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The authors also extend a special thanks to Scot Rumburg for his help and investigation of specific outliers observations.

SUMMARY

The National Agricultural Statistics Service (NASS) conducts quarterly Multiple Frame (MF) hog inventory surveys. The survey direct expansion estimator for hogs is separated into outlier and non-outlier components during summary calculations. This report documents a procedure for identifying when the outlier component is unusually large or small. A simple robust estimator that reduces the impact of unusual outlier components is also presented. The Agricultural Statistics Board used information from these procedures when setting the December 1989 hog estimates and revising September 1989 estimates.

To identify unusual outlier components, standardized outlier components (SDOC) are calculated and charted for several quarters. The SDOC gives reviewers a way to judge if the current quarter's outlier component is influential when compared with previous outlier components. The robust estimator substitutes the current quarter's outlier component with an average outlier component over several quarters. This discounts the current outlier component and spreads its influence over time. However, the SDOC and the robust estimator can be heavily influenced by unusual historic outlier components if not enough historic data are used in the calculations.

Review of December 1989 robust indications and the Board estimates indicate that the robust indications influenced Board actions for States with unusual SDOC's. Simulation of the standardized outlier totals and robust indications for September 1989 indicate that this information would have been helpful to the Board. SDOC control charts clearly show the presence of unusual outlier components for seven States in September. The December Board revised the total hog estimates for five of these seven States in the direction of the robust indication. These revisions probably would have been reduced or eliminated if the SDOC's and robust indications had been available in September.

Clearly these procedures provided useful information to the December 1989 Hog Board. Currently, only the robust indication is supplied for the 10 State, 16 State and U.S. total hog estimates. No State level robust indications are used and no standardized outlier charts are used at any level.

NASS research and operational statistical methodology units should put high priority on jointly developing and implementing robust multiple frame procedures. Based on this review and evaluation of the procedures used for the December 1989 Hog Board, we recommend the following:

1. Examine methods that reduce the impact of unusual historic outlier components on the SDOC and robust estimator. This should include reviewing the amount of historic data used for calculating the SDOC and robust indications.

2. Review present outlier cutoff limits and examine other criteria for determining these cutoff limits. Current cutoff limits do not provide meaningful outlier components for many States.

3. Research staff should study the statistical characteristics of individual outliers and other components to aid in the development of effective outlier detection and robust estimation procedures.

4. Modify the operational summary systems with several new experimental outlier cutoff limits and store individual outlier observations for robust estimation analysis and review.

Once 1 through 4 have been resolved then:

5. The Agency should make it an important goal to implement outlier detection and robust estimation techniques for SSO and National Board reviews of most MF crop and livestock estimates.

A Review and Evaluation of Unusual Outlier Component Detection and Robust Estimation Procedures used by the December 1989 Hog Board

Gary Keough and Charles R. Perry, Jr.

INTRODUCTION

Outliers are common in agricultural commodity survey data because populations are often highly skewed with a large number of small values and a few very large values. However, limited attention is given to outliers until they dominate the estimator. Thomas, Perry, and Viroonsri[4] examined Empirical Bayes and right censored estimators for highly skewed populations in order to dampen outlier effects. This report documents procedures to identify when the outlier component in repeated survey data are unusually larger or smaller than expected, and a simple robust estimator to be used when this occurs. Dr. Charles Perry developed these procedures for the National Agricultural Statistics Service (NASS) December 1989 Hog Board. The Chairperson of the Agricultural Statistics Board, Rich Allen, felt outliers overly influenced the September 1989 hog data and a procedure for dampening their effect was needed. Since outlier observations frequently occur in successive NASS Agricultural Surveys within a survey year (June-March) due to sample design, numerous outliers were expected in the December 1989 survey.

For this report, an outlier will be broadly defined as an expanded value considered unusual or influential by some defined procedure. The outlier component is the sum of these expanded values.

Methods

Current procedures

Estimation program

NASS has estimated quarterly hog numbers in the 10 major hog producing States since 1975. These States are Georgia, Illinois, Indiana, Iowa, Kansas, Minnesota, Missouri, Nebraska, North Carolina, and Ohio. In 1988 NASS started making quarterly estimates for the 16 major hog producing States by adding Kentucky, Michigan, Pennsylvania, South Dakota, Tennessee, and Wisconsin. These 16 States produce about 90 percent of the U.S. total hogs. Only annual estimates as of December 1 are made for the remaining States.

Estimators

NASS uses a multiple frame (MF) approach for estimating major agricultural commodities from the Agricultural Survey Program (ASP). This approach utilizes a list frame and an area frame for providing survey indications. The list frame consists of a list of farming operations and associated control data. Control data are used to stratify the list frame to improve sampling efficiency. A major disadvantage of almost any list frame is that it seldom contains the entire population of interest. The NASS area frame is complete and allows any area of land in the continuous 48 States to be selected with a known probability. Consequently, the area frame is used to account for the list frame's incompleteness in the MF approach.

Each reporting unit in the area frame sample is matched against the list frame to determine whether it is on the list or not. Reporting units not on the list frame represent the nonoverlap (NOL) population. The MF estimator is the sum of the list and NOL components. The NOL component is the main contributor to the variance of the estimator. Outliers typically come from small operation list strata and the NOL domain. These have small sampling fractions and therefore have large expansion factors. For a more detailed discussion of NASS's multiple frame approach see Nealon[2] or Thomas et al.[4]

A second MF indication adjusts the MF direct expansion (DE) for nonresponse based on information about presence or absence of hogs for the nonrespondents[1]. Any outliers that affect the original MF DE would also affect the adjusted indication.

Outlier detection procedures

NASS uses two different procedures in the current hog summary and analysis system for detecting outliers. Each procedure is described below.

The oldest procedure, Procedure 1, uses fixed State level cutoff values to identify if an observation's expanded value is an outlier. Table 1 gives the cutoffs by State in 1,000's. This procedure is used on both the LIST and NOL components of the multiple frame data. The history of Procedure 1 is obscure. No historical documentation describing its development is available. The procedure has been a part of NASS's Enumerative Summary System since its implementation in 1977.

TABLE 1 -- Procedure 1 cutoff values in 1,000's of hogs

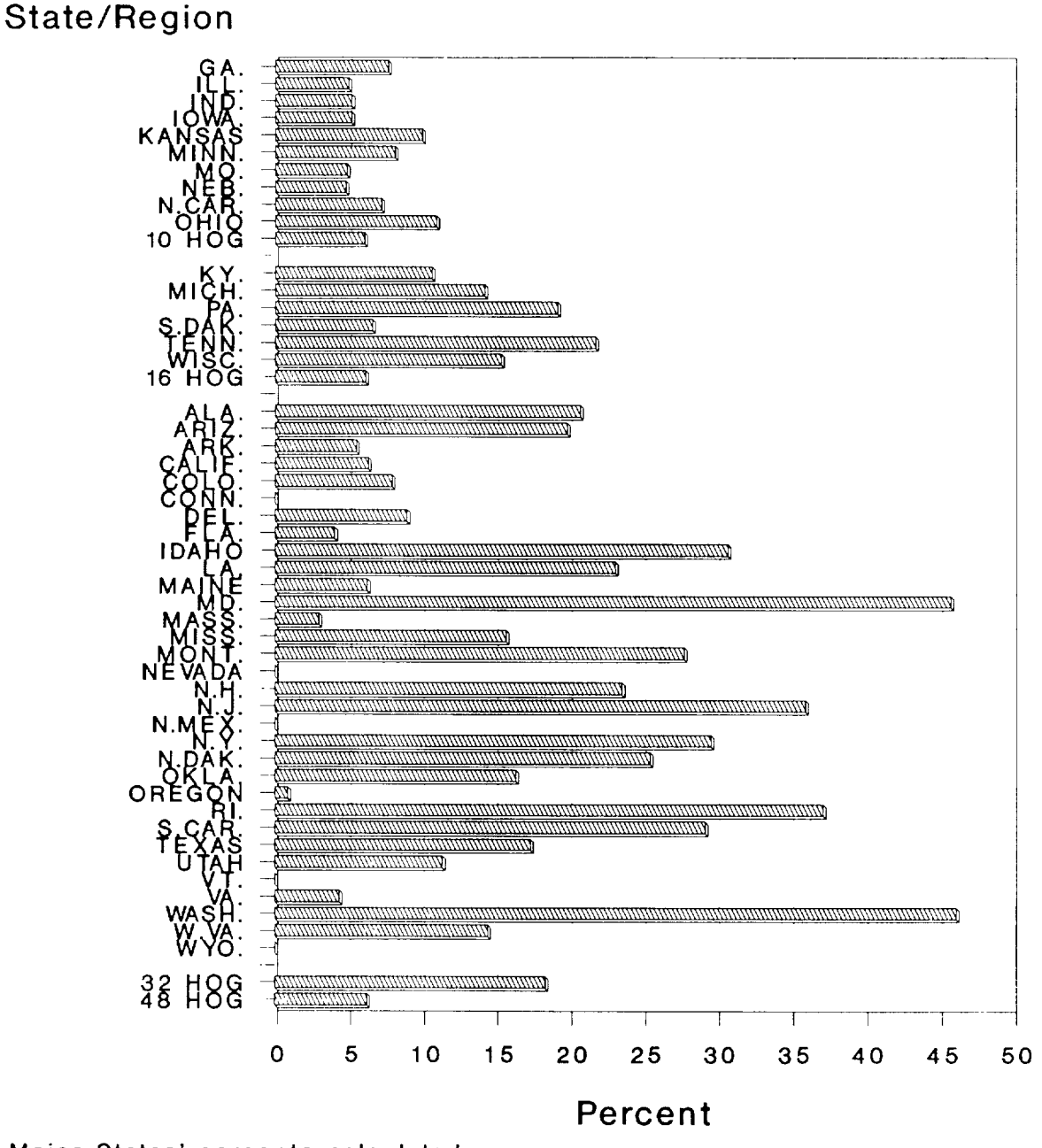
16 major hog States							
Georgia	25	Kansas	20	N. Carolina	30	Pennsylvania	20
Illinois	50	Minnesota	40	Ohio	25	S. Dakota	25
Indiana	40	Missouri	40	Kentucky	20	Tennessee	20
Iowa	80	Nebraska	40	Michigan	15	Wisconsin	25
Remaining 32 States							
Alabama	10	Idaho	5	N. Hampshire	3	S. Carolina	10
Arizona	5	Louisiana	5	N. Jersey	5	Texas	20
Arkansas	10	Maine	3	N. Mexico	5	Utah	5
California	5	Maryland	5	N. York	5	Vermont	3
Colorado	10	Massachusetts	5	N. Dakota	5	Virginia	15
Connecticut	5	Mississippi	10	Oklahoma	15	Washington	5
Delaware	5	Montana	5	Oregon	5	W. Virginia	5
Florida	10	Nevada	4	Rhode Island	3	Wyoming	5

It appears the State cutoffs are set at approximately one percent of State's historical hog inventory. Except for the addition of some smaller States, cutoff limits have the not changed since 1977.

The average percent of the MF DE due to the outlier component was calculated using 1975 to 1989 quarterly information for the 10 major hog States. Average percentages for the remainder of States were calculated using 1988 and 1989 information. Figure 1 shows the outlier component is typically 5 to 10 percent of the MF DE for the 10 major hog States and about 6 percent at the 48 State level. The average percent varies more among the remaining States. Some States have had outlier components averaging over 45 percent of the MF DE for these 2 years. Nine states have averaged over 25 percent.

Cutoff limits should be reviewed to insure that meaningful outlier components are provided. Outlier components that are 40 percent or more of the estimate are hardly useful or meaningful. However, it may not be possible to provide consistently meaningful cutoff limits for the very small states with just a few positive reports since any of these reports can have a large influence on the total DE. Thomas et al.[4] discuss cutoff limits in terms of upper quantiles.

Figure 1. Outlier Component as a Percent of the Direct Expansion



10 Major States' percents calculated from 1975-1989 quarterly data, others calculated from 1988-1989 quarterly data

The historical NASS database contains State level outlier components and standard deviations from all observations classified as outliers by this procedure, but neither the individual outliers nor the number of outliers have been archived. Quarterly State level outlier components and standard deviations are available for the 10 major hog producing States starting with the December 1975 quarter. All other States start with the March 1988 quarter.

