Assessing the Effect of Calibration on Nonresponse Bias in the 2008 ARMS Phase III Sample Using Census 2007 Data

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Abstract
The USDA's National Agricultural Statistics Service (NASS) conducts the annual Agricultural Resource Management Survey (ARMS). ARMS is a detailed economic survey suffering from relatively low response rates for a federal survey. To adjust for ARMS nonresponse bias, coverage and measurement errors, NASS uses calibration weighting. Prior research using 2002 Census of Agriculture data, available for 2005-2006 ARMS samples, indicated that calibration decreased nonresponse bias except in two cases; however, because not all ARMS calibration targets were collected on the 2002 Census of Agriculture, NASS did not fully replicate the ARMS calibration process. This study replicates prior research for the 2008 ARMS using the 2007 Census of Agriculture data, which includes equivalent variables for all ARMS calibration targets thus allowing NASS to assess fully the effectiveness of ARMS calibration.

Key Words: Nonresponse; Bias; Calibration; Response Rate

1. Introduction

Survey nonresponse happens; the question is, how do we address it? In 2003, the Federal Government's Federal Committee on Statistical Methodology (FCSM) formed a subcommittee of the Interagency Council on Statistical Policy (ICSP) representative nominees to update Federal standards for statistical surveys. This Subcommittee on Standards for Statistical Surveys concluded that in order to ensure the quality, objectivity, utility, and integrity of Federal Government data, nonresponse bias should be assessed when surveys exhibit insufficient response rates. Under the guidance of the FCSM and ICSP, ICSP representatives recommended Federal survey standards and guidelines to the Executive Office of the President's Office of Management and Budget in 2004. After public review, the Executive Office of the President ultimately released the *Office of Management and Budget Standards and Guidelines for Statistical Surveys* on September 22, 2006.

The United States Department of Agriculture's (USDA) National Agricultural Statistics Service (NASS) along with several other federal statistical agencies helped develop the OMB's new standards and guidelines for statistical surveys. This paper focuses specifically on Standard 3.2. Standard 3.2 addresses response rates and analysis of nonresponse bias, requiring that "Agencies must appropriately measure, adjust for, report, and analyze unit and item nonresponse to assess their effects on data quality and to

inform users" when survey response rates fall below 80 percent. (Office of Management and Budget, 2006, p. 14).

In 2005 and 2006, the Agricultural Resource Management Survey Phase III (ARMS III) response rate fell below the OMB response rate threshold of 80 percent listed in Guideline 3.2.9, and as a result NASS conducted two independent analyses of nonresponse bias (Earp, McCarthy, Schauer, & Kott, 2008; Earp et al., 2009). Both assessments were done using the Census of Agriculture 2002 data as a proxy; However, since the key variables of interest included expenditures which were not included in the 2002 short form, the analysis was limited to only those responding to the 2002 Census of Agriculture long form. Furthermore, the analysis was also limited by the fact that not all of the calibration targets used for ARMS III adjustments were collected on the 2002 Census of Agriculture. This report assesses the effectiveness of calibration as a tool for reducing nonresponse bias to insignificant levels, using the 2007 Census of Agriculture data as a proxy. Unlike the 2002 Census of Agriculture, the 2007 Census of Agriculture consisted of one form that included expenditure items as well as all items necessary to replicate fully the ARMS III 2008 calibration process.

The ARMS is conducted in three phases. Phase I screens for potential samples for Phases II and III. Phase II collects data on cropping practices and agricultural chemical usage, while Phase III collects detailed economic information about the agricultural operation, as well as information about the operator's household. Phase III is the only phase of the 2006 ARMS with response rates lower than 80 percent.

Due to lower response rates with the ARMS Phase III, the potential for nonresponse bias is greater there. NASS weights the ARMS Phase III respondent sample in such a way that estimated variable totals for a large set of items match "targets" determined from other sources. This is done through a weighting process called "calibration." Calibration is the process of adjusting survey weights so that certain targets are met. NASS uses official estimates of farm numbers; corn, soybean, wheat, cotton, fruit and vegetable acreage; egg and milk production; and cattle, hog, broiler, and turkey inventories as calibration targets. For example, after calibration, the calibration-weighted sum of the survey data will equal the NASS estimate for corn acreage. In addition to reducing confusion in the user community that might result from NASS releasing alternative estimates for the same totals, calibration weighting produces ARMS Phase III estimates with generally lower variances and reduces nonresponse biases. This report describes an ongoing research effort aimed at measuring the potential for nonresponse bias in the ARMS Phase III and the success or failure of calibration in removing it.

