does not have a large effect on the magnitude of the adjustment factors that come after GREG or on the magnitude of the point estimates.

F. Is the GREG procedure introducing bias into the replicate estimates?

Although we are not directly connecting bias to issues with variances, it is a concern with use of the GREG procedure and we believe it is worth studying. While the production variance estimator does include a measure of ratio estimation bias, other biases such as coverage error, imputation error, and response error are not measured. The first part of the analysis to answer this question replicates a portion of analysis done by Robert Fay (Fay 2007). This analysis used 2001-2005 5-year estimates, which were produced as part of the MYES, and used only the 34 ACS test counties. Fay's results showed evidence of a small amount of bias that could be attributed to GREG. A natural question is whether this result from the test counties extends to tracts and counties nationwide. As in Fay's analysis, we group the profile estimates into the following classes: Total households, Total HUs, Total population, Age/sex variables, Race/Hispanic origin variables, all other totals.

In each class of estimates, we compute two measures to summarize the differences between estimates that use GREG and those that do not use GREG. The first is the percent absolute difference (PAD).

$$PAD = \frac{100}{n} \sum \frac{|Y_{GREG} - Y_{noGREG}|}{(Y_{GREG} + Y_{noGREG})/2} \quad (3)$$

where *n* is the number of estimates. This is a simple average of individual absolute percent differences. The second measure is the weighted percent absolute difference (WPAD).

$$WPAD = 100 \frac{\Sigma \ |Y_{GREG}-Y_{noGREG}|}{\Sigma \ ((Y_{GREG}+Y_{noGREG})/2)} \qquad (4)$$

PAD and *WPAD* will be computed for each summary level, plus at the county and tract-level in the 34 test counties.

The second part of this analysis focuses on individual estimates to determine if certain individual estimates are more prone to bias, whether positive or negative, that results from GREG. For each estimate, we compute the percent difference (PAD1).

$$PAD1 = \frac{Y_{GREG}-Y_{noGREG}}{(Y_{GREG}+Y_{noGREG})/2} \qquad (5)$$

3.   Results

Table F.1 provides the statistics PADS and WPADS as well as the number of estimates for each of the six geographic summary areas as well as for the 34 ACS test counties and the tracts in those counties.

Table F.1. Bias Measures Percent Absolute Difference (PADS) and Weighted Percent Absolute Difference (WPADS) by Geographic Summary Level

TYPE	Variable	Nation	State	County	County Sub.	Place	Tract	Test* County	Test Tract*
AGE/ SEX	PADS	0.023	0.069	0.979	7.105	7.156	9.655	0.425 (0.24)	10.317 (8.53)
	WPADS	0.007	0.017	0.096	1.929	1.279	6.164	0.043 (0.03)	6.529 (5.30)
	# of estimates_	26	1326	81718	544622	506532	1881828	936	87126
OTHER	PADS	0.459	0.822	4.309	6.546	7.317	9.652	3.099 (2.67)	10.086 (8.82)
	WPADS	0.304	0.331	0.673	2.357	1.788	6.964	0.493 (0.45)	7.367 (6.17)
	# of estimates_	303	15453	952329	6359651	5903666	21909454	10908	1014733
RACE	PADS	0.520	2.659	5.918	3.734	4.707	7.558	6.187 (5.12)	8.202 (7.61)
	WPADS	0.051	0.092	0.248	1.406	1.336	6.818	0.224 (0.20)	7.783 (6.58)
	# of estimates_	48	2448	150864	1005456	935136	3474144	1728	160848
TOTAL HOUSE HOLDS	PADS	0.265	0.249	0.708	4.632	4.410	5.223	0.433 (0.33)	5.355 (4.66)
	WPADS	0.265	0.267	0.339	1.552	1.097	4.712	0.290 (0.23)	4.876 (4.00)
	# of estimates_	1	51	3143	21029	19486	72242	36	3347
TOTAL HUS	PADS	0.000	0.008	0.232	4.262	4.196	5.154	0.060 (0)	5.297 (4.56)
	WPADS	0.000	0.004	0.034	1.553	1.021	4.664	0.017 (0)	4.797 (3.92)
	# of estimates_	1	51	3143	21029	19486	72242	36	3347
TOTPOP	PADS	2.30E-06	5.40E-06	0.095	4.360	4.062	5.756	0 (0)	6.116 (5.64)
	WPADS	2.30E-06	2.30E-06	0.001	0.531	0.318	5.247	0 (0)	5.617 (4.96)
	# of estimates_	1	51	3143	20947	19482	72378	36	3351

*Value in parenthesis is from Robert Fay (Fay 2007) using 2001-2005 5-year estimates

Table F.2. shows distribution results of PAD1 over the profile lines for each of the six geographic summary area profile lines.

Table F.2 Distribution of PAD1 by Geographic Summary Level Analysis Variable: pad1 Percent diff

	Mean	Std Dev	Minimum	Maximum	N	1st Pctl	5th Pctl
Nation	0.0001	0.0060	-0.0331	0.0196	380	-0.0189	-0.0098
State	-0.0001	0.0264	-1.3846	0.4335	19375	-0.0624	-0.0215
County	-0.0009	0.0961	-1.9153	1.8261	1106108	-0.3140	-0.1164
Cnt Sub	-0.0015	0.1498	-1.9153	1.6522	5401971	-0.4615	-0.2222
Place	0.0051	0.1550	-1.9153	1.8298	5447884	-0.4658	-0.2222
Tract	-0.0024	0.1802	-1.9298	1.8298	21710787	-0.5625	-0.2703
	10th Pctl	Lower Quartile	Median	Upper Quartile	90th Pctl	95th Pctl	99th Pctl
Nation	-0.0070	-0.0033	0.0002	0.0041	0.0071	0.0090	0.0149
State	-0.0124	-0.0044	0.0003	0.0053	0.0118	0.0198	0.0590
County	-0.0639	-0.0179	0.0000	0.0190	0.0632	0.1120	0.2857
Cnt Sub	-0.1440	-0.0537	0.0000	0.0547	0.1438	0.2222	0.4000
Place	-0.1389	-0.0486	0.0000	0.0621	0.1538	0.2381	0.4444
Tract	-0.1818	-0.0781	0.0000	0.0800	0.1818	0.2639	0.4865

4.   Analysis

Note first of all that these measures of bias have the limitation of effectively treating the NOGREG estimate as the true value which is of course not true. They perhaps could be better described as measures of difference between GREG and NOGREG estimates. In addition, it is not clear why one measure is termed as weighted and the other is not. WPAD effectively weights all estimates the same while PAD uses a larger weight for smaller estimates. Both PAD and WPAD are measures of absolute bias at a summary area level.

From Table F.1, the small values of PAD and WPAD for estimates aggregated to the county,

state, and national level invite the conclusion that there is no evidence of systematic bias, which pushes the error in the same direction over aggregation. For estimates aggregated to a larger summary level, if the bias is not systematic the difference between aggregated estimated totals from GREG and NOGREG will be reduced since pluses are compensated by minuses. Significant systematic bias would cause higher PAD and WPAD values at the county, state, and national level than seen here. The results for the test tracts and test counties are similar to those shown in Fay (2007) using 2001-2005 5-year estimates. The Fay (2007) report noted that while WPAD for total households was small at 0.23 for counties, the aggregated value over all test sites was 0.22 indicating some systematic bias. GREG raised the total household estimate in 29 of 34 counties. The new results for all counties in the nation show a similar trend with WPAD for total households of 0.339 for counties, and an aggregated value of 0.265 over the entire

nation indicating some systematic bias. The level of this relative bias for estimated total households is small at less than 0.3 percent. For topics, RACE and OTHER the national level PAD values are close to 0.5. Note that although a PAD of 0.5 is ½ if a percent, at the national-level this represents a large number of persons. For example, for an estimate of 30 million for a race minority, a ½ percent error is 150,000 persons. Smaller geographic summary levels have larger average absolute percent differences (PAD) for topics AGESEX and OTHER. However the decrease from MCD to county is much greater for AGESEX for which a MCD level PAD of 7.105 is decreased to 0.979 for counties. For topic RACE the PAD for counties is actually somewhat larger at 5.918 than the value of 3.734 for county sub-division.

Table F.2 presents results for the PAD1 statistic, which does not involve an absolute value and can thus be negative or positive. Thus, the mean can tend to zero when positive differences are balanced by negative differences. The smallest mean is -0.0024 for tracts and the largest is 0.0051 for places. The largest geographic areas have means closer to zero, -0.0001 for states and 0.0001 for the nation. The minimum and maximum PAD1 values are further from zero for places and tracts with a minimum of about -1.9 percent and a maximum of 1.8 percent. Thus the relative biases even for places and tracts are all less than two percent in absolute value.

Overall this analysis indicates that there are some biases in GREG estimates, as measured by differences with NOGREG estimates. These biases are small in a relative sense and tend to be larger for smaller summary level areas. There is some evidence of small systematic biases due to aggregation from smaller to largest geographic areas. Although the relative biases at the national level are very small, they do represent a rather large number of persons or housing units.

IV. SUMMARY AND POTENTIAL FUTURE RESEARCH

The concern for variances of 5-year national level estimates larger than variances of the corresponding 1-year estimates is more properly expressed as a concern about **mean squared error (ratio estimation bias only)** of 5-year national level estimates that are larger than the **mean squared error** of the corresponding 1-year estimates. This concern only applies at the national level and appears to be caused by small ratio estimation biases due to GREG at the weighting area (tract) level aggregating to high levels where, although relatively small, they grow in relation to the sampling variance. Estimates formed without using GREG do not share this national level concern. Thus, this phenomenon at the national level is the result of ratio estimation bias and not sampling variance. For both GREG and NOGREG estimates the production variance estimator, which actually is an estimate of mean squared error (ratio estimation bias only), is appropriate. The NOGREG estimate likely has less bias but is not unbiased.

The sampling variance portion of the mean squared error is likely similar for GREG and NOGREG.

All replicates estimates higher or lower than the point estimate is an indication of ratio estimation bias, as measured by the production variance estimator, in the point estimates themselves. The second term of the decomposition of the production variance estimate is $4(\bar{\theta}_r - \hat{\theta}_0)^2$. When all replicates are larger or smaller than the production estimate the absolute value of the difference between the replicate average and the production estimate is greater than

if some replicate estimates are higher and some are lower than the production estimate. Limitations in the production variance estimator's accuracy in estimation of the ratio estimation bias of mean squared error could well be a contributor to the increased ratio bias measured.

These results indicate that it is only at the national level using GREG that there is a substantial ratio estimation bias component, likely caused by aggregation. The variance at the national level is very small for both GREG and NOGREG but the bias, although small in a relative sense, is larger for GREG than NOGREG. The GREG weighting does not result in large changes to the point estimates. The advantage in using GREG is reduction in variances of the point estimates at the tract level.

For all results presented here the form of the GREG model is determined using the full sample weight and that same model is used for each replicate for variance estimation. We had planned to reweight allowing the GREG model to be selected independently for each replicate. Due to resource limitations, we have not done this for this report. This may be done in the future, if after reviewing all the results presented, we think that doing so would provide useful information and resources are available.

Histograms of the average ratio of the NOGREG estimate to the GREG estimate over summary topic categories show that the estimates themselves are not much affected by GREG.

The small values of the Percent Absolute Difference (PAD) and Weighted Absolute Difference (WPAD) statistics when summed to the county, state, and national level invite the conclusion that there is no evidence of meaningful systematic bias (not limited to ratio estimation bias). Systematic bias pushes error in the same direction over aggregation. This would cause higher PAD and WPAD values at the county, state, and national level than seen here. Overall the bias analysis indicates that there are some biases in GREG estimates, as measured by differences with NOGREG estimates. These relative biases are small and tend to be larger for smaller summary level areas. There is some evidence of **small** systematic biases due to aggregation from smaller to largest geographic areas. Although the relative biases at the national level are very small, they do represent a rather large number of persons or housing units.

Finally, none of the analyses in this report suggest a need for changes in the production implementation of GREG or to the production variance estimation.

There are two topics of potential research that may be considered in the future pending available resources. Results from research such as this might be used to make minor changes and provide modest improvement in the GREG process, which as noted above does not need to be changed.

- Selecting GREG models independently for each replicate. As noted above simulation of this change was not done here due to resource limitations.
- Data used for independent variables. The production GREG process uses the administrative record counts of persons in age/sex and race/origin groups for ACS households linked to the administrative record. An alternative would be to use the ACS collected data for linked households as the independent counts instead of the administrative counts. Since the regression model for a given characteristic uses a dependent variable equal to the ACS collected total of the dependent variable, it seems

possible that the model fit would be better if ACS collected data were used for both the independent and dependent variables of the regression model.

V.   REFERENCES

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APPENDIX 1 TABLES

Table 1 National CV Ratios (5-year/1-year) and Number of Estimates with CV Ratio Greater Than 0.9 by Topic

Topic	Total # Estimates	FLAG_GREG Y	Average GREG CV Ratio	FLAG_NO GREG Y	Average NOGREG CV Ratio
Age and Sex	26	0	0.308	0	0.309
Ancestry	27	0	0.448	0	0.407
Number of Bedrooms	6	1	0.679	0	0.442
Citizenship	2	1	0.701	0	0.428
Civilian Population	1	0	0.291	0	0.348
Class of Worker	4	1	0.598	0	0.418
Educational Attainment	7	5	0.999	0	0.436
Educational Enrollment	6	2	0.729	0	0.431
Fertility	2	0	0.505	0	0.400
Household Fuel	9	2	0.630	0	0.439
Grandparents	8	0	0.439	0	0.421
Household Type	13	7	1.386	0	0.398
Hispanic Origin Status	6	0	0.439	0	0.397
Family Income	10	4	0.778	0	0.422
Household Income	16	6	0.749	0	0.430
Industry	12	1	0.602	0	0.432
Journey To Work	6	0	0.557	0	0.430
Language	11	0	0.602	0	0.439

Topic	Total # Estimates	FLAG_GREG Y	Average GREG CV Ratio	FLAG_NO GREG Y	Average NOGREG CV Ratio
Labor Force	12	0	0.672	0	0.410
Marital Status	10	6	1.252	0	0.437
Migration	7	3	0.877	0	0.389
Mortgage	2	2	1.444	0	0.412
Occupation	6	2	0.749	0	0.391
Occupied Housing Unit	1	1	1.548	0	0.362
Occupants Per Room	3	1	0.829	0	0.420
Place of Birth	6	3	0.683	0	0.415
Foreign Place of Birth	7	1	0.598	0	0.429
American Indian Race	4	0	0.446	0	0.466
Race Alone or in Combination	6	0	0.460	0	0.386
Asian Race	7	0	0.491	0	0.461
Only One Major Race	6	0	0.481	0	0.433
Race Non-Hispanic	9	0	0.567	0	0.431
Native Hawaiian Pacific Islander Race	4	0	0.495	0	0.518
Only One Race	1	0	0.894	0	0.410
Two or More Races	5	1	0.666	0	0.454
Relationship	7	3	1.079	0	0.418

Topic	Total # Estimates	FLAG_GREG Y	Average GREG CV Ratio	FLAG_NO GREG Y	Average NOGREG CV Ratio
Amount of Rent	17	4	0.703	0	0.456
Number of Rooms	9	3	0.737	0	0.442
Housing Unit Facilities (Plumbing, Kitchen, Telephone)	3	0	0.607	0	0.437
Mortgage Data	28	9	0.830	0	0.426
Tenure	2	2	1.507	0	0.432
Total Households	1	1	1.524	0	0.425
Total Housing Units	1	1	1.972	1	2.541
Units at Address	9	1	0.737	0	0.434
Value of Housing Unit	8	6	0.928	0	0.408
Number of Vehicles	4	2	0.856	0	0.454
Veteran Status	1	0	0.486	0	0.442
Year Built	9	1	0.504	0	0.417
Year Moved In	6	4	0.985	0	0.414
Year of Entry	5	1	0.621	0	0.429
Total	378	88		1	
Average			0.773		0.465

Table 2 National Level5-year/1-year CV Ratio Greater than 0.9 and Averages Alternative Variance Estimation