The newer procedure, Procedure 2, uses historical stratum variances to detect influential list observations at the stratum level. Procedure 2 was implemented in 1982.[5] This procedure compares each observation's value to the stratum mean. List values larger than 10 standard deviations from the stratum mean are classified as outliers. This procedure's outlier component was about 3.5 percent of the National estimate in June 1989 and about 4 percent in September 1989.

Two censored estimates that adjust for outliers are computed from Procedure 2. The first excludes outlier observations and treats them as inaccessible responses. The summary system adjusts the sample count of usable observations used to calculate the stratum expansion factors. The second also excludes outlier observations but treats them as positive inaccessible responses in the nonresponse adjustment procedure.

The historical NASS database does not contain individual observations or the summary statistics from this procedure. However, the list frame individual outliers are available for all quarterly surveys starting with the December 1988 quarter in special databases managed by Statistical Methods Branch. The censored estimates are also available starting with the June 1989 quarter. Several additional quarters of censored estimates from microfilm copies of the hog analysis package output could be recovered with a sufficient clerical effort.

It should be noted that Procedure 2 involves only the list frame and therefore gives no indication of outliers in the NOL component of the multiple frame estimates. Because the NOL accounts for between 2/3 to 3/4 of the total variance in the hog series and because of limited data, no further analyses using Procedure 2 data was justified.

New Procedures

The techniques described below were produced using Procedure 1 historical data. They are intended to supplement current indications used by the Agricultural Statistics Board in setting National, Regional and State hog estimates.

The techniques can be divided into two logical groups for ease of discussion;

1. Standardized outlier component control charts for the detecting unusual outlier components, and

2. A simple robust procedure which will dampen the effect of unusual outlier components.

These procedures are based on the assumption that an average outlier component is expected each survey. It is recognized that a sample is not perfect and the outlier component from a sample may not truly represent the population. The new procedures are designed to identify when unusually large or small outlier component occur and dampen their affect on the survey expansion.

Standardized Outlier Component Control Charts

Standardized outlier component (SDOC) control charts identify when the current outlier component is unusual compared to previous outlier components. The SDOC for quarter t, $SDOC_t$, is calculated as:

$$SDOC_t = (O_t - \bar{O}_{h1}) / S_o$$

where

O_t = the outlier component for quarter t;

$$\bar{O}_{h1} = [\frac{1}{n_1}] \sum_{k=1}^{n_1} O_k,$$

is the mean of the historic outlier components;

$$S_o = [[\frac{1}{n_1 - 1}] \sum_{k=1}^{n_1} (O_k - \bar{O}_{h1})^2)]^{\frac{1}{2}}$$

is the standard deviation of the historic outlier components;

and n_1 = the number of quarters from t=1 to t-1.

The quarters 1 through n_1 make up a sliding window. Each quarter, the previous n_1 quarter's outlier components make up the historic base used to calculate SDOC's.

For general guidelines to interpret SDOC control charts, consider the standardized normal distribution, a normal distribution with mean zero and variance of one. Typically, any observation from a standardized normal distribution with a value greater than two or less than minus two is considered unusual. The SDOC values can be interpreted similarly. This is a generalization and does not imply we can assign probabilities to the event a SDOC is larger than a

given value. However, as the SDOC gets larger in absolute value, the more unusual the outlier component is compared to historic outlier components. We can consider SDOC's within plus or minus two as common. However, when SDOC's are beyond plus or minus two the outlier component is influencing the MF DE and more consideration should be given to the robust estimator.

Note the outlier component for the current quarter is not used to calculate the historic outlier component mean and standard deviation. Consequently, the current quarter SDOC is an independent comparison of the current outlier component against its historic base. The SDOC is not an indication of the size of the outlier component. Also, SDOC's, as defined here, are to be recalculated each quarter because each current quarter has a different historic base.

Robust Estimator

When an unusually large or small outlier component occurs, the MF will provide an unreliable indication of the population total. Recall that an underlying assumption of this robust approach is that it is possible for an unusual outlier component to occur on any survey but its value may not be representative of the true outlier component. A better estimate is an average which spreads unusual outlier levels over several surveys. Thomas et al.[4] examined an empirical Bayes method to stabilize the current survey estimate. A right-censored estimator for the NOL component of the MF estimate was also examined. The robust estimator presented here is similar to the right-censored estimator but is applied to the NOL and list components of the sample. The robust estimator introduced to the December 1989 Hog Board smooths out the current quarter's outlier component's influence by replacing it with the average outlier component from several quarters. The main reason for using the procedure is it's simplicity. The robust estimator for quarter t, R_t, is calculated as:

$$R_t = X_t - O_t + \bar{O}_{h2}; \qquad (1)$$

where

X_t = indication for quarter of interest,

O_t = the outlier component for quarter of interest,

$$\bar{O}_{h2} = [\frac{1}{n_2}] \sum_{k=1}^{n_2} O_k$$

is the mean outlier component, and

n_2 = n_1 plus the curent quarter.

Notice the robust estimator uses all outlier components in calculating the mean outlier component. This procedure spreads an unusual outlier component's influence out over several quarters so that it does not dominate the current quarter's indication.

The number of quarters, n_2, is presently a subjective choice. Guidelines for choosing the number of quarters should be examined. If n_2 is too small, influential outlier components are not spread over enough quarters, possibly causing the robust estimator to be biased. Similarly, if n_2 is too large, any trend in the size of the outlier component may also cause the robust estimator to be biased.

December 1989 Hog Board

For the December 1989 Hog Board, the robust estimator was applied to the MF DE and the adjusted MF DE indications. SDOC control charts and time series charts showing the relationship of the MF DE, adjusted MF DE, robust DE, adjusted robust DE, MF DE minus outlier component, adjusted MF DE minus outlier component, and outlier component were provided. Time series charts and additional computer listings displayed warning messages when the SDOC was 2 or larger. Charts and listings were generated for the individual 48 multiple frame States, the 16 State Region, 32 State Region, and 48 State Region.

SDOC's and robust indications were calculated using outlier components from the March 1988 through December 1989 quarters. This corresponds to the start of MF estimates for 48 continuous States. This was done for convenience since data prior to March 1988 is not available for all States. The standardized outlier component for December 1989, $SDOC_{D89}$, was calculated as:

$$SDOC_{D89} = (O_{D89} - \bar{O}_{h1}) / S_o$$

where

O_{D89} = outlier component for December 1989,

$\bar{O}_{h1}$ = mean outlier component calculated using outlier totals from March 1988 through September 1989,

S_o = standard deviation calculated using outlier totals from March 1988 through September 1989.

The robust indications were calculated as:

$$R_{D89\_i} = X_{D89\_i} - O_{D89} + \bar{O}_{h2},$$

where

X_{D89_i} = the MF DE when i=1,
the adjusted MF DE when i=2,

$\bar{O}_{h2}$ = mean outlier component calculated using outlier components from March 1988 through December 1989.

Note that March 1988 through September 1989 robust indications were estimated using the $\bar{O}_{h2}$. Thus, robust indications for these quarters are calculated using one or more future outlier components. This was done because of the limited amount of data available. In an operational setting, only previous outlier components would be used.

Applications since December 1989

Currently, only U.S., 10 State, and 16 State Regional charts showing the robust indications and Board estimates are provided to the Board. These charts show March 1988 to present quarter indications. Robust indications are calculated using the March 1988 to present outlier components. No State level time series charts are used and no SDOC control charts are used at any level by the Board.

RESULTS

Results will be presented in two sections. The first section documents materials provided to the December 1989 Hog Board. The second section presents an analysis of the September 1989 survey with SDOC's and robust indications.

Results for December 1989

Charts A1 through A11 in the Appendix are copies of 48 State region material provided the December 1989 Hog Board. Charts A1 through A8 show different combinations of the Multiple frame indications, Multiple frame indications minus outlier components, robust indications, first Board estimates, first Board revisions, and the outlier component. Chart A9 shows only the indications from Chart A3 on a different scale. Chart A11 is a SDOC control chart. Figures 2-4 are reproductions of the SDOC control charts for the 48 State region, 10 State region, and Georgia.

Figures 2 and 3 show that the December SDOC is about -0.5. This implies the December outlier components are not unusual compared to the previous seven quarters. Figure 4 shows Georgia's SDOC for December was about 3.5. This indicates the Georgia's robust indications should be followed more closely than the MF DE and adjusted MF DE. The large December SDOC is due to one NOL operation that expanded to about 714,000 head in December, or about 60 percent of the State's total.

