Working Papers

NONRESPONSE UNDER MANDATORY VS. VOLUNTARY REPORTING IN THE 1989 SURVEY OF POLLUTION ABATEMENT COSTS AND EXPENDITURES (PACE)

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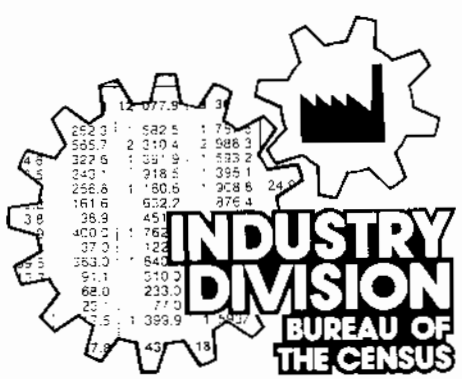

U.S. Department of Commerce
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A. Background

1. Mandatory vs. Voluntary

The Economic Area of the Census Bureau conducts economic censuses every 5 years and economic surveys annually, quarterly, and monthly. Many of these surveys are conducted under mandatory reporting authority by law, but some are conducted under voluntary reporting. The nonresponse rates to date for the Census Bureau's voluntary economic surveys are higher than those for other surveys, and there is great concern about the possible causes and remedies, as well as quality implications. Of course, the remedies are dependent upon the causes, and quality implications are dependent upon the accuracy of imputation techniques.

For any survey, there are many possible causes or reasons for nonresponse, and these vary by degree according to the survey. The possible reasons for noncooperation include collectability of the desired data, respondent burden, concerns about confidentiality, indifference to data usefulness, modes of collection and follow-up, mandatory vs. voluntary reporting, etc. In the process of following up on the largest nonrespondents of the voluntary economic surveys, anecdotal evidence suggests that some companies refuse to respond to surveys only because they are voluntary. However, the lack of empirical evidence, and the perception that other voluntary surveys conducted by other agencies are not experiencing the same degree of refusals, caused skepticism as to what degree voluntary reporting actually contributes to the Census Bureau's higher nonresponse.

Therefore, there was a need to design and implement an experiment to measure nonresponse under mandatory vs. voluntary reporting without the confounding effects from other reasons for nonresponse. The ideal test would have been to develop a new survey and conduct one half of the survey under mandatory reporting and the other half under voluntary reporting (split panels) and compare the response rates. Conducting a new survey would have ensured that no bias would be introduced by the fact that some sample units had previous exposure to the survey, and thus, would be conditioned to reporting regardless of whether the survey was mandatory or voluntary.

2. Survey of Pollution Abatement Costs and Expenditures (PACE)

When such a test was being considered in 1989, there was no new survey to serve as the test vehicle for mandatory vs. voluntary reporting. However, in 1989 there was an ongoing annual mandatory survey, the Survey of Pollution Abatement Costs and Expenditures (PACE), being reselected based on the 1987 economic census of manufactures and the 1989 Annual Survey of Manufactures (ASM). The PACE collects pollution abatement expenditures and operating costs.

The timing of this survey and the selection of a new PACE sample presented an opportunity to study some aspects of nonresponse under mandatory vs. voluntary reporting. There were some long-term concerns about confusing major company respondents with two kinds of collection and about the effects of any experiment on final PACE estimates. These concerns led to some assumptions which influenced the design of this study.

A probability design and the use of estimated sampling errors would permit inquiries into whether there is a difference in response rates between mandatory and voluntary reporting, and if so, whether this difference impacts the PACE estimates. However, any attempt to measure nonsampling error or to test whether that component of error is affected by the two treatments would be speculative and therefore, was not considered.

The actual test consisted of selecting a panel from the newly selected 1989 PACE sample, collecting this panel's data on a voluntary basis, and comparing the response rates for this voluntary panel with those from the mandatory panel.

B. Survey Design

1. Assumptions

The main goal of this study was to test for significant differences in response rates between mandatory and voluntary reporting, and this goal, along with the concerns mentioned above, dictated the design of the experiment. At the outset of this study, it was assumed, based upon the experience noted for other economic surveys at the Census Bureau, that the voluntary rate of response would likely be less than the mandatory rate. As a result of this basic assumption, we decided that we wanted to be able to detect response rate differences of at least 10 percent for any of the mandatory vs.

voluntary comparisons. Ten percent was arbitrarily chosen as the critical value because it was felt that unless the voluntary rate was at least this close to the mandatory rate, we would not consider converting the survey to voluntary.

A second assumption made in considering the design of this study was that prior conditioning would bias response rates upwards. Under this assumption, we decided it was important to not only compare overall mandatory and voluntary response rates, but also response rates for establishments with previous exposure to the PACE survey ('old' establishments) and response rates for establishments with no previous exposure to the PACE ('new' establishments).

Finally, our basic assumption presumed that a certain percentage of establishments would no longer provide data once converted to a voluntary status. For the large plants of certainty companies (certainty companies being large companies which have all of their plants included in the ASM), this loss of vital reported data could possibly affect the quality of the PACE estimates. In order to avoid this potential problem, we decided to exclude all establishments of certainty companies from any chance of selection for the voluntary segment of the study sample.

2. Sample Design

a. PACE

As mentioned above, a new sample was selected for the 1989 PACE survey. The PACE survey is an establishment-based survey and is resampled every 5 years as a subsample of the ASM. The PACE is sampled using a probability proportionate to size (PPS) design. The measure of size used to determine sampling probabilities for each establishment is weighted ASM total value of shipments (TVS). As the TVS for each establishment increases, the corresponding probability of selection also increases. Therefore, the PACE sample may be composed of predominantly larger establishments. This fact introduces a potential upward bias in response relative to the complete manufacturing universe since the larger establishments are more likely to respond than the smaller establishments.

Once the PACE survey is mailed, the following efforts are made to obtain data for delinquent establishments:

- after 60 days, reminder letter mailed
- after 90 days (survey due date), questionnaire remailed with follow-up letter
- after 120 days, another follow-up letter mailed

These procedures were followed for both the mandatory and the voluntary panels.

b. Voluntary Sample

Frame Creation

There were many activities involved in creating the sampling frame for the voluntary portion of the 1989 PACE survey. These frame creation activities involved four files: the new 1989 PACE sample, the sample of 1988 ASM births to be added to the new sample, the 1988 PACE sample (sample selected in 1984), and the 1989 ASM company certainty cases.

The first operation involving these four files was to append the 1988 ASM births to the 1989 PACE sample. The 1988 birth universe had no chance of selection for the new PACE panel, whose ultimate selection was based upon the 1987 census. Therefore, it was necessary to carry forward the ASM birth sample for 1988 so that the birth universe was represented in the PACE sample. This yielded the final PACE sample of 17,332 establishments.

The next step was to split the PACE sample into single units and multiunits. There were two reasons for performing this split. First of all, ASM company certainties were to be excluded from the scope of the mandatory/voluntary study to avoid the expected loss of integral reporters in the transition from mandatory reporting to voluntary reporting. So, the first reason for this split was to ensure that multiunits from the PACE sample could be matched to the file of ASM company certainties. Any multiunit from the PACE sample which matched an ASM company certainty was removed from the voluntary frame. When this operation was complete, 11,187 establishments remained in the voluntary sampling frame.

The second reason for the split was to ensure that all establishments in each multiunit company received only one type of form (mandatory or voluntary). To accomplish this, multiunits had to be sampled for the voluntary portion on a company basis, with every plant within a selected company being voluntary.

Once the voluntary sampling frame was established, the next step was to partition the frame into 'new' and 'old' strata. 'New' refers to establishments which had no previous exposure to the PACE survey, and 'old' refers to those which had previous exposure. This was accomplished by matching the new PACE panel to the previous PACE panel. Matches were classified as 'old' while new panel nonmatches were classified as 'new.' These matching operations resulted in a total of 4,798 'new' single units and 210 'old' single units. Multiunits were matched at the company level, resulting in 2,189 'new' companies (2,601 establishments) and 2,021 'old' companies (3,578 establishments). This stratification for multiunit establishments was not perfectly clean. Multiunits classified as 'old' may have had establishments which were new to the PACE survey. This point is further addressed later in this paper.