Topic	Total # Estimates	FLAG_GREG Y	Average GREG CV Ratio	FLAG_NO GREG Y	Average NOGREG CV Ratio
Age and Sex	26	0	0.309	0	0.317
Ancestry	27	0	0.394	0	0.408
Number of Bedrooms	6	0	0.437	0	0.451
Citizenship	2	0	0.413	0	0.436
Civilian Population	1	0	0.508	0	0.484
Class of Worker	4	0	0.400	0	0.417
Educational Attainment	7	0	0.428	0	0.436
Educational Enrollment	6	0	0.448	0	0.434
Fertility	2	0	0.371	0	0.399
Household Fuel	9	0	0.447	0	0.444
Grandparents	8	0	0.409	0	0.419
Household Type	13	0	0.372	0	0.390
Hispanic Origin Status	6	0	0.383	0	0.395
Family Income	10	0	0.402	0	0.422
Household Income	16	0	0.424	0	0.436
Industry	12	0	0.422	0	0.437
Journey To Work	6	0	0.430	0	0.432
Language	11	0	0.418	0	0.436
Labor Force	12	0	0.400	0	0.412
Marital Status	10	0	0.411	0	0.439
Migration	7	0	0.362	0	0.380
Mortgage	2	0	0.485	0	0.461
Occupation	6	0	0.392	0	0.393
Occupied Housing Unit	1	0	0.510	0	0.474
Occupants Per Room	3	0	0.421	0	0.426
Place of Birth	6	0	0.396	0	0.418
Foreign Place of Birth	7	0	0.418	0	0.429
American Indian Race	4	0	0.443	0	0.465
Race Alone or in Combination	6	0	0.375	0	0.390

Topic	Total # Estimates	FLAG_GREG Y	Average GREG CV Ratio	FLAG_NO GREG Y	Average NOGREG CV Ratio
Asian Race	7	0	0.438	0	0.462
Only One Major Race	6	0	0.421	0	0.439
Race Non-Hispanic	9	0	0.421	0	0.433
Native Hawaiian Pacific Islander Race	4	0	0.472	0	0.516
Only One Race	1	0	0.364	0	0.395
Two or More Races	5	0	0.442	0	0.451
Relationship	7	0	0.421	0	0.435
Amount of Rent	17	0	0.452	0	0.468
Number of Rooms	9	0	0.456	0	0.475
Housing Unit Facilities (Plumbing, Kitchen, Telephone)	3	0	0.424	0	0.451
Mortgage Data	28	0	0.439	0	0.437
Tenure	2	0	0.495	0	0.511
Total Households	1	0	0.480	0	0.450
Total Housing Units	1	0	0.800	0	0.771
Units at Address	9	0	0.429	0	0.435
Value of Housing Unit	8	0	0.397	0	0.410
Number of Vehicles	4	0	0.443	0	0.455
Veteran Status	1	0	0.437	0	0.454
Year Built	9	0	0.411	0	0.415
Year Moved In	6	0	0.429	0	0.418
Year of Entry	5	0	0.411	0	0.430
Total	378	0		0	
Average			0.430		0.440

Table 3 State Level 5-year/1-year CV Ratio Greater than 0.9 and Averages Production Variance Estimation

Topic	Total GREG # Estimates	FLAG_ GREG Y	Average GREG CV Ratio	Total NOGREG # Estimates	FLAG_NO GREG Y	Average NOGREG CV Ratio
Age and Sex	758	0	0.347	758	0	0.349
Ancestry	1377	0	0.424	1377	0	0.429
Number of Bedrooms	306	0	0.429	306	0	0.433
Citizenship	102	0	0.438	102	0	0.445
Civilian Population	51	0	0.375	51	0	0.376
Class of Worker	204	0	0.413	204	0	0.409
Educational Attainment	357	0	0.455	357	0	0.433
Educational Enrollment	306	0	0.431	306	0	0.432
Fertility	102	0	0.424	102	0	0.433
Household Fuel	451	0	0.444	451	0	0.436
Grandparents	408	0	0.436	408	0	0.447
Household Type	663	8	0.489	663	0	0.426
Hispanic Origin Status	204	0	0.462	204	0	0.475
Family Income	510	0	0.442	510	0	0.434
Household Income	816	0	0.454	816	0	0.442
Industry	612	0	0.424	612	0	0.426
Journey To Work	306	0	0.427	306	0	0.433
Language	561	0	0.443	561	0	0.455
Labor Force	612	0	0.443	612	0	0.443
Marital Status	510	1	0.477	510	0	0.439
Migration	356	0	0.468	356	0	0.453
Mortgage	102	2	0.524	102	0	0.426
Occupation	306	0	0.438	306	0	0.428
Occupied Housing Unit	51	4	0.607	51	0	0.436

Topic	Total GREG # Estimates	FLAG_ GREG Y	Average GREG CV Ratio	Total NOGREG # Estimates	FLAG_NO GREG Y	Average NOGREG CV Ratio
Occupants per Room	153	2	0.508	153	0	0.463
Place of Birth	306	0	0.431	306	0	0.438
Foreign Place of Birth	357	0	0.444	357	0	0.452
American Indian Race	187	1	0.481	187	1	0.488
Race Alone or in Combination	306	0	0.405	306	0	0.409
Asian Race	357	1	0.443	357	0	0.457
Only One Major Race	306	0	0.412	306	0	0.417
Race Non-Hispanic	459	7	0.448	459	7	0.453
Native Hawaiian Pacific Islander Race	184	3	0.493	184	6	0.505
Only One Race	51	0	0.430	51	0	0.419
Two or More Races	254	0	0.464	254	0	0.470
Relationship	357	2	0.489	357	0	0.442
Amount of Rent	867	0	0.442	867	0	0.444
Number of Rooms	459	0	0.442	459	0	0.437
Housing Unit Facilities (Plumbing, Kitchen, Telephone)	153	0	0.438	153	0	0.447
Mortgage Data	1426	2	0.448	1426	0	0.431
Tenure	102	5	0.556	102	0	0.421
Total Households	51	3	0.588	51	0	0.431

Topic	Total GREG # Estimates	FLAG_ GREG Y	Average GREG CV Ratio	Total NOGREG # Estimates	FLAG_NO GREG Y	Average NOGREG CV Ratio
Total Housing Units	51	39	1.547	51	37	1.645
Units at Address	458	1	0.429	458	0	0.429
Value of Housing Unit	408	0	0.439	408	0	0.421
Number of Vehicles	204	0	0.446	204	0	0.434
Veteran Status	51	0	0.405	51	0	0.409
Year Built	459	0	0.431	459	0	0.440
Year Moved In	306	0	0.443	306	0	0.422
Year of Entry	255	0	0.456	255	0	0.465
	18558	81		18558	51	
Average			0.473			0.460

Table 4 State Level 5-year/1-year CV Ratio Greater than 0.9 and Averages Alternative Variance Estimation

Topic	Total GREG # Estimates	FLAG_ GREG Y	Average GREG CV Ratio	Total NOGREG # Estimates	FLAG_NO GREG Y	Average NOGREG CV Ratio
Age and Sex	758	0	0.346	758	0	0.350
Ancestry	1377	0	0.421	1377	0	0.429
Number of Bedrooms	306	0	0.420	306	0	0.432
Citizenship	102	0	0.426	102	0	0.444
Civilian Population	51	0	0.377	51	0	0.377
Class of Worker	204	0	0.400	204	0	0.409
Educational Attainment	357	0	0.425	357	0	0.432
Educational Enrollment	306	0	0.421	306	0	0.431
Fertility	102	0	0.420	102	0	0.432
Household Fuel	451	0	0.427	451	0	0.435
Grandparents	408	0	0.434	408	0	0.446
Household Type	663	0	0.400	663	0	0.425
Hispanic Origin Status	204	0	0.459	204	0	0.475
Family Income	510	0	0.425	510	0	0.434
Household Income	816	0	0.433	816	0	0.441
Industry	612	0	0.417	612	0	0.425
Journey To Work	306	0	0.422	306	0	0.433
Language	561	0	0.436	561	0	0.455
Labor Force	612	0	0.431	612	0	0.443
Marital Status	510	0	0.420	510	0	0.439
Migration	356	0	0.440	356	0	0.454
Mortgage	102	0	0.413	102	0	0.425
Occupation	306	0	0.420	306	0	0.428
Occupied Housing Unit	51	0	0.422	51	0	0.446

Topic	Total GREG # Estimates	FLAG_ GREG Y	Average GREG CV Ratio	Total NOGREG # Estimates	FLAG_NO GREG Y	Average NOGREG CV Ratio
Occupants per Room	153	0	0.441	153	0	0.461
Place of Birth	306	0	0.420	306	0	0.438
Foreign Place of Birth	357	0	0.437	357	0	0.452
American Indian Race	187	1	0.480	187	1	0.488
Race Alone or in Combination	306	0	0.400	306	0	0.410
Asian Race	357	1	0.441	357	0	0.457
Only One Major Race	306	0	0.407	306	0	0.418
Race Non-Hispanic	459	7	0.443	459	7	0.453
Native Hawaiian Pacific Islander Race	184	2	0.492	184	6	0.505
Only One Race	51	0	0.408	51	0	0.419
Two or More Races	254	0	0.455	254	0	0.470
Relationship	357	0	0.421	357	0	0.441
Amount of Rent	867	0	0.431	867	0	0.443
Number of Rooms	459	0	0.427	459	0	0.438
Housing Unit Facilities (Plumbing, Kitchen, Telephone)	153	0	0.432	153	0	0.446
Mortgage Data	1426	0	0.425	1426	0	0.430
Tenure	102	0	0.400	102	0	0.420
Total Households	51	0	0.392	51	0	0.423
Total Housing Units	51	34	1.164	51	34	1.146

Topic	Total GREG # Estimates	FLAG_ GREG Y	Average GREG CV Ratio	Total NOGREG # Estimates	FLAG_NO GREG Y	Average NOGREG CV Ratio
Units at Address	458	0	0.414	458	0	0.428
Value of Housing Unit	408	0	0.414	408	0	0.420
Number of Vehicles	204	0	0.420	204	0	0.433
Veteran Status	51	0	0.402	51	0	0.409
Year Built	459	0	0.427	459	0	0.439
Year Moved In	306	0	0.416	306	0	0.420
Year of Entry	255	0	0.448	255	0	0.465
Total	18558	45		18558	48	
Average			0.438			0.450

Table 5 County Year/1-year CV Ratio Greater than 0.9 and Averages Production Variance
Estimation

Topic	Total GREG # Estimates	FLAG_ GREG Y	Average GREG CV Ratio	Total NOGREG # Estimates	FLAG_NO GREG Y	Average NOGREG CV Ratio
Age and Sex	19801	218	0.361	19801	223	0.364
Ancestry	20368	96	0.449	20368	103	0.453
Number of Bedrooms	4835	4	0.428	4835	5	0.440
Citizenship	1612	4	0.444	1612	5	0.456
Civilian Population	807	98	1.149	807	94	1.110
Class of Worker	3003	4	0.418	3003	4	0.424
Educational Attainment	5649	1	0.429	5649	1	0.434
Educational Enrollment	4842	1	0.421	4842	3	0.431
Fertility	1609	0	0.432	1609	0	0.444
Household Fuel	5707	75	0.452	5707	75	0.455
Grandparents	6160	10	0.452	6160	12	0.461
Household Type	10490	11	0.410	10490	10	0.431
Hispanic Origin Status	2890	89	0.499	2890	93	0.514
Population in Households	797	51	0.987	797	51	0.987
Family Income	8069	0	0.428	8069	0	0.436
Household Income	12911	1	0.436	12911	1	0.444
Industry	9684	1	0.420	9684	1	0.428
Journey to Work	4759	14	0.432	4759	13	0.440
Language	8371	88	0.458	8371	101	0.470
Labor Force	9523	11	0.428	9523	10	0.438
Marital Status	8067	2	0.422	8067	2	0.438
Migration	5608	10	0.442	5608	12	0.455
Mortgage	1614	0	0.412	1614	0	0.419
Occupation	4836	2	0.422	4836	1	0.431

Topic	Total GREG # Estimates	FLAG_ GREG Y	Average GREG CV Ratio	Total NOGREG # Estimates	FLAG_NO GREG Y	Average NOGREG CV Ratio
Occupied Housing Unit	807	0	0.443	807	0	0.456
Occupants per Room	2340	8	0.455	2340	6	0.471
Place of Birth	4841	13	0.438	4841	13	0.449
Foreign Place of Birth	4933	91	0.473	4933	98	0.480
American Indian Race	1065	138	0.613	1065	135	0.613
Race Alone or in Combination	4396	222	0.468	4395	226	0.475
Asian Race	4432	144	0.502	4432	148	0.511
Only One Major Race	4381	151	0.455	4381	150	0.462
Race Non-Hispanic	6019	294	0.494	6019	314	0.502
Native Hawaiian Pacific Islander Race	745	145	0.676	745	147	0.681
Only One Race	807	8	0.430	807	10	0.437
Two or More Races	3595	105	0.486	3595	110	0.497
Relationship	5649	1	0.422	5649	3	0.438
Amount of Rent	13586	15	0.439	13586	19	0.450
Number of Rooms	7241	7	0.435	7241	9	0.443
Housing Unit Facilities (Plumbing, Kitchen, Telephone)	2343	6	0.446	2343	6	0.457
Mortgage Data	21740	52	0.435	21740	47	0.438
Tenure	1614	1	0.414	1614	1	0.424

Topic	Total GREG # Estimates	FLAG_GREG Y	Average GREG CV Ratio	Total NOGREG # Estimates	FLAG_NOGREG Y	Average NOGREG CV Ratio
Total Households	807	1	0.415	807	1	0.434
Total Housing Units	807	61	0.554	807	61	0.556
Total Population	1	0	0.593	1	0	0.600
Units at Address	6781	41	0.425	6781	38	0.437
Value of Housing Unit	6391	7	0.424	6391	5	0.428
Number of Vehicles	3228	0	0.422	3228	0	0.434
Veteran Status	807	0	0.413	807	0	0.419
Year Built	7263	2	0.428	7263	3	0.438
Year Moved In	4841	0	0.415	4841	0	0.419
Year of Entry	3914	27	0.467	3914	30	0.478
Total	287386	2331		287385	2400	
Average			0.475			0.483

Table 6 County 5-year/1-year CV Ratio Greater than 0.9 and Averages Alternative Variance Estimation

Topic	Total GREG # Estimates	FLAG_ GREG Y	Average GREG CV Ratio	Total NOGREG # Estimates	FLAG_NO GREG Y	Average NOGREG CV Ratio
Age and Sex	19801	217	0.375	19801	224	0.378
Ancestry	20368	95	0.448	20368	100	0.453
Number of Bedrooms	4835	4	0.427	4835	5	0.439
Citizenship	1612	3	0.442	1612	4	0.456
Civilian Population	807	98	1.338	807	94	1.306
Class of Worker	3003	4	0.417	3003	4	0.424
Educational Attainment	5649	1	0.426	5649	1	0.433
Educational Enrollment	4842	1	0.420	4842	3	0.431
Fertility	1609	0	0.431	1609	0	0.444
Household Fuel	5707	74	0.449	5707	75	0.455
Grandparents	6160	10	0.451	6160	12	0.460
Household Type	10490	11	0.403	10490	10	0.431
Hispanic Origin Status	2890	90	0.498	2890	93	0.514
Population in Households	797	51	1.004	797	51	1.004
Family Income	8069	0	0.427	8069	0	0.436
Household Income	12911	1	0.434	12911	1	0.444
Industry	9684	1	0.419	9684	1	0.428
Journey to Work	4759	15	0.431	4759	13	0.439
Language	8371	86	0.457	8371	99	0.470
Labor Force	9523	10	0.427	9523	10	0.438
Marital Status	8067	2	0.418	8067	2	0.438
Migration	5608	10	0.440	5608	12	0.455
Mortgage	1614	0	0.404	1614	0	0.418
Occupation	4836	2	0.420	4836	1	0.430