Figure 2. SDOC Control Chart
U.S. level, December 1989

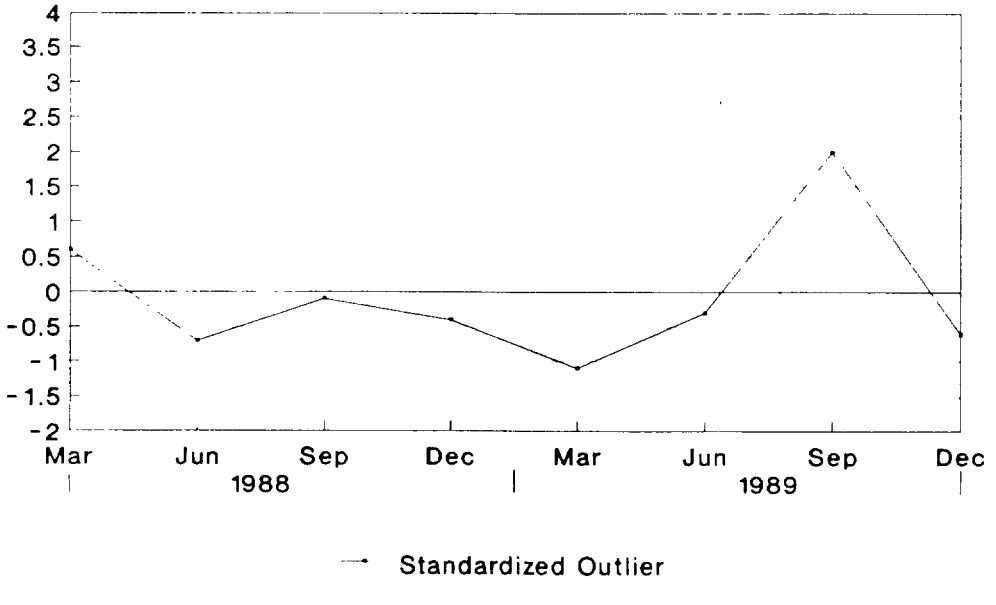


Figure 3. SDOC Control Chart, 10 State level, December 1989

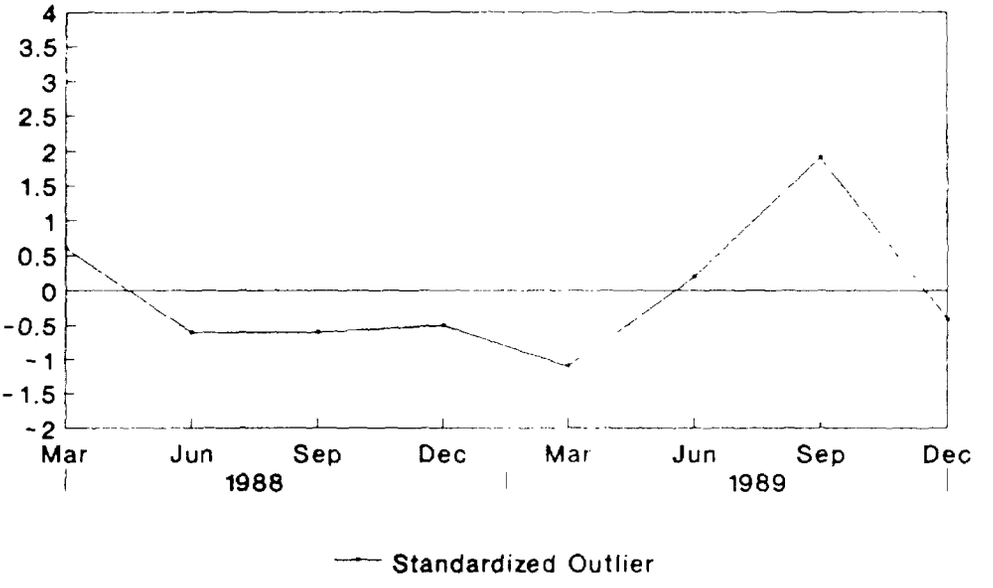


Figure 4. SDOC Control Chart, Georgia, December 1989

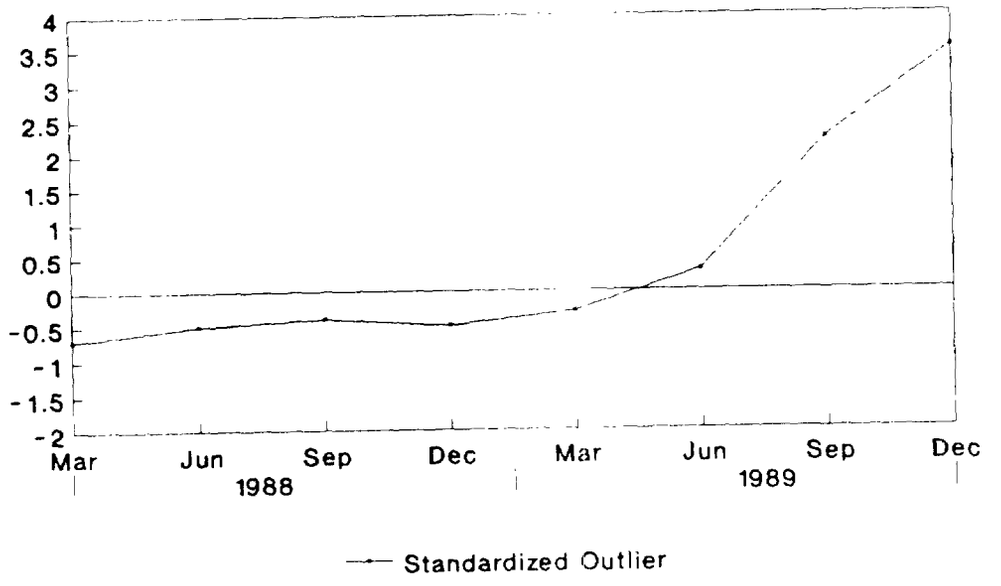


Table 2 shows the SDOC's for the 10 State, 16 State, 32 State, 48 State Region, and the 16 individual States from the December 1989 Survey. Besides the unusually large SDOC for Georgia, unusually small outlier components for Minnesota and the 32 State Region are present. Although Table 2 alone would identify potential outlier problems, review of the control charts is recommended to identify any long term problems or trends. For instance, Figure 4 shows that Georgia's outlier component had been fairly constant until March 1989 then it substantially increased in June, September, and December. This information should help with post-survey analysis and revisions. It is also noteworthy that the Regional SDOC's show no apparent outlier problems, but unusual SDOC's could exist for individual states. In the December 1989 survey, Georgia and Minnesota help offset each other so that the 10 State and 16 State regional SDOC's are small. It is important to review each published State's control chart.

Recognizing the unusual outlier levels for Georgia, Minnesota, and the 32 State Region, Figures 5,6,7, show how the Board used the simple robust indications in these situations. For Georgia, the December MF DE and adjusted MF DE are biased upward due to outliers so the Board more closely followed the robust indications. For Minnesota and the 32 State Region the MF DE and adjusted MF DE are biased downward due to small outlier levels, so the Board more closely followed the higher levels indicated by the robust indications. In all three cases, apparently the robust indications were influential on the Board estimate. Table A1 (in the Appendix) shows the indications, first Board and revised estimates, and differences for all 16 States and the regions.

Additional review of Figure 5 illustrates the problem of not spreading influential outlier components over enough quarters. Note that the March 1988 through March 1989 robust DE and adjusted robust DE are substantially higher than the MF DE, adjusted MF DE, and Board values. This is because the large September and December outlier components are included in the average outlier component. Recall equation 1,

$$R_t = X_t - O_t + \bar{O}_{h2}.$$

If the average outlier component ($\bar{O}_{h2}$) is substantially larger than the current outlier component (O_t), the robust indication will be substantially larger than the DE. The intent of the estimator is that this average will be a "better" indication of the true outlier component level. However, the average used in Figure 5 includes the large September and December outlier component values. Consequently, averages and robust estimates are probably biased upward for all quarters. This is most noticeable in March 1988 through March 1989 where the original outlier component was relatively small. This impact could possibly be reduced by increasing the number of quarters used to calculate $\bar{O}_{h2}$. Although this is an artificial setting since future data are used to

calculate the average outlier component, it still shows large outlier components in previous quarters have a major impact on the average outlier component if it is calculated with too few quarters.

Figure 5. Total Hogs--Georgia December 1989

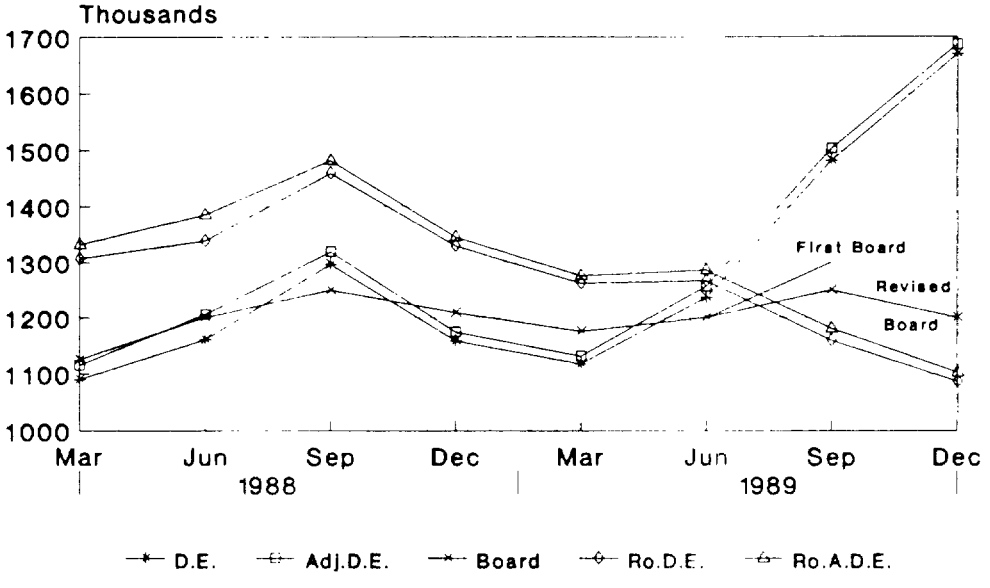


Figure 6. Total Hogs--Minnesota December 1989

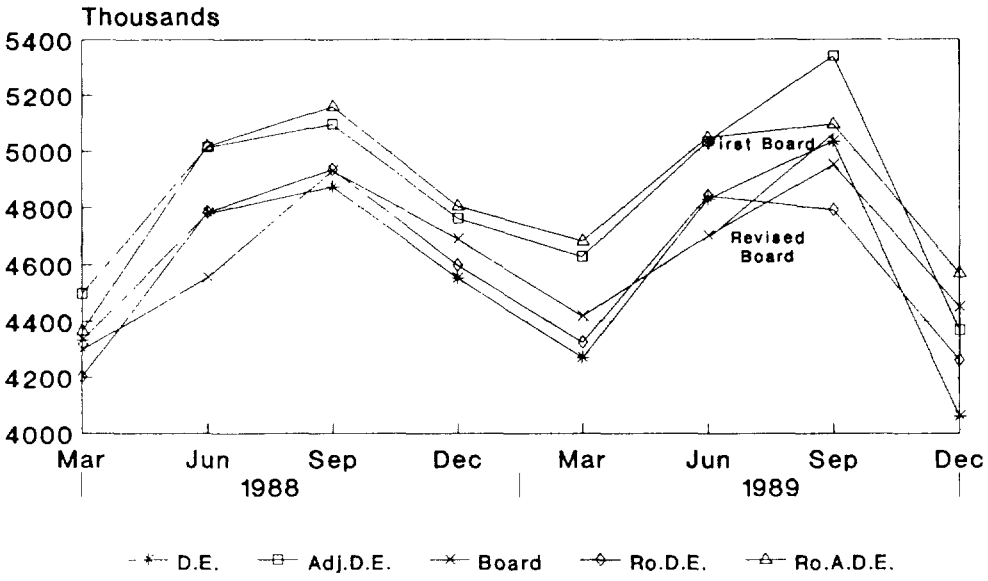


Figure 7. Total Hogs--32 State December 1989

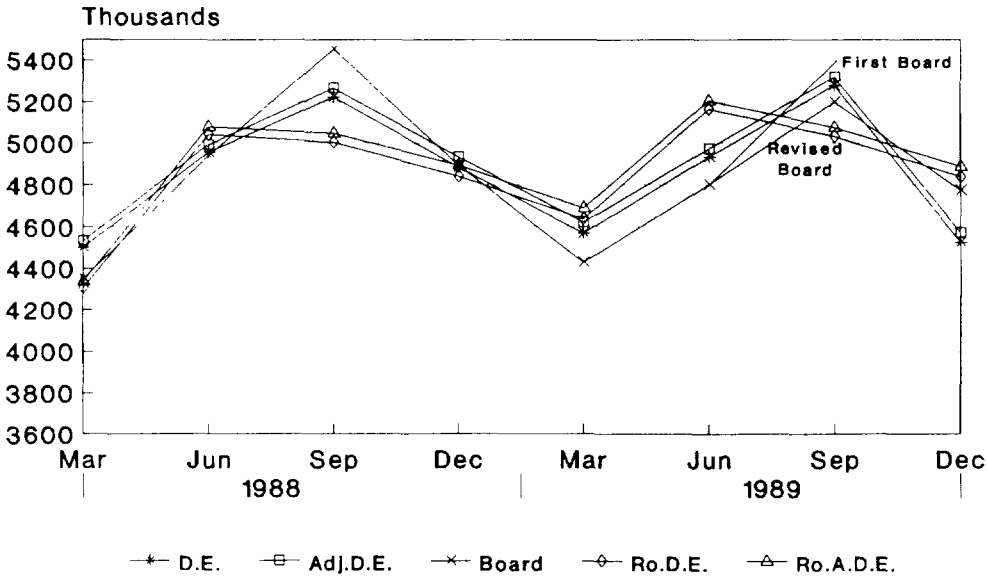


Table 2 -- SDOC's for December 1989 Multiple Frame Survey by State

State	Standardized Outlier Totals	State	Standardized Outlier Totals	State	Standardized Outliers Totals	State	Standardized Outlier Totals
GA.	3.5	KANSAS	-0.4	N.CAR.	-1.2	PA.	0.3
ILL.	-1.1	MINN.	-2.0	OHIO	-1.4	S.DAK.	1.0
IND.	0.3	MO.	-1.0	KY.	0.4	TENN.	-1.6
IOWA.	-1.5	NEB.	1.2	MICH.	0.5	WISC.	1.6
10 HOG	-0.4	16 HOG	-0.2	32 HOG	-2.0	48 HOG	-0.6

Results of September 1989 Simulation

During the September 1989 survey, it was recognized that outliers were greatly affecting the survey indications. Analysis was conducted to examine the possible impact of the outlier detection and robust estimation techniques if they had been available. To do this the SDOC's and robust indications were recalculated as if in an operational setting. That is, each charted robust indication was calculated using only previous survey data. The SDOC values for the original 10 major hog States were calculated using the previous seven quarters' (December 1987-June 1989) outlier components, while the previous six quarters (March 1988-June 1989) outlier components were used for the remaining six States. This simulation is only an example of many possible approaches. This approach was chosen to mirror the December 1989 procedures as much as possible.

Figure 8 is an example of a simulated September 1989 time series chart using Georgia hogs indications. Figure 9 is the SDOC control chart. These figures are similar to Charts A5 and A6, respectively.