At this point, we proceeded to examine allocation options for the voluntary sample. Of the 11,187 establishments in the voluntary sampling frame, 7,399 were classified as 'new' (66.1 percent) and 3,788 were classified as 'old' (33.9 percent). To replicate this allocation for the desired sample of 1,000 cases would suggest sampling 661 'new' establishments and 339 'old' establishments. As mentioned earlier, we wanted to be able to detect significant differences of at least 10 percent. To do this, we assumed a worst-case (in terms of sampling error) mandatory response rate of 50 percent. With this assumption, along with assuming simple random sampling, we could detect significant differences of at least 4 percent at the 95 percent confidence level for 'new' establishments and 6 percent for 'old' establishments. This was deemed to be acceptable.

Sample Selection

Since we wanted to control the voluntary sample on the basis of 'new' and 'old' establishments, sampling was done in two steps. The first step entailed selecting an expected sample of 661 'new' establishments. The second step entailed selecting an expected sample of 339 'old' establishments. To select these samples, the two respective sampling frames had to be prepared. The sampling frame for 'new' plants was obtained by merging the 'new' single units and 'new' multiunits. The sampling frame for 'old' establishments was obtained by merging the 'old' single units and 'old' multiunits.

Once this was done, sampling probabilities were developed for each sampling unit in both the 'new' and the 'old' sampling frames. We wanted to control the voluntary sample by company in order to ensure that all establishments of each company received the same type of form, so the voluntary sample was selected on a company basis. We also wanted each company, and thus, each establishment to have an equal chance of selection.

To accomplish this, the probability of selection was calculated as the expected sample size divided by the number of establishments in the frame. For the frame of 'new' establishments, the sampling probability was 0.08934 (661 expected/7,399 total), and for the frame of 'old' establishments, the sampling probability was 0.08949 (339 expected/3,788 total). After the probabilities of selection were assigned for both frames, the voluntary sample was drawn. This was done using independent Poisson sampling, but with each sampling entity having an equal chance of selection, regardless of size. The programs to perform this sampling were run several times for both the 'new' frame and the 'old' frame until the desired sample sizes were obtained. The sample size from each frame was the sum of selected single unit plants and all plants within selected multiunit alphas. Ultimately, a sample of 661 'new' establishments and 365 'old' establishments was drawn, for a total voluntary sample of 1,026 establishments.

Upon completion of these sampling operations, the study frame of 11,187 establishments was partitioned in the following manner:

MANDATORY	SU	MU	TOTAL
NEW	4375	2363	6738
OLD	199	3224	3423
TOTAL	4574	5587	10161

VOLUNTARY	SU	MU	TOTAL
NEW	423	238	661
OLD	11	354	365
TOTAL	434	592	1026

Post-Sampling Operations

One other partitioning operation was done at this juncture. As mentioned earlier, the stratification of establishments into 'new' and 'old' strata was not perfectly clean. Some multiunit companies classified as 'old' may have had some establishments which were new to the PACE survey. The mandatory vs. voluntary response rate comparison involving establishments with previous exposure to the PACE survey excludes these 'new' establishments. They are, however, included in the overall response rate comparison. Therefore, establishments of 'old' multiunits were further stratified into 'new' and 'old' substrata. This was done by matching establishments of selected 'old' multiunits with the 1988 PACE sample. This operation yielded the following breakdown of 'old' multiunit establishments:

	ACTUAL STATUS		
	NEW	OLD	TOTAL
MANDATORY	1510	1714	3224
VOLUNTARY	141	213	354
TOTAL	1651	1927	3578

This partitioning operation was not done prior to sampling since multiunits were sampled on a company basis to ensure all establishments of each multiunit received the same kind of form (mandatory or voluntary).

At this point, we learned of several delete and ghost actions for some establishments in the study. Ghost actions are cases where one company acquires the establishments of another company. These actions were resolved by reconciling our master study file with the Standard Statistical Establishment List (SSEL), a name and address file consisting of all establishments in the manufacturing universe. Reconciling these files altered both the total number of establishments in the study and the establishment counts within each partition of the study frame. Upon completion of these operations, the total number of establishments in the study was 11,204. New establishment counts also were generated for each partition. These counts were as follows:

MANDATORY	SU	MU	TOTAL
NEW	4369	2384	6753
OLD	199	3226	3425
TOTAL	4568	5610	10178

VOLUNTARY	SU	MU	TOTAL
NEW	422	239	661
OLD	11	354	365
TOTAL	433	593	1026

3. Response Rate and Variance Estimation

a. Response Rate Estimation

All of the results from this study and the interpretations of these results are based on the various response rates and the standard errors calculated on these response rates. In the planning stages of this experiment, the initial thought was to calculate weighted sample response rates to obtain sample estimates of response rates for the complete universe. However, upon further consideration, we decided that the more meaningful rates were relative to the particular PACE panel that was selected. In other words, we did not want to extrapolate the response rates to the entire universe.

The reasoning behind this decision was as follows. Response rates are measured by comparing the number of questionnaires received to the number mailed. Large establishments, which are more likely to respond, are a much larger proportion of the sample panel than they are of the universe since we utilize PPS sampling to select the PACE panel. With this type of sample design, we should always expect a higher response rate for the PACE panel than for the complete universe. The complete universe is replete with very small plants which are less likely to respond.

Therefore, the more meaningful question to ask was, "What would happen if we conducted the noncertainty portion of the present panel, chosen using a PPS design, on a voluntary basis?" We can envisage the entire PACE panel being conducted on a voluntary basis, but simply because of economics, we cannot

envisage that panel being the complete manufacturing universe. The comparative rates and standard errors we estimate are thus conditional on the selection of the current PACE panel.

Using i to denote the possible sample partitions (mandatory overall, voluntary 'new', mandatory 'old', etc.), the response rate for partition i was calculated using the following simple formula:

$$R_i' = X_i / n_i$$

where, X_i = total number of sample respondents in partition i
n_i = total number of sample establishments in partition i

The use of this "unweighted" estimator for the overall mandatory and overall voluntary partitions was justified by the fact that the sampling fractions for the 'new' and the 'old' panels were virtually the same. Thus, the simple estimate is equivalent to a weighted estimate.

b. Variance Estimation

There are several ways to view the estimation of variance on response rates for this study. In considering the possible sources of error on these response rates, one could consider all three stages of sampling involved in eventually obtaining the voluntary portion of the study panel. These three stages are as follows:

1st stage: ASM sampled from manufacturing universe
2nd stage: PACE sampled from ASM
3rd stage: voluntary panel sampled from PACE

However, as stated earlier, the response rates themselves and interpretations of any observed differences are only extrapolated to the PACE panel which was selected. Therefore, significance testing of observed response rate differences could be done by treating the selected PACE panel as the universe. Sampling error in this case arises only as a result of selecting the voluntary panel from the PACE.

Since it is our belief that the sample sizes for the various partitions were more than sufficient to measure differences we considered to be important, we finally decided to accommodate all possible sources

of error and to calculate variances which take into account all three stages of sampling. Consequently, these variances serve as upper bounds. Differences found to be significant using them also would be significant if variances were calculated treating the PACE panel as the universe or the ASM as the universe. Therefore, this maximized variance was estimated for each response rate using the following formula:

$$\sigma^2_{R_i'} \approx \frac{1}{n^2}\left(\sigma^2_{X_i} + R^2\sigma^2_{n_i} - 2R\sigma_{X_i n_i}\right)$$

$$\approx \frac{1}{n^2}\left[S^2_{X_i} + \left(R_i'\right)^2 S^2_{n_i} - 2R_i' S_{X_i n_i}\right]$$

$$\approx \frac{1}{n^2}\left[S^2_{X_i} + \left(R_i'\right)^2 S^2_{n_i} - 2R_i' S^2_{X_i}\right]$$

$$\approx \frac{1}{n^2}\left[\left(1-2R_i'\right)S^2_{X_i} + \left(R_i'\right)^2 S^2_{n_i}\right]$$

$$\approx \frac{1}{n^2}\left[\left(1-2R_i'\right)\sum_{j=1}^{n} A_{ij}X_{ij}(1-p_{ij}) + \left(R_i'\right)^2 \sum_{j=1}^{n} A_{ij}(1-p_{ij})\right]$$

$$\approx \frac{1}{n^2}\left[\left(1-2R_i'\right)\sum_{j=1}^{n_i} X_{ij}(1-p_{ij}) + \left(R_i'\right)^2 \sum_{j=1}^{n_i}(1-p_{ij})\right]$$

where, n = total number of sample establishments in study panel

A_{ij} = 1 if establishment j is in partition i
0 otherwise

X_{ij} = 1 if establishment j is respondent
0 otherwise

p_{ij} = probability of establishment j being in partition i

$S^2_{X_i}$ = sample estimate of variance on variable X_i (total number of sample respondents in partition i)

$S^2_{n_i}$ = sample estimate of variance on variable n_i (total number of sample establishments in partition i)

$S_{X_i n_i}$ = sample estimate of covariance between variables X_i and n_i

and n_i and R_i' are defined as before.