Topic	Total GREG # Estimates	FLAG_ GREG Y	Average GREG CV Ratio	Total NOGREG # Estimates	FLAG_NO GREG Y	Average NOGREG CV Ratio
Occupied Housing Unit	807	0	0.427	807	0	0.456
Occupants per Room	2340	8	0.450	2340	6	0.470
Place of Birth	4841	13	0.437	4841	14	0.449
Foreign Place of Birth	4933	90	0.472	4933	98	0.480
American Indian Race	1065	135	0.611	1065	135	0.613
Race Alone or in Combination	4396	221	0.467	4395	227	0.475
Asian Race	4432	141	0.502	4432	148	0.511
Only One Major Race	4381	149	0.454	4381	149	0.462
Race Non-Hispanic	6019	294	0.493	6019	310	0.502
Native Hawaiian Pacific Islander Race	745	143	0.674	745	145	0.680
Only One Race	807	8	0.428	807	10	0.437
Two or More Races	3595	104	0.485	3595	111	0.497
Relationship	5649	2	0.417	5649	3	0.438
Amount of Rent	13586	15	0.438	13586	19	0.449
Number of Rooms	7241	7	0.433	7241	9	0.442
Housing Unit Facilities (Plumbing, Kitchen, Telephone)	2343	5	0.445	2343	6	0.457
Mortgage Data	21740	51	0.432	21740	47	0.437
Tenure	1614	1	0.400	1614	1	0.423

Topic	Total GREG # Estimates	FLAG_ GREG Y	Average GREG CV Ratio	Total NOGREG # Estimates	FLAG_NO GREG Y	Average NOGREG CV Ratio
Total Households	807	1	0.403	807	1	0.432
Total Housing Units	807	60	0.564	807	61	0.561
Total Population	1	0	0.591	1	0	0.596
Units at Address	6781	40	0.423	6781	39	0.437
Value of Housing Unit	6391	7	0.422	6391	5	0.427
Number of Vehicles	3228	0	0.420	3228	0	0.434
Veteran Status	807	0	0.412	807	0	0.418
Year Built	7263	2	0.427	7263	3	0.438
Year Moved In	4841	0	0.412	4841	0	0.418
Year of Entry	3914	29	0.466	3914	32	0.478
Total	287386	2312		287385	2394	
Average			0.477			0.487

Table 7 Minor civil division Year/1-year CV Ratio Greater than 0.9 and Averages Production Variance Estimation

Topic	Total GREG # Estimates	FLAG_ GREG Y	Average GREG CV Ratio	Total NOGREG # Estimates	FLAG_NO GREG Y	Average NOGREG CV Ratio
Age and Sex	5018	7	0.38	5018	7	0.432
Ancestry	4844	34	0.451	4844	30	0.455
Number of Bedrooms	1149	0	0.417	1149	0	0.433
Citizenship	386	0	0.425	386	0	0.447
Civilian Population	193	0	0.327	193	0	0.436
Class of Worker	663	3	0.427	663	3	0.440
Educational Attainment	1351	0	0.425	1351	0	0.437
Educational Enrollment	1158	0	0.411	1158	0	0.440
Fertility	379	1	0.440	379	1	0.454
Household Fuel	1152	35	0.469	1152	35	0.474
Grandparents	1298	14	0.475	1298	12	0.484
Household Type	2508	0	0.393	2508	0	0.428
Hispanic Origin Status	1089	10	0.452	1089	9	0.485
Population in Households	193	20	0.715	193	20	0.718
Family Income	1925	0	0.431	1925	0	0.439
Household Income	3083	0	0.429	3083	1	0.446
Industry	2316	0	0.421	2316	0	0.431
Journey To Work	1152	0	0.427	1152	0	0.439
Language	2057	6	0.436	2057	4	0.461
Labor Force	2208	8	0.411	2208	7	0.443
Marital Status	1926	1	0.422	1926	2	0.440
Migration	1346	3	0.444	1346	3	0.461
Mortgage	386	0	0.387	386	0	0.414

Topic	Total GREG # Estimates	FLAG_GREG Y	Average GREG CV Ratio	Total NOGREG # Estimates	FLAG_NOGREG Y	Average NOGREG CV Ratio
Occupation	1100	4	0.427	1100	5	0.441
Occupied Housing Unit	193	0	0.432	193	0	0.446
Occupants per Room	545	6	0.433	545	2	0.461
Place of Birth	1157	2	0.420	1157	2	0.443
Foreign Place of Birth	1172	19	0.457	1172	20	0.476
American Indian Race	126	22	0.663	126	27	0.657
Race Alone or in Combination	1064	25	0.450	1064	27	0.481
Asian Race	1075	20	0.500	1075	18	0.513
Only One Major Race	980	14	0.434	980	17	0.466
Race Non-Hispanic	1445	32	0.473	1445	31	0.495
Native Hawaiian Pacific Islander Race	47	25	0.900	47	25	0.857
Only One Race	193	1	0.439	193	1	0.439
Two or More Races	851	16	0.521	851	17	0.527
Relationship	1351	0	0.408	1351	0	0.441
Amount of Rent	3209	9	0.436	3209	5	0.450
Number of Rooms	1726	2	0.427	1726	2	0.438
Housing Unit Facilities (Plumbing, Kitchen, Telephone)	506	5	0.455	506	6	0.462
Mortgage Data	4813	35	0.438	4813	35	0.443

Topic	Total GREG # Estimates	FLAG_ GREG Y	Average GREG CV Ratio	Total NOGREG # Estimates	FLAG_NO GREG Y	Average NOGREG CV Ratio
Tenure	386	0	0.386	386	0	0.422
Total Households	193	0	0.364	193	0	0.417
Total Housing Units	193	0	0.356	193	0	0.421
Total Population	193	169	1.595	193	168	1.630
Units at Address	1514	11	0.414	1514	10	0.434
Value of Housing Unit	1462	6	0.432	1462	5	0.437
Number of Vehicles	772	0	0.414	772	0	0.433
Veteran Status	193	0	0.400	193	0	0.420
Year Built	1731	2	0.427	1731	2	0.441
Year Moved In	1158	0	0.405	1158	0	0.421
Year of Entry	946	7	0.457	946	6	0.477
Total	68074	574		68074	565	
Average			0.469			0.489

Table 8 Minor civil division Year/1-year CV Ratio Greater than 0.9 and Averages Alternative
Variance Estimation

Topic	Total GREG # Estimates	FLAG_ GREG Y	Average GREG CV Ratio	Total NOGREG # Estimates	FLAG_NO GREG Y	Average NOGREG CV Ratio
Age and Sex	5018	7	0.379	5018	7	0.432
Ancestry	4844	34	0.450	4844	30	0.454
Number of Bedrooms	1149	0	0.415	1149	0	0.432
Citizenship	386	0	0.424	386	0	0.447
Civilian Population	193	0	0.326	193	0	0.436
Class of Worker	663	3	0.425	663	3	0.439
Educational Attainment	1351	0	0.423	1351	0	0.436
Educational Enrollment	1158	0	0.410	1158	0	0.440
Fertility	379	1	0.439	379	1	0.454
Household Fuel	1152	35	0.467	1152	34	0.473
Grandparents	1298	13	0.473	1298	12	0.483
Household Type	2508	0	0.390	2508	0	0.428
Hispanic Origin Status	1089	10	0.451	1089	9	0.484
Population in Households	193	20	0.840	193	20	0.839
Family Income	1925	0	0.429	1925	0	0.438
Household Income	3083	0	0.427	3083	1	0.445
Industry	2316	0	0.420	2316	0	0.431
Journey To Work	1152	0	0.427	1152	0	0.439
Language	2057	6	0.435	2057	4	0.461
Labor Force	2208	8	0.410	2208	6	0.443
Marital Status	1926	1	0.420	1926	2	0.439
Migration	1346	3	0.443	1346	3	0.461
Mortgage	386	0	0.383	386	0	0.414
Occupation	1100	4	0.426	1100	5	0.441

Topic	Total GREG # Estimates	FLAG_ GREG Y	Average GREG CV Ratio	Total NOGREG # Estimates	FLAG_NO GREG Y	Average NOGREG CV Ratio
Occupied Housing Unit	193	0	0.424	193	0	0.447
Occupants per Room	545	6	0.431	545	2	0.461
Place of Birth	1157	2	0.419	1157	2	0.442
Foreign Place of Birth	1172	18	0.456	1172	20	0.476
American Indian Race	126	22	0.660	126	27	0.656
Race Alone or in Combination	1064	25	0.449	1064	26	0.481
Asian Race	1075	20	0.499	1075	18	0.512
Only One Major Race	980	14	0.433	980	17	0.466
Race Non-Hispanic	1445	32	0.472	1445	31	0.495
Native Hawaiian Pacific Islander Race	47	24	0.895	47	25	0.854
Only One Race	193	1	0.437	193	1	0.437
Two or More Races	851	16	0.519	851	17	0.526
Relationship	1351	0	0.405	1351	0	0.441
Amount of Rent	3209	9	0.435	3209	5	0.450
Number of Rooms	1726	2	0.425	1726	2	0.437
Housing Unit Facilities (Plumbing, Kitchen, Telephone)	506	5	0.454	506	6	0.462
Mortgage Data	4813	35	0.436	4813	34	0.442
Tenure	386	0	0.380	386	0	0.421

Topic	Total GREG # Estimates	FLAG_ GREG Y	Average GREG CV Ratio	Total NOGREG # Estimates	FLAG_NO GREG Y	Average NOGREG CV Ratio
Total Households	193	0	0.359	193	0	0.416
Total Housing Units	193	0	0.355	193	0	0.421
Total Population	193	189	1.446	193	189	1.458
Units at Address	1514	10	0.413	1514	8	0.433
Value of Housing Unit	1462	6	0.430	1462	5	0.437
Number of Vehicles	772	0	0.413	772	0	0.433
Veteran Status	193	0	0.399	193	0	0.419
Year Built	1731	2	0.426	1731	2	0.441
Year Moved In	1158	0	0.403	1158	0	0.420
Year of Entry	946	7	0.456	946	6	0.477
Total	68074	590		68074	580	
Average			0.467			0.487

Table 9 Place Year/1-year CV Ratio Greater than 0.9 and Averages Production Variance Estimation

Topic	Total GREG # Estimates	FLAG_ GREG Y	Average GREG CV Ratio	Total NOGREG # Estimates	FLAG_NO GREG Y	Average NOGREG CV Ratio
Age and Sex	13233	12	0.383	13233	13	0.426
Ancestry	12560	100	0.456	12560	108	0.459
Number of Bedrooms	3047	1	0.420	3047	1	0.437
Citizenship	1020	0	0.429	1020	0	0.452
Civilian Population	510	2	0.348	510	2	0.430
Class of Worker	1778	11	0.425	1778	10	0.438

Topic	Total GREG # Estimates	FLAG_ GREG Y	Average GREG CV Ratio	Total NOGREG # Estimates	FLAG_NO GREG Y	Average NOGREG CV Ratio
Educational Attainment	3569	0	0.427	3569	0	0.440
Educational Enrollment	3060	0	0.417	3060	0	0.441
Fertility	1004	0	0.435	1004	0	0.449
Household Fuel	2975	115	0.472	2975	103	0.475
Grandparents	3632	27	0.468	3632	25	0.477
Household Type	6627	0	0.403	6627	0	0.433
Hispanic Origin Status	2864	25	0.459	2864	26	0.493
Population in Households	510	82	1.133	510	82	1.131
Family Income	5088	1	0.433	5088	1	0.442
Household Income	8151	0	0.433	8151	0	0.447
Industry	6118	0	0.421	6118	0	0.432
Journey To Work	3037	6	0.431	3037	6	0.441
Language	5396	28	0.442	5396	29	0.469
Labor Force	5935	15	0.417	5935	14	0.442
Marital Status	5096	2	0.426	5096	2	0.442
Migration	3551	8	0.440	3551	11	0.456
Mortgage	1020	0	0.398	1020	0	0.418
Occupation	2995	5	0.426	2995	6	0.440
Occupied Housing Unit	510	0	0.440	510	0	0.450
Occupants per Room	1467	7	0.441	1467	6	0.466
Place of Birth	3058	2	0.421	3058	2	0.445
Foreign Place of Birth	3202	36	0.459	3202	36	0.478
American Indian Race	525	84	0.650	525	93	0.652

Topic	Total GREG # Estimates	FLAG_ GREG Y	Average GREG CV Ratio	Total NOGREG # Estimates	FLAG_NO GREG Y	Average NOGREG CV Ratio
Race Alone or in Combination	2923	49	0.445	2923	53	0.473
Asian Race	3028	52	0.491	3028	50	0.504
Only One Major Race	2781	34	0.435	2781	41	0.465
Race Non-Hispanic	3938	66	0.461	3938	71	0.483
Native Hawaiian Pacific Islander Race	495	95	0.669	495	93	0.675
Only One Race	510	10	0.429	510	11	0.431
Two or More Races	2238	47	0.503	2238	43	0.508
Relationship	3570	0	0.415	3570	0	0.445
Amount of Rent	8474	22	0.437	8474	21	0.450
Number of Rooms	4568	3	0.429	4568	4	0.440
Housing Unit Facilities (Plumbing, Kitchen, Telephone)	1395	10	0.454	1395	9	0.462
Mortgage Data	13053	87	0.441	13053	84	0.444
Tenure	1020	0	0.395	1020	0	0.424
Total Households	510	0	0.378	510	0	0.423
Total Housing Units	510	2	0.374	510	2	0.430
Total Population	489	383	1.516	489	380	1.501
Units at Address	4136	20	0.417	4136	19	0.435
Value of Housing Unit	3931	11	0.435	3931	9	0.440

Topic	Total GREG # Estimates	FLAG_ GREG Y	Average GREG CV Ratio	Total NOGREG # Estimates	FLAG_NO GREG Y	Average NOGREG CV Ratio
Number of Vehicles	2040	0	0.419	2040	0	0.435
Veteran Status	510	0	0.410	510	0	0.425
Year Built	4552	8	0.427	4552	5	0.443
Year Moved In	3046	1	0.405	3046	1	0.418
Year of Entry	2499	9	0.459	2499	13	0.478
Total	181754	1478		181754	1485	
Average			0.473			0.491

Table 10 Place Year/1-year CV Ratio Greater than 0.9 and Averages Alternative Variance Estimation

Topic	Total GREG # Estimates	FLAG_ GREG Y	Average GREG CV Ratio	Total NOGREG # Estimates	FLAG_NO GREG Y	Average NOGREG CV Ratio
Age and Sex	13233	12	0.383	13233	13	0.426
Ancestry	12560	100	0.455	12560	107	0.459
Number of Bedrooms	3047	1	0.419	3047	1	0.436
Citizenship	1020	0	0.428	1020	0	0.452
Civilian Population	510	2	0.347	510	2	0.430
Class of Worker	1778	11	0.424	1778	10	0.438
Educational Attainment	3569	0	0.425	3569	0	0.439
Educational Enrollment	3060	0	0.416	3060	0	0.441
Fertility	1004	0	0.434	1004	0	0.448
Household Fuel	2975	115	0.470	2975	99	0.474
Grandparents	3632	27	0.467	3632	25	0.477
Household Type	6627	0	0.399	6627	0	0.432
Hispanic Origin Status	2864	25	0.470	2864	26	0.503
Population in Households	510	82	1.311	510	83	1.309
Family Income	5088	1	0.432	5088	1	0.442
Household Income	8151	0	0.431	8151	0	0.447
Industry	6118	0	0.420	6118	0	0.432
Journey to Work	3037	6	0.430	3037	6	0.441
Language	5396	29	0.441	5396	29	0.469
Labor Force	5935	15	0.416	5935	14	0.442
Marital Status	5096	2	0.424	5096	2	0.442
Migration	3551	8	0.439	3551	11	0.456
Mortgage	1020	0	0.393	1020	0	0.418
Occupation	2995	5	0.425	2995	6	0.439
Occupied	510	0	0.430	510	0	0.451

