

Appendixes

Appendix A

Survey Methodology

Introduction and Overview

In support of the Automation and the Workplace study undertaken by the congressional Office of Technology Assessment, Westat conducted a survey to identify education and training requirements inherent in the use of programmable automation in manufacturing settings. The survey describes current levels of utilization of programmable automation, as well as existing instructional opportunities focused on this form of technology, and elicits various opinions related to current and anticipated education and training needs resulting from applications of computer-based automation.

Survey data were collected by the Westat Telephone Research Center on three samples: 1) users, 2) producers of computer-automated technologies in manufacturing, and 3) a diverse sample of knowledgeable others. The surveys used structured instruments developed for the study. Data were collected by telephone interviews over a 2-week period in August 1982.

Methodology

This section briefly describes the methodology used for the survey. The first part describes sampling procedures, the second describes data collection instruments and methodology, and the third describes data analysis procedures.

Sample

Three groups were contacted for this study: users and producers of computer-automated equipment and systems, and others, a diverse group of individuals involved in instruction for employees in computer-automated manufacturing environments or for individuals preparing for careers in such settings. Formal sampling procedures were used only for the user group, and for a subset of the others. Details of the procedures are described below.

USERS

Sampling Frame.—The sample of users was composed of manufacturing establishments from industries identified as currently using or likely to use computer-programmable equipment and systems in the near future. An establishment was defined as an individual location of company. This location might constitute

a division, subsidiary, plant, branch, or the entire company.

Three major manufacturing industries were represented: transportation equipment manufacturing, electric and electronic equipment manufacturing, and industrial and metalworking machinery manufacturing. For each of these three major industries, specific standard industrial classifications (SIC) were selected based on two criteria: 1) proportion of total employees in industry accounted for by establishments within the SIC code; and 2) likelihood of establishments within the SIC code using computer-automated technology. SIC codes meeting the second criteria were selected based on judgments of project staff, as well as OTA Automation Study Advisory Panel members. The selected SIC codes for the transportation equipment industry account for 76 percent of the total workers employed in the industry; SIC codes in electric and electronic equipment manufacturing account for 59 percent of the total employees; and the SIC codes in industrial and metalworking machinery account for 41 percent.

The data source for constructing the frames for the three user samples was National Business Lists (NBL), a firm which compiles a national list of most types of establishments, including manufacturing and commercial. The NBL lists rely heavily on the Dun & Bradstreet directory of establishments, supplemented by NBL's own sources.

Sampling Methodology.—A probability sample of users in the three industries was selected from the NBL lists using a two-stage sampling approach. This sampling procedure involved stratification by size and regional location, and included as selections with certainty a small number of establishments known to use computer-automated equipment for manufacturing. These were included to assure a minimum of current users within the sample to provide an adequate basis for analysis of this subgroup.

The first step in a two-stage sampling procedure entailed compiling a list of approximately 5,000 establishments from the NBL master file in the three major industry groups specified earlier. The purpose of "oversampling" establishments at this initial stage was to obtain a sufficiently large sample for examining the size distribution of establishment by SIC group for subsequent use in deriving appropriate (and more nearly optimal) sampling rates. Since larger establishments account for a larger share of the work force while ac-

counting for a smaller share of the total number of establishments, selection of the initial sample from NBL was stratified by establishment size. The size strata used by the initial sampling were:

Small:	1-99 employees
Medium:	100-499 employees
Large:	500 or more employees

Furthermore, to take these size differences into account in the sampling, large establishments were sampled at a higher rate than small ones. Therefore, the initial sample consisted of all of the large establishments in NBL for each of the three industries, *one-half* of the medium-sized establishments and *one-tenth* of the small establishments. Since the listings of establishments in the NBL file were geographically sorted within each of the three size classes, and the samples were selected systematically (using a random start), the method of sample selection simplicity included stratification by geographic region. These proportions yielded 5,128 total establishments in the initial sample.

In the second stage of the sampling procedure, the 5,128 establishments were further stratified by industry type, establishment size, and regional location. Regional location was defined by the four regions delineated by the U.S. Census Bureau (i.e., Northeast, North Central, West, and South). In addition to the three major size strata defined above, the "small" size class was further subdivided into two classes for sampling (1-20 and 20-99). This more detailed stratification by size permitted a more nearly optimal allocation of the sample cases to the various strata. This stratification yielded 48 different cells in which establishments were placed for sampling.

To determine the appropriate sampling rates to select the second-stage sample, three options were considered:

1. The sample could be allocated to each cell in proportion to the total number of establishments in that cell.
2. The samples could be allocated to each cell in proportion to the total employment in that cell.
3. The samples could be allocated to each cell in proportion to some function of employment, say square root of employment.

The implication of the first option was to have large numbers of small establishments and few large establishments since most manufacturing establishments have fewer than 500 employees. This would be desirable for estimation of counts of establishments, but would not be sufficient for estimation of magnitude variables such as employment.