C. Results

The results of this study are displayed in several tables and graphs, which can be seen in the appendices to this paper. This section provides brief descriptions of each table and each graph.

Appendices A-1 and A-2 deal with final response rates for the three mandatory vs. voluntary comparisons. Appendix A-1 is a table showing final mandatory and voluntary response rates for the overall, the 'new', and the 'old' comparisons. Along with the response rates themselves, the components of each response rate (i.e., the number of establishments in each stratum and the number of respondents in each stratum) also are shown. Standard errors on each response rate are provided as a means to test whether observed response rate differences are significant. One thing should be noted when looking at this table. Totals for the 'new' and 'old' comparisons do not add to the overall comparison totals. This is because 'new' plants of 'old' companies were not included in the 'old' response rate comparisons, but were included in the overall comparison. This ensured that the 'old' comparison would truly be a comparison of plants which had previous exposure to the PACE survey.

Appendix A-2 is a graphical representation of the results seen in the table in Appendix A-1. Response rates for the three mandatory vs. voluntary comparisons are plotted together to give a clearer picture of the differences seen in each comparison.

Appendices B-1 through B-3 relate to the timeliness of response for all three comparisons. Appendix B-1 is a timeline displaying response rates for the overall mandatory vs. voluntary comparison from the time of the first follow-up through closeout. Using this timeline, response rates can be compared at each weekly interval (each data transmission date). The three follow-ups are denoted on the timeline so that response behavior after each follow-up can be clearly observed. Similar timelines can be seen for the 'new' and 'old' response rate comparisons in Appendices B-2 and B-3 respectively.

Appendices C-1 and C-2 examine the average total value of shipments (TVS) for respondents vs. nonrespondents for both mandatory and voluntary reporting. Appendix C-1 is a table showing these average TVS values. Along with each average TVS, the table also shows the number of establishments contributing to each average. These comparisons between respondents and nonrespondents were done to give an indication of whether or not establishments reporting data are larger, on average, than establishments not reporting

data, and whether similar results are seen for both mandatory and voluntary reporting.

Appendix C-2 is a graphical representation of the results seen in the table in Appendix C-1. Average TVS is plotted for respondents vs. nonrespondents for both mandatory reporting and voluntary reporting. Again, this gives a clearer depiction of observed differences.

Appendices D-1 through D-4 relate to final response rates for the three mandatory vs. voluntary comparisons broken into three size categories based on TVS. The three size groups were defined using the following criteria:

'small': TVS < $10 million
'medium': $10 million ≤ TVS < $50 million
'large': TVS ≥ $50 million

This was done to see whether response rates are dependent upon establishment size. Appendix D-1 is a table displaying the mandatory and voluntary response rates for the three size strata. In addition to the response rates, the number of establishments in each stratum and the number of respondents in each stratum also are shown. Once again, totals for the 'new' and 'old' comparisons do not add to totals for the overall comparison for the same reason described earlier for Appendix A-1.

Appendix D-2 is a graphical representation of the results for the 'small' establishments seen in the table in Appendix D-1. Response rates for all three mandatory vs. voluntary comparisons are shown. Similar graphs displaying the three rate comparisons for the 'medium' plants and the 'large' plants can be seen in Appendices D-3 and D-4 respectively. In Appendix D-3, the TVS range for the 'medium' size stratum is shown as 10 ≤ TVS < 50, where the end values correspond to TVS in millions of dollars, as seen in Appendix D-1.

D. Analysis and Evaluation

1. Interpretations

Results obtained from this study indicate that mandatory reporting is more effective in obtaining higher response rates than voluntary reporting. Mandatory rates are higher than voluntary rates for all three comparisons of interest.

The first response rate comparison we looked at was the overall mandatory vs. voluntary comparison. The final response rate for mandatory reporting was 82.5 percent, which was 21 percentage points higher than the

corresponding final voluntary rate of 61.5 percent. Based upon the standard errors on these response rates, this difference of 21 percentage points is statistically significant. This result indicates that when a new sample is selected for an existing survey concurrently with a shift from mandatory to voluntary reporting, response deteriorates.

The second comparison we investigated was the comparison between mandatory and voluntary response rates for establishments with no previous exposure to the PACE survey (i.e., 'new' establishments). This comparison enabled us to most closely simulate a new survey. As with the overall mandatory vs. voluntary comparison, the final response rate obtained for mandatory reporting was significantly higher than the voluntary rate. The mandatory response rate of 81.2 percent was almost 25 percentage points higher than the voluntary rate of 56.4 percent. This result indicates that higher response can be obtained if a new survey is mandatory rather than voluntary.

The last comparison was between mandatory and voluntary response rates among establishments with previous exposure to the PACE survey (i.e., 'old' establishments). This comparison allows us to examine the effects of prior conditioning on response. Once again, the final mandatory response rate was higher than the corresponding voluntary rate. However, the mandatory rate of 85.4 percent was only about 11 percentage points higher than the voluntary rate of 74.1 percent. Although this smaller difference is still statistically significant, this result seems to indicate that prior conditioning has some effect on response, though not enough to obtain the same response rate with voluntary reporting as with mandatory reporting. Furthermore, we can speculate, but are not able to show from this study, that over time this conditioning effect would dissipate, resulting in higher nonresponse. The results of these three comparisons can be seen in Appendices A-1 and A-2.

In addition to comparing final mandatory and voluntary response rates, we also compared the timeliness of response for mandatory and voluntary reporting. This was done by monitoring response at weekly time intervals. Appendix B-1 shows mandatory and voluntary rates for the overall comparison at each weekly data transmission from the first follow-up to closeout. This timeline shows that response under mandatory reporting was markedly higher (about 15 percent) even before follow-up began. After the first follow-up, mandatory response increased at a higher rate than voluntary response. After each

succeeding follow-up, mandatory and voluntary response rates increased at similar rates. From these results, we conclude that mandatory reporting also improves the timeliness of response.

Appendices B-2 and B-3 further support the idea that mandatory reporting provides better timeliness of response than voluntary reporting. Appendix B-2 shows weekly response rates for the 'new' comparison and Appendix B-3 shows the 'old' comparison rates. The 'new' comparison exhibits the same kind of pattern as the overall comparison. The mandatory response rate at the time of first follow-up was higher than the voluntary rate, and under mandatory reporting, there was a greater increase in response immediately after the first follow-up, followed by increases similar to those seen under voluntary reporting until closeout. The only difference seen for the 'old' comparison was that mandatory and voluntary response rates before follow-up were more similar than for the overall and 'new' comparisons (only about 4 percent different). All of these results lend more support to the notion that timeliness of response is better under mandatory reporting than under voluntary reporting.

We also examined results relative to establishment size based on TVS. First of all, we found that the average TVS for mandatory respondents was $27.4 million, compared with $23.1 million for mandatory nonrespondents. Similarly, the average TVS among voluntary respondents was $27.3 million, while voluntary nonrespondents had an average TVS of $20.6 million. These results can be seen in Appendices C-1 and C-2.

In order to more closely examine the relationship between establishment size and response, we partitioned the study panel into three size categories. This enabled us to see whether or not we would obtain similar mandatory vs. voluntary response rate differences among size groups as we observed for the same comparisons over the entire panel.

The response rate differences for the three comparisons within size groups were quite similar to those seen in the comparisons over the entire study panel. The differences exhibited for the 'large' establishments were slightly lower, reflecting the possibility that more intensive effort, such as analyst phone calls, might have been expended to collect data from larger establishments whose data are considered vital to the estimates. However, mandatory rates were still higher than corresponding voluntary rates for all comparisons.