Topic	Total GREG # Estimates	FLAG_ GREG Y	Average GREG CV Ratio	Total NOGREG # Estimates	FLAG_NO GREG Y	Average NOGREG CV Ratio
Housing Unit						
Occupants per Room	1467	7	0.438	1467	6	0.466
Place of Birth	3058	2	0.420	3058	2	0.445
Foreign Place of Birth	3202	34	0.458	3202	36	0.477
American Indian Race	525	83	0.648	525	93	0.651
Race Alone or in Combination	2923	48	0.444	2923	54	0.473
Asian Race	3028	52	0.490	3028	50	0.504
Only One major Race	2781	34	0.434	2781	41	0.465
Race Non-Hispanic	3938	68	0.460	3938	71	0.483
Native Hawaiian Pacific Islander Race	495	93	0.668	495	93	0.675
Only One Race	510	10	0.426	510	11	0.430
Two or More Races	2238	47	0.501	2238	42	0.508
Relationship	3570	0	0.412	3570	0	0.445
Amount of Rent	8474	22	0.436	8474	21	0.450
Number of Rooms	4568	3	0.427	4568	4	0.440
Housing Unit Facilities (Plumbing, Kitchen, Telephone)	1395	10	0.453	1395	9	0.462
Mortgage Data	13053	87	0.439	13053	81	0.444
Tenure	1020	0	0.388	1020	0	0.423
Total Households	510	0	0.372	510	0	0.423

Topic	Total GREG # Estimates	FLAG_ GREG Y	Average GREG CV Ratio	Total NOGREG # Estimates	FLAG_NO GREG Y	Average NOGREG CV Ratio
Total Housing Units	510	2	0.372	510	2	0.429
Total Population	489	411	1.421	489	411	1.414
Units at Address	4136	19	0.416	4136	18	0.434
Value of Housing Unit	3931	11	0.433	3931	9	0.439
Number of Vehicles	2040	0	0.417	2040	0	0.435
Veteran Status	510	0	0.409	510	0	0.424
Year Built	4552	7	0.426	4552	5	0.443
Year Moved In	3046	1	0.403	3046	1	0.417
Year of Entry	2499	9	0.458	2499	13	0.478
Total	181754	1501		181754	1508	
Average			0.473			0.493

Table 11 Mean Standard Error Ratios (GREG/NOGREG) by Topic

Topic	Nation	State	County	County Sub.	Place	Tract
Overall	1.681	1.022	0.994	0.991	1.011	0.944
Age and Sex	0.992	0.998	1.043	0.956	0.989	0.847
Ancestry	1.103	0.991	1.004	1.011	1.026	1.017
Number of Bedrooms	1.541	0.991	0.981	0.993	1.009	0.956
Citizenship	1.607	0.985	0.988	1.004	1.008	0.971
Civilian Population	0.836	0.999	1.095	0.913	0.962	0.707
Class of Worker	1.425	1.010	0.993	0.995	1.019	0.943
Educational Attainment	2.327	1.053	0.989	0.998	1.018	0.972
Educational Enrollment	1.675	1.003	0.980	0.982	1.010	0.929
Fertility	1.296	0.984	0.983	1.010	1.019	1.013
Household	1.410	1.026	0.997	1.004	1.022	0.966

Topic	Nation	State	County	County Sub.	Place	Tract
Fuel						
Grandparents	1.048	0.976	0.997	1.014	1.032	1.021
Household Type	3.641	1.160	0.957	0.973	1.000	0.894
Hispanic Origin Status	1.096	1.104	1.108	0.997	1.006	0.916
Population in Households	2.090	1.200	0.994	0.993	1.030	0.685
Family Income	1.908	1.026	0.990	1.008	1.025	1.002
Household Income	1.773	1.031	0.987	0.995	1.014	0.966
Industry	1.388	0.998	0.989	1.005	1.022	0.994
Journey To Work	1.285	0.987	0.989	1.000	1.017	0.972
Language	1.372	0.972	0.994	1.001	1.010	0.952
Labor Force	1.670	1.003	0.978	0.970	1.002	0.851
Marital Status	2.913	1.086	0.965	0.986	1.007	0.948
Migration	2.195	1.027	0.975	0.989	1.005	0.948
Mortgage	3.567	1.247	0.980	0.981	1.010	0.931
Occupation	1.878	1.026	0.982	0.997	1.018	0.960
Occupied Housing Unit	4.191	1.363	0.929	0.956	0.978	0.896
Occupants per Room	1.988	1.104	0.966	0.970	1.000	0.852
Place of Birth	1.633	0.985	0.984	0.989	1.013	0.854
Foreign Place of Birth	1.403	0.981	0.999	1.003	1.007	0.980
American Indian Race	0.956	0.985	1.009	1.011	1.019	1.020
Race Alone or in Combination	1.199	0.994	1.009	0.994	1.008	0.932
Asian Race	1.076	0.971	1.003	1.011	1.011	1.020
Only One Major Race	1.105	0.986	1.004	0.990	1.004	0.923
Race Non-Hispanic	1.304	0.994	1.006	0.995	1.009	0.955

Topic	Nation	State	County	County Sub.	Place	Tract
Native Hawaiian Pacific Islander Racerace Non-Hispanic	0.942	0.962	1.005	1.008	1.004	1.019
Only One Race	2.181	1.030	0.990	0.989	1.026	0.706
Two or More Races	1.467	0.997	1.003	1.013	1.027	1.031
Relationship	2.570	1.106	0.956	0.968	0.996	0.893
Amount of Rent	1.535	0.991	0.980	0.995	1.005	0.972
Number of Rooms	1.683	1.011	0.987	0.997	1.013	0.982
Housing Unit Facilities (Plumbing, Kitchen, Telephone)	1.370	0.971	0.983	0.996	1.007	0.998
Mortgage Data	1.988	1.047	0.998	1.007	1.025	1.005
Tenure	3.539	1.336	0.965	0.972	0.999	0.862
Total Households	3.596	1.365	0.945	0.946	0.987	0.661
Total Housing Units	0.776	1.021	0.996	0.922	0.969	0.470
Total Population	2.403	1.250	0.839	1.004	1.045	0.696
Units at Address	1.712	0.997	0.985	0.987	1.002	0.954
Value of Housing Unit	2.308	1.052	0.998	1.009	1.028	1.011
Number of Vehicles	2.049	1.033	0.977	0.992	1.012	0.951
Veteran Status	1.102	0.992	0.989	0.985	1.007	0.967
Year Built	1.184	0.983	0.985	1.000	1.015	0.982
Year Moved In	2.420	1.060	0.991	0.996	1.017	0.969
Year of Entry	1.446	0.978	0.992	1.005	1.011	0.976

Table 12 Estimates with Point Estimate Higher or Lower than all Replicate Estimates

Topic	Nation All Reps Hi or Low			State All Reps Hi or Low			County All Reps Hi or Low		
	N	GREG	NO GREG	N	GREG	NO GREG	N	GREG	NO GREG
Age and Sex	26	1	0	1326	0	0	79114	35	33
Ancestry	27	0	0	1377	0	0	72679	6	3
Number of Bedrooms	6	0	0	306	0	0	18720	0	0
Citizenship	2	1	0	102	0	0	6122	0	0
Civilian Population	1	0	0	51	0	0	3143	10	9
Class of Worker	4	1	0	204	0	0	12149	0	0
Educational Attainment	7	4	0	357	0	0	21993	0	0
Educational Enrollment	6	0	0	306	0	0	18812	1	1
Fertility	2	0	0	102	0	0	6109	3	3
Household Fuel	9	1	0	459	0	0	22610	0	1
Grandparents	8	0	0	408	0	0	23265	3	3
Household Type	13	8	0	663	8	0	40785	7	4
Hispanic Origin Status	6	0	0	278	0	0	10975	1	1
Family Income	10	4	0	510	0	0	31228	0	0
Household Income	16	4	0	816	0	0	50076	8	8
Industry	12	1	0	612	0	0	37540	0	0
Journey To Work	6	0	0	306	0	0	18140	2	2
Language	11	0	0	561	0	0	29882	6	3
Labor Force	12	0	0	612	0	0	36731	3	1
Marital Status	10	6	0	510	0	0	31260	3	3
Migration	7	4	0	356	0	0	21502	0	0
Mortgage	2	2	0	102	0	0	6283	1	0
Occupation	6	2	0	306	0	0	18849	0	0
Occupied Housing Unit	1	1	0	51	1	0	3143	0	0
Occupants per Room	3	1	0	153	4	0	8834	6	6
Place of Birth	6	1	0	306	0	0	18736	0	0
Foreign Place of Birth	7	0	0	357	0	0	16949	1	0
American Indian	4	0	0	202	0	0	4605	1	0

Topic	Nation All	Reps Hi	or Low	State All	Reps Hi	or Low	County All	Reps Hi	or Low
Race									
Race Alone or in Combination	6	0	0	306	0	0	16974	6	3
Asian Race	7	0	0	357	0	0	12458	6	6
Only one Major Race	6	0	0	306	0	0	16094	5	6
Race Non-Hispanic	9	0	0	459	0	0	22557	13	11
Native Hawaiian Pacific Islander Race	4	0	0	202	0	0	2718	1	1
Only One Race	1	1	0	51	0	0	3143	0	0
Two or More Races	5	1	0	255	0	0	12435	4	5
Relationship	7	3	0	357	2	0	21979	25	20
Amount of Rent	17	2	0	867	0	0	51591	2	2
Number of Rooms	9	1	0	459	0	0	28038	0	0
Housing Unit Facilities (Plumbing, Kitchen, Telephone)	3	0	0	153	0	0	8988	0	0
Mortgage Data	28	9	0	1428	0	0	85256	2	0
Tenure	2	2	0	102	7	0	6285	4	2
Total Households	1	1	0	51	2	0	3143	7	7
Total Housing Units	1	1	1	51	1	3	3143	11	9
Units at Address	9	1	0	459	0	0	25795	1	0
Value of Housing Unit	8	5	0	408	0	0	24394	0	1
Number of Vehicles	4	2	0	204	0	0	12559	1	1
Veteran Status	1	0	0	51	0	0	3141	0	0
Year Built	9	0	0	459	0	0	28214	0	0
Year Moved In	6	3	0	306	0	0	18849	2	3
Year of Entry	5	1	0	255	0	0	14191	2	3

Topic	County subdiv. All Reps Hi or Low			Place All Reps Hi or Low			Tract All Reps Hi or Low		
	N	GREG	NO GREG	N	GREG	NO GREG	N	GREG	NO GREG
Age and Sex	511534	71	65	495739	20	19	1865106	13	9
Ancestry	312389	24	24	296358	12	10	1238290	11	7
Number of Bedrooms	101992	1	0	99563	1	0	382591	1	0
Citizenship	22441	13	13	24363	3	2	132010	1	1
Civilian Population	20947	1	0	19482	0	0	72374	1	0
Class of Worker	64860	2	2	61291	2	2	230393	3	3
Educational Attainment	132189	8	7	129920	9	7	499115	0	0
Educational Enrollment	105226	18	17	106150	8	6	420050	5	3
Fertility	23054	17	15	25929	8	6	109141	15	14
Household Fuel	104522	1	0	87849	0	0	313943	0	0
Grandparents	61460	7	6	76835	4	5	303450	6	5
Household Type	240010	4	1	239633	1	1	913961	1	3
Hispanic Origin Status	57043	14	20	63855	6	6	304682	9	6
Family Income	160161	2	1	160446	1	1	645517	0	1
Household Income	275992	4	3	277387	0	0	1088986	3	1
Industry	202925	14	14	205900	15	14	834234	4	4
Journey To Work	89376	25	23	87178	13	11	368004	8	5
Language	111557	48	37	115675	17	15	577928	18	15
Labor Force	222660	6	7	214756	2	2	810058	4	3
Marital Status	169596	53	46	174708	16	10	682232	13	10
Migration	103730	44	35	110343	9	8	449511	7	7
Mortgage	40629	0	0	38743	0	0	142729	0	0
Occupation	114810	3	6	109803	3	4	397219	0	0
Occupied Housing Unit	18318	0	0	18676	0	0	69658	0	0
Occupants per Room	34124	1	3	36134	0	0	149023	1	2
Place of Birth	106734	25	16	103361	18	13	418678	5	3
Foreign Place of Birth	48975	23	22	54086	2	1	298314	3	3
American Indian	4384	4	3	6435	2	1	16976	2	1

Topic	County subdiv. All Reps Hi or Low			Place All Reps Hi or Low			Tract All Reps Hi or Low		
Race									
Race Alone or in Combination	60651	33	35	67958	8	5	318672	10	9
Asian Race	20610	13	13	26154	1	3	159194	15	16
Only one Major Race	51644	28	26	59271	8	6	281792	11	10
Race Non-Hispanic	71493	35	34	80986	9	8	364546	19	21
Native Hawaiian Pacific Islander Race	1109	1	1	3278	0	0	9819	1	1
Only One Race	20946	15	12	19482	12	8	72377	3	2
Two or More Races	33329	18	16	39349	7	5	175136	16	17
Relationship	128917	89	85	129461	28	26	499838	38	30
Amount of Rent	205006	8	2	237557	3	0	962256	5	3
Number of Rooms	148895	0	0	148761	0	0	574479	1	1
Housing Unit Facilities (Plumbing, Kitchen, Telephone)	27563	1	1	29785	1	2	118776	1	2
Mortgage Data	416286	2	2	417263	2	2	1516789	2	1
Tenure	39704	1	0	38393	0	0	143701	1	0
Total Households	20947	1	2	19482	0	0	72227	1	2
Total Housing Units	21029	0	1	19486	0	1	72242	4	0
Units at Address	88975	1	2	104148	0	0	426529	1	1
Value of Housing Unit	123769	0	1	110104	0	0	437675	0	1
Number of Vehicles	74647	1	0	74815	0	0	283460	0	0
Veteran Status	19746	0	0	19282	0	0	72000	0	0
Year Built	159555	2	1	156136	1	0	578836	0	0
Year Moved In	114923	1	2	113206	1	1	414610	1	1
Year of Entry	48695	28	23	53827	6	2	277055	5	3

Table 13 Ethnicity Independent Variables Selected For GREG Model Count of Tracts

Origin Cell	Frequency	Percent
0	37311	51.62
1	8362	11.57
2	10465	14.48
3	3374	4.67
12	3994	5.52
13	4532	6.27
23	985	1.36
123	3261	4.51
Total	72284	100

Table 14 Age/Sex Independent Variables Selected for GREG Model Count of Tracts

Choice	Frequency	Percent
0	430	0.59
1	370	0.51
2	2645	3.66
3	12393	17.14
4	56446	78.09
Total	72284	99.99

Table 15 Cross-classification of Ethnicity and Age/Sex GREG Model Choice Count of Tracts

Origin Cell		Choice				
		0	1	2	3	4
0	Frequency	430	370	1586	6687	28238
	Percent	0.59	0.51	2.19	9.25	39.07
1	Frequency	0	0	296	1622	6444
	Percent	0	0	0.41	2.24	8.91
2	Frequency	0	0	357	1803	8305
	Percent	0	0	0.49	2.49	11.49
3	Frequency	0	0	93	494	2787
	Percent	0	0	0.13	0.68	3.86
12	Frequency	0	0	130	638	3226
	Percent	0	0	0.18	0.88	4.46
13	Frequency	0	0	103	650	3779
	Percent	0	0	0.15	0.9	5.23
23	Frequency	0	0	13	106	866
	Percent	0	0	0.01	0.15	1.2
123	Frequency	0	0	67	393	2801
	Percent	0	0	0.09	0.55	3.87

