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DO MANUFACTURING EXTENSION PROGRAMS MATTER?

Eric Oldsman

Building on the pioneering efforts of the states, Congress mandated in 1988 that the National Institute for Standards and Technology (NIST) assume a more active role in promoting industrial modernization. The Omnibus Trade and Competitiveness Act authorized NIST to establish regional Manufacturing Technology Centers to transfer technology and disseminate relevant information to manufacturing firms. By the end of 1992, seven MTCs were in operations in California, Kansas, Ohio, Michigan, Minnesota, New York, and South Carolina. NIST is now moving rapidly to establish a nationwide network of manufacturing extension programs under the Manufacturing Extension Partnership (MEP). FY 1994, the federal government committed roughly $55 million to support 35 manufacturing extension programs in different parts of the United States.[1] The FY 1995 budget further increased the MEP's funding. When fully developed, the Manufacturing Extension Partnership (MEP) will consist of over 100 manufacturing extension programs operating throughout the country. Assuming an equal match from state and local governments, it is conceivable that more than $300 million per year will be spent on manufacturing extension programs by the end of the decade.

Productivity, Wages and Job Security

Interest in manufacturing extension programs is motivated, in part, by concerns about productivity. The standard of living of most people in the United States is tied directly to the jobs they hold and the wages they earn. The housing they can afford, the clothes they can buy, the food they can put on the table all depend on the size of their weekly paychecks. If real wages and living

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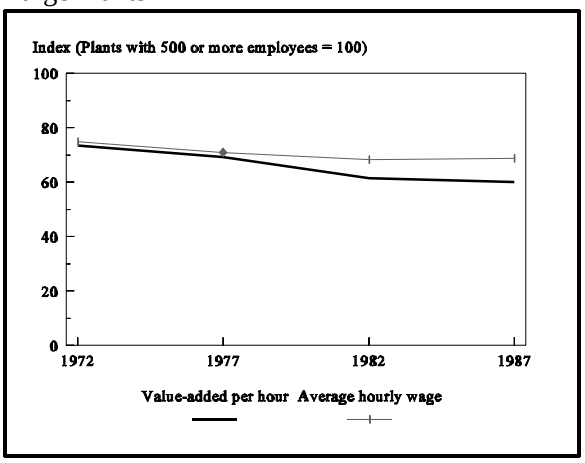
[1]The FY-1994 appropriation for the NIST Manufacturing Extension Partnership (MEP) is $30 million. An additional $25 million was allocated to manufacturing extension program under the Technology Reinvestment Program (TRP).

standards are to increase, productivity must rise. While productivity growth in manufacturing has been relatively strong overall, productivity gains among smaller manufacturers have been lagging.

In 1972, small manufacturers employed 58.2 percent of the manufacturing labor force and produced 51.4 percent of the value added in manufacturing; fifteen years later, these figures had risen to 64.0 percent and 54.1 percent, respectively.[2] Therein lies a dilemma. On the one hand, more and more responsibility for production in the United States is concentrated in smaller plants. On the other, smaller plants are relatively less efficient. Between 1972 and 1987, adjusted for inflation, value added per production labor hour in small plants increased by just under two percent per year -- well-below the 3.4 percent rate of growth experienced by large manufacturing plants (Figure 2.1).[3] In 1987, value added per production hour in small plants was 40 percent below that of large plants.

There are several possible explanations for the apparent gap in productivity between small and large manufacturers:[4]

Figure 2.1 Productivity and Wages: Small Versus Large Plants



- **Economies of scale**. Small plants may not be able to fully exploit scale economies available in a particular industry. Average unit costs may be higher in small plants as a result of indivisibilities of human and physical capital, and less specialization (Scherer, 1980). In certain circumstances, this may be the price companies pay for serving local and / or small markets. Transportation costs for some products may be sufficiently high to warrant construction of small plants which are close to customers, even if these plants operate below the minimum efficient scale. Furthermore, small plants may be serving niche markets where volumes are such that average costs remain relatively high.
- **Capital investment and production technologies**. Capital investment in small plants tends to be lower than in large plants. Moreover, the rate of new investment in small plants has steadily declined over the past 15 years relative to large plants. By 1987, small

[2]U.S. Bureau of the Census, *Census of Manufactures*. A small manufacturer is defined as a plant with less than 500 employees. The vast majority of American firms operate single plants. Moreover, there is a high correlation between firm size and plant size (Miller, 1978).