The implication of the second option was to have large numbers of large establishments and very few small establishments, since manufacturing establish-

ments of 500 or more employees account for most of the work force. This would be approximately optimum for estimation of magnitude variables (in particular, those correlated with employment), but would be less efficient for estimates of the numbers of establishments.

The final option, which combines the first and second options by sampling with probabilities proportionate to the square root of employment, distributes the numbers of establishments somewhat more evenly across cells. This last option was selected because it provided a better basis for making comparisons between the different size classes, in addition to being reasonably efficient for estimating both magnitude and count variables.

Sampling Methodology.—Establishments from the user sampling frame were screened to eliminate from the user samples those not meeting the following criteria:

1. establishments must be performing manufacturing functions at the location contacted (purely administrative facilities were dropped); and
2. establishments must be able to identify an individual within the first three referrals during the phone call who can answer selected key questions. (Those unable to do so were treated as non-responses.)

Selection of the second-stage sample, therefore, was based on the assumption that there would be extensive dropouts due to ineligibility and nonresponse. From the initial sample of 5,000 user establishments, 200 establishments were drawn from each user industry group for a total of 600 sample establishments. These were allocated to the various size strata in proportion to the aggregate measure of size based on the square root of employment. This sample included 18 establishments that were selected with certainty in addition to the 600 selected establishments. The sample allocation of the noncertainties in each user industry group by size class is shown in table A-1.

Detailed records were kept of establishments failing to meet these criteria as well as refusals and non-responses. Table A-2 shows the distribution of the initially sampled cases and the final number of completed interviews by size strata and region.

PRODUCERS

Sampling Methodology.—The producer group was composed of companies who manufacture and/or sell programmable equipment to U.S. manufacturing industries. The compilation of a list of producer companies was no simple task, since no such lists were readily available. An intensive search to identify com-

Table A-I. -Sample Allocation for User Groups

Size class (employment)	Number of establishments in NBL	MOS ^a based on square root of employment	Sample allocation
Transportation equipment			
1-19	2,070	5,430	30
20-99	1,030	7,050	40
100-499	596	9,020	50
500+	287	14,969	80
Total	3,983	36,469	200
Electrical and electronic machinery			
1-19	4,520	11,440	40
20-99	2,090	14,510	50
100-499	1,244	18,742	60
500+	363	14,240	50
Total	8,217	58,932	200
Machinery manufacturers			
1-19	12,620	30,900	60
20-99	3,590	22,450	50
100-499	1,296	19,092	50
500+	318	12,005	40
Total	17,824	84,447	200

^aMeasure-of-size: For a given size class, the aggregate MOS was computed as $S = \frac{N}{2} E_i$, where E_i is the average employment size of all establishments in the SIC group and size class based on 1979 County Business Patterns, and where the summation extends over all establishments in the NBL frame.

SOURCE: Westat.

Table A-2.—Stratification of User Establishments and Costs of Initially Sampled Cases and Completed Interviews^a

	Northeast	North	Central	South	West
Transportation region					
1-19	4 : 2	8 : 1	6 : 1	12 : 4	12 : 4
20-99	8 : 4	14 : 8	6 : 3	12 : 4	12 : 4
100-499	8 : 3	26 : 16	8 : 8	8 : 2	8 : 2
500 or more	12 : 6	42 : 24	16 : 11	10 : 6	10 : 6
Electrical/electronic region					
1-19	12 : 3	8 : 3	8 : 4	12 : 4	12 : 4
20-99	18 : 9	10 : 4	8 : 4	14 : 8	14 : 8
100-499	22 : 11	14 : 7	12 : 4	12 : 7	12 : 7
500 or more	16 : 9	12 : 8	10 : 6	12 : 6	12 : 6
Machinery region					
1-19	12 : 5	28 : 13	10 : 4	10 : 3	10 : 3
20-99	10 : 5	28 : 9	10 : 8	6 : 2	6 : 2
100-499	10 : 5	26 : 10	10 : 3	4 : 1	4 : 1
500 or more	8 : 7	20 : 12	8 : 6	4 : 1	4 : 1

^aThe number on the left in each cell shows the initial sample count, and the number on the right shows the number of completed interviews. The number of completed interviews shown in this table does not include the nine completed users which were sampled with certainty, since these were not preassigned to a size class.

SOURCE: Westat.

panies who were involved in manufacturing or selling computer-automated equipment was conducted by OTA, with assistance from Westat & Hadron, a subcontractor. The list used in this study was constructed from a variety of sources, including rosters of exhibitors at conventions on computer-automated manufac-

turing, lists from organizations such as the Robotics Institute of America, trade publications citing companies involved with such products, and personal contacts with relevant companies. The final list consisted of 203 producers, and is considered to be a fairly good approximation of the actual universe of companies producing computer-automated equipment for manufacturing in the United States.