Table 16 Distribution of Average g weight by Model Choice

Origin Cell	Choice	Mean	Standard Deviation	Minimum	Maximum	N
All Tracts		1.021	0.079	0.608	6.004	72284
0	0	1	0	1	1	430
	1	1.024153	0.08859	0.775368	1.336142	370
	2	1.034369	0.177832	0.706514	6.003993	1586
	3	1.024499	0.099588	0.607737	2.491919	6687
	4	1.020187	0.069822	0.65723	1.913527	28238
1	2	1.015317	0.091231	0.750481	1.382721	296
	3	1.023228	0.091568	0.770812	1.542969	1622
	4	1.019483	0.075602	0.748437	1.734282	6444
2	2	1.028264	0.107968	0.807825	1.90992	357
	3	1.018961	0.08709	0.74389	1.788052	1803
	4	1.018166	0.070663	0.770411	1.520343	8305
3	2	1.010873	0.100176	0.720932	1.514339	93
	3	1.021535	0.079502	0.721556	1.35177	494
	4	1.019486	0.063066	0.805793	1.731126	2787
12	2	1.018414	0.082841	0.084346	0.887604	130
	3	1.016749	0.078098	0.077392	0.795617	638
	4	1.019407	0.070675	0.069491	0.82336	3226
23	2	1.024657	0.086132	0.07873	1.352762	103
	3	1.031045	0.083877	0.082789	0.815233	650
	4	1.023641	0.066603	0.065023	0.789486	3779
32	2	0.996861	0.125344	0.115406	0.92786	13
	3	1.010608	0.081072	0.073896	0.886333	106
	4	1.021235	0.069167	0.067249	0.845553	866
123	2	1.031536	0.072195	0.058946	0.97589	67
	3	1.018928	0.069753	0.061451	0.904879	393
	4	1.021148	0.063543	0.059195	0.864796	2801

Table 17 Distributions of Difference between Administrative Frame Count and Unbiased Sample Estimate

Variable	N	Mean	Std Dev	Sum	Minimum	Maximum
Frame Count	72284	2.038	122.780	147306.000	-687.755	1228.000
Male/Female 0-17	56446	5.753	167.671	324752.000	-1142.000	941.359
Male/Female 18-29	56446	3.857	129.126	217710.000	-810.401	773.665
Male 30-44	56446	3.700	80.943	208869.000	-539.262	546.079
Female 30-44	56446	3.408	79.020	192360.000	-593.891	483.695
Male 45-64	56446	1.221	80.093	68925.000	-473.293	474.019
Female 45-64	56446	0.938	80.040	52921.000	-504.521	456.054
Male/Female 65+	56446	-3.074	89.864	-173513.000	-675.475	568.433
Male/Female 0-17	12393	-9.756	174.989	-120911.000	-1096.000	1050.000
Male/Female 18-44	12393	-19.888	189.997	-246470.000	-1150.000	831.804
Male/Female 45-64	12393	-23.315	186.726	-288939.000	-1248.000	818.392
Total Persons	2645	-123.926	361.117	-327785.000	-2442.000	1107.000
Hispanic	20149	0.131	260.389	2638.000	-2167.000	1663.000
Black Non-Hispanics	18705	6.718	224.456	125654.000	-1641.000	1385.000
Other Non-White Non-Hispanics	12152	7.089	185.167	86150.000	-1610.000	1175.000

Table 18 NOGREG and GREG Estimates Random Sample of Estimates Before HU Controls

TOPIC	STUB	STATE	Y_NOGREG	Y_GREG	Ratio
Age and Sex	Females 15-years and over	Kentucky	1646176	1656531	0.994
HU Value	$200,000 to $299,999	Alabama	160554	162757	0.986
Ancestry	Portuguese	Arizona	15634	15534	1.006
Industry	Transportation and warehousing, and utilities	Arkansas	64440	64691	0.996
Family Income	$50,000 to $74,999	Arkansas	152006	152606	0.996
Family Income	$10,000 to $14,999	Delaware	4769	4640	1.028
Educational Attainment	Less than 9th grade	District of Columbia	16679	15645	1.066
Civilian Population	Civilian population 18 years and over	District of Columbia	401151	401114	1.000
Ancestry	Irish	District of Columbia	35762	35781	0.999
Household Income	$50,000 to $74,999	Florida	1301003	1311533	0.992
Fertility	Women 15 - 50 years old gave birth in the past 12 months	Georgia	130346	132665	0.983
Industry	Construction	Hawaii	46142	45906	1.005
Foreign Place of Birth	Europe	Kansas	14053	13904	1.011
Educational Attainment	Associate's degree	Minnesota	322937	325540	0.992
Tenure	Renter-occupied	Missouri	690266	687558	1.004
Language	Other languages	Nebraska	9182	9081	1.011
Migration	Same county	New Hampshire	92159	90311	1.020
Grandparents	1 or 2 years	North Carolina	21656	21670	0.999
Household Incomeinch	$75,000 to $99,999	Rhode Island	56284	56741	0.992
Mortgage Data	Less than $100	Rhode Island	159	155	1.027

TOPIC	STUB	STATE	Y_NOGREG	Y_GREG	Ratio
Household incomeinch	$150,000 to $199,999	Tennessee	65310	66386	0.984
Household Income	With retirement income	Vermont	42737	42648	1.002
Occupation	Sales and office occupations	Wisconsin	677425	681681	0.994
Educational Attainment	9th to 12th grade, no diploma	Wyoming	18915	18725	1.010
American Indian Race	Sioux tribal grouping	Kentucky	219	257	0.854
Only One Major Race	Some other race	Louisiana	44635	44843	0.995
Raceone	One race	Montana	860940	867079	0.993
Total Households	Total households	Kansas	1080613	1085819	0.995
Total Housing Units	Total housing units	New York	7995295	7998708	1.000
Total Population	Total population	Rhode Island	986936	987048	1.000

Table 19 : NOGREG and GREG Estimates Random Sample of Estimates After HU Controls

TOPIC	STUB	STATE	Y_NOGREG	Y_GREG	Ratio
Age And Sex	55 to 59 years	California	1995083	2004663	0.995
Year Built	Built 1939 or earlier	Arkansas	78351	78199	1.002
Family Income	$75,000 to $99,999	Colorado	191673	192699	0.995
Household Fuel	Solar energy	Colorado08	2387	2393	0.998
Family Income	$200,000 or more	District of Columbia	16545	16684	0.992
Foreign Place of Birth	Foreign-born population, excluding population born at sea	Georgia	837221	835067	1.003
Household Type	65-years and over	Iowa	134369	135579	0.991
Family NCF	$200,000 or more	Kansas	28855	29489	0.978
Mortgage Data	Not computed	Kansas	1102	1071	1.028
Rent	$200 to $299	Kansas	12844	12771	1.006
Grandparents	Responsible for grandchildren	Maryland	46156	45920	1.005
Ancestry	English	Michigan	1003904	1009808	0.994
Grandparents	Who are married	Missouri	35086	34754	1.010
Units at Address	3 or 4 units	Montana	20795	20677	1.006
Ancestry	French Canadian	New Jersey	23531	23674	0.994
Language	Asian and Pacific Islander languages	North Carolina	110090	110465	0.997
Journey To Work	Walked	Rhode Island	11628	11657	0.998
Fuel	Coal or coke	South Dakota	259	257	1.008
Language	Speak English less than "very well"	Tennessee	149672	147807	1.013

TOPIC	STUB	STATE	Y_NOGREG	Y_GREG	Ratio
Housing Unit Facilities (Plumbing, Kitchen, Telephone)	Lacking complete kitchen facilities	Texas	72881	72371	1.007
Mortgage Data	30.0 to 34.9 percent	Vermont	12159	12261	0.992
Journey To Work	Other means	Virginia	50159	50213	0.999
Value of Housing Unit	$50,000 to $99,999	Wisconsin	210046	211448	0.993
Family Income	$50,000 to $74,999	Wyoming	32633	32584	1.001
Two or More Races	White and American Indian and Alaska Native	Maryland	16869	16541	1.020
Race Non-Hispanic	Asian alone	Texas	828525	831436	0.996
Native Hawaiian Pacific Islander Racerace Non-Hispanic	Guamanian or Chamorro	Wyoming	35	33	1.041
Total Households	Total households	Missouri	2343709	2349866	0.997
Total Housing Units	Total housing units	Arizona	2776053	2776053	1.000
Total Population	Total population	Colorado	4671555	4674933	0.999

APPENDIX 2   GRAPHS

Graph 1 Nation Level Profile Line Histogram for SE Ratio

(GREG/NOGREG)

Distribution of SERATIO
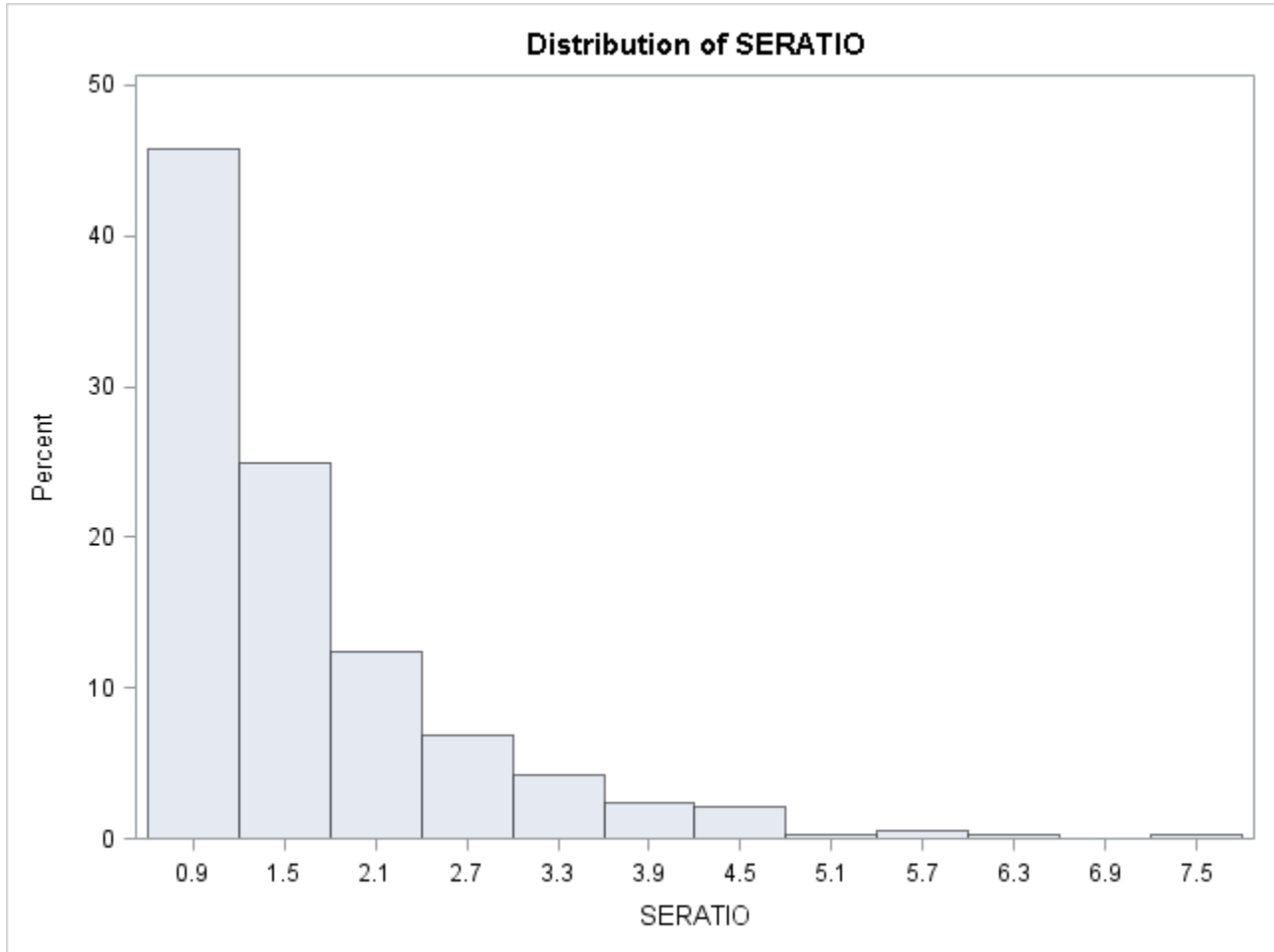
Graph 2 State Level Profile Line Histogram for SE Ratio

(GREG/NOGREG)

Distribution of SERATIO
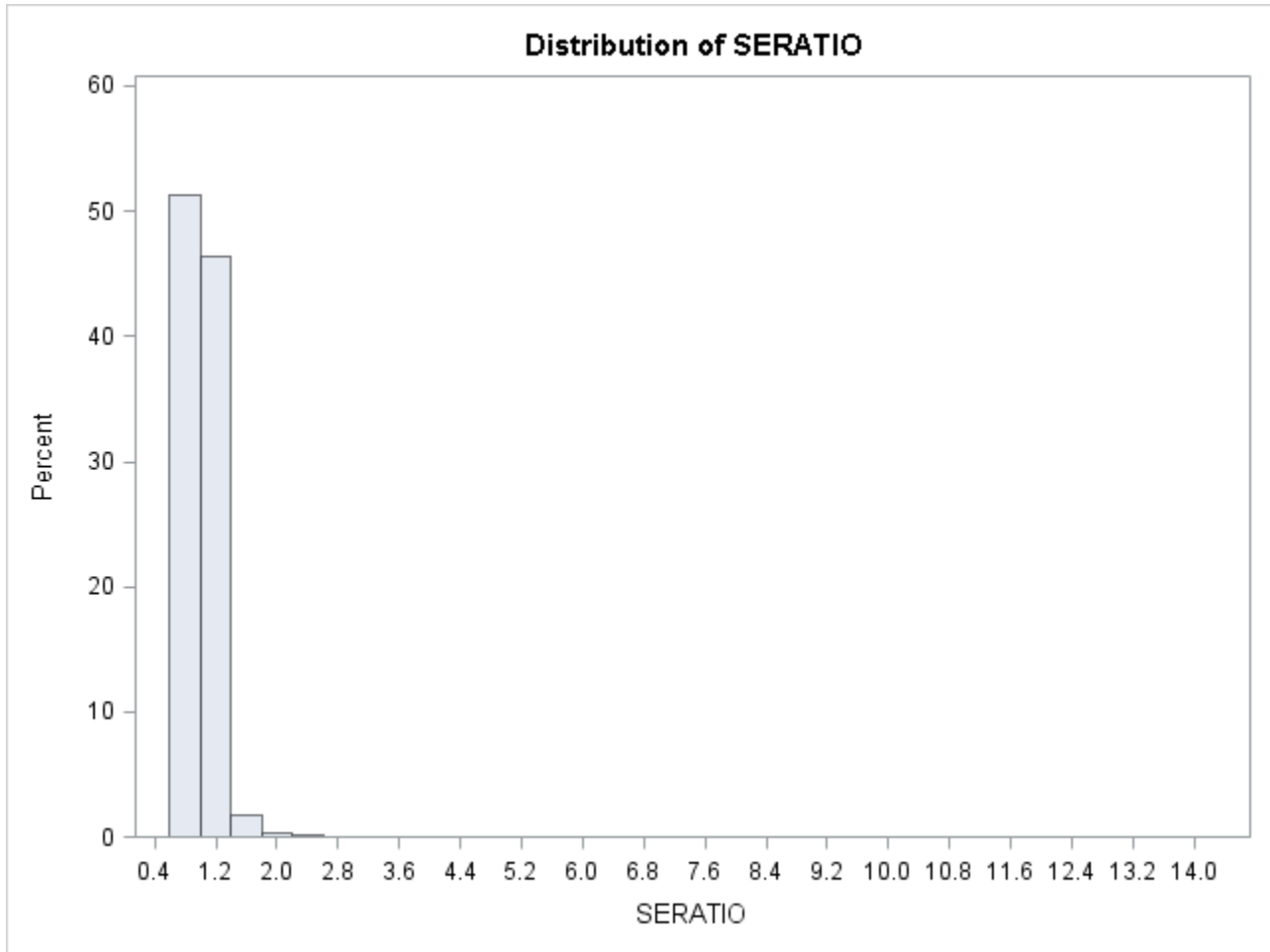
Graph 3 County Level Profile Line Histogram for SE Ratio

(GREG/NOGREG)