Nonresponse bias is very difficult to measure directly. Fortunately, an indirect measure of nonresponse bias is available for assessing ARMS III using an operation's Census of Agriculture data as a proxy.

The Census of Agriculture is a mandatory collection of data from all known agricultural operations. NASS has data from the Census on items of interest for many of the ARMS nonrespondents; however, the Census itself is incomplete. An estimated 16.24 percent of all farms were missing from the 2007 Census Mailing List, and 14.65 percent of farms on the List failed to respond to the Census (USDA, 2007, Table A). Moreover, 5.67 percent of the operations sampled for ARMS III could not be matched to 2007 Census records. Nevertheless, by comparing the 2007 Census values of ARMS III respondents to the full sample of ARMS III respondents as a whole, we can measure the difference between the

average ARMS III respondent and the average of the full sample without any nonresponse adjustment. Additionally, this analysis intends to measure the reduction of that difference from using a calibration-weighting process similar to the one used for the 2008 ARMS.

Although the 2007 Census data do not perfectly match the 2008 ARMS Phase III data, they are moderately to highly correlated (see Appendix Tables A-2 & A-3). The present evaluation will effectively compare 2008 ARMS Phase III survey respondents to nonrespondents using their 2007 Census data.

2. Method

Our analytical data set consists of census values for farms sampled for the ARMS III that responded to the 2007 Census of Agriculture.

The *base sampling weight* for a farm in our analytical data set was its ARMS III sample weight before calibration multiplied by its Census weight. Each ARMS III responding farm was calibrated to produce weighted totals for the calibration variables that were equal to the base-sampling-weighted totals computed from both respondents and nonrespondents. The calibration variables used were inventory/acreage numbers for cattle, corn, cotton, pigs, soybeans, wheat, fruit, vegetables, broilers, and turkeys. We used all the target variables, plus egg and milk production, in calibrating the ARMS III data.

As in the operational program, the ARMS III respondent subset was calibrated independently in 20 regions. These included the 15 leading cash receipt states (Arkansas, California, Florida, Georgia, Illinois, Indiana, Iowa, Kansas, Minnesota, Missouri, Nebraska, North Carolina, Texas, Washington, and Wisconsin). The remaining 33 states (Alaska and Hawaii are not sampled for the ARMS) were grouped using the five production regions: 1) Atlantic, 2) South, 3) Midwest, 4) Plains, and 5) West (Figure 1).

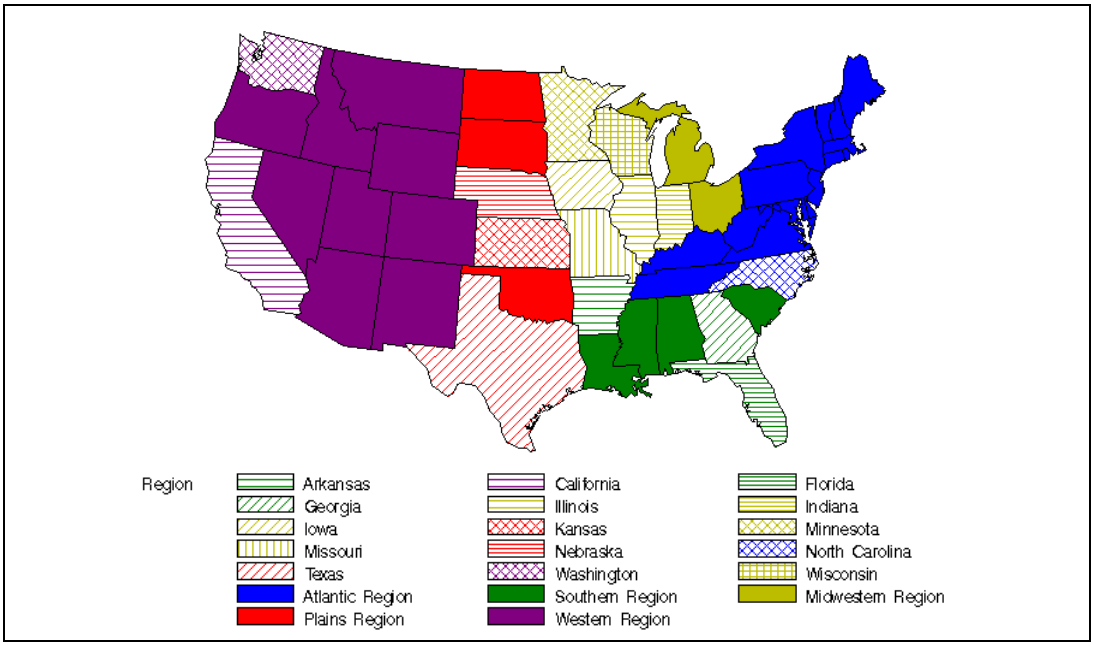

Figure 1. ARMS III Estimation Regions

Our analysis focuses on 17 specific (non-calibration) variables collected on both the ARMS and the Census:

1. Total Acres
2. Total Sales
3. Acres Rented
4. Cropland Acres
5. Total Production Expenses
6. Crop Expenses
7. Seed Expenses
8. Fertilizer Expenses
9. Chemical Expenses
10. Livestock Purchases
11. Feed Purchases
12. Hired Labor Expenses
13. Machinery and Equipment Value
14. Government Payments
15. Operator's Age
16. Operator's Race
17. Farm Type.

These variables were also included in a similar analysis for the 2005 and 2006 ARMS Phase III (Earp *et al.*, 2008 & Earp *et al.*, 2009).

Letting $\bar{y}_r$ denote the base-sample or calibrated-sample mean among the ARMS respondent subset for a study variable, and $\bar{y}_t$ denote the corresponding base-sample mean among the entire matched sample, it is a simple matter to compute the relative bias of the former with respect to the latter, relBias = $\frac{\bar{y}_r - \bar{y}_t}{\bar{y}_r}$. The statistical significance of this value is much harder to assess since the samples on which $\bar{y}_r$ and $\bar{y}_t$ are based are complex and overlapping.

Fortunately, we can easily test the persistence or absence of a systematic bias across the 20 regions. To this end, we compute the following measure of bias of an ARMS-respondent mean (before or after calibration) with respect to the Census mean in every region:

$$
\begin{aligned}
M &= \log(\bar{y}_r) - \log(\bar{y}_t) \\
&= \log\left(\bar{y}_r \Big/ \bar{y}_t \right) \\
&= \log\left(1 + \frac{\bar{y}_r - \bar{y}_t}{\bar{y}_t} \right) \approx \frac{\bar{y}_r - \bar{y}_t}{\bar{y}_t}
\end{aligned}
$$

This measure is conveniently symmetric, $\log(\bar{y}_t) - \log(\bar{y}_r) = -[\log(\bar{y}_r) - \log(\bar{y}_t)]$ while retaining the scale-invariance property of the relative bias (*i.e.*, multiplying the reported item value on each farm by a fixed factor does not affect the overall relative bias).

The bias measure *M* for a study variable in a region can be treated as an independent random variable. The null hypothesis of no bias (again, either before or after calibration) can be tested against an alternative hypothesis of a persistent bias (*p* %) across all the regions. The conventional *t* test based on the 20 observations (one per region) is asymptotically normal under both the null and alternative hypotheses. We follow the standard practice of approximating the distribution of this test statistic with a Student's *t* having 19 degrees of freedom. This may lead to liberal inferences (the inappropriate rejection of the null hypothesis when it is true) because the *M*-values for the study variable may not be normally distributed with a common variance across regions. Nevertheless, by taking logs we create a test statistic that is more nearly normal and homoscedastic than absolute biases would be.

A sign and a signed-rank test of the 20 paired observations for a study variable before and after calibration was conducted. The sign test is not as powerful as the other two tests (*i.e.*, it more often fails to find that *M* is significantly different from 0 when, in fact, there is a persistent bias across the regions), but it assumes neither that *M* is normal nor homoscedastic. The signed-rank test assumes the latter, but not the former. We include all three analyses in our results for completeness.

3. Results

Table 1 provides a summary of the results. All estimates exhibited significant bias before calibration; however, after calibration the following estimates no longer exhibited significant bias: Total Sales, Acres Rented, Cropland Acres, Total Production Expenses, Cropland Expenses, Seed Expenses, Chemical Expenses, Livestock Purchases, Feed Purchases, Hired Labor Expenses, Government Payments, and Farm Type. This finding is consistent with the results of the 2005 and 2006 analyses for the estimates where Feed Expenses, Total Production Expenses, Seed Expenses, Livestock Purchases, Cropland Expenses, and Hired Labor Expenses were shown to no longer exhibit significant bias after calibration (Earp *et al.*, 2008 & Earp *et al.*, 2009).