The following is a summary of the differences between mandatory and voluntary reporting for all comparisons:

	OVERALL	'NEW'	'OLD'
ENTIRE PANEL	21.0%	24.8%	11.3%
'SMALL'	20.4%	22.9%	9.0%
'MEDIUM'	24.2%	29.0%	13.8%
'LARGE'	12.8%	17.6%	8.4%

Why the 'medium' size group shows larger differences than the 'small' group for all three comparisons is unclear. Perhaps more of the smaller plants have no pollution abatement expenditures and are able to easily respond without having to spend inordinate amounts of time completing the questionnaire. Results from these comparisons by size can all be seen in Appendices D-1 through D-4.

All of these results seem to show that regardless of establishment size, mandatory reporting yields higher response rates than voluntary reporting. Even though the differences between mandatory and voluntary reporting for 'large' establishments are not quite as significant as those seen for the other size group comparisons, any difference in response for 'large' establishments may be more significant in terms of loss of vital data. Therefore, these differences also are significant and further strengthen the idea that mandatory reporting provides higher response than voluntary reporting.

Another interesting fact we discovered in this study was that response among establishments of multiunit companies with more than one establishment in the study panel was usually complete. In other words, all establishments of a particular company either reported or did not report. Under both mandatory and voluntary reporting, only 13 percent of all companies with more than one establishment in the study panel had a mix of response and nonresponse (117 of 898 mandatory companies and 13 of 98 voluntary companies). So, this seems to indicate that the decision on whether or not to report in this survey was made at the company level.

The last analysis done for this study was to investigate the impact of nonresponse on the PACE estimates for operating costs and expenditures. In other words, how would these estimates be affected if the PACE survey were conducted on a voluntary basis? This analysis was done on the mandatory respondents in the study for both the 'new' stratum and the 'old' stratum. Delinquent imputation which would have been used had each plant not

reported was replicated. This entailed using the appropriate imputation ratios for operating costs and imputing zero for expenditures. Once this was done, a probability of response under voluntary reporting was assigned for both the 'new' and the 'old' portions (probabilities based on respective voluntary response rates obtained in this study). Expected values were then calculated for each plant and both actual and expected simple weighted estimates were computed for both the 'new' and the 'old' strata. The actual and expected weighted estimates were then compared to determine the impact on the estimates under the assumption that the PACE survey was conducted on a voluntary basis.

Results from this analysis are quite interesting. For operating costs, the expected final weighted estmate for the 'new' comparison was 9.5 percentage points lower assuming that the PACE was voluntary. The expected final weighted estimate for the 'old' comparison was 3.6 percentage points lower than the actual weighted estimate for the stratum. Both of these differences were considered trivial when compared with the actual weighted estimate for operating costs for the entire mandatory portion of the study panel.

Results obtained from the analysis on expenditures estimates showed that nonresponse has a larger effect on these estimates. As mentioned earlier, zero is imputed for nonresponse, which as our results show, may not be a good assumption. In the 'new' comparison, the expected weighted estimate was 43.6 percentage points lower than the actual estimate for that portion of the panel, while the 'old' comparison showed the expected estimate to be 25.9 percentage points lower than the actual weighted estimate. These results seem to show that imputing zero for nonresponse for expenditures may not be a good idea, and that further research may be needed to develop an imputation algorithm for expenditures.

2. Limitations of the Results

There were several factors involved in this study which may have affected the results and/or the interpretations of these results. The first contributing factor was the limited scope of the study. The PACE survey excludes all establishments with total employment (TE) less than 20, therefore, the study did not include any of these establishments. Also, establishments of ASM certainty companies were excluded from any chance of selection for the voluntary portion of the study panel, so they were not included in the study. These plants were excluded to prevent the potential loss of vital data.

Another factor which may have affected our results was the fact that the study panel remained fixed throughout the course of the study. While deaths in the panel could be identified, births were not identified and, consequently, were not added to the study panel.

Since the PACE survey was used as the test vehicle for this study of mandatory vs. voluntary reporting, all of the operating procedures normally followed for the PACE survey were executed as usual. For instance, regular PACE follow-up procedures were followed for nonresponse. Additional follow-up methods could have been tested as a means for trying to obtain voluntary response rates comparable to the higher mandatory rates. This idea is precisely the basis for the follow-up study being done using the 1990 PACE survey. This follow-up study is described briefly later in this paper. Therefore, it should be realized that the results obtained from this test of mandatory vs. voluntary reporting apply to the PACE survey itself, and care should be exercised in extrapolating these results to other surveys.

The response rate comparison involving the 'new' establishments was as controlled as possible. The new PACE sample was matched to the old PACE sample (selected in 1984) to determine whether or not establishments had previous exposure to the PACE survey. This match ensured no previous exposure in the last several years. Any possible exposure to the PACE in samples selected prior to the one selected in 1984 was assumed to have no response conditioning effect. It was felt that any conditioning would have dissipated over time.

One other factor which affected the results and/or the interpretations of these results was sampling error. All of the study sample estimates are subject to sampling error. All significance testing for this experiment was done at the 95 percent confidence level.

E. Recommendations

1. Current Research

Based upon the results obtained from this study, mandatory reporting seems to yield higher response than voluntary reporting. Mandatory response rates for every response rate comparison are higher than the corresponding voluntary rates. These results, and any conclusions based upon these results, may only be applicable to the PACE survey. Care should be used in extrapolating results to other surveys.

Despite the suggestion that results only be extrapolated to the PACE survey itself, this is a well-controlled study which provides some concrete evidence that response under mandatory reporting is higher than response under voluntary reporting. This is only the beginning for research in the area of nonresponse under mandatory vs. voluntary reporting. Further research needs to be done to follow-up on the results obtained in this study. The 1990 PACE follow-up study, which is currently in progress, is designed to provide further information on the issue of nonresponse under mandatory vs. voluntary reporting.

2. Additional Research

As a result of the 1989 PACE split panel test, other research questions arose. What effects would telephone prompting, telephone follow-up, or certified letter follow-up have on the voluntary response rates? Would such data collection techniques narrow the difference between the response rates for mandatory vs. voluntary reporting? Therefore, another test was developed. In this test, the voluntary portion of the 1990 PACE survey (both 1989 respondents and nonrespondents) was randomly split into five panels. For each panel, a different data collection technique is tested to improve response.

Panel I - For this panel, a premail telephone call was made to each sample unit 30 days prior to mailout to inform the respondents to expect a PACE questionnaire in the mail soon. The normal PACE follow-up procedures referred to earlier were followed. This panel tests the effects of a prenotification telephone call on voluntary response rates.

Panel II - For this panel, a post-mail telephone call was made to each sample unit 30 days after mailout to confirm receipt of the PACE questionnaire and to remind the respondent of the questionnaire's due date. Again, the normal PACE follow-up procedures referred to earlier were followed. This panel tests the effects of a reminder telephone call on voluntary response rates.

Panel III - For this panel, residual nonrespondents received follow-up telephone calls to obtain the requested data at the 90-day due date and the 120-day follow-up date. This panel tests the effects of follow-up telephone calls on voluntary response rates.

Panel IV (control group) - For this panel, the normal PACE follow-up procedures referred to earlier were followed.

Panel V - For this panel, residual nonrespondents received certified mail follow-up letters to obtain the requested data at the 90-day due date and the 120-day follow-up date. This panel tests the effects of certified mail follow-up letters on voluntary response rates.

The original allocation of the sample among these five panels was as follows:

Panel I (premail phone) - 106
Panel II (post-mail phone) - 105
Panel III (total phone follow-up) - 105
Panel IV (control group) - 556
Panel V (total certified mail follow-up) - 154

This sample allocation was mainly based on the expected telephone workload that our analyst staff could support. It also seemed sufficient to detect significant response rate differences for the various treatments. Also, the allocation of the sample was done in such a way as to ensure that each of the five panels had a proportionate share of the respondents from the prior year's survey.