[3]U.S. Bureau of the Census, *Census of Manufactures.* Value added was deflated using the producer price index for manufactured products, U.S. Bureau of Labor Statistics.

[4]In addition to the reasons cited in the text, it is possible that monetary gains obtained through underlying productivity improvements are essentially transferred to customers in the form of lower prices. Many small manufacturers are suppliers of materials, parts and subassemblies to other, larger manufacturers. Either due to contractual arrangements requiring periodic price cuts, or price competition in the open market, suppliers face significant pressure to lower prices. This is particularly true in markets with undifferentiated products, where small plants essentially sell manufacturing services. Even if small manufacturers were able to reduce unit costs, subsequent price cuts may match these reductions, resulting in no apparent gain in productivity. Therefore, the apparent gap in productivity may be due, in part, to measurement error.

plants invested only $520 in new capital equipment per employee for every $1000 dollars invested per employee in large plants. Numerous studies have demonstrated that small plants are less likely than large plants to employ production technologies and techniques such as numerical control (NC) or computer numerical control (CNC) machine tools, computer-aided design (CAD) or computer-aided engineering (CAE) tools, automated inspection, robots, manufacturing cells and statistical process control (Shapira, 1992; Rephann and Shapira, 1993; Flamm, 1988; Mansfield, 1989; Kelly and Brooks, 1988, Bureau of the Census, 1988). To the extent that these technologies enhance productivity, one would expect lower usage to be associated with lower productivity.

- **Organizational and management capabilities**. Productivity growth is dependent on organizing the physical and human resources of the plant in a way that yields higher value at lower unit costs. This requires an ability to plan, operate and control the process of turning purchased inputs into products bought and paid for by customers (Lazonick, 1991). Small firms may face greater difficulties and costs in turning productive resources into valued products due to weaker organizational and management capabilities. In turn, these internal capabilities depend upon an ability to identify, collect and absorb information from outside the firm. High search costs, coupled with a lack of internal expertise and openness to new ideas, contribute to relatively poor performance (Nootebaum, 1993).

The differences in rates of productivity growth have contributed to a widening gap in wages paid by small and large plants over the last 15 years. In 1987, the average production worker in a small plant was paid $8.98 per hour, 31 percent less than the $13.42 paid to the typical worker in a large plant.[5]

Moreover, workers in small plants are less likely to be covered by health insurance or participate in a retirement plan than employees of larger plants.[6]

Finally, a person employed at a small plant is more likely to lose his or her job than a worker at a large plant. Today, one frequently hears about the job creating prowess of small manufacturing firms; what is less well-publicized is the fact the small firms also shed workers at a relatively high rate. The gross rate of job loss in small plants is 50 percent higher than that in large plants. (Davis, et al, 1993) In any year, workers in small plants have a one in eight chance of losing their jobs, compared with a one in 12 chance in large plants.

The Need for Evaluation

If lagging productivity, low wages and job insecurity are the problem, are manufacturing extension programs the answer? This paper presents findings from one of the first comprehensive evaluations of a manufacturing extension program in the United States.[7] It draws primarily on an in-depth review of the Industrial Technology Extension Service program in New York State -- a forerunner of the MTC program. The New York

[5]U.S. Bureau of the Census, *Census of Manufactures*. Studies have shown that wage differentials persist after taking into account such factors as industry, location, unionization and worker characteristics (Brown, et al, 1990; Schmidt and Zimmermann, 1991). Wage differentials might also be due to people preferring to work in small plants to large plants, all else being equal (Scherer, 1976).

[6]Brown (1990). The authors state that unions are instrumental in ensuring employee benefits, irrespective of the size of the firm or plant. However, smaller plants are less likely to be unionized.

[7]The impact of extension programs in West Virginia on the adoption of technology was examined in Rephann and Shapira, 1993. Daniel Luria and colleagues at the Industrial Technology Institute (ITI) in Michigan have done an extensive analysis of differences in manufacturing performance between companies participating in the Midwest MTC and a similar group of non-participating companies.

State Legislature established the Industrial Technology Extension Service (ITES) program within the New York State Science and Technology Foundation in 1990 to help small and medium-sized manufacturers upgrade production technologies and management practices.[8] As delineated in enabling legislation, the basic purposes of the ITES program are:

- to improve the competitiveness and increase the market share of viable New York State industries and firms through increased knowledge of new technologies and other innovations;
- to assist in the retention and expansion of industrial firms and employment in New York State.

The State has committed approximately $1.2 million per year to the program since its inception. Some 1300 companies participated in the ITES program between July 1990 and March 1993 as *active* clients, representing a total expenditure of approximately $2600 per company.