In over 70 percent (12/17) of the study variables exhibiting persistent biases using the base sample weights, calibration weighting was able to reduce the bias so that it was no longer significantly different from zero using a t-test with $p < .05$. The rate of bias elimination was slightly lower than found in 2005 to 2006 (Earp *et al.*, 2008 & Earp *et al.*, 2009); however, in previous years our proxy data was limited since expenditure data was only collected from a subset of Census 2002 records. Furthermore, the following new calibration targets were used in this analysis that were not used in previous analyses: hay acreage, rice acreage, peanut acreage, sugarcane/sugar beet acreage, tobacco acreage, nursery/floriculture acreage, cattle on feed inventory, milk production, egg production, number of farms by eight economic classes, number of farms by nonestimate states, and total number of farms. Although egg and milk production were technically used to create calibration weights for the 2005 and 2006 ARMS III respondents, these data were not collected on the Census 2002 and therefore could not be included in our previous analyses. All of the other new calibration targets were added after 2006 to improve further our nonresponse and undercoverage adjustments.

All of these variables show a significant reduction in bias levels using a paired t-test. After calibration, five study variables had significant remaining bias. This result varied from 2005 and 2006, where for each year only one estimate still had significant remaining bias after calibration: fertilizer expense in 2005 and total sales in 2006 (Earp *et al.*, 2008 & Earp *et al.*, 2009). While Fertilizer Expenses exhibited significant bias after calibration in 2005, it did not in 2006, but did again in 2008. Total Sales no longer has significant remaining bias after calibration in 2008. The following four estimates that did exhibit significant bias after calibration in 2005 or 2006 continued to do so in 2008: Total Acres Operated, Fuel and Oil Expenses, Machinery and Equipment Value, and Operator's Age. We explored the bias levels of all five estimates still exhibiting significant bias after calibration at the regional level to determine if calibration performed better or worse in certain regions. Overall nonresponse bias levels significantly decreased for all estimates after calibration adjustment; however, at the regional level nonresponse bias levels did increase after calibration adjustment in the South Region for Total Acres Operated and Machinery Equipment Value, and in California, Indiana, and the Atlantic Region for Operator's Age.

As in 2005 and 2006, the estimated bias of livestock purchases remains the largest among the study variables. Using only the base-sampling weights, this bias was highly significant using all three test statistics. After calibration, although still large in magnitude, the estimated bias was reduced to statistical insignificance in terms of all the tests. For this variable, calibration continues to reduce the bias significantly, if not completely.

4. Discussion

ARMS data are used by farm organizations, commodity groups, agribusiness, Congress, State Departments of Agriculture, and the USDA. The USDA uses ARMS data to evaluate the financial performance of farms and ranches, which influences agricultural policy decisions. The Department also uses Phase III data for objective evaluation of critical issues related to agriculture and the rural economy. Due to the broadness of the ARMS Phase III data user community and the survey's impact on agricultural policy, it is crucial that the calibration process effectively adjusts for nonresponse bias. Assuming that the adjustment process is even more effective than demonstrated here using the actual ARMS III data, it appears that NASS is appropriately addressing the issue of nonresponse bias in ARMS Phase III through the calibration process. Furthermore, NASS has expanded the number of calibration targets used since 2006 to include hay acreage, peanut acreage, rice acreage, sugarcane/sugar beet acreage, tobacco acreage, nursery/floriculture acreage, cattle on feed inventory, number of farms by states for which separate estimates are not produced, total number of farms, and number of farms by eight economic classes.

Using the 2007 Census data as a proxy for 2009 ARMS III data, we demonstrated that although significant bias was exhibited using just the base sample weights, it was reduced to insignificant levels for the following 12 estimates through calibration weighting: Feed Purchases, Total Production Expenses, Total Sales, Seed Expenses, Livestock Purchases, Cropland Expenses, Hired Labor Expenses, Chemical Expenses, Acres Rented, Cropland Acres, Government Payments, and Farm Type. Although the magnitude of the relative bias of the mean estimate remained high for livestock purchases using the calibrated

weights, calibration reduced the magnitude of this bias to statistical insignificance (see Table 1).

While calibration appears to be less effective than demonstrated in previous years (Earp *et al.*, 2008 & Earp *et al.*, 2009), the analysis of the ARMS III 2008 sample was more thorough, since the 2007 Census collected data on egg and milk production and expenditure items from all farming operations, as opposed to just a subset, as was done on the 2002 Census. Unlike previous years, we were able to replicate fully the 2008 ARMS III calibration process, using all 2008 ARMS III sampled operations that completed the 2007 Census.

Limitations of this analysis include the inability to: 1) assess farms not covered or responding to the 2007 Census of Agriculture; 2) correlate items between the 2008 ARMS III and the 2007 Census; and 3) recognize localized biases in the ARMS data (tests were limited to persistent biases across regions).

Knowing that the analyzed data come from the 2007 Census and not from the 2008 ARMS Phase III survey does not limit, but strengthens the analysis. It allows us to focus entirely on the impact of the nonresponse *per se*.