The precise allocation of the sample was altered as a result of deletions and shifting between panels. Ghosted establishments were allowed to shift panels to ensure that all establishments of a particular company received the same treatment. The following summarizes the final establishment counts and response rates for each panel:

	# estab	# resp	resp. rate
mandatory	9965	8590	86.2%
Panel I	104	55	52.9%
Panel II	102	71	69.6%
Panel III	105	67	63.8%
Panel IV	538	314	58.4%
Panel V	147	103	70.1%

Comparing these response rates shows that the mandatory response rate was still the highest. The lowest response rate was for the voluntary panel in which phone calls were made 30 days prior to mailout (Panel I). It is safe to say that these phone calls were not effective in improving response. In fact, response rates for Panel I were the lowest among all voluntary panels from the outset of the study. Perhaps to be more effective, these premail phone calls should have been made closer to mailout. That way, respondents would be more likely to remember the phone calls.

While the premail phone calls did not seem to improve response, the post-mail phone calls seemed to have a positive effect on improving response rates. Response rates for the voluntary panel employing post-mail phone calls (Panel II) were significantly higher than those for all other voluntary panels before follow-up. The final response rate for this panel was also among the highest.

With regards to follow-up, it appears that certified mail was the most effective follow-up method for improving response (increase of just over 31 percentage points from the time follow-up began to closeout). Based upon the results obtained from this study, the use of certified mail follow-up, in conjunction with post-mail phone calls, should be strongly considered. The post-mail phone calls would greatly improve the timeliness of response, while certified mail follow-up would then be more effective in convincing remaining delinquent plants to respond.

Finally, the Industry Division of the Bureau of the Census is planning to conduct additional data collection research in other surveys in the near future to identify more data collection improvements. With these improvements, we hope to improve our survey response rates and, hence, the quality of data for our users.

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Ogus, Jack L. and Clark, Donald F. (1971), Technical Paper No. 24, The Annual Survey of Manufactures: A Report on Methodology, Industry Division, Bureau of the Census.

Tulp Jr., Daniel R. (1990), Internal Documentation, "Summary of the Sample Selection Operations for the Voluntary Portion of the 1989 Survey of Pollution Abatement Costs and Expenditures (PACE) - MA200(V)," Industry Division, Bureau of the Census.

PACE (MA200) --- MANDATORY VS. VOLUNTARY STUDY

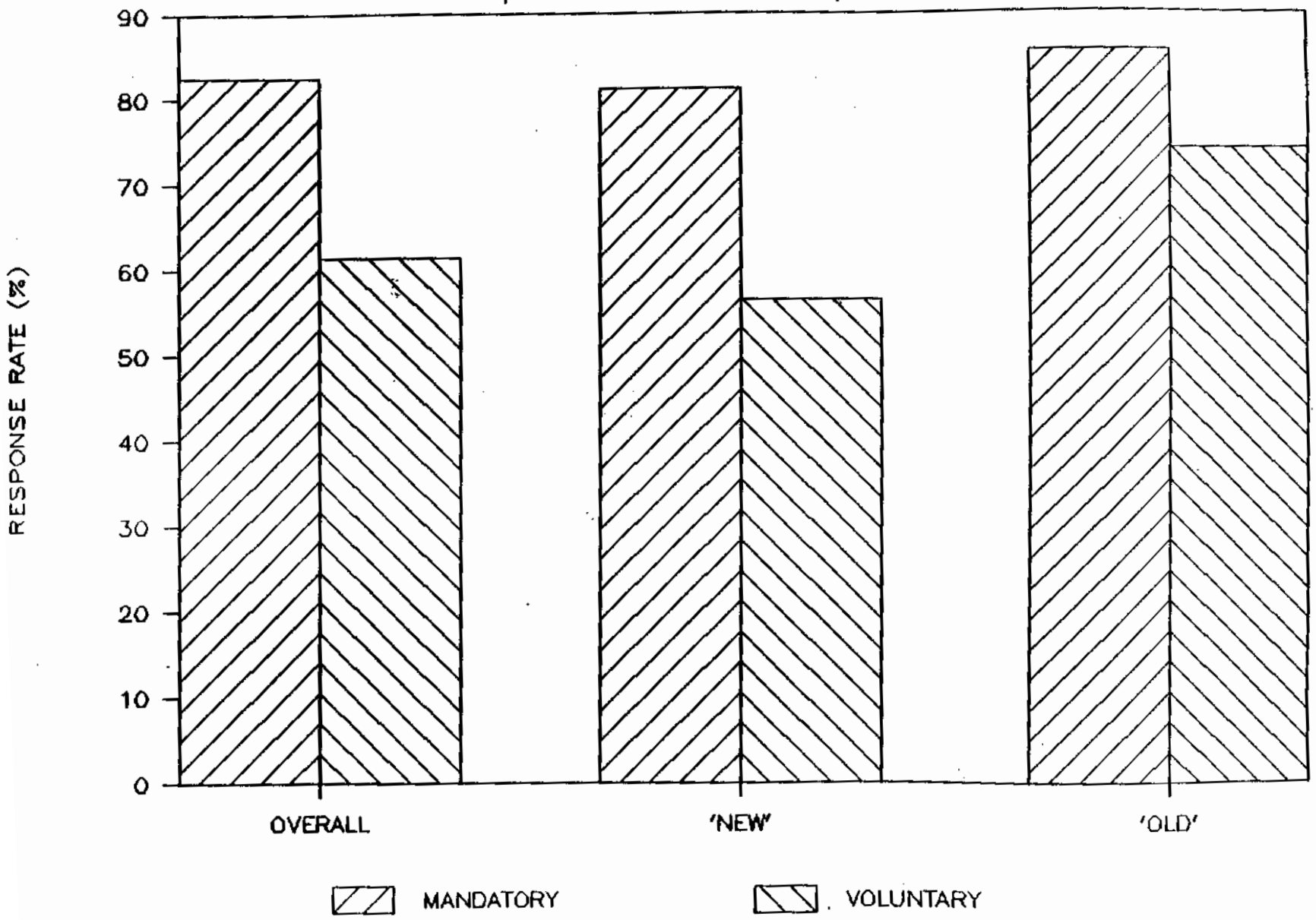
Final Response Rates for the Three Comparisons

	Overall				'New'				'Old'			
	# Cases in Stratum	# Resp. in Stratum	Resp. Rate (%)	S.E. (%)	# Cases in Stratum	# Resp. in Stratum	Resp. Rate (%)	S.E. (%)	# Cases in Stratum	# Resp. in Stratum	Resp. Rate (%)	S.E. (%)
MANDATORY	10178	8401	82.5	0.3	6753	5483	81.2	0.4	1909	1631	85.4	0.5
VOLUNTARY	1026	631	61.5	1.8	661	373	56.4	2.1	224	166	74.1	3.3
DIFFERENCE (%) =			21.0				24.8				11.3	