Figure 8 shows the robust indications support the Board estimates up through June 1989. The large September outlier component causes the MF survey indications to increase over 200,000 hogs from the June indications while the robust indications decline slightly. Figure 9 shows Georgia's September SDOC is about 8, extremely unusual. Figures 8 and 9 clearly show the September 1989 outlier component in Georgia was unusually large and affected the multiple frame indications.

Figure 8. Total Hogs--Georgia September 1989

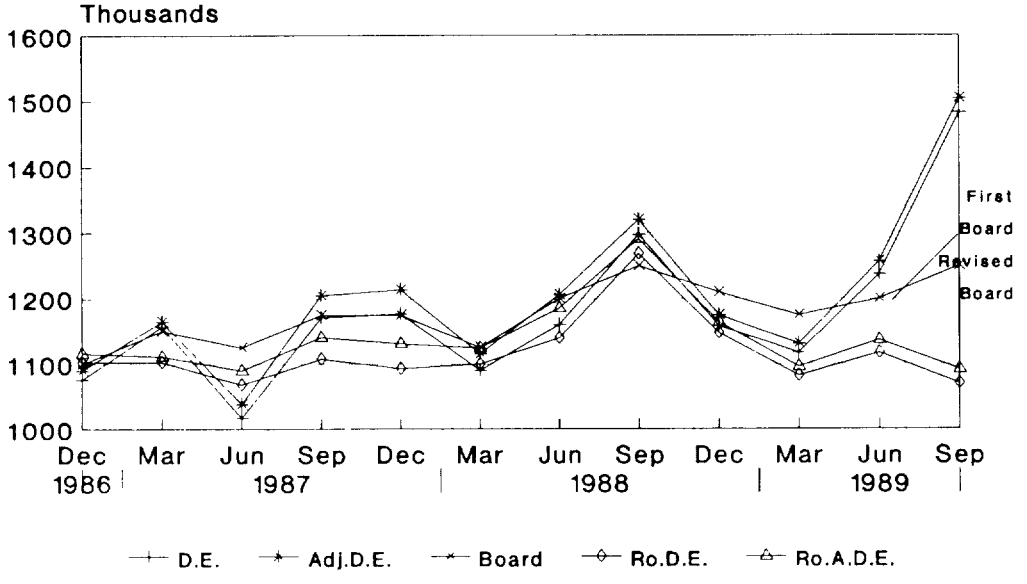
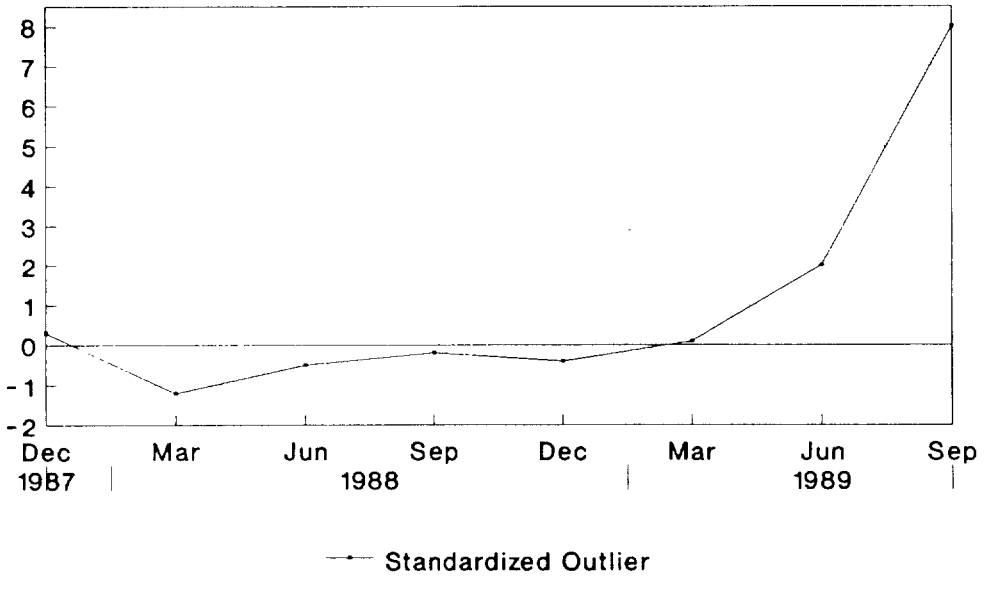


Figure 9. SDOC Control Chart, Georgia, September 1989



Comparing Figure 9 (Georgia's September SDOC control chart) with Figure 4 (Georgia's December SDOC control chart) illustrates the impact that an unusually large outlier component can have on SDOC values. Georgia's September outlier component was 598,574. The September chart (Figure 9) shows this value had a SDOC of about eight while the December chart (Figure 4) shows September with a SDOC of about two. This is because a different historic base is used each month to calculate the historic outlier component average ($\bar{O}_{h1}$) and standard deviation (S_o). September's large outlier component is not used to calculate Figure 9's SDOC's while it is used to calculate Figure 4's SDOC's. This also shows that one previous quarter's large outlier component can have a major impact on the current quarter's SDOC if it is calculated with too few quarters of data. Table 3 shows the historic mean and standard deviations are very different for each chart. This demonstrates that the current quarter SDOC is simply a comparison of the current quarter outlier component against its historic base. It does not indicate the actual size of the outlier component.

Table 3 -- Comparison of Georgia's SDOC values

SDOC Chart	Historic Mean	Historic Standard Deviation	September Outlier Component	September SDOC Value 1/
September	127,398	585,810	598,574	8
December	192,323	188,331	598,574	2

1/ SDOC = $\frac{\text{September Outlier Component-Historic Mean}}{\text{Historic Standard Deviation}}$

Table 4 shows six States, Georgia, Indiana, Minnesota, Nebraska, Ohio, and Wisconsin would have had SDOC's greater than two. The SDOC for N. Carolina would have been -2.7. Also the, 10 State Region, 16 State Region, and National levels would have had similarly high SDOC's. It is obvious there were several unusual outlier components in the September data.

Table 4 -- Simulated standardized outlier components for September 1989 Multiple Frame Survey by State

State	SDOC	State	SDOC	State	SDOC	State	SDOC
GA.	8.0	KANSAS	-1.9	N.CAR.	-2.7	PA.	1.1
ILL.	0.6	MINN.	3.5	OHIO	3.4	S.DAK.	-0.2
IND.	3.0	MO.	-1.2	KY.	0.5	TENN.	-1.1
IOWA.	-0.6	NEB.	3.4	MICH.	-0.3	WISC.	3.2
10 HOG	3.4	16 HOG	4.4	32 HOG	1.3	48 HOG	3.3

Recognizing the impact that the SDOC charts and robust indications had on the December Board estimates, it is probable that the September estimates would have been similarly affected. Estimates for States with large SDOC's (larger than two) would have followed the lower robust indications more closely than the operational MF indication. Estimates for States with small SDOC's (smaller than minus two) would have followed the larger robust indication more closely. The initial Board estimates for these targeted States and Regions were subsequently revised as indicated in Table 5. In general, these revisions were in the direction anticipated by the SDOC value and robust indication. Only North Carolina and Ohio were not revised. Quite likely, revisions would not have been necessary or at least reduced if these procedures had been available in September.

Table 5 -- September 1989 Hog Indications and Board Estimate

State	Simulated SDOC	MF DE	Robust DE	First Board	Revised Board
GA.	8.0	1482	1070	1300	1250
IND.	3.0	5158	4440	4650	4550
MINN.	3.5	5036	4802	5050	4950
NEB.	3.4	4424	4132	4450	4350
N.CAR.	-2.7	2627	2780	2700	2700
OHIO	3.4	2277	2125	2300	2300
WISC.	3.2	1407	1239	1350	1300
10 HOG	3.4	45927	44511	45800	45200
16 HOG	4.4	53199	51526	53045	52395

Table A2 shows the indications, first Board and revised estimates, and differences for all States and Regions.

CONCLUSIONS

Occasionally and unpredictably, outliers have a large impact on State, Regional, and National survey indications. Techniques are needed to identify when unusual outliers occur and to provide robust indications that dampen the effect of the outliers. After a thorough review of outlier detection and robust techniques, simple procedures were developed and implemented for the December 1989 Hog Board. SDOC control charts clearly identified that unusually large and small outlier components were present for some States and Regions in the December 1989 data. Review of the Official estimates indicate that the robust indications did influence the Board action for these States and Regions. Analysis also indicates that SDOC control charts would have identified unusual outlier components in the September 1989 data and that using the robust indications could have reduced or eliminated the revisions that were later necessary. However, unusual outlier components will have a large impact on the SDOC and robust estimator if not enough historic data are used. Also, current outlier cutoff limits are not meaningful for many States.

RECOMMENDATIONS

NASS research and operational statistical methodology units should put high priority on jointly developing and implementing more robust multiple frame procedures. After reviewing how the SDOC control charts and the robust estimator performed for the December 1989 Hog Board and in the September 1989 simulation, we recommend the following:

1. Examine methods that reduce the impact of unusual historic outlier components on the SDOC and robust estimator. This should include reviewing the amount of historic data used for calculating the SDOC and robust indications.

2. Review present outlier cutoff limits and examine other criteria for determining these cutoff limits. Current cutoff limits do not provide meaningful outlier components for many States.

3. Research staff should study the statistical characteristics of individual outliers and other components to aid in the development of effective outlier detection and robust estimation procedures.

4. Modify the operational summary systems with several new experimental outlier cutoff limits and store individual outlier observations for robust estimation analysis and review.

Once 1 through 4 have been resolved then:

5. The Agency should make it an important goal to implement outlier detection and robust estimation techniques for SSO and National Board reviews of most MF crop and livestock estimates.

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6. U.S. Department of Agriculture, Statistical Reporting Service. Scope and Methods of the Statistical Reporting Service. Misc. Publ. No. 1308, September 1983.

APPENDIX

Table A1 -- Multiple frame and robust indications, first and revised Board estimates, 16 major hog States, December 1989

State	Multiple Frame Ind.				Robust Ind.				Board		
	DE	*diff	Adj. DE	*diff	DE	*diff	Adj. DE	*diff	First	*diff	Revised
					(000)						
GA.	1670	-470	1687	-487	1086	114	1103	97	1200	0	1200
ILL.	5307	393	5696	4	5460	240	5849	-149	5700	0	5700
IND.	4307	43	4489	-139	4196	154	4379	-29	4350	0	4350
IOWA.	13022	478	13481	19	13500	0	13959	-459	13500	0	13500
KANSAS	1367	83	1461	-11	1378	72	1472	-22	1450	0	1450
MINN.	4062	388	4369	81	4262	188	4569	-119	4450	0	4450
MO.	2539	161	2612	88	2598	102	2672	28	2700	0	2700
NEB.	3793	407	4131	69	3628	572	3966	234	4200	0	4200
N.CAR.	2564	6	2651	-81	2664	-94	2751	-181	2570	0	2570
OHIO	1807	273	1916	164	1906	174	2015	65	2080	0	2080
10 HOG	40437	1763	42492	-292	40680	1520	42735	-535	42200	0	42200
KY.	961	14	990	-15	940	35	968	7	975	0	975
MICH.	1247	13	1282	-22	1224	36	1258	2	1260	0	1260
PA.	940	35	955	20	926	49	941	34	975	0	975
S.DAK.	1754	-34	1862	-142	1709	11	1817	-97	1720	0	1720
TENN.	653	47	671	29	795	-95	813	-113	700	0	700
WISC.	1298	-48	1329	-79	1166	84	1197	53	1250	0	1250
16 HOG	47289	1791	49579	-499	47438	1642	49728	-648	49080	0	49080
32 HOG	4526	246	4573	199	4840	-68	4886	-114	4772	0	4772
US HOG	51816	2036	54152	-300	52278	1574	54615	-763	53852	0	53852

*diff is the Revised Board Estimate minus the previous indication.