Distribution of SERATIO
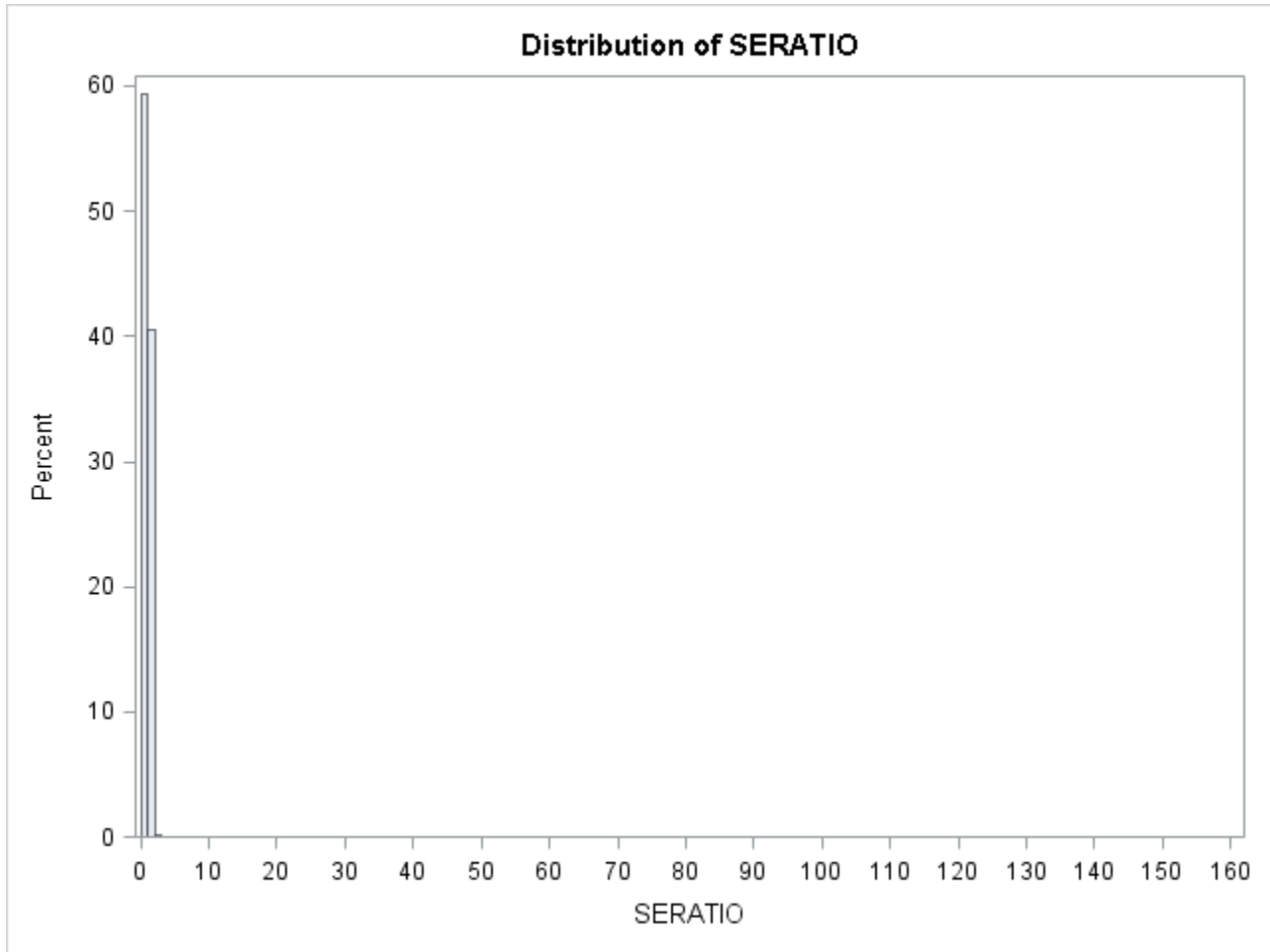
Graph 4 Cminor civil division Level Profile Line Histogram for SE Ratio
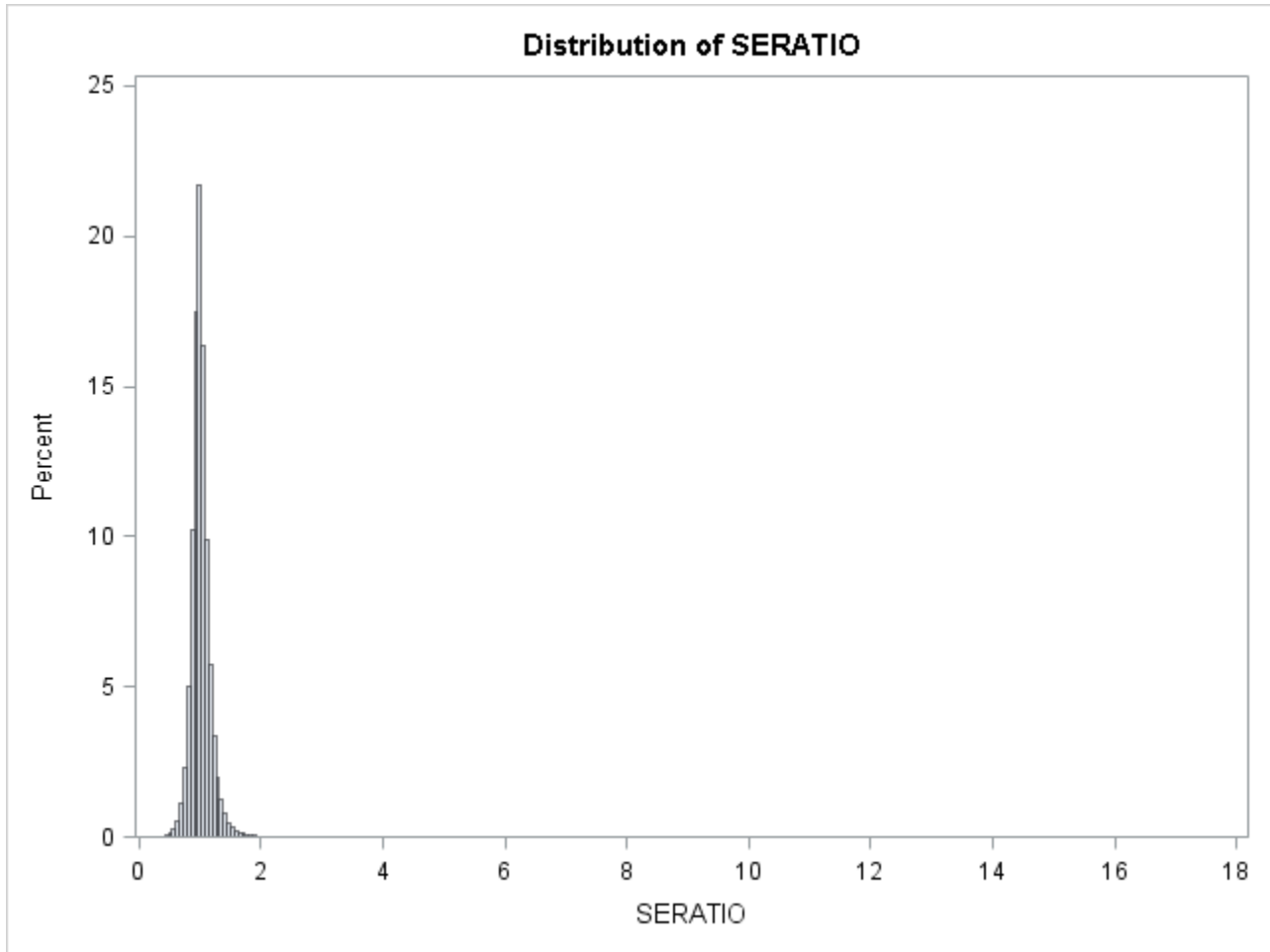
(GREG/NOGREG)

Graph 5 Place Level Profile Line Histogram for SE Ratio

(GREG/NOGREG)

Distribution of SERATIO
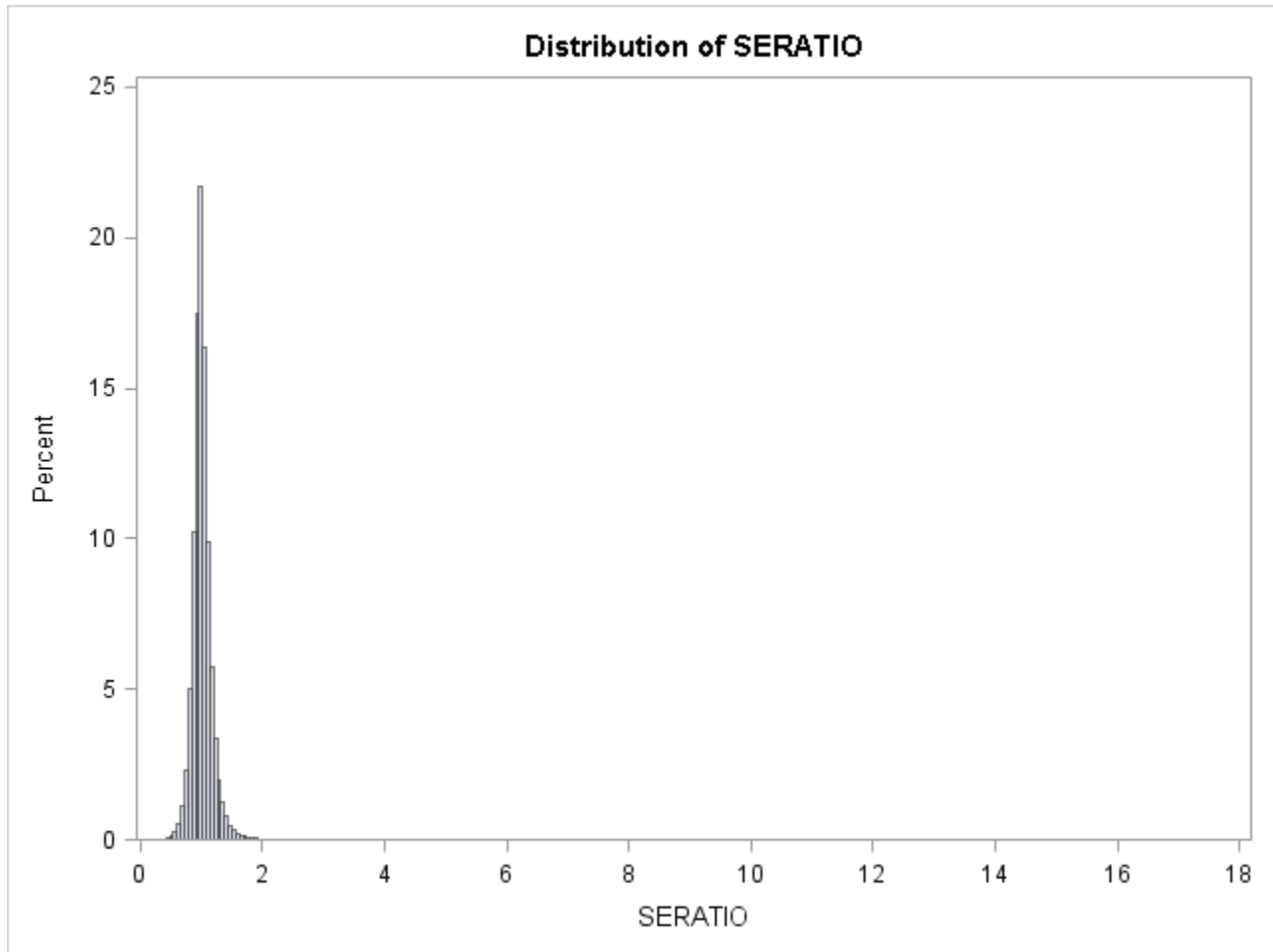
Graph 6 Tract-level Profile Line Histogram for SE Ratio

(GREG/NOGREG)

Distribution of SERATIO
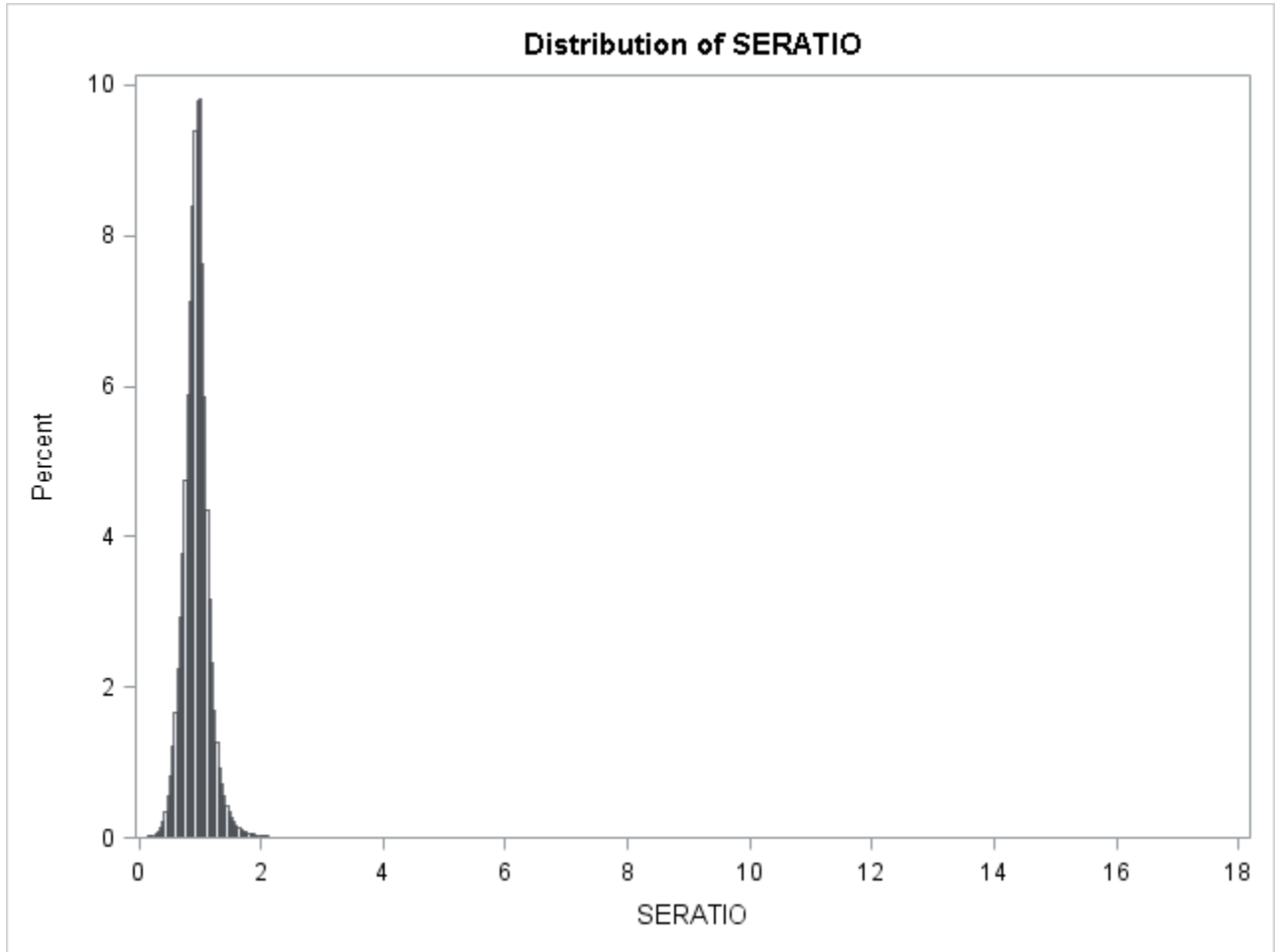
Graph 7 Histogram for Mean Tract g Weight
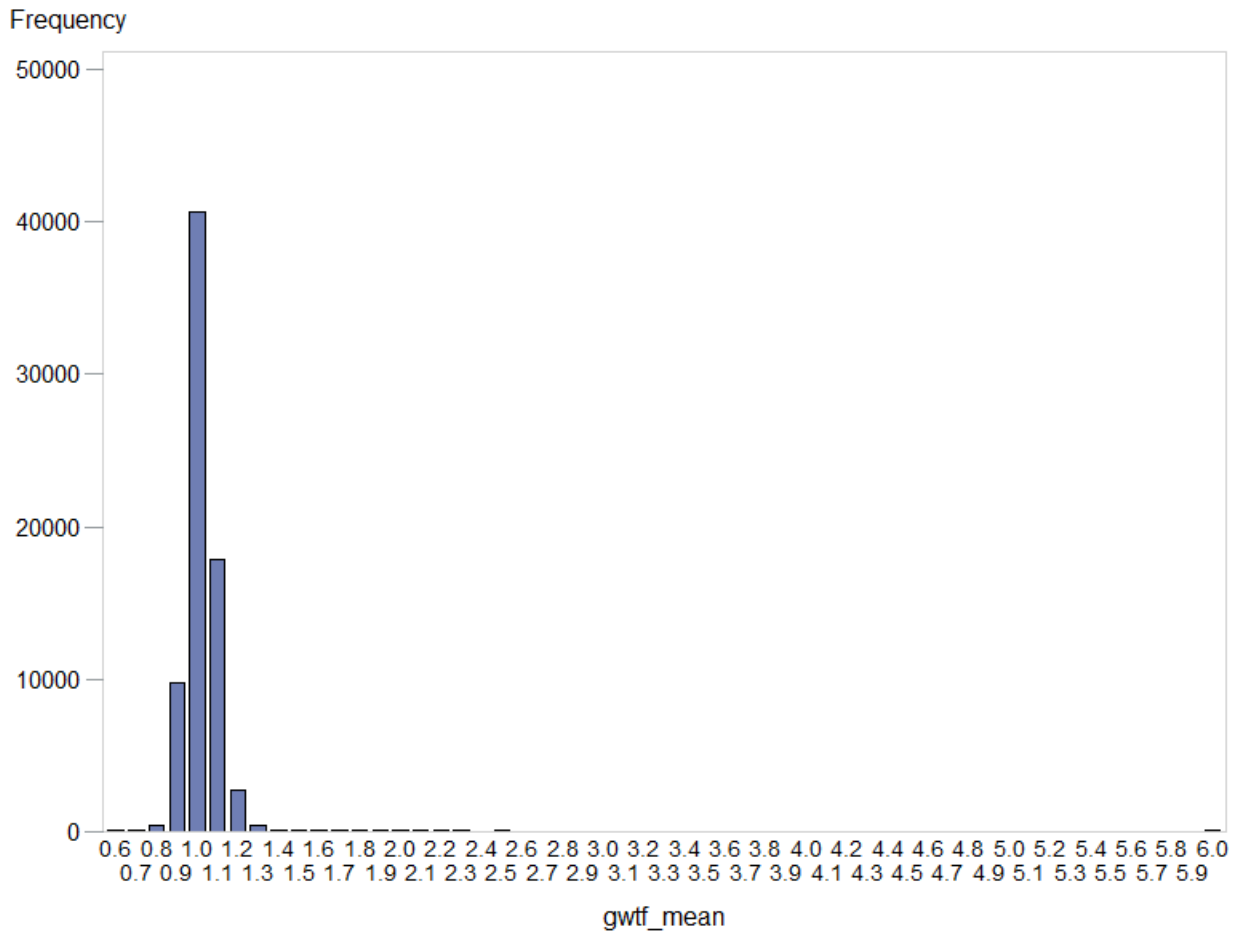
Graph 8 Dependent Variable High Final GREG Housing Weight