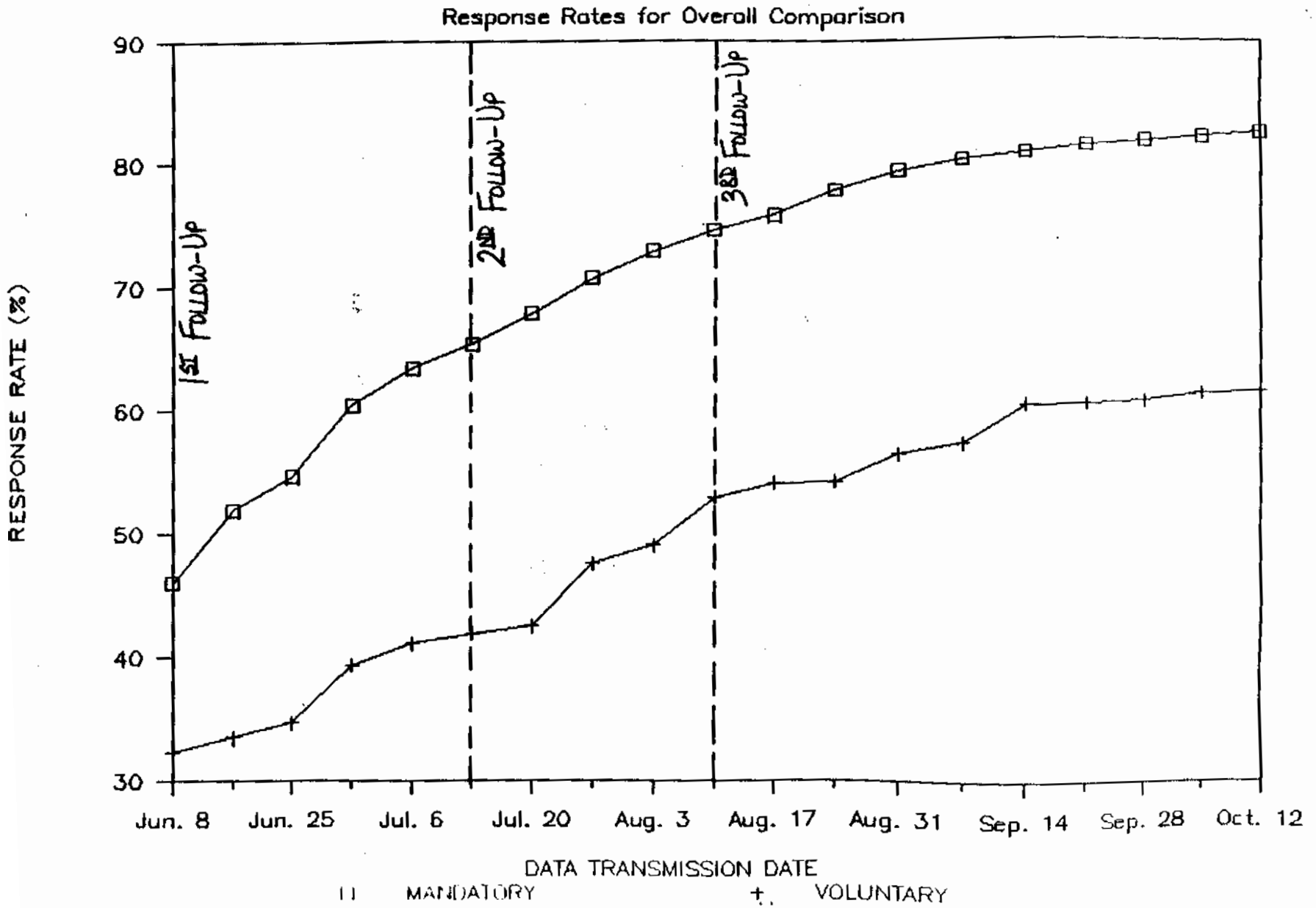
* NOTE: TOTALS FOR 'NEW' + 'OLD' DO NOT EQUAL OVERALL TOTALS DUE TO THE FACT THAT 'NEW' PLANTS OF 'OLD' COMPANIES WERE NOT INCLUDED IN THE 'OLD' COMPARISON, BUT WERE INCLUDED IN THE OVERALL COMPARISON. THIS ENSURED THAT THE 'OLD' COMPARISON WOULD TRULY BE A COMPARISON OF PLANTS WHICH HAD PREVIOUS EXPOSURE TO THE PACE SURVEY.