At the heart of the ITES program is a regional network of field agents of 17 full-time and several part-time field agents. Agents help companies identify matters requiring improvement and offer suggestions on what steps they should take to improve their capabilities. At times, agents provide direct advice to companies based on their own expertise and experience. However, the more general practice is for agents to refer companies to other organizations in the State for assistance. Agents also organize and conduct seminars and workshops on topics of interest to manufacturers in their regions.

This chapter describes the ITES evaluation design and primary sources of data. There is then a discussion of how the ITES program is implemented. This helps lay a foundation for understanding and interpreting findings with respect to the impact of the program. To assess these impacts, an impact model is developed, which describes the links between ITES services and desired policy outcomes. This model is used to assess the impact of the ITES program. A critical element of this assessment is an analysis of how different types of services affected changes in manufacturing practices and overall performance of client companies. The chapter concludes with a summary of the principal findings and the implications for program design.

Evaluation Design

The evaluation represents an advance on current practices in several ways. First, it uses a variety of measures and methods to assess the program, helping to ensure the validity of results. Second, it sets out to draw a careful link between services rendered, actions taken by clients, intermediate impacts, business outcomes, and policy outcomes. Finally, it attempts to determine the net impact of the ITES program with respect to important policy outcomes, controlling for extraneous factors.

Data collection

A detailed understanding of the processes involved in the program is central to providing a basis for causal inference and improving management and administration. To this end, documents relevant to the ITES program were reviewed, including the enabling legislation, funding requests, annual proposals submitted by each contracting organization, minutes of meetings of the Operating Advisory Committee, letters written by field agents to individual companies, and brochures and other material describing programs of other affiliated organizations. In addition, numerous conversations were held with program managers and individual field agents in each of the ten regional offices.

Six case studies of companies participating in the ITES program were prepared. The case studies

[8] The ITES program is the successor of an earlier program called the Industrial Innovation Extension Service (IIES), established in 1985 in five regions on a pilot basis. In 1990, the program was modified and implemented on a statewide basis under Section 3102-A of Article 10-A of the Public Authorities Law, State of New York.

followed a standard protocol, delineating the areas of interest, specific questions, people to be interviewed and quantitative data to be collected. All of the case studies included visits to the companies. Each visit lasted between two and three hours. The case studies focused on describing the interactions between the company and the field agents, services rendered, actions taken by the firm in response to assistance received, and resulting benefits. Additional interviews with other companies were undertaken by telephone.

In addition to case studies and various internal reports, the evaluation draws on three sources of quantitative data: monthly reports submitted by field agents, a mail survey of ITES clients, and Employment Security (ES-202) files. Each of these is discussed below.

- **Monthly reports submitted by ITES Regional Offices**. Each of the ten ITES regional offices is required to submit monthly reports, detailing activities undertaken during that period. Reports follow a standard format but vary in content, with little codification of program elements. Copies of the 300 or so monthly reports submitted between July 1990 and March 1993 were provided for purposes of the evaluation. Considerable effort was spent on translating the data into a computerized database. The database describes program activities in terms of the ITES office rendering the service, the companies served, the type of service provided, problems addressed, organizations involved, and the date of the action. All told, over 5000 transactions are contained within the database.
- **Client Survey**. The purpose of the mail survey was to obtain information on the characteristics of companies participating in the ITES program, nature and magnitude of participation, satisfaction with services, and perceived benefits. The 12-page questionnaire was sent out to all companies that had been active in the program between July 1990 and March 1993. A total of 222 completed surveys were returned, representing an effective response rate of 20 percent.
- **Employment data from ES-202 Files**. The New York State Department of Labor (DOL) provided data drawn from employment service's unemployment insurance files (ES-202) which all nonagricultural businesses with one or more employees on their payroll are required to file on a quarterly basis. For companies involved in the ITES program, DOL provided the primary SIC code and quarterly employment data for the period between January 1991 and March 1993. In addition to plant level data, the NYS DOL provided average employment of plants with less than 500 employees within 25 industry groups in each of ten regions of the state.