Table A2 -- Multiple frame and simulated robust indications, first and revised Board estimates, 16 major hog States, September 1989

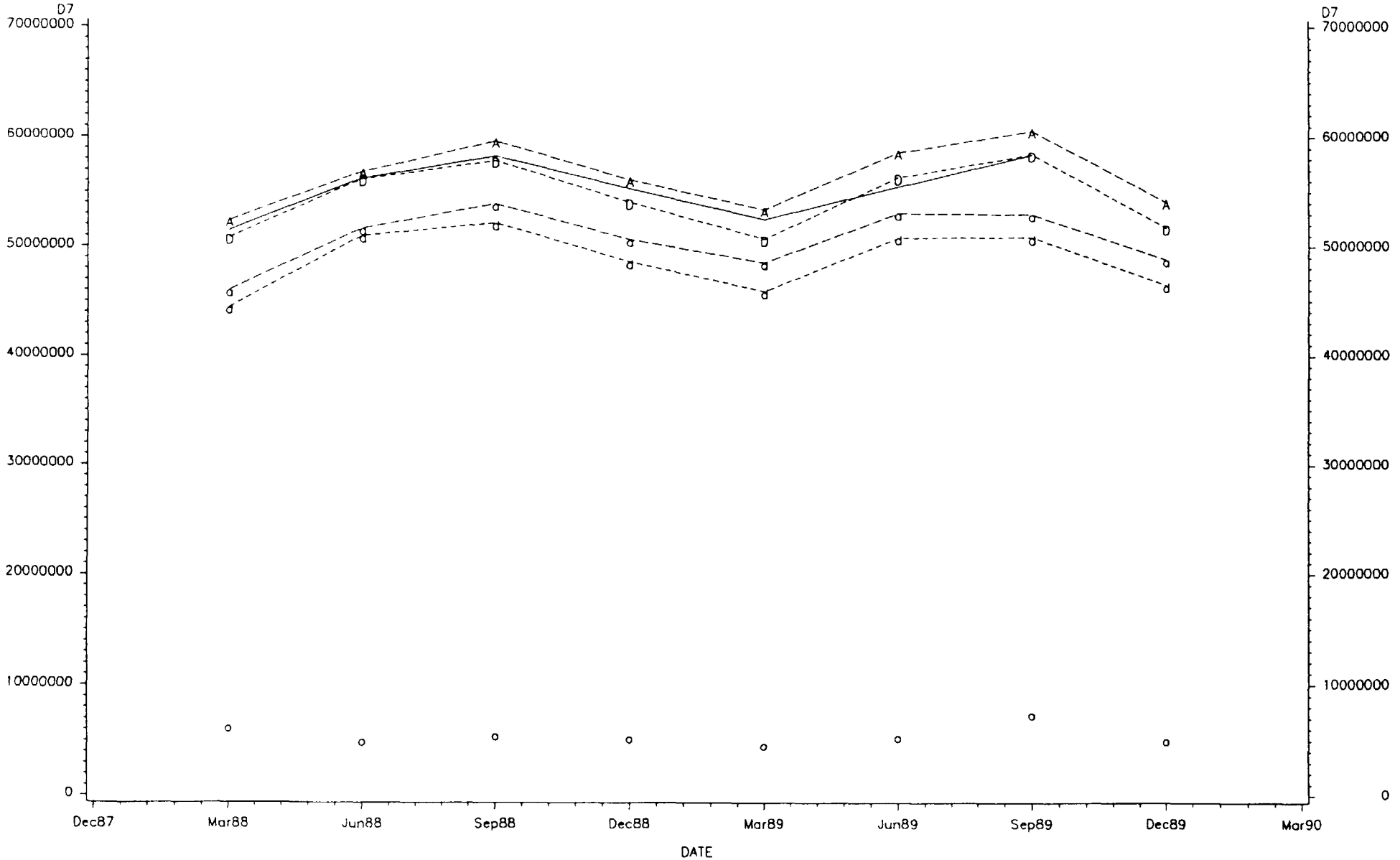
	Multiple Frame Ind.				Simulated Robust Ind.				Board		
State	DE	*diff	Adj. DE	*diff	DE	*diff	Adj. DE	*diff	First	*diff	Revised
					(000)						
GA.	1482	-232	1504	-254	1070	180	1092	15	1300	-50	1250
ILL.	5951	149	6181	-81	5879	221	6108	-8	6100	0	6100
IND.	5158	-608	5289	-739	4440	110	4571	-21	4650	-100	4550
IOWA.	14635	-35	15208	-608	14816	-216	15389	-789	14800	-200	14600
KANSAS	1536	14	1639	-89	1579	-29	1682	-132	1600	-50	1550
MINN.	5036	-86	5341	-391	4802	148	5108	-158	5050	-100	4950
MO.	2801	49	2854	-4	2889	-39	2942	-92	2850	0	2850
NEB.	4424	-74	4708	-358	4132	218	4415	-65	4450	-100	4350
N.CAR.	2627	73	2676	24	2780	-80	2829	-129	2700	0	2700
OHIO	2277	23	2363	-63	2125	175	2211	89	2300	0	2300
10 HOG	45927	-727	47764	-2564	44511	689	46348	-1148	45800	-600	45200
KY.	1028	-3	1047	-22	998	27	1017	8	1025	0	1025
MICH.	1262	38	1315	-15	1277	23	1330	-30	1300	0	1300
PA.	1038	-18	1045	-25	982	38	989	31	1020	0	1020
S.DAK.	1756	-6	1860	-110	1767	-17	1871	-121	1750	0	1750
TENN.	781	19	813	-13	874	-74	906	-106	800	0	800
WISC.	1407	-107	1429	-129	1239	61	1261	39	1350	-50	1300
16 HOG	53199	-804	55273	-2878	51526	869	53600	-1205	53045	-650	52395
32 HOG	5280	-80	5320	-120	5400	-200	5078	122	5114	86	5200
US HOG	58479	-884	60594	-2999	58445	-850	56687	908	58601	-1006	57595

*diff is the Revised Board Estimate minus the previous indication.

Chart A1

TOTAL HOGS -- U.S. LEVEL

LEVEL=1 GROUP=No apparent outliers SIGN=2 SIZE=0.6 FIPS=99 ST_REG=48 HOG

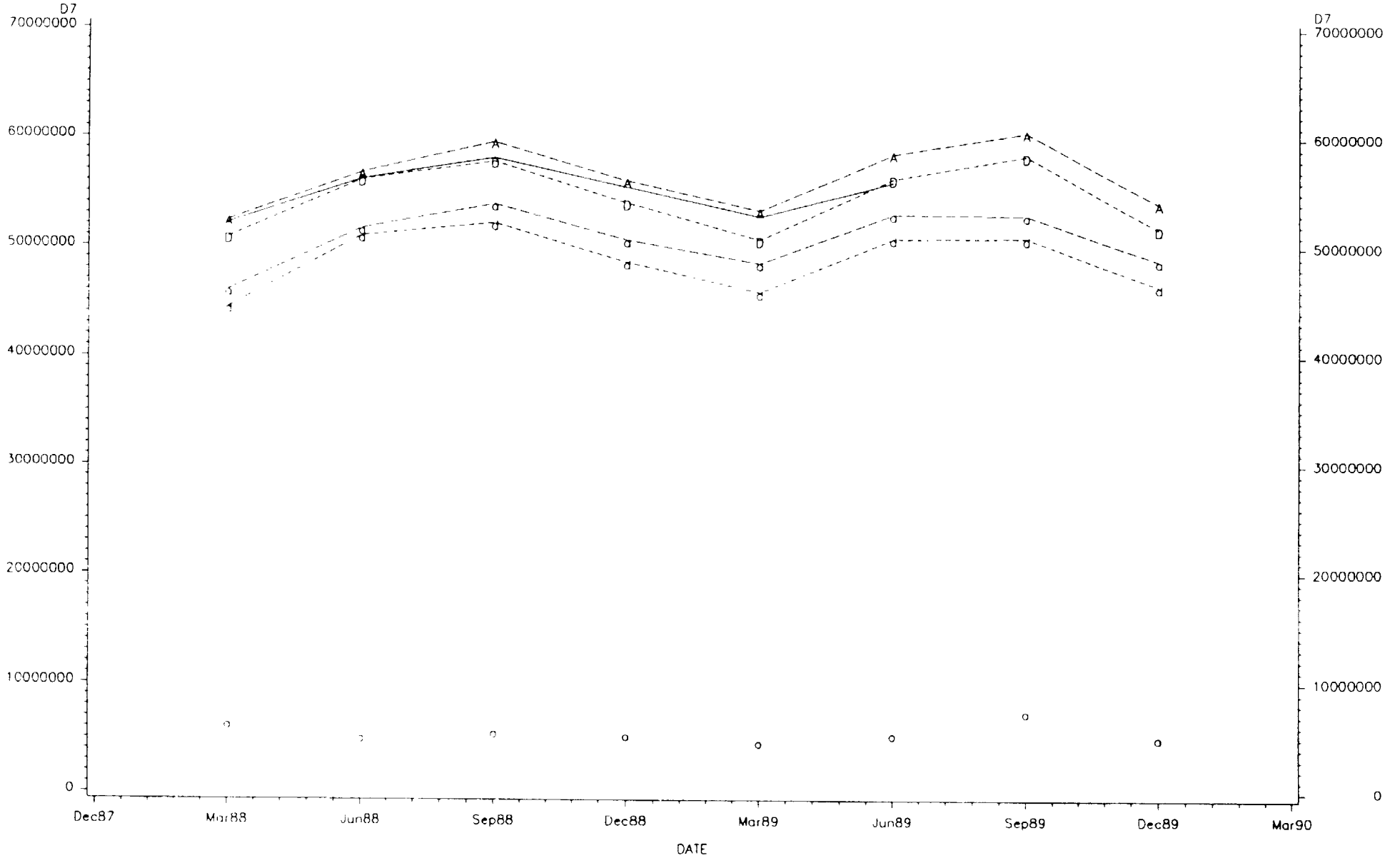


D: Direct Expansion.
A: Adjusted.
d: Direct Expansion Less Current Outliers.
a: Adjusted Less Current Outliers.
-: First Board Estimate.
o Sum of all Outliers.