ROC Curve for Model
Area Under the Curve = 0.8008
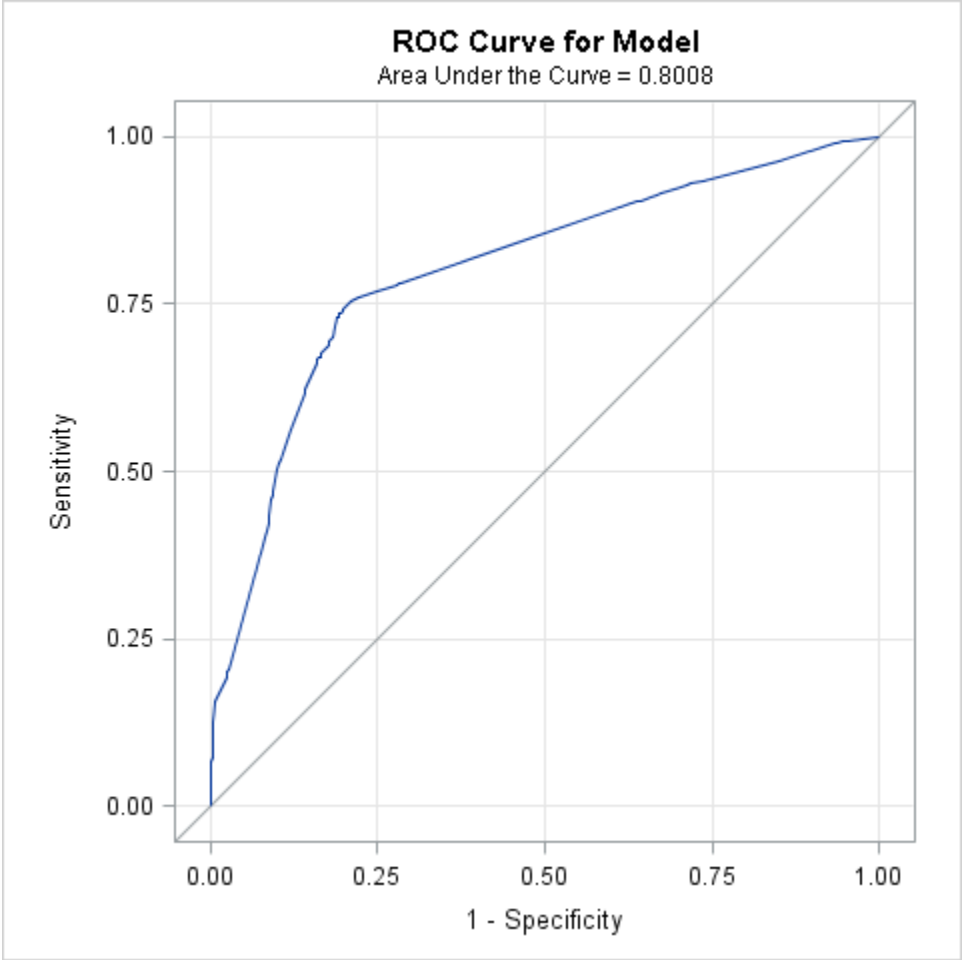
Graph 9 Dependent Variable Low Final GREG Housing Weight

ROC Curve for Model

Area Under the Curve = 0.9334
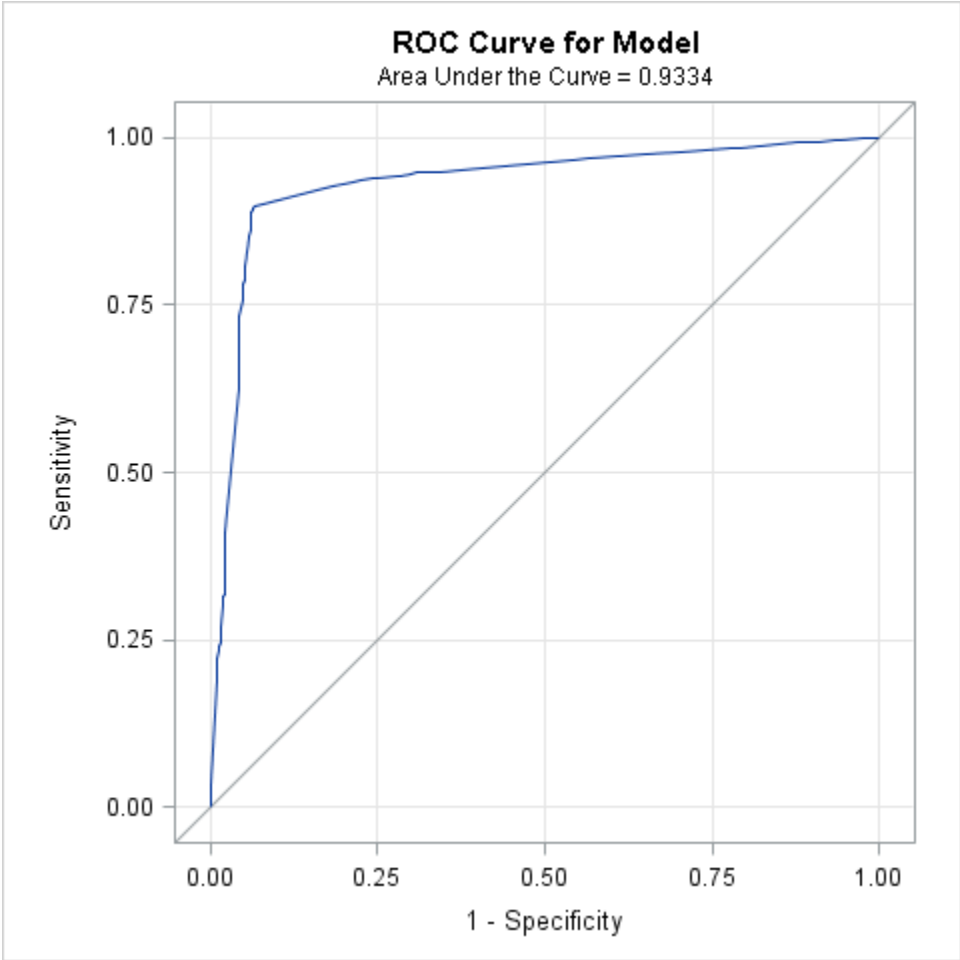
Graph 10 Dependent Variable High Final NOGREG Housing Weight

ROC Curve for Model
Area Under the Curve = 0.8171
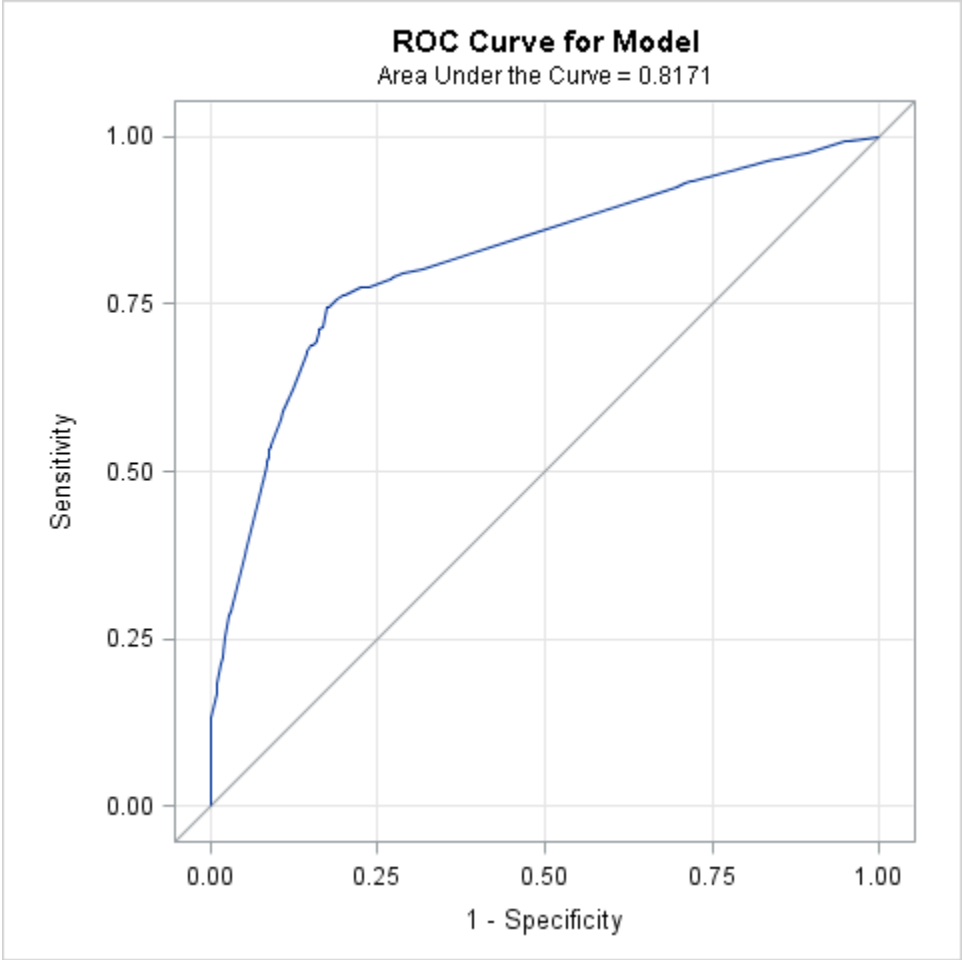
Graph 11 Dependent Variable Low Final NOGREG Housing Weight

ROC Curve for Model
Area Under the Curve = 0.9651
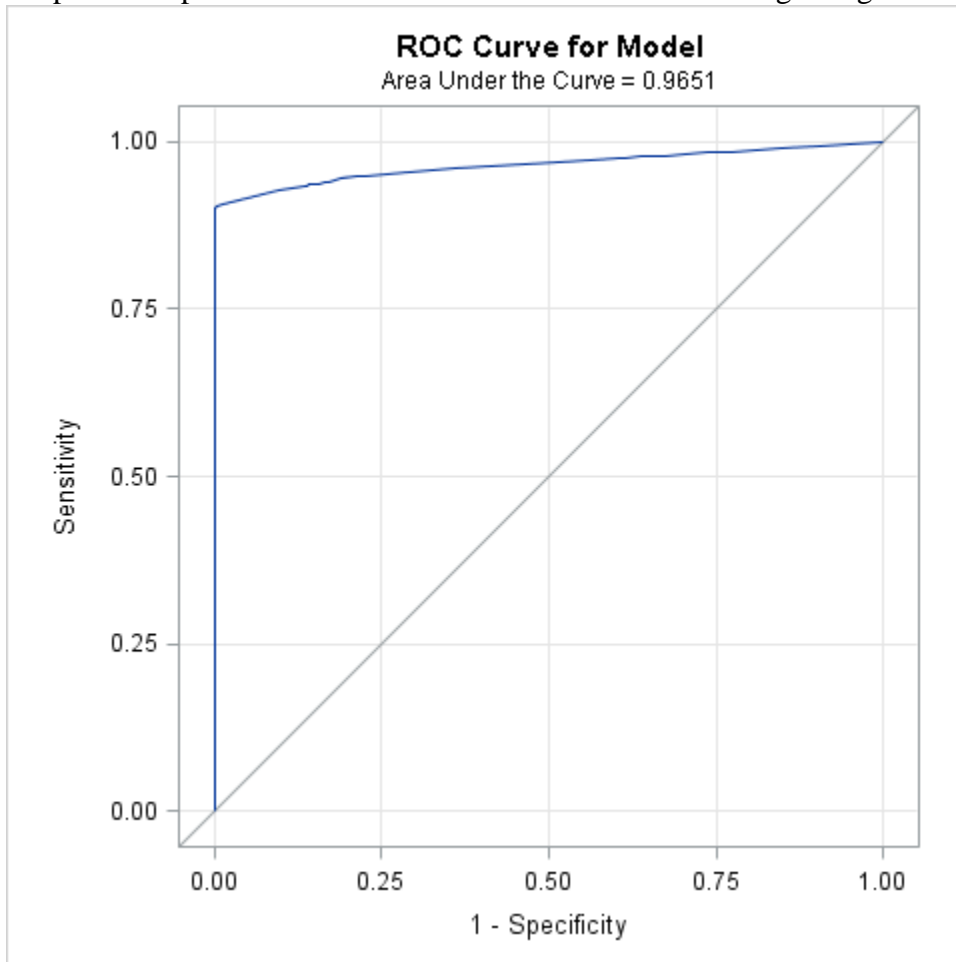
Graph 12 Dependent Variable High Final GREG Person Weight