Use of comparison groups

How effective is direct assistance? Have companies adopted new technologies? Has productivity increased? Has employment gone up? All of these beg the question: compared to what? The only way to judge the effectiveness of the program is to compare companies receiving assistance with other similar companies. As such the evaluation of the ITES program employed a quasi-experimental design (Cook, 1979). This approach centers on comparing the performance of one group of companies to another group, statistically controlling for differences in variables affecting outcomes. It is not necessary for companies in the comparison group to receive no treatment. As will be demonstrated in subsequent sections, the nature and magnitude of services delivered to companies varies from one case to another. For example, some companies receive direct assistance from field agents, others referrals to outside service providers. Some participate for months on end, others for days or weeks. An examination of the performance of similar companies receiving *different* services can cast light on the relative effectiveness of different approaches. In addition, the impact assessment relies, in part, on evidence of a *dosage effect.* Evidence that

outcomes are related to the degree of interaction between clients and field agents adds greater credibility to claims that the program actually *caused* companies to take certain actions and improve performance.

Program Implementation

In keeping with the enabling legislation, the Foundation contracts with a variety of not-for-profit organizations for the services of field agents. Most of the ITES field agents are employed by Technology Development Organizations (TDOs) under contract to the Foundation. A few agents are contracted directly by the Foundation on an individual basis. Coverage is statewide, with representation in all ten economic development regions.

All field agents have extensive experience in manufacturing. Some complement technical backgrounds with expertise in marketing and sales. In some cases, agents offer direct assistance to companies, helping them to resolve specific problems based on their own expertise. Sometimes recommendations may deal with very routine issues related to the condition of the work place. Other times, advice offered by the ITES agents is related to specific production processes. Consider the following case studies:

A company was having problems securing brass tube assemblies into die-cast aluminum flanges; the joints were failing in the field. The agent researched potential solutions and recommended a slight modification in the design of the part and the use of a commercially available adhesive.

During a plant visit, a field agent noted that tooling was not compatible with a technique known as single minute exchange of dies (SMED), which had been shown to have significant benefits with respect to improved performance, lower capital costs, reduced labor, lower maintenance costs, and lower space requirements. The agent recommended that tooling purchased in the future incorporate uniform locating pin orientations and spacing, clamp locations, etc., to enable the company to adopt SMED at a latter date without prohibitive switching costs.

The process that a particular food products manufacturer was using to dry its products was taking three times as long as its competitors. This was resulting in longer production cycle times and higher energy costs. The agent recommended the purchase of an off-the-shelf, low-cost instrument to measure and record temperature and relative humidity to better monitor the process. He further instructed the company on how to conduct an experiment to identify the variables that have the greatest impact on drying times.

As noted above, while field agents frequently provide direct assistance, the more common practice is for agents to refer companies to other organizations in the State for aid and support. As one agent put it, "our basic job is to broker technical services." This process is illustrated by the following example:

The Regional State Department of Development office referred a company that manufactures quartzware for the semiconductor industry to the local ITES agent. The agent visited the plant, made some immediate suggestions, and referred the company to a variety of other organizations for further assistance. The agent brought in a representative of the Regional Education Center for Economic Development (RECED) to assess the current production system and develop the basis for a skills certification program. The RECED representative spent three to four days in meetings with employees and developed

Table 2.1
Subject of Referrals Made by ITES Field Agents

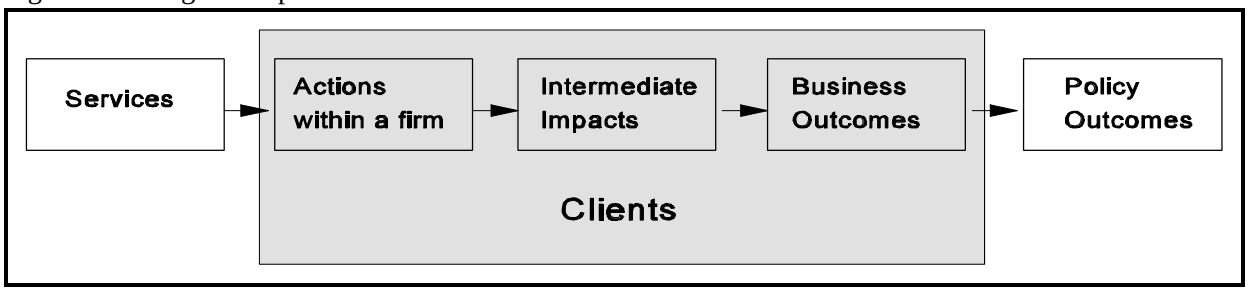
Problem area	% of all referrals*
Design and engineering	7.9
Manufacturing operations	9.6
Manufacturing processes	2.3
Environmental, health and safety	3.5
Vendor and supplier relations	6.7
Business, management and finance	26.0
Marketing and sales	12.6
Human resources	20.6
Quality	7.9
Other	2.9