Table 1: Mean Comparisons and Indicated Biases for Matching Records Using Base Sampling Weights versus Calibrated Weights

	National Estimates		Regional Estimates (n = 20)				Testing the Effect of Calibration on Regional Bias Means							
Variable	Mean	Bias	Mean[3]	Bias Mean[3]	Bias Mininmum[3]	Bias Maximum[3]	t[3]	p value[3]	Sign[3]	p value[3]	Signed Ranks[3]	p value[3]	t_{paired}[3]	p value[3]
1. Total Sales														
All Matching Records[1]	128,884.58		158,219.44											
Matching Respondents[2]	98,947.35	-23.23%	124,849.17	**-23.12%**	-75.36%	-8.45%	**-6.98**	**0.00**	**-10.00**	**0.00**	**-105**	**0.00**		
Matching Respondents Calibrated[2]	124,574.92	-3.34%	152,009.47	-3.32%	-41.65%	6.13%	-1.57	0.13	-5.00	**0.04**	-61.00	**0.02**	**-10.12**	**0.00**
2. Acres Rented														
All Matching Records[1]	173.66		181.07											
Matching Respondents[2]	137.66	-20.73%	146.72	**-19.47%**	-34.34%	-2.79%	**-10.85**	**0.00**	**-10.00**	**0.00**	**-105.00**	**0.00**		
Matching Respondents Calibrated[2]	171.05	-1.50%	176.98	-2.02%	-18.16%	4.99%	-1.87	0.08	**-6.00**	**0.01**	-52.00	0.05	**-10.05**	**0.00**
3. Cropland Acres														
All Matching Records[1]	188.94		208.20											
Matching Respondents[2]	150.01	-20.60%	172.94	**-16.81%**	-28.91%	1.19%	**-10.97**	**0.00**	**-9.00**	**0.00**	**-104.00**	**0.00**		
Matching Respondents Calibrated[2]	187.37	-0.83%	206.42	-0.55%	-3.52%	1.58%	-1.96	0.07	-3.00	0.26	-48.00	0.08	**-11.91**	**0.00**
4. Total Production Expenses (Dollars)														
All Matching Records[1]	97,003.85		117,303.22											
Matching Respondents[2]	74,960.66	-22.72%	92,444.03	**-22.82%**	-81.56%	-9.02%	**-6.37**	**0.00**	**-10.00**	**0.00**	**-105.00**	**0.00**		
Matching Respondents Calibrated[2]	93,306.03	-3.81%	112,015.40	-3.82%	-49.75%	3.17%	-1.53	0.14	-5.00	**0.04**	-60.00	**0.02**	**-9.97**	**0.00**
5. Cropland Expenses (Dollars)														
All Matching Records[1]	17,608.14		21,964.29											
Matching Respondents[2]	13,250.21	-24.75%	17,419.74	**-24.17%**	-45.24%	-12.92%	**-13.88**	**0.00**	**-10.00**	**0.00**	**-105.00**	**0.00**		
Matching Respondents Calibrated[2]	17,262.09	-1.97%	21,633.12	-1.78%	-12.70%	3.79%	-1.93	0.07	-3.00	0.26	-41.00	0.13	**-13.11**	**0.00**
6. Seed Expenses (Dollars)														
All Matching Records[1]	5,275.50		6,537.51											
Matching Respondents[2]	3,938.19	-25.35%	5,155.10	**-25.56%**	-50.50%	-12.92%	**-13.88**	**0.00**	**-10.00**	**0.00**	**-105**	**0.00**		
Matching Respondents Calibrated[2]	5,128.76	-2.78%	6,406.42	-1.78%	-12.70%	3.79%	-1.16	0.26	-2.00	0.50	-24.00	0.39	**-10.07**	**0.00**
7. Chemical Expenses (Dollars)														
All Matching Records[1]	4,281.90		5,463.50											
Matching Respondents[2]	3,212.30	-24.98%	4,342.70	**-24.27%**	-44.88%	-6.94%	**-11.56**	**0.00**	**-10.00**	**0.00**	**-105.00**	**0.00**		
Matching Respondents Calibrated[2]	4,248.50	-0.78%	138,277.99	-0.27%	-10.34%	7.32%	-0.28	0.78	0.00	1.00	-5.00	0.87	**-13.61**	**0.00**
8. Livestock Purchases (Dollars)														
All Matching Records[1]	8,519.00		9,907.00											
Matching Respondents[2]	5,074.00	-40.44%	5,840.70	**-40.39%**	146.45%	4.30%	**-4.91**	**0.00**	**-7.00**	**0.00**	**-99.00**	**0.00**		
Matching Respondents Calibrated[2]	7,206.90	-15.40%	7,911.90	-15.25%	113.91%	21.58%	-1.91	0.07	-3.00	0.26	-43.00	-11.00	**-6.09**	**0.00**