Chart A2

TOTAL HOGS -- U.S. LEVEL

LEVEL=1 GROUP=No apparent outliers SIGN=2 SIZE=0.6 FIPS=99 ST_REG=48 HOG

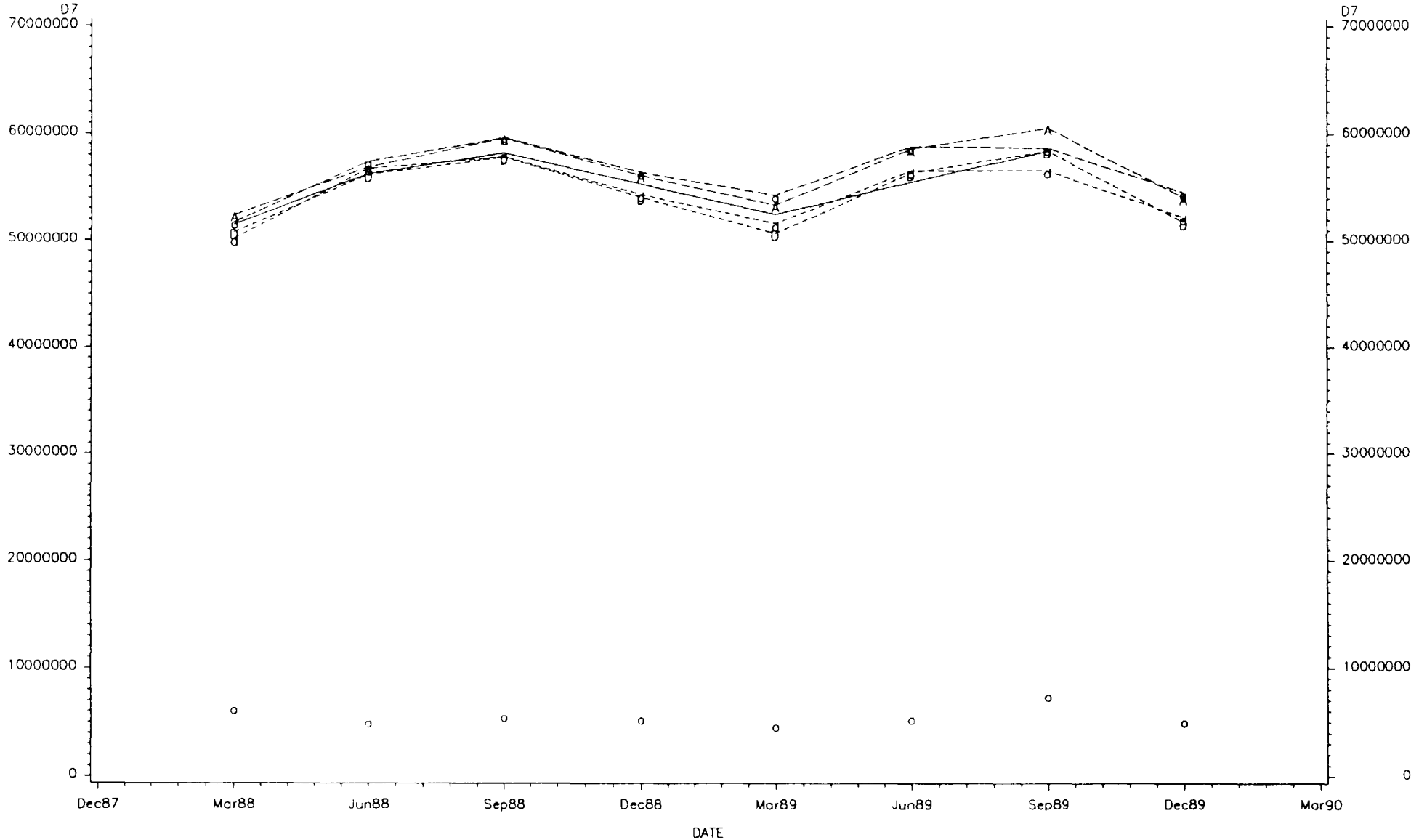


D: Direct Expansion.
A Adjusted.
d. Direct Expansion Less Current Outliers.
a Adjusted Less Current Outliers
– First Board Revision
o Sum of all Outliers.

Chart A3

TOTAL HOGS -- U.S. LEVEL

LEVEL=1 GROUP=No apparent outliers SIGN=2 SIZE=0 6 FIPS=99 ST_REG=48 HOG

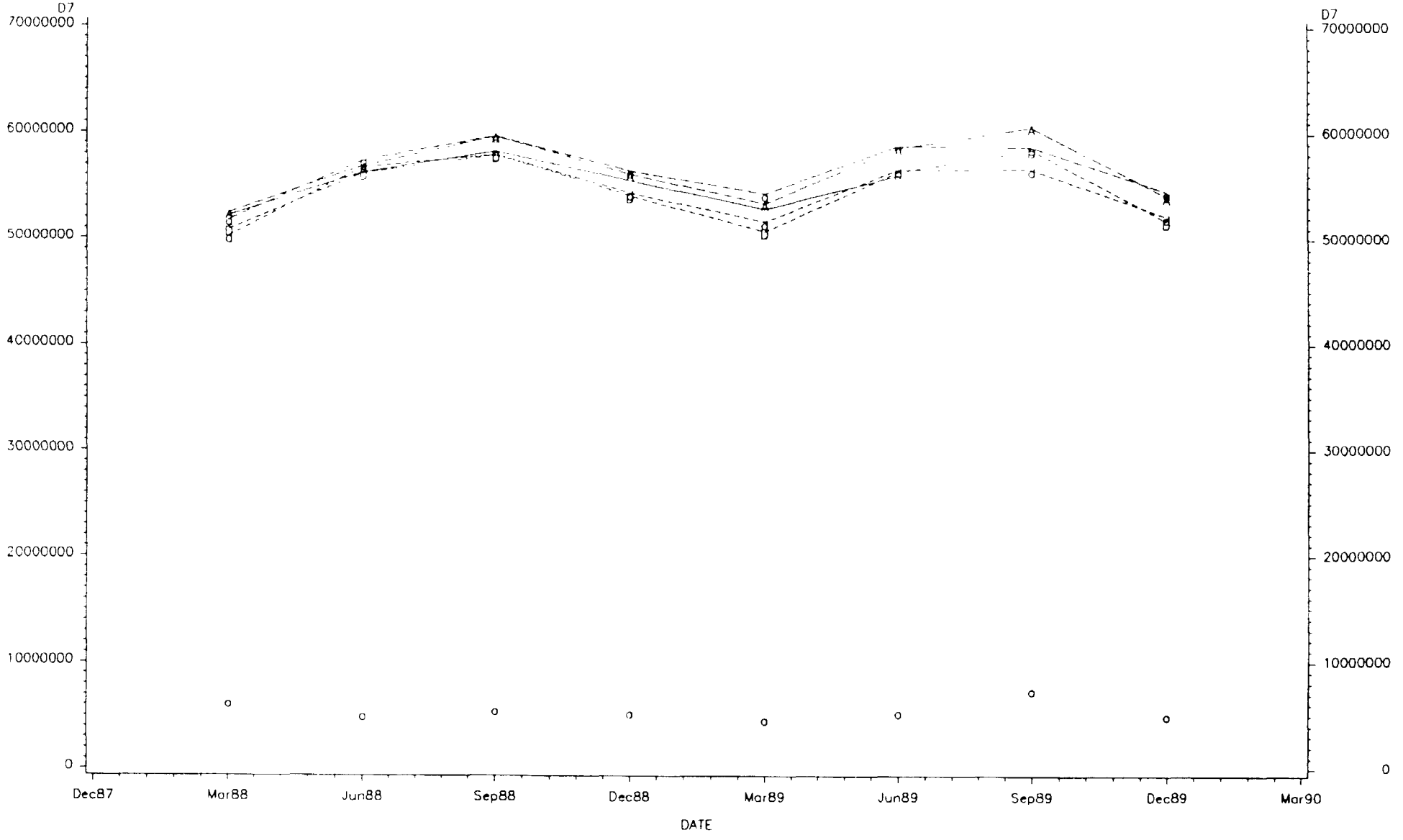


D. Direct Expansion.
A: Adjusted.
d: Direct Expansion Less Current Outliers
Plus Mean of historical Outliers..
a: Adjusted Less Current Outliers
Plus Mean of historical Outliers.
– First Board Estimate.
o: Sum of all Outliers.

TOTAL HOGS -- U.S. LEVEL

Chart A4

LEVEL=1 GROUP=No apparent outliers SIGN=2 SIZE=0 6 FIPS=99 ST_REG=48 HOG

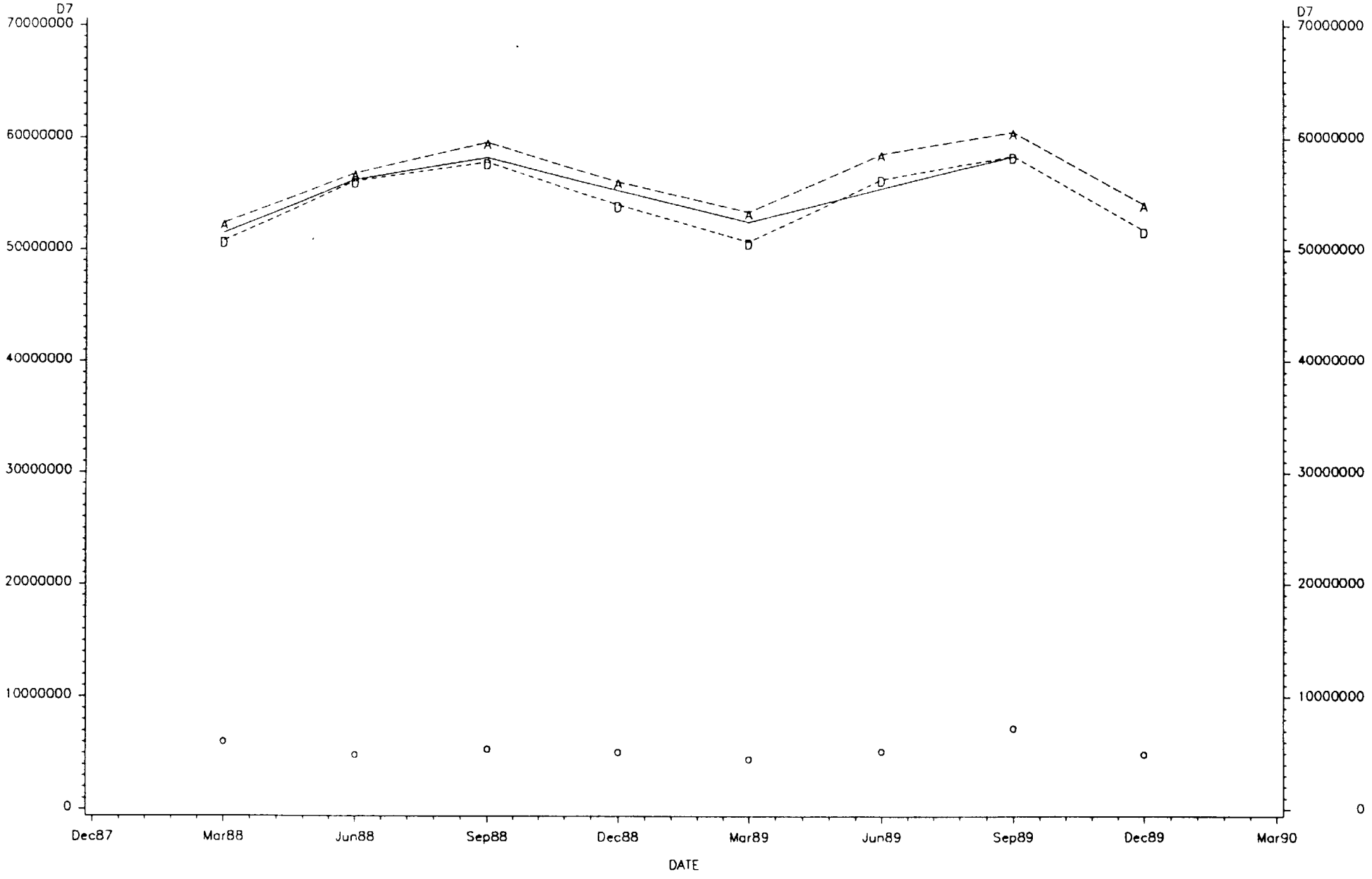


D. Direct Expansion.
A: Adjusted.
d: Direct Expansion Less Current Outliers
Plus Mean of historical Outliers..
a: Adjusted Less Current Outliers
Plus Mean of historical Outliers
– First Board Revision
o. Sum of all Outliers