Source: Author's calculations based on monthly reports
*Percentage of all referrals where a problem was specified or inferred from the type of organization to which the company was referred.

an outline for the program. The field agent also helped arrange a grant under the Economic Development Strategic Training Program (EDSTP) to fund a training program for employees in statistical process control. The six-week course was conducted by faculty from a local community college at the company's plant. He also arranged for three MBA students to do a study on customer satisfaction as part of a marketing class. The study was carried out over a two-month period during the fall semester. The field agent attempted to arrange for training related to computer numerical control (CNC) machine tools through the Northeast Manufacturing Technology Center (NEMTC) and the Hudson Valley Community College. However, while the company was interested, the price tag was too high; the company was strapped for cash and was forced to postpone the project. Finally, the agent assisted the company in securing a grant to retain consultants under the IEP program. The company was awarded $3,000 under the IEP program for a Preliminary Productivity Assessment (PPA). The field agent supplied a number of names of potential consultants and assisted in the grant application process. The company interviewed three people and chose one. The company had never used a consultant before, so the process was unfamiliar. The PPA identified several problems in different areas which warranted attention and offered some suggestions on how they might be resolved. The company has applied for a grant for a Full Productivity Assessment (FPA) and at the time of the our visit was still waiting to hear if it will be awarded. The FPA will focus on the implementation of a total quality management (TQM) and skills certification program.

As can be seen in the example, referrals are used to address a number of different problems faced by a client. In this case, problems revolved around skills upgrading, quality control and marketing. Overall, as shown in Table 2.1 , one in four referrals made during the study period dealt with issues related to business, management and finance.

Figure 2.2. Program Impact Model



The example presented above also highlights the fact that ITES field agents draw on a broad range of resources to meet the needs of client companies. According to information contained within monthly reports, field agents referred companies to some 400 different state agencies, universities, community colleges, local economic development organizations, companies and independent consultants in New York State.

Because of the voluntary nature of the program, companies are free to call on the services of the ITES agent at any time for as long a period as needed. Most companies participate in the program for a short period of time -- one to two months. However, some have participated month after month throughout the program's history.

Impacts of the ITES Program

This section examines the impact of the ITES program on the performance of participating companies. At the outset, it is important to recognize that there is no single "treatment" that all participating companies receive. To the contrary, as the previous section has demonstrated, there is tremendous variability within the program with respect to the nature of services provided, problems addressed and resources used. Each instance of an interaction with a particular company is unique, with its own intended outcomes and service specifications. There is no cut-and-dried process. Field agents are granted a great deal of latitude in deciding whether and how they deal with individual clients. Choices regarding how much time is committed to a particular company, the types of problems that will be addressed, and the set of resources that will be marshaled are at the discretion of the individual handling the case. The particular manner in which an agent decides to work with a company depends upon the particular needs of the client, specialized knowledge of the agent, and availability of other resources in the local area. The characteristics of participating companies, the intensity and duration of participation, and types of services rendered vary substantially from case to case. All of these factors have bearing on the impact of the program and need to be taken into account, to the extent possible, in an analysis of the program's impact.

The section of the paper first presents an impact model, describing the links between services and desired policy outcomes. It then turns to an assessment of the impact of the ITES program within the context of the model. One critical element of this assessment is an analysis of the effects of different types of services on manufacturing practices and business performance. This section concludes with an analysis of the net impact of the ITES program on employment and business survival.

Impact model

It is useful to illustrate the relationship between the program and desired outcomes with an impact model. An impact model specifies the causal factors underlying problems and describes how the program addresses these factors. For example, various people have pointed to the relatively low level of productivity among small manufacturers. Some have attributed this phenomenon to

inadequate investment in advanced manufacturing technologies. On the one hand, the impact model defines a "causal hypothesis" stating that the increased use of advanced manufacturing technologies will raise productivity. On the other hand, it specifies the relationship between the program and the use of manufacturing technologies. To demonstrate that the program is meeting its objectives, both parts of the model must be shown to be true.

Figure 2.2 presents an impact model for the ITES program. It calls attention to the complex chain of events, leading from services to desired policy outcomes. Program staff, often working in conjunction with other organizations, provide services to clients to address problems that they are facing. These services are intended to lead to specific actions or changes in behavior within the firm. Actions taken by the firm are intended to produce intermediate impacts, including resolution of identified problems and improvements along a number of dimensions. By resolving problems, it is expected that the firm will increase sales, reduce costs, or otherwise generate higher profits. Finally, these favorable business outcomes are expected to lead to desired policy outcomes, e.g., increased employment or business retention.