[1] Means computed using the base sampling weights for all matching cases with Census 2007 data (n = 34,327)

[2] Means computed only for ARMS III respondents with Census 2007 data (n = 22,720)

[3] Regional estimates are based on the 20 ARMS III estimation regions shown in *Figure 1* using only ARMS III respondents

Note: Significant bias and corresponding t scores and p values are identified in **red** font
Significant reduction in bias is identified in **blue** font

Table 1 (Cont.): Mean Comparisons and Indicated Biases for Matching Records Using Base Sampling Weights versus Calibrated Weights

	National Estimates		Regional Estimates (n = 20)				Testing the Effect of Calibration on Regional Bias Means							
Variable	Mean	Bias	Mean[3]	Bias Mean[3]	Bias Mininmum [3]	Bias Maximum[3]	t[3]	p value[3]	Sign[3]	p value[3]	Signed Ranks[3]	p value[3]	t_{paired}[3]	p value[3]
9. Feed Purchases (Dollars)														
All Matching Records [1]	17,706.48		21,186.00											
Matching Respondents [2]	14,519.87	-18.00%	17,130.40	-23.17%	115.80%	3.83%	-3.83	0.00	-8.00	0.00	-100.00	0.00		
Matching Respondents Calibrated [2]	16,966.23	-4.18%	19,884.10	-5.69%	-79.95%	9.41%	-1.39	0.18	-4.00	0.12	-47.00	0.08	-5.73	0.00
10. Hired Labor Expenses (Dollars)														
All Matching Records [1]	10,669.50		13,039.00											
Matching Respondents [2]	8,200.80	-23.14%	10,151.80	-27.20%	-57.17%	-4.33%	-8.44	0.00	-10.00	0.00	-105.00	0.00		
Matching Respondents Calibrated [2]	10,145.73	-4.91%	12,424.50	-3.96%	-25.60%	9.63%	-2.08	0.05	-5.00	0.04	-51.00	0.06	-10.85	0.00
11. Government Payments (Dollars)														
All Matching Records [1]	9,155.00		11,638.50											
Matching Respondents [2]	8,243.10	-9.96%	10,381.90	-10.69%	-21.58%	0.68%	-8.03	0.00	-9.00	0.00	-103.00	0.00		
Matching Respondents Calibrated [2]	9,317.60	1.78%	11,785.20	1.21%	-9.12%	8.85%	1.24	0.23	3.00	0.26	35.00	0.20	-11.35	0.01
12. Farm Type (Dollars)														
All Matching Records [1]	8.49		8.06											
Matching Respondents [2]	8.71	2.59%	8.20	2.08%	-0.21%	8.55%	3.73	0.00	7.00	0.00	99.00	0.00		
Matching Respondents Calibrated [2]	8.48	-0.12%	8.04	-0.17%	-2.53%	3.25%	-0.62	0.54	1.00	0.82	-25.00	0.37	5.01	0.00
13. Total Acres Operated														
All Matching Records [1]	385.30		378.70											
Matching Respondents [2]	319.10	-17.18%	321.10	-14.63%	-25.40%	-5.73%	-11.59	0.00	-10.00	0.00	-105.00	0.00		
Matching Respondents Calibrated [2]	378.50	-1.76%	371.30	-2.30%	-9.98%	1.25%	-3.43	0.00	-6.00	0.00	-84.00	0.00	-8.88	0.00
14. Fertlizer Expenses (Dollars)														
All Matching Records [1]	8,050.60		9,963.20											
Matching Respondents [2]	6,099.60	-24.23%	7,921.80	-23.28%	-42.46%	-5.97%	-11.98	0.00	-10.00	0.00	-105.00	0.00		
Matching Respondents Calibrated [2]	7,884.80	-2.06%	9,778.60	-2.08%	-7.91%	1.54%	-3.43	0.00	-5.00	0.04	-75.00	0.00	-12.81	0.00
14. Fuel & Oil Expenses (Dollars)														
All Matching Records [1]	5,521.90		6,398.40											
Matching Respondents [2]	4,506.67	-18.39%	5,318.00	-18.01%	-34.34%	-4.81%	-11.14	0.00	10.00	0.00	-105.00	0.00		
Matching Respondents Calibrated [2]	5,432.40	-1.62%	6,297.90	-1.40%	-7.72%	2.60%	-2.31	0.03	-3.00	0.26	-53.00	0.05	-13.15	0.00
16. Machinery & Equipment Value (Dollars)														
All Matching Records [1]	87,417.50		95,096.70											
Matching Respondents [2]	74,665.10	-14.59%	82,708.40	-13.21%	-21.37%	-5.39%	-12.36	0.00	-10.00	0.00	-105.00	0.00		
Matching Respondents Calibrated [2]	85,250.50	-2.48%	93,291.20	-1.98%	-6.40%	1.74%	-3.97	0.00	-6.00	0.01	-82.00	0.00	-10.13	0.00
17. Operator's Age (Dollars)														
All Matching Records [1]	57.74		57.64											
Matching Respondents [2]	58.07	0.57%	58.07	0.74%	-0.44%	1.69%	5.00	0.00	7.00	0.00	90.00	0.00		
Matching Respondents Calibrated [2]	57.93	0.33%	57.98	0.59%	-0.53%	1.52%	4.58	0.00	7.00	0.00	88.00	0.00	3.34	0.00