PACE (MA200) ------ M vs. V STUDY

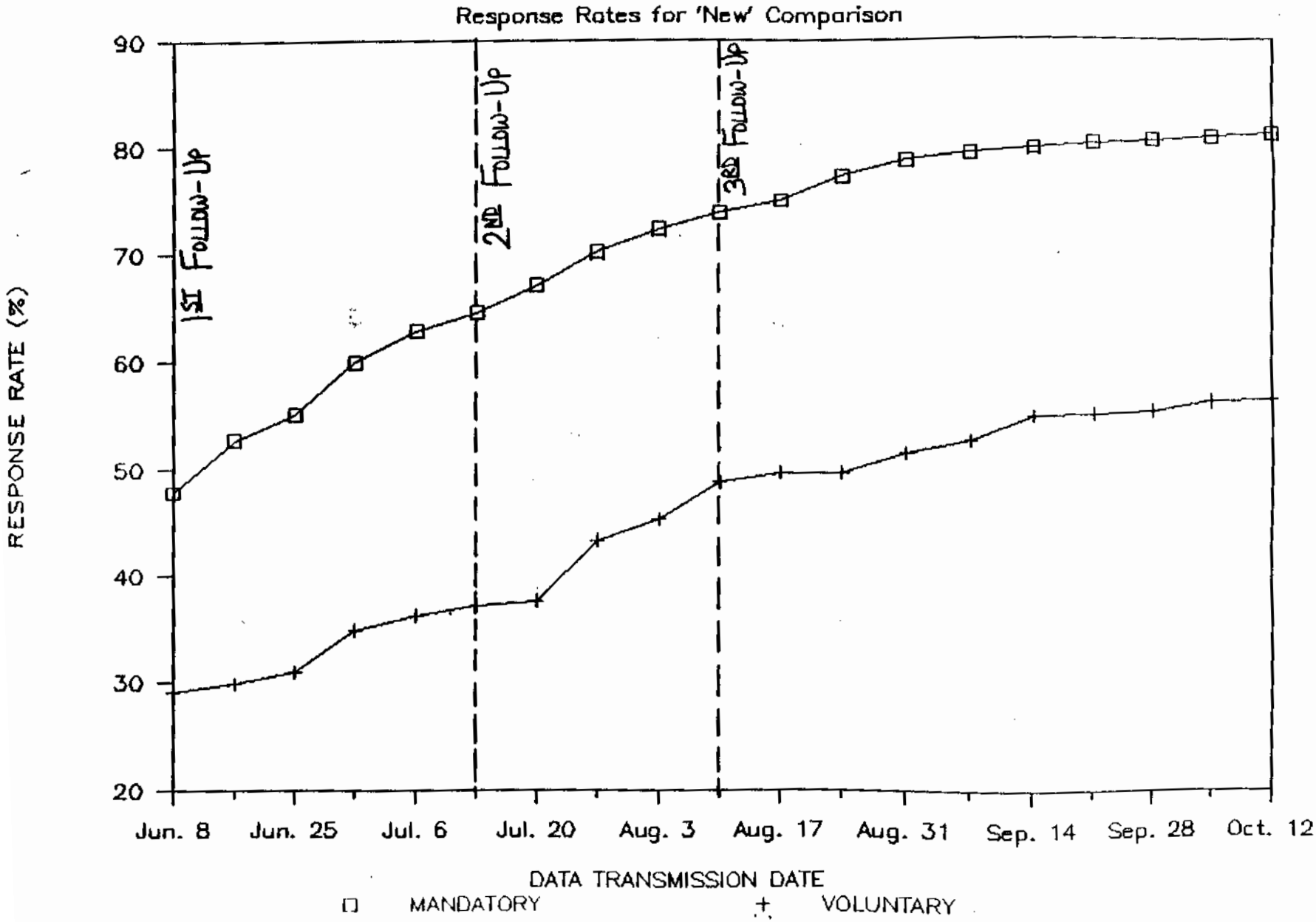
Response Rates for Three Comparisons



PACE (MA200) ------ M vs. V STUDY

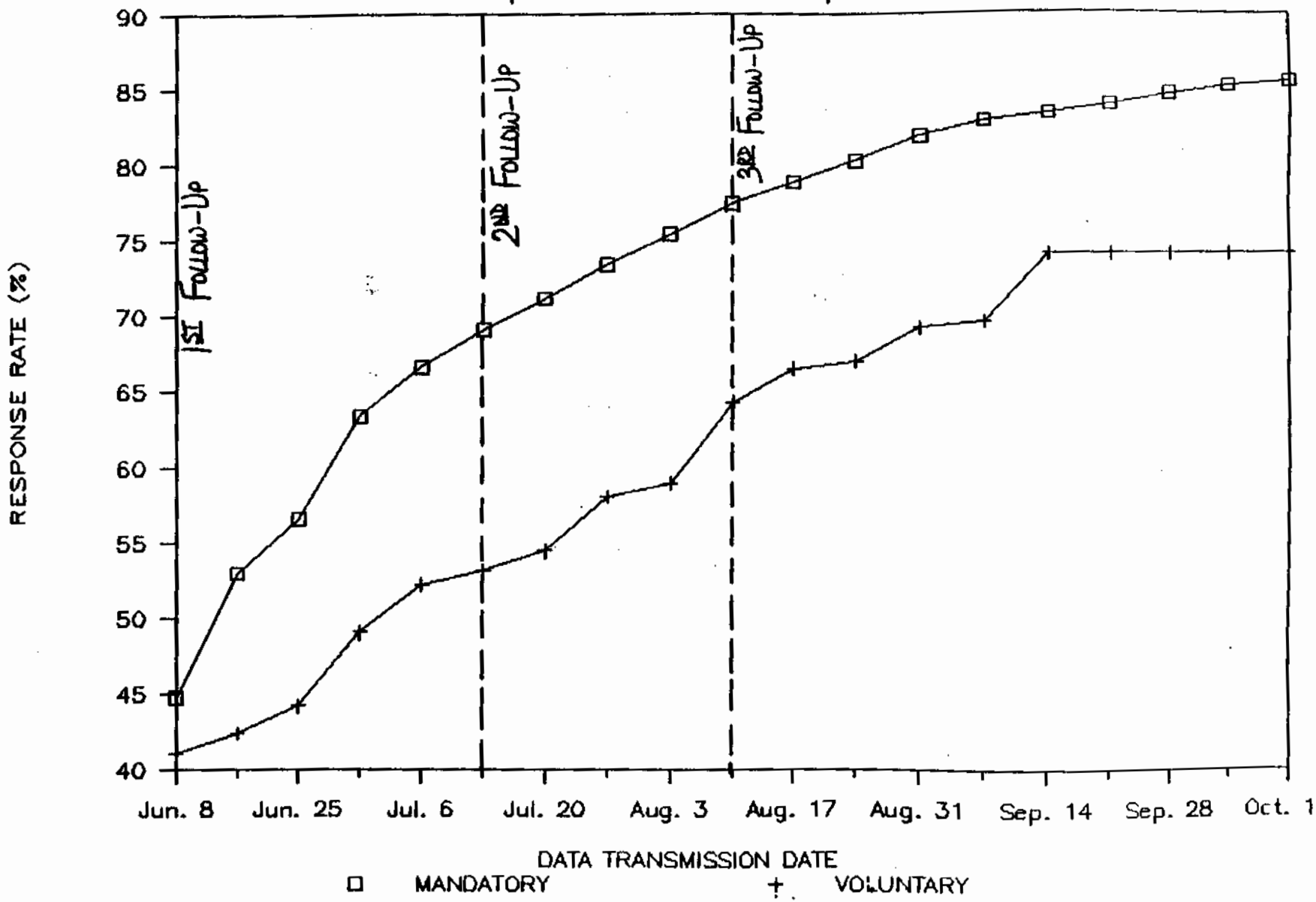


PACE (MA200) ------ M vs. V STUDY



PACE (MA200) ------ M vs. V STUDY

Response Rates for 'Old' Comparison



APPENDIX C-1

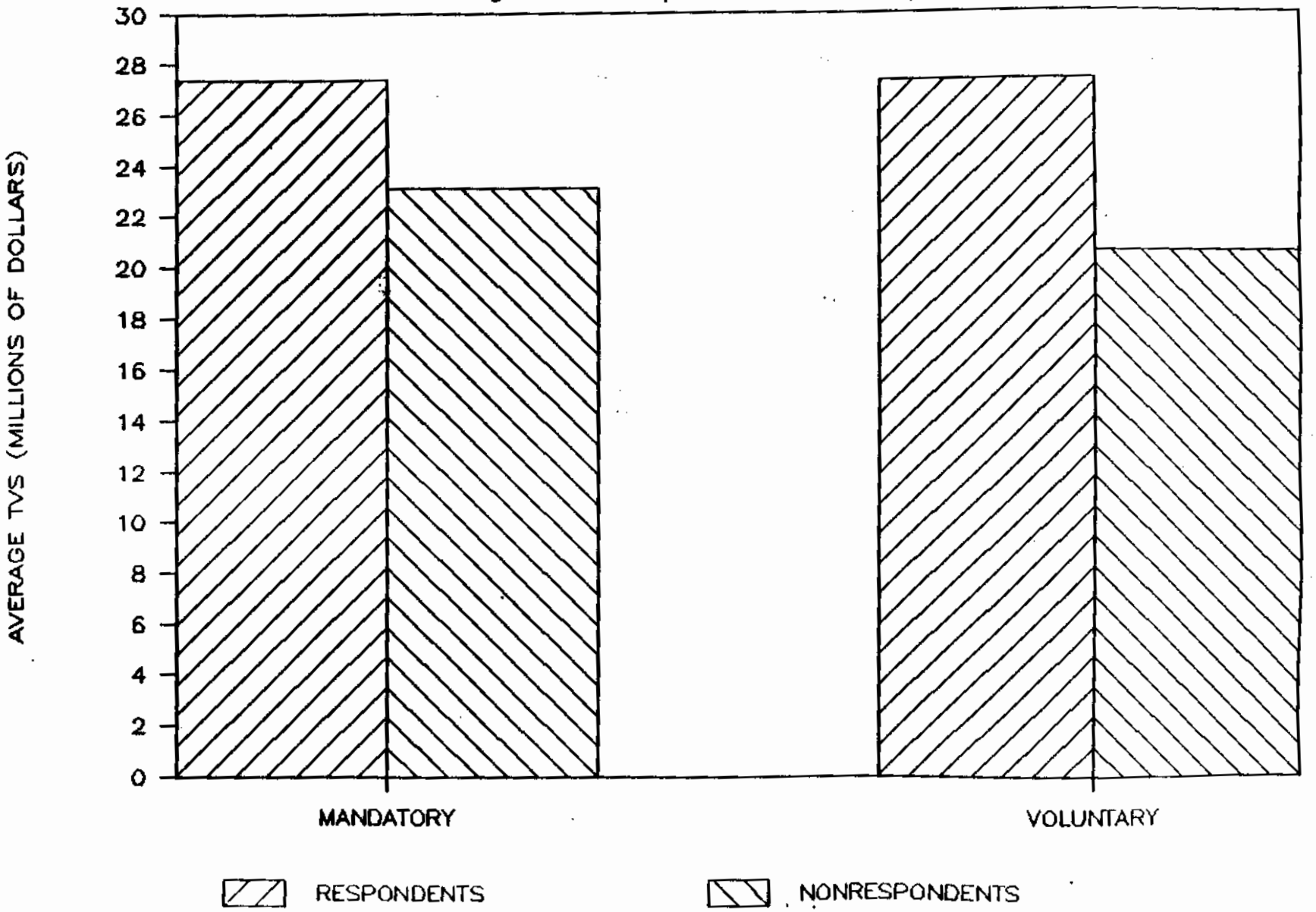
PACE (MA200) --- MANDATORY VS. VOLUNTARY STUDY

Comparison of Average TVS for Respondents vs. Nonrespondents

	Response Status	# Cases in Stratum	Average TVS (millions of dollars)
MANDATORY	Respondent	8401	27.4
	Nonrespondent	1777	23.1
VOLUNTARY	Respondent	631	27.3
	Nonrespondent	395	20.6

PACE (MA200) ------ M vs. V STUDY

Avg. TVS for Respondents vs. Nonresp.