Producers were contacted in random order until 101 companies had completed interviews.

OTHERS

Sampling Frame.—The others group was composed of individuals who have had experience in designing and/or delivering and/or evaluating formal instruction for employees operating in computer-automated or conventional manufacturing environments. These others were selected because of their pertinent expertise and/or because they represented institutions (e.g., unions) whose opinions are important to consider in formulating policy in this area. A list of 280 others was compiled by OTA. The list was composed of six subgroups:

- Traditional educational institutions (e.g., colleges and universities, community colleges, technical schools);
- proprietary educational institutions (private, profit-seeking, trade and technical schools that operate on the secondary and postsecondary level);

- labor unions and labor organizations;
- training industry representatives (individual consultants and training firm representatives);
- State and local agency representatives (e.g., vocational education and economic development agencies); and
- miscellaneous others (e.g., Federal Government and trade association representatives, individual scholars, and experts).

Sampling Methodology.—Representatives of traditional educational institutions were randomly sampled, while attempts were made to contact all those in the other five subgroups. The initial goal of obtaining 25 interviews from the traditional education subgroup and 75 from the remaining subgroups had to be revised, due to nonresponse rates among the five other subgroups. Actual portions are presented below.

Final Samples and Response Rates

A total of 506 interviews were completed for the study. There were 303 users (105 in transportation equipment, 98 in electric and electronic equipment, and 100 in industrial and metalworking machinery), 101 producers, and 102 others. In the others sample, there were 34 traditional educators, 11 educators from proprietary educational institutions, 13 union representatives, 2 representatives of the training industry, 17 representatives of State and local agencies, and 25 "others."

The response rates obtained (defined as the number of completed interviews plus refusals) were 82 percent overall, 76 percent for the users, 89 percent for the producers, and 95 percent for the others. The completion

rates (defined as the number of completed interviews divided by all completes plus all incomplete) were somewhat lower, due to unknowledgeable, unavailable, or nonlocatable respondents. Table A-3 summarizes the final completion status of the telephone surveys conducted with further explanations of various completion statuses in table A-4.

Data Collection Instruments and Methodology

SURVEY INSTRUMENTS

Three telephone survey instruments (for users, producers, and others) were developed for the study. The instruments were closed-ended in format—i.e., response options were provided for most of the questions. A core set of questions was asked three groups, along with additional questions designed specifically for each group. The instruments were designed to require approximately 15 to 20 minutes per interview.

In general, the instruments were designed to obtain information about the extent and nature of the involvement of the respondents with programmable automation technology, their involvement with education and training focused on the application of various forms of programmable automation in manufacturing settings, and their opinions about a variety of issues related to such instruction. In addition, questions on basic background characteristics (e.g., size of the work force) were also included in the instruments.

Table A-5 presents the major topics covered by the three survey instruments. The greatest number of questions were asked of the users, although most topics were covered in the three instruments. One major dif-

Table A-3.—Final Response and Completion, Statuses of Telephone Surveys

Status codes	Users				Producers	Others	Total	survey sample
	Group 1	Group 2	Group 3	All users				
Complete	105	98	100	303	101	102	506	
Admin Hdqtrs.	32	21	22	75	1	—	76	
Not working	11	9	11	31	11	—	42	
No answer	1	11	12	24	—	—	24	
No new tech.	—	—	—	—	39	—	39	
No E&T	—	—	—	—	—	3	3	
Duplicate	1	2	—	3	7	7	17	
Final refusal	31	28	35	94	12	5	111	
Not available	11	13	13	37	23	14	74	
Not locatable	—	21	14	35	9	5	49	
E&T knowledge	—	1	—	1	—	—	1	
Response rates ^a	77 %/0	780/o	74 %/10	76%	890/o	95%	820/o	
Completion rates ^b	71 %/0	61 %/0	620/o	650/o	70 %/10	81 %/0	68 %/0	

^a Response rate = $\frac{\text{No. completes}}{(\text{No. completes}) + (\text{No. final refusals})} \times 100$

^b Completion rate = $\frac{\text{No. completes}}{(\text{No. completes}) + (\text{No. noncompletes})} \times 100$

SOURCE: Westat.