Chart A5

TOTAL HOGS -- U.S. LEVEL

LEVEL=1 GROUP=No apparent outliers SIGN=2 SIZE=0.6 FIPS=99 ST_REG=48 HOG

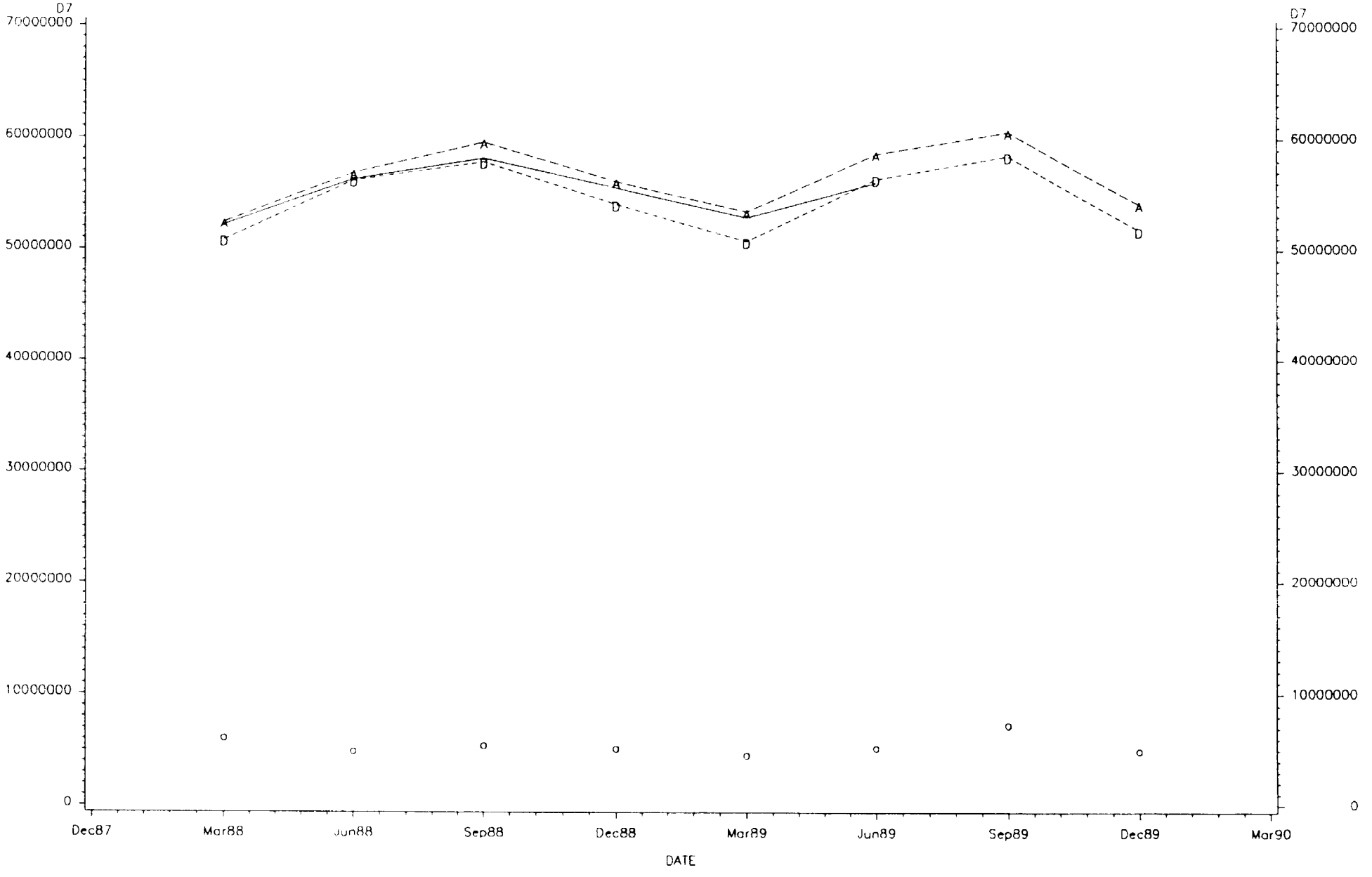


D. Direct Expansion.
A. Adjusted.
-: First Board Estimate.
o: Sum of all Outliers.

TOTAL HOGS -- U.S. LEVEL

Chart A6

LEVEL=1 GROUP=No apparent outliers SIGN=2 SIZE=0.6 FIPS=99 ST_PEG=48 HOG

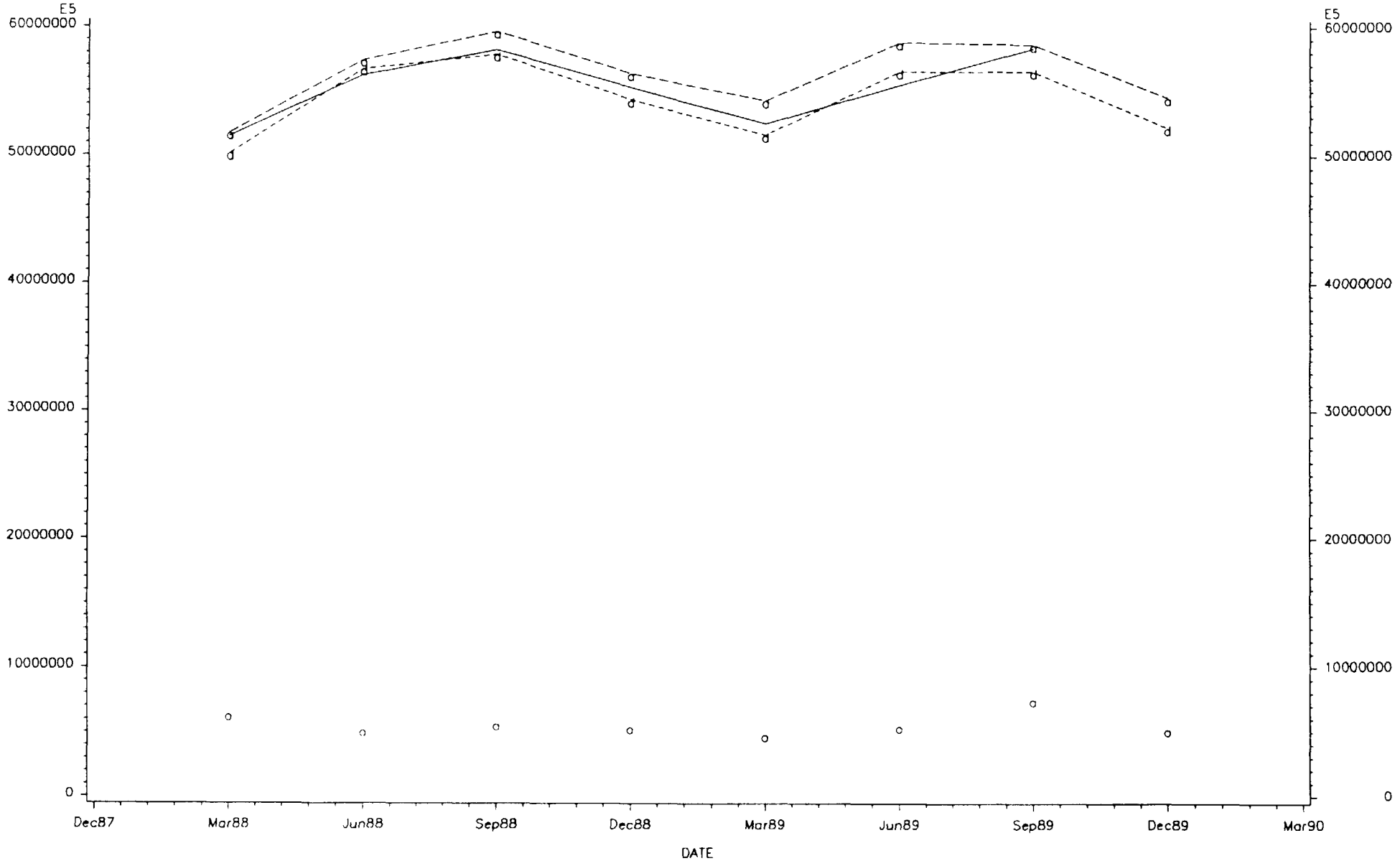


D: Direct Expansion.
A: Adjusted.
– First Board Revision
o Sum of all Outliers

Chart A7

TOTAL HOGS -- U.S. LEVEL

LEVEL=1 GROUP=No apparent outliers SIGN=2 SIZE=0.6 FIPS=99 ST_REG=48 HOG

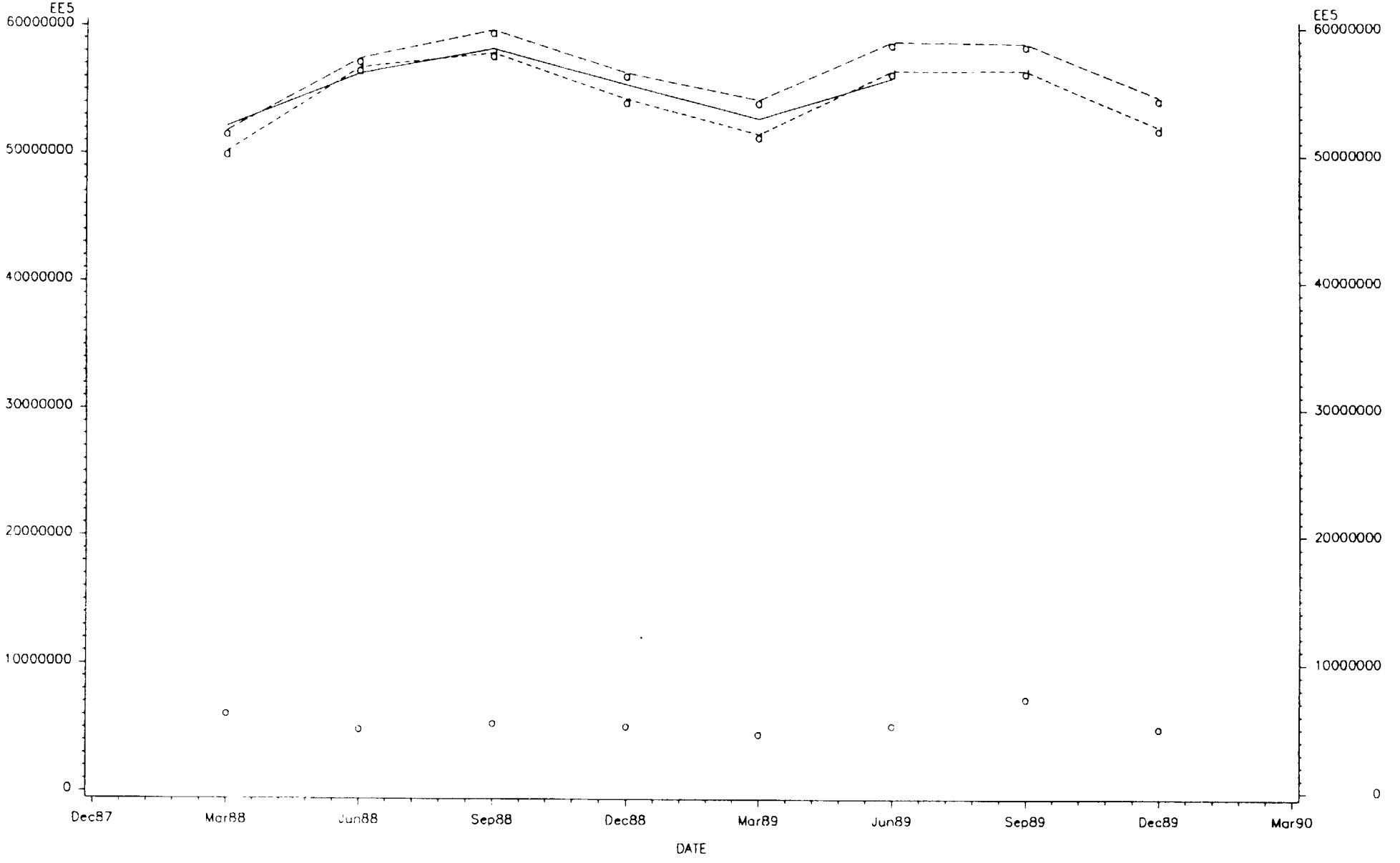


d: Direct Expansion Less Current Outliers
Plus Mean of historical Outliers..
a: Adjusted Less Current Outliers
Plus Mean of historical Outliers.
– First Board Estimate.
o: Sum of all Outliers.