ROC Curve for Model
Area Under the Curve = 0.6781
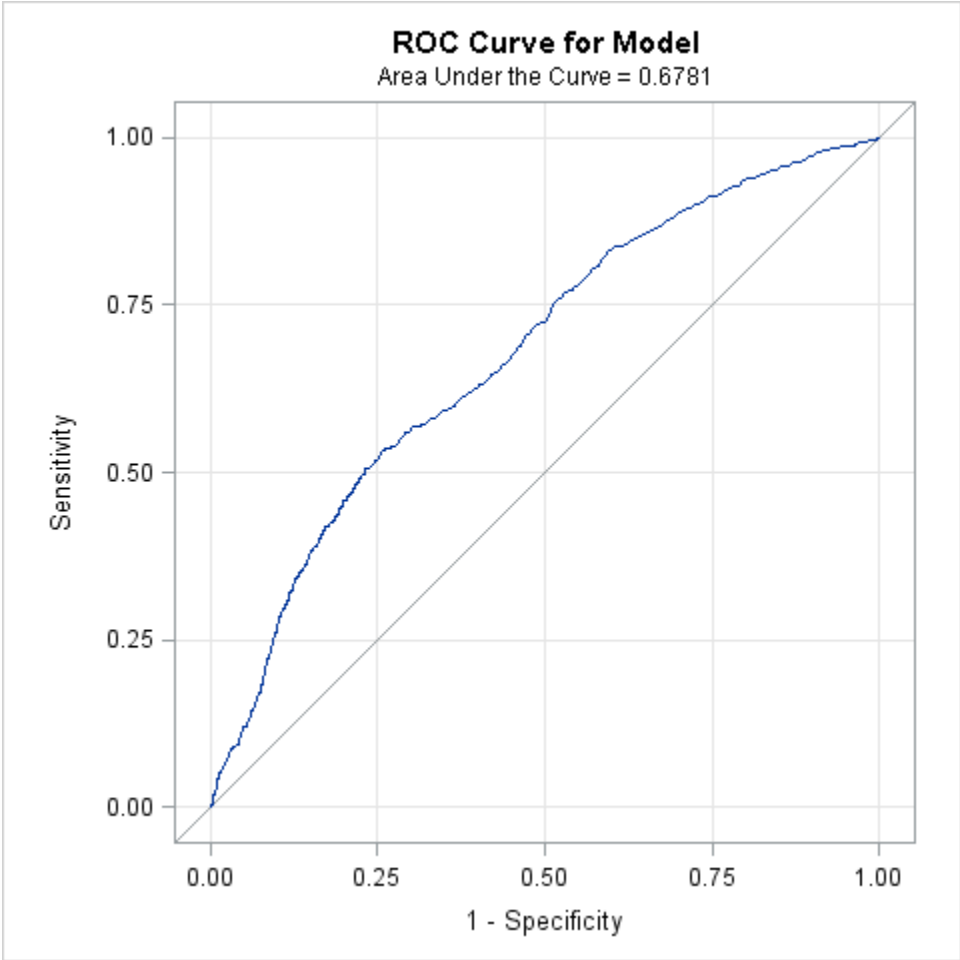
Graph 13 Dependent Variable Low Final GREG Person Weight

ROC Curve for Model
Area Under the Curve = 0.6339
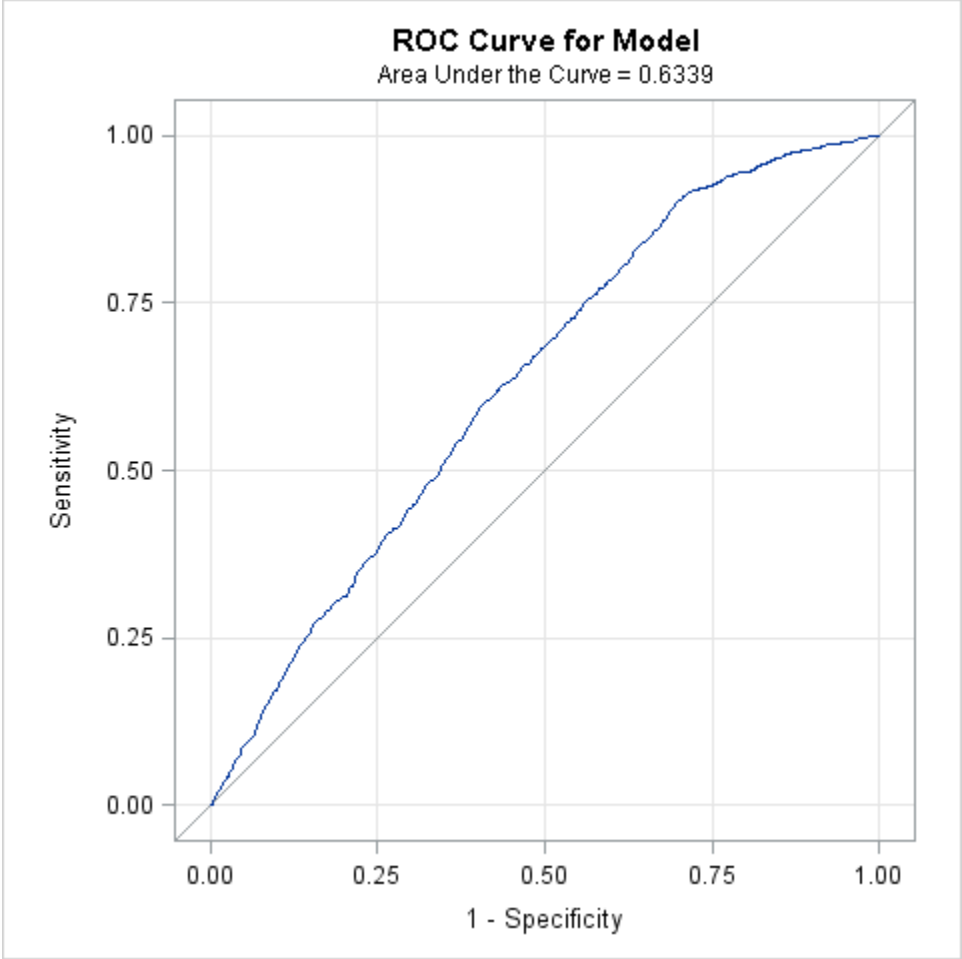
Graph 14 Dependent Variable High Final NOGREG Person Weight

ROC Curve for Model
Area Under the Curve = 0.6823
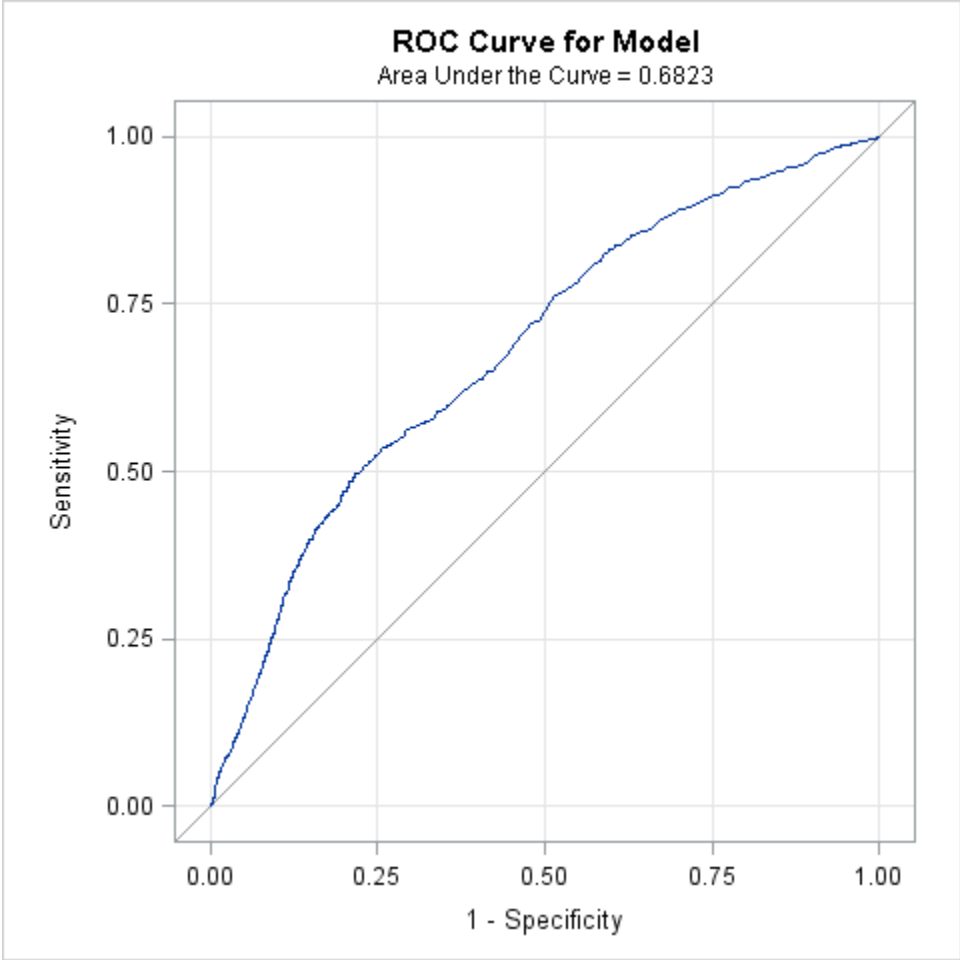
Graph 15 Dependent Variable Low Final GREG Person Weight
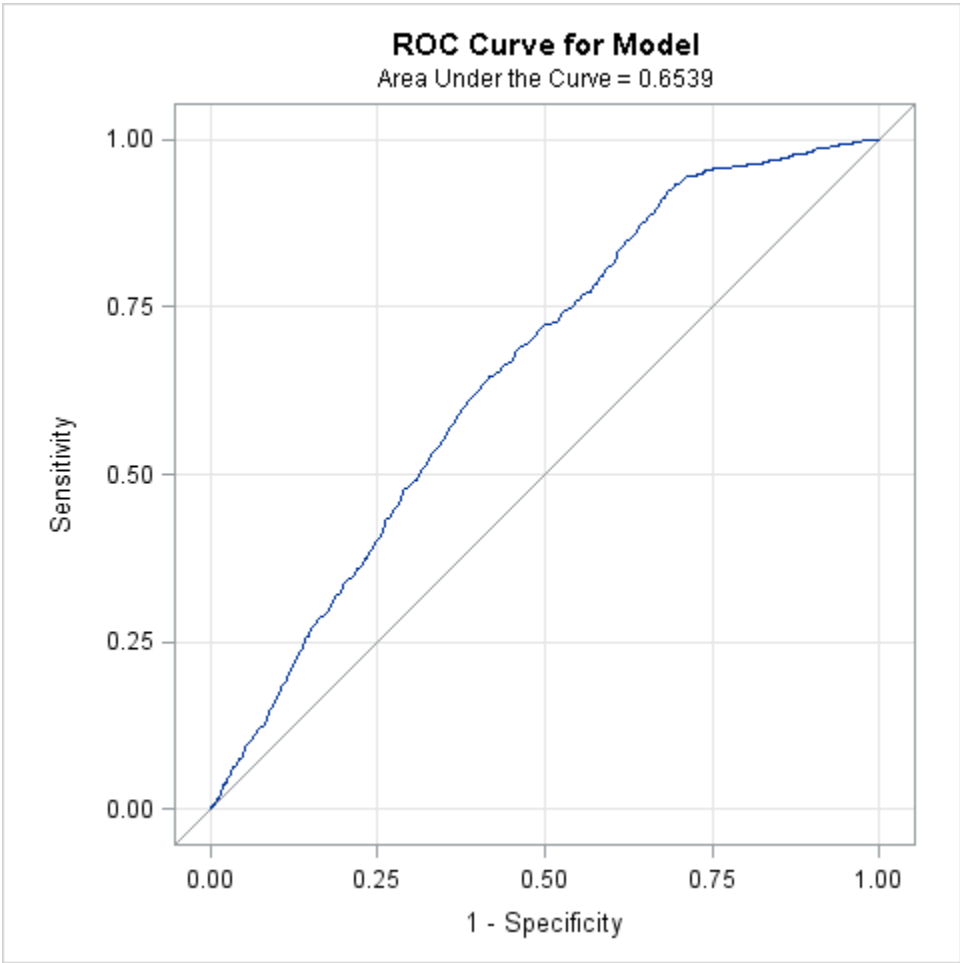
Graph 16: NOGREG/GREG Average Ratios Before HU Controls
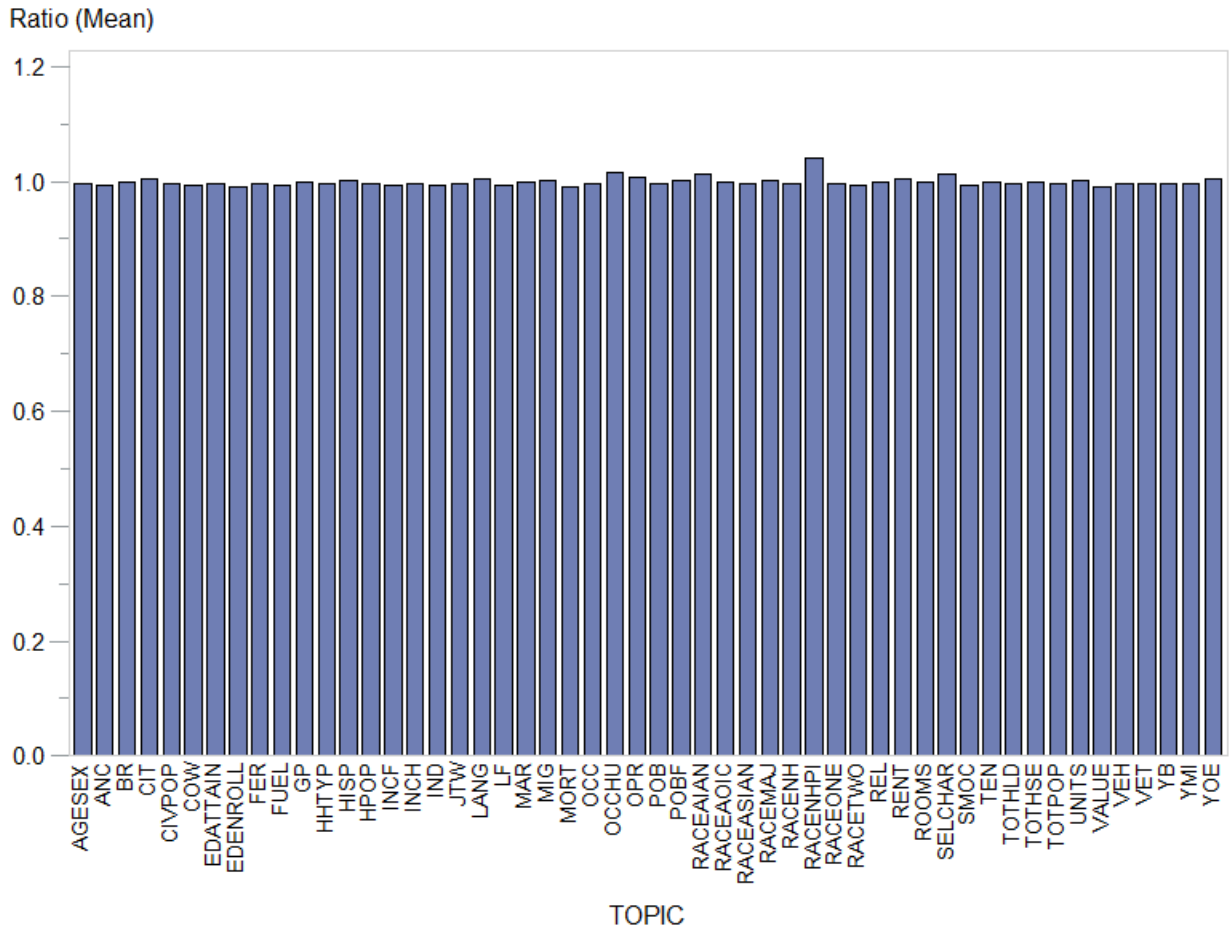
Graph 17: NOGREG/GREG Average Ratios After HU Controls