[1] Means computed using the base sampling weights for all matching cases with Census 2007 data (n = 34,327)

[2] Means computed only for ARMS III respondents with Census 2007 data (n = 22,720)

[3] Regional estimates are based on the 20 ARMS III estimation regions shown in *Figure 1* using only ARMS III respondents

Note: Significant bias and corresponding t scores and p values are identified in **red** font
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5. References

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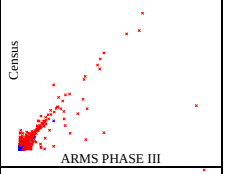
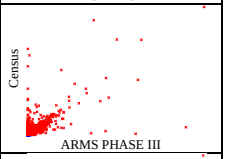
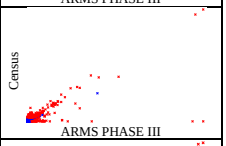
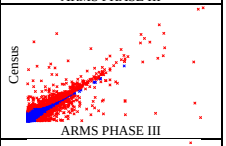
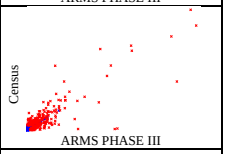
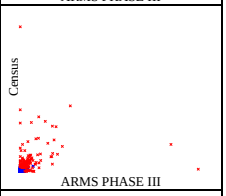
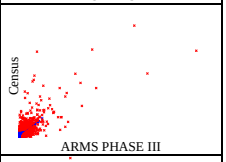
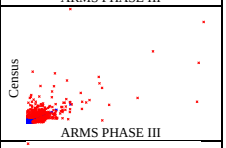
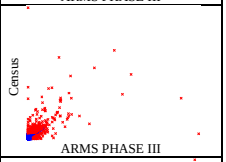
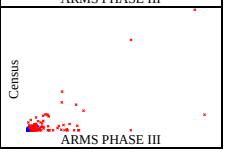
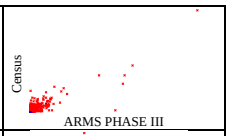
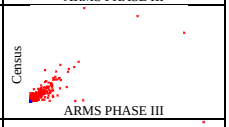
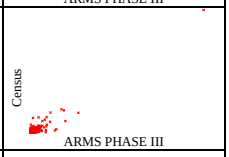
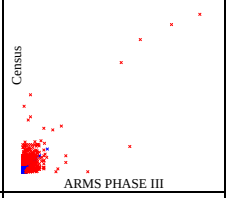
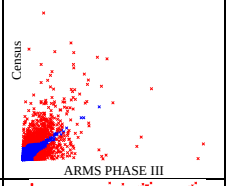
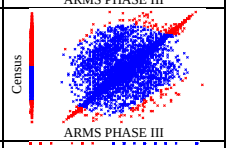
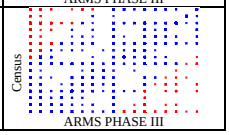
6. Appendix