Chart A8

TOTAL HOGS -- U.S. LEVEL

LEVEL=1 GROUP=No apparent outliers SIGN=2 SIZE=0 6 FIPS=99 ST_REG=48 HOG

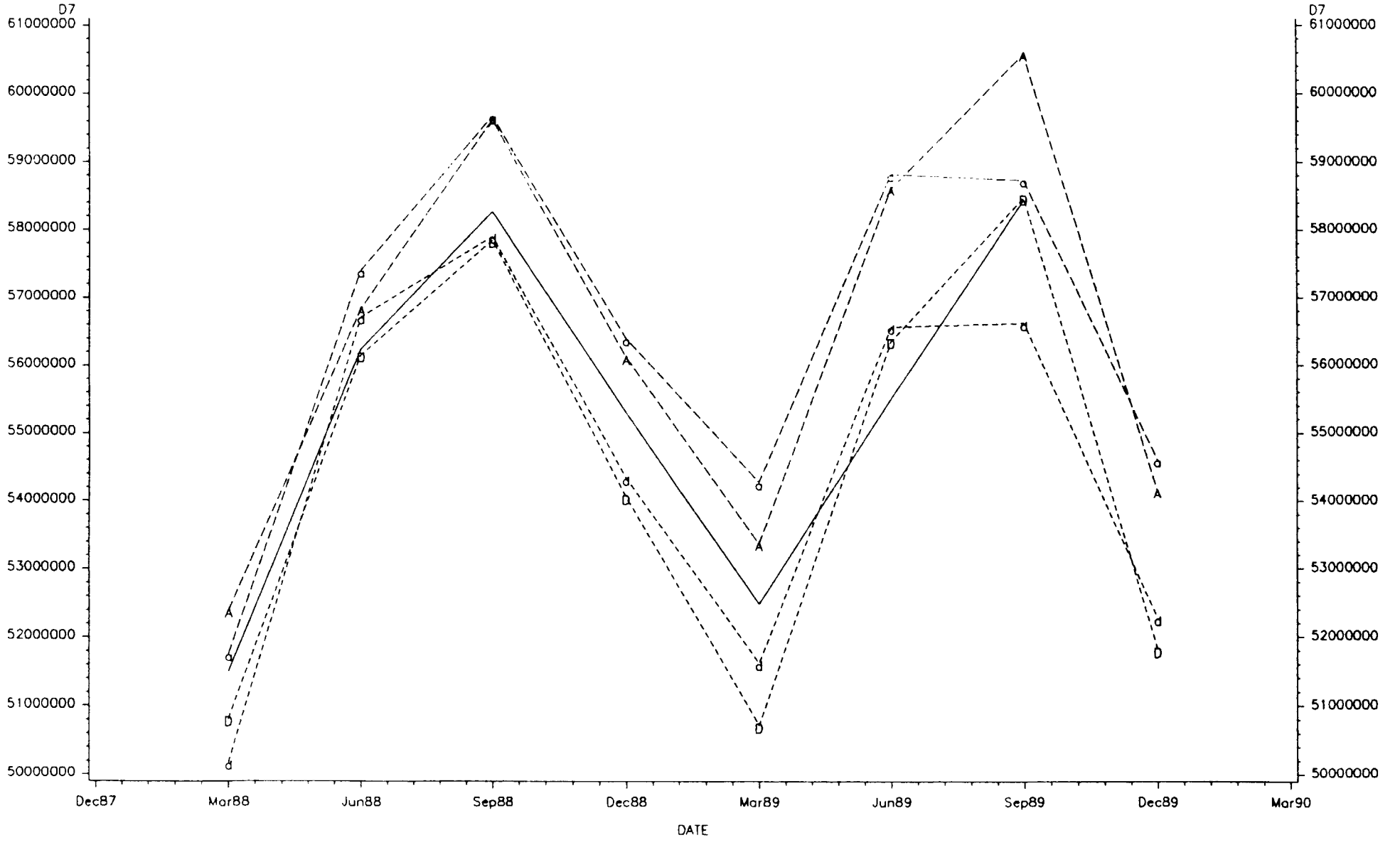


d: Direct Expansion Less Current Outliers
Plus Mean of historical Outliers .
a: Adjusted Less Current Outliers
Plus Mean of historical Outliers
-. First Board Revision
c Sum of all Outliers

TOTAL HOGS -- U.S. LEVEL

Chart A9

LEVEL=1 GROUP=No apparent outliers SIGN=2 SIZE=0.6 FIPS=99 ST_REG=48 HOG

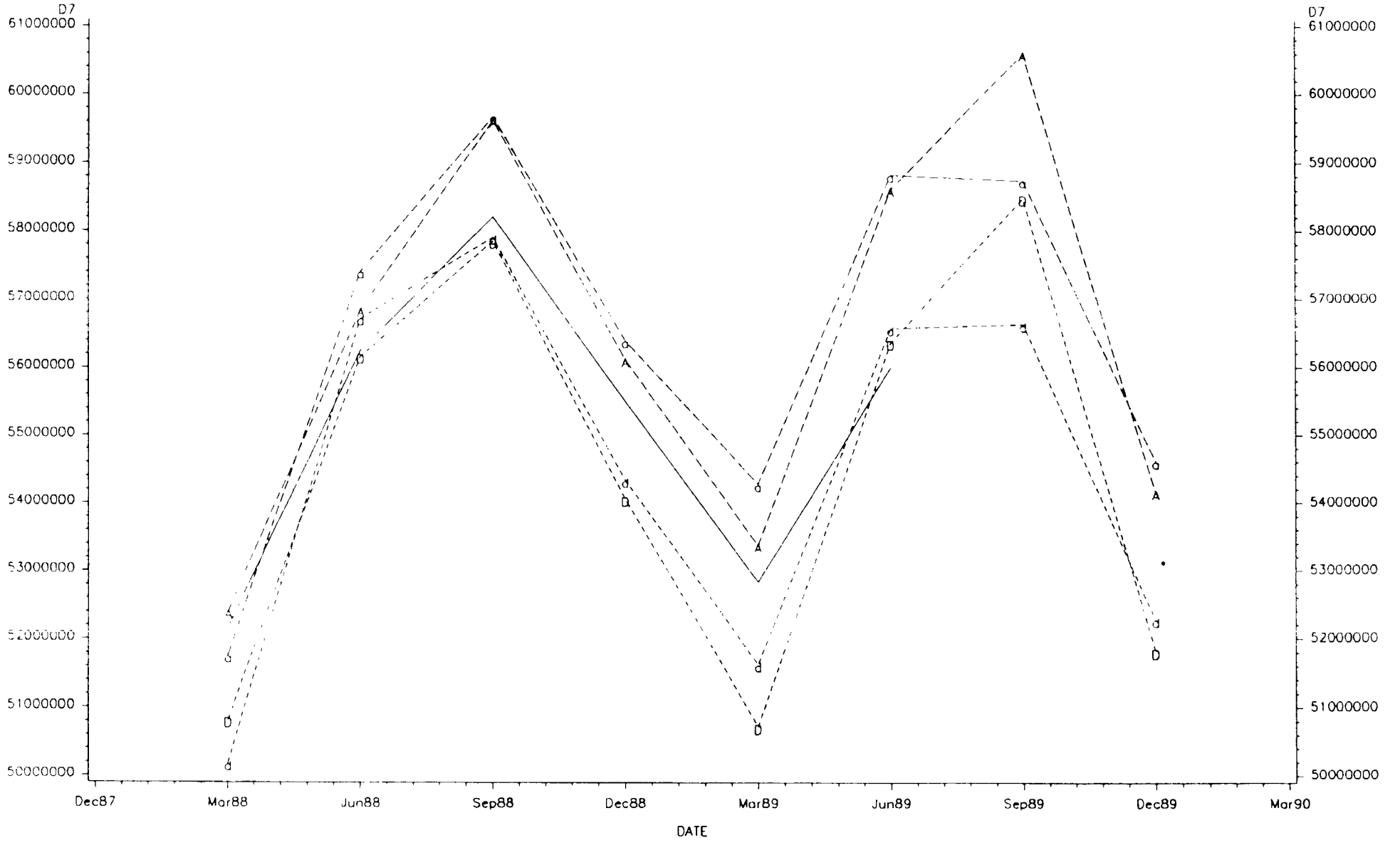


D: Direct Expansion.
A: Adjusted.
d: Direct Expansion Less Current Outliers Plus Mean of historical Outliers..
a: Adjusted Less Current Outliers Plus Mean of historical Outliers.
– First Board Estimate.

Chart A10

TOTAL HOGS -- U.S. LEVEL

LEVEL=1 GROUP=No apparent outliers SIGN=2 SIZE=0.6 FIPS=99 ST_REG=48 HOG

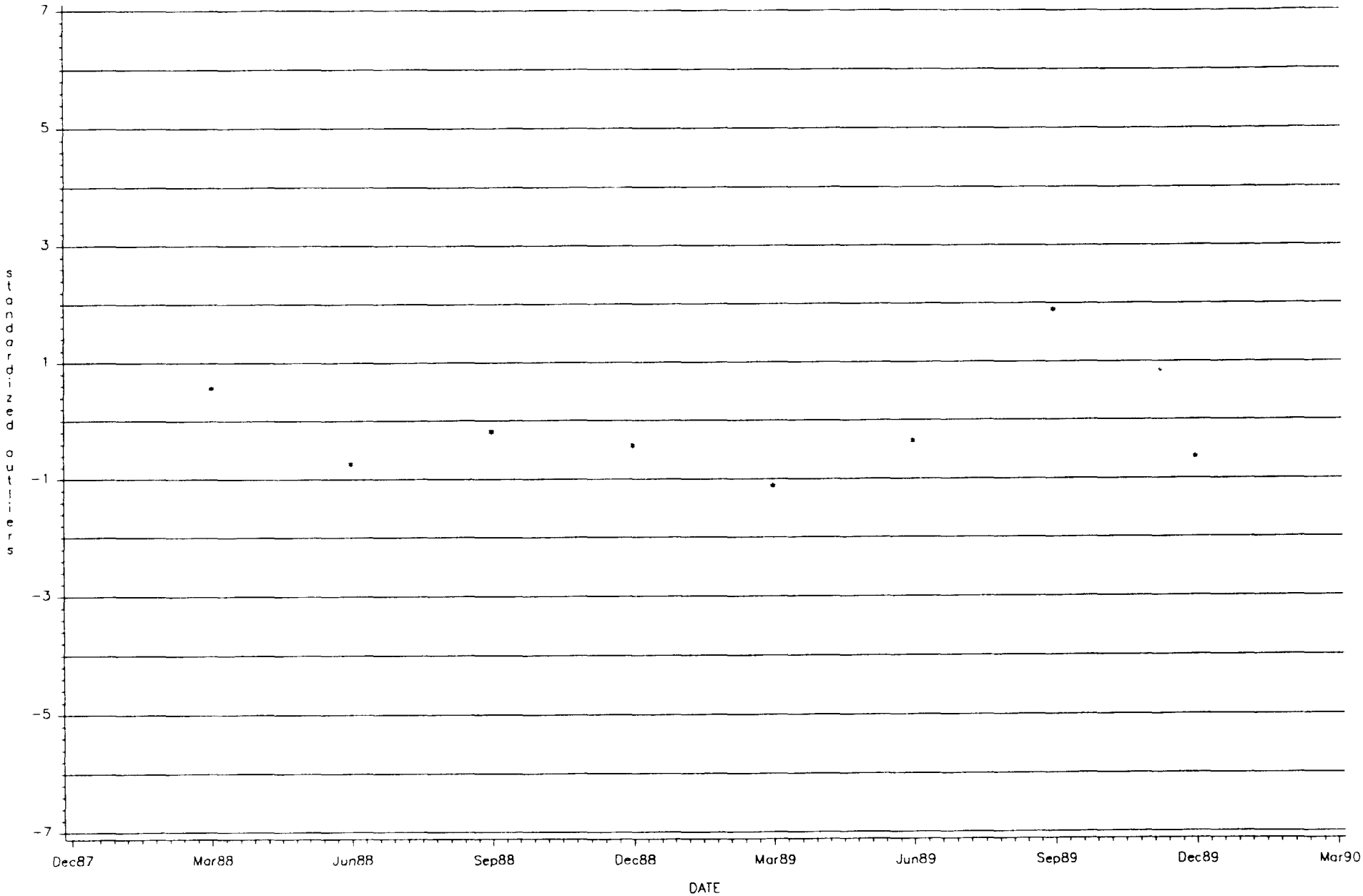


D: Direct Expansion
A: Adjusted.
d: Direct Expansion Less Current Outliers Plus Mean of historical Outliers.
a: Adjusted Less Current Outliers Plus Mean of historical Outliers.
– First Board Revision.

Chart All

TOTAL HOGS -- U.S. LEVEL

LEVEL=1 GROUP=No apparent outliers SIGN=2 SIZE=0.6 FIPS=99 ST_REG=48 HOG



$$\text{o} = \frac{\text{current outliers} - \text{historical outliers mean}}{\text{historical standard error of outliers}}$$

* U.S. G.P.O.:1991-281-097:40038/NASS