Table A-4.—Definitions of Completion, Ineligible, and Nonresponse Status Codes

I. Completion	
A.	Complete(C)-completed entire interview. A complete means all pertinent questions have been answered.
//. Intelligibility (The following categories of respondents were screened out of the survey.)	
A.	Admin hdqtrs (I) —user establishment is an administrative headquarters which does not perform a manufacturing function.
B.	Not working (NW) —phone number is not in service and, after calling directory assistance, there is no new listing for that facility.
C.	No answer (NA)—there is no answer after three attempts at different times on different days.
D.	No new tech (N L) —producers only; if producer establishment is not manufacturing or selling new technology included in the survey.
E.	No E&T (S2)—others only; if respondent represents a traditional educational institution, proprietary educational institution, or a training firm, which does not have an education and training program.
F.	Duplicate (OA)—duplicate respondent.
///. Noncompletion (The following categories of respondents are included in computation of a completion rate.)	
A.	Final refusal (R B) —respondent refuses the interview or breaks off interview.
B.	Not avai/ab/e (0)—respondent was not available during field period.
C.	Not locatable (SI)—appropriate respondent was not located after three referrals or the respondent was not knowledgeable about new technology for his/her establishment.

SOURCE: Westat.

ference should be noted in the questions on education and training in the three instruments. Users were asked about the education and training provided to their own employees. In contrast, producers and others were asked about the instruction they provide to customers or clientele, not their own staff.

The instruments were developed in several stages by Westat & Hadron staff, in collaboration with OTA. At the start of the research effort, 12 in-depth interviews were conducted, in person and on the telephone by Westat & Hadron staff, to identify important issues and develop possible questions and response options for the instrument. A topic guide was developed for these interviews.

Based on these preliminary interviews, a list of draft questions and response options was submitted to OTA. Comments from OTA staff and further interviews by Westat & Hadron staff were used to refine and shorten the questionnaires.

The instruments were pretested by the Westat Telephone Center on a small number of respondents, and further minor changes resulted from the pretests.

Data Analysis

SAMPLE WEIGHTS

Since disproportionate sampling procedures were employed in drawing the user samples—i.e., different sampling ratios were used for the different strata—

Table A-5.—Topics in Survey Instruments

	User	Producer	Other
Background			
• Year founded	X	X	X
• Gross sales	X	X	X
• Work force or clientele characteristics	X	X	X
Computer automation			
• Use, production, or sale of new technologies	X	X	
• Extent of computerization	X		
• Computerized integration of equipment	X		
Education and training (E&T)			
• Presence of general E&T, and E&T for new technology	X	X	X
• Priority given to setting up E&T	X	X	X
• Barriers to setting up new technology instruction	X	X	X
• Work force/clientele percentage who received or will need E&T	X		X
• Number of instructors for new technology	X	X	X
• Forms of instruction	X	X	X
• Sources for designing/delivering instruction	X		
• Target occupational groups	X	X	X
• Skill and knowledge areas covered	X	X	X
• Policies and opportunities on E&T outside the company	X		
Opinions			
• Current and future readiness of institutions to provide instruction	X	X	X
• Options for institutional collaboration on E&T	X	X	X
• Sources of funding for E&T	X	X	X

SOURCE: Westat.

mechanisms to equalize the differential probabilities of selection attached to establishments from the different strata were required. Such weighting adjustments are necessary in cases where generalizations are made from the sample to a larger sampling frame or universe, and to take into account nonresponse.

Weights were applied only to the user sample and the others. Weights were not necessary for the producers, since they did not constitute a sample from a larger universe of such firms. Users were given weights such that the sample represented an estimated 24,142 active and eligible establishments in the NBL frame—and the other sample was weighted to represent the 280 others in the original sampling list. The estimated 24,142 active and eligible user establishments was obtained by summing up the weights of the responding establishments in the sample and compares with about 30,000 establishments in the designated SIC groups in the NBL frame.

The sampling weights for the OTA samples (user and other groups) were computed from the formula: where

W_{hi} = The weight for establishment i in stratum h (for a particular group).

n_h = The total number of establishments (in the frame) in stratum h .

N_h = The number of establishments in stratum h that were finally sampled.

n'_h = The number of eligible and responding establishments in stratum h .

n''_h = The number of eligible but nonresponding establishments in stratum h .

The factor, $(n'_h + n''_h)/n'_h$, in the above expression represents an upward adjustment for total questionnaire nonresponse. The weight for any given establishment depends on the stratum (and group) from which the establishment was sampled, but is uniform for all responding establishments in a particular stratum. Weights for the establishments selected with certainty would be 1.0 if there were no nonresponding cases, and otherwise exceed 1.0 by a factor representing an adjustment for nonresponse.

Table A-6.—Sampling Weights for Estimation

Respondent group	Sampling stratum				
	Certainty < 20 employees	20-99 employees	100-499 employees	500+ employees	
User 1 (transportation)	2.5	155.2	42.8	18.4	4.8
User 2 (electric and electronic).	4.0	248.4	74.5	36.1	10.0
User 3 (industrial and metalworking)	1.0	419.0	136.6	52.2	10.3
Others	1.2	Noncertainties ^a : 4.7			

^aAs indicated in "Others" section in text, all traditional educators except for educational institutions were included in the sample with certainty. Educational institutions were sampled at a fixed rate of about 1 prior to adjustments for nonresponse.

SOURCE: Westat.