APPENDIX D-1

PACE (MA200) --- MANDATORY VS. VOLUNTARY STUDY

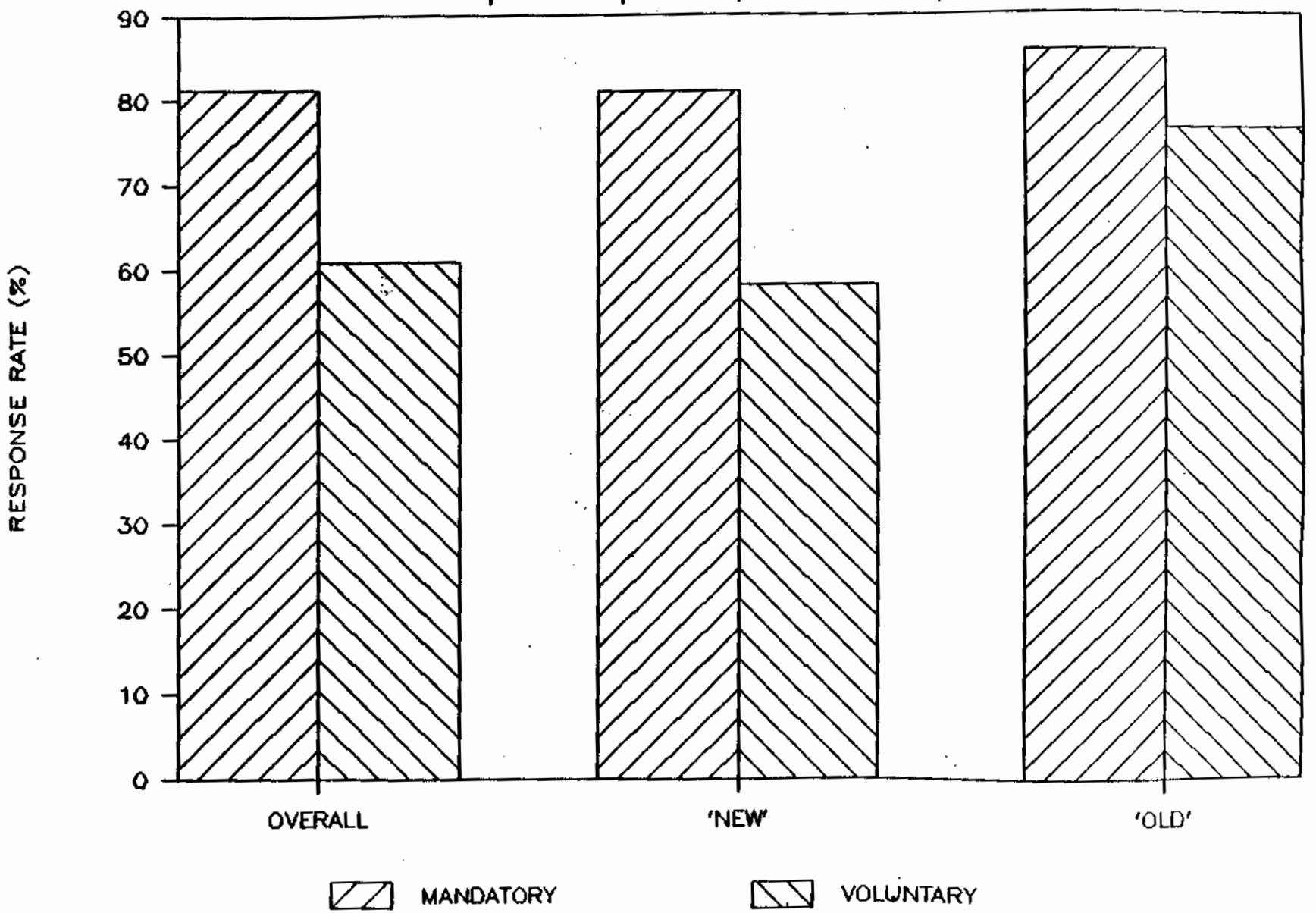
Final Response Rates for the Three Comparisons By TVS Size Groups

	TVS (MILLIONS OF DOLLARS)								
	< 10			≥ 10 and < 50			≥ 50		
	# OBS.	# RESP.	RATE (%)	# OBS.	# RESP.	RATE (%)	# OBS.	# RESP.	RATE (%)
MANDATORY	4720	3837	81.3	4105	3415	83.2	1353	1149	84.9
'NEW'	4198	3401	81.0	2195	1795	81.8	360	287	79.7
'OLD'	83	71	85.5	976	827	84.7	850	733	86.2
VOLUNTARY	460	280	60.9	437	258	59.0	129	93	72.1
'NEW'	399	232	58.1	233	123	52.8	29	18	62.1
'OLD'	17	13	76.5	117	83	70.9	90	70	77.8

* NOTE: TOTALS FOR 'NEW' + 'OLD' DO NOT EQUAL OVERALL TOTALS DUE TO THE FACT THAT 'NEW' PLANTS OF 'OLD' COMPANIES WERE NOT INCLUDED IN THE 'OLD' COMPARISON, BUT WERE INCLUDED IN THE OVERALL COMPARISON. THIS ENSURED THAT THE 'OLD' COMPARISON WOULD TRULY BE A COMPARISON OF PLANTS WHICH HAD PREVIOUS EXPOSURE TO THE PACE SURVEY.

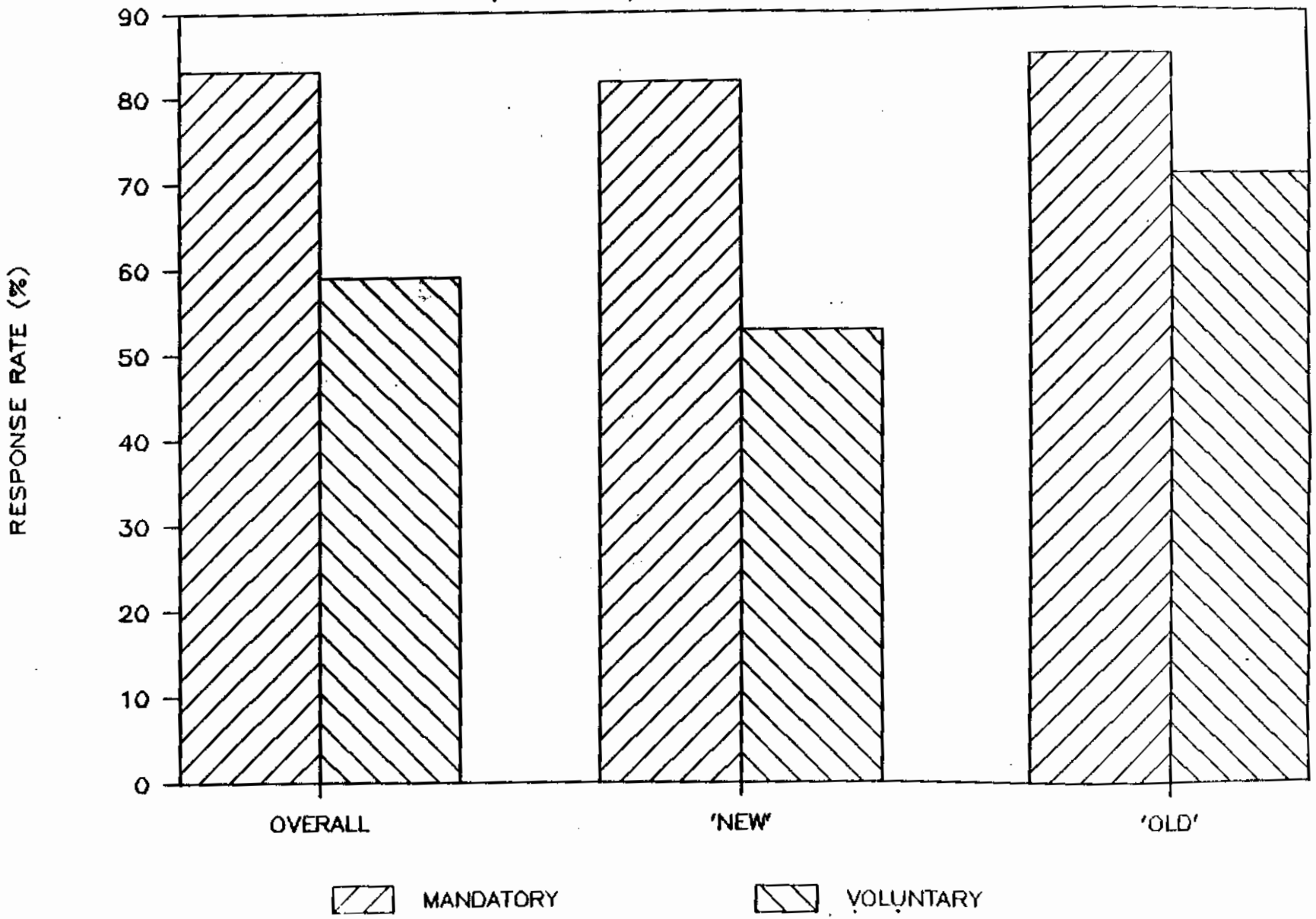
PACE (MA200) ------ M vs. V STUDY

Response Comparisons (TVS < 10 Million)



PACE (MA200) ------ M vs. V STUDY

Response Comparisons (10 ≤ TVS < 50)



PACE (MA200) ------ M vs. V STUDY

Response Comparisons (TVS ≥ 50 Million)