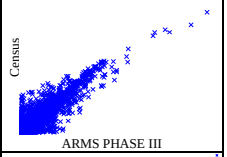
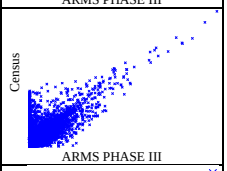
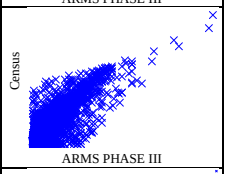
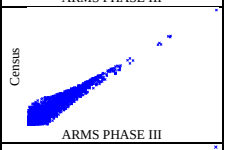
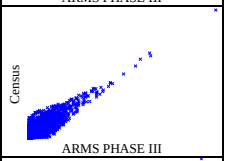
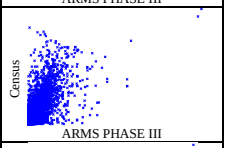
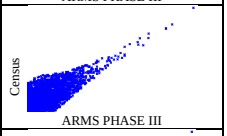
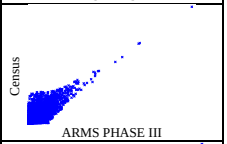
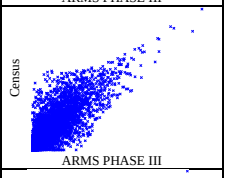
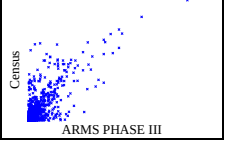
Table A-1: Census 2007 and ARMS Phase III 2008 Variable Correlations with Outliers

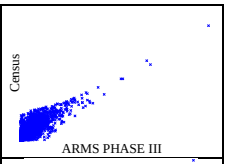
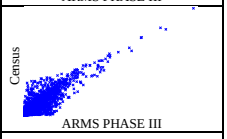
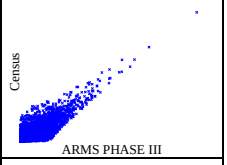
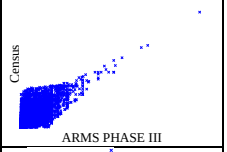
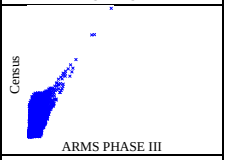
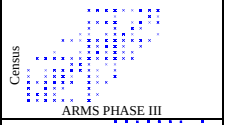
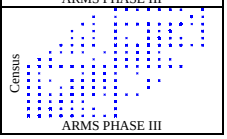
	r	r^2	Scatter Plots
Total Acres Operated	.89603 (*n* = 22,720)	.80287	
Total Sales	.70927 (*n* = 21,987)	.50306	
Acres Rented	.75192 (*n* = 21,276)	.53654	
Cropland Acres	.88253 (*n* = 22,258)	.77886	
Total Production Expenses	.87044 (*n* = 22,720)	.75767	
Seed Expenses	.39646 (*n* = 22,720)	.15718	
Fertilizer Expenses	.79022 (*n* = 22,720)	.62455	
Chemical Expenses	.73953 (*n* = 22,720)	.54690	
Crop Expenses	.68397 (*n* = 22,720)	.46781	
Livestock Purchases	.68277 (*n* = 22,720)	.46618	

Feed Purchases	.86243 (*n* = 22,720)	.74379	
Hired Labor Expenses	.81630 (*n* = 22,657)	.66635	
Fuel & Oil Expenses	.91400 (*n* = 22,720)	.83540	
Machinery & Equipment	.73324 (*n* = 22,720)	.53764	
Government Payments	.62929 (*n* = 12,890)	.39601	
Operator's Age	.34654 (*n* = 22,720)	.12001	
Farm Type	.73019 (*n* = 22,720)	.53318	

1. All correlations were significant at the .05 level.
2. Correlations were only estimated for ARMS respondents.
3. Outliers were flagged using DFFITS, Cook's D, and studentized residuals and are shown in red.

Table A-2: Census 2007 and ARMS Phase III 2008 Variable Correlations without Outliers

	r	r^2	Scatter Plots
Total Acres Operated	.94389 (*n* =22,398)	.89093	
Total Sales	.76027 (*n* =21,290)	.57801	
Acres Rented	.89592 (*n* =20,977)	.80267	
Cropland Acres	.96328 (*n* =21,401)	.92791	
Total Production Expenses	.89508 (*n* =22,367)	.80117	
Seed Expenses	.72660 (*n* =22,526)	.52795	
Fertilizer Expenses	.85389 (*n* =22,007)	.72913	
Chemical Expenses	.83845 (*n* =22,141)	.70300	
Crop Expenses	.87174 (*n* =22,309)	.75993	
Livestock Purchases	.59306 (*n* =22,583)	.35172	

Feed Purchases	.86233 (*n* =22,382)	.74361	
Hired Labor Expenses	.89342 (*n* =22,356)	.79820	
Fuel & Oil Expenses	.86510 (*n* =22,020)	.74840	
Machinery & Equipment	.75614 (*n* =21,978)	.57175	
Government Payments	.76001 (*n* =12,054)	.57762	
Operator's Age	.63436 (*n* =20,765)	.40241	
Farm Type	.90607 (*n* =21,149)	.82096	

1. All correlations were significant at the .05 level.
2. Correlations were only estimated for ARMS respondents.