The following case study serves to illustrate the model as well as provide evidence of the impact of the ITES program.

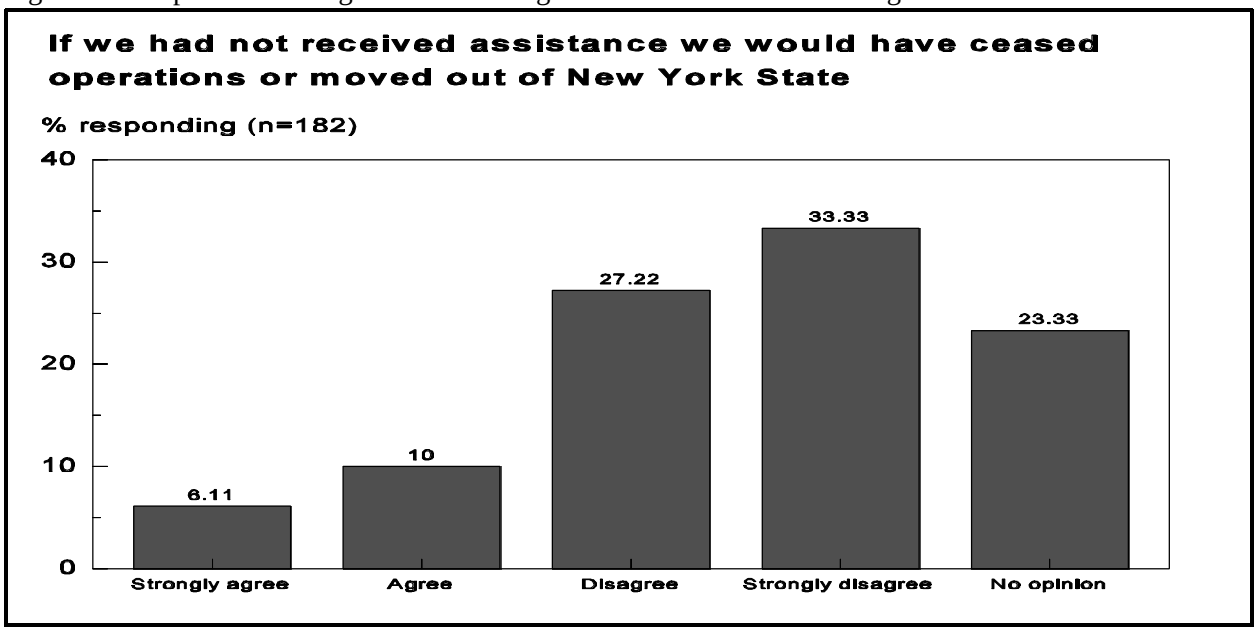
A small manufacturer faced significant problems -- it was becoming harder and harder to turn a profit. A major new competitor had entered the market, wreaking havoc with existing customers. The company was struggling to maintain sales. What is more important, it was losing money on whatever sales it did have. Suppliers were threatening to cut the firm off, banks had accelerated repayment of their outstanding loans, and investors were clamoring for their money. The president of the company had tried to take steps to increase productivity -- he had invested in new equipment that boosted capacity and promised to reduce direct labor requirements. However, increased automation did not yield impressive returns -- in fact, the machine lay idle most of the day as work-in-process inventory was gradually worked off. The trouble was not obsolete equipment, it wasn't the lack of new material; nor, for that matter, was it insufficient sales. The basic problem was that the company had rework rates in excess of 50 percent. It was taking two times through the line to get each unit ready for shipment. This meant that roughly twice as much labor, energy and equipment time were consumed in the production process as was necessary. If the company could get rework in line, it would be able to cut its operating expenses, reduce inventories and free up capacity needed to meet increased sales. As the president put it, "The issue was taking the sales we had, making a good product and making money with what we had."

With assistance provided by field staff of a local manufacturing extension program, the president of the company undertook an extensive analysis of the production system to identify bottlenecks and production problems. The most visible change was getting rid of the scrap, materials and finished goods that littered the aisles between machines. However, the analysis also led to changes in how they wrote up job tickets, implementation of a simple program where each machine operator signed off on the previous operator's work, and redesign of the layout of the plant. Finally, the analysis led to a decision to jettison unprofitable product lines.

The results have been truly impressive. The company has reduced rework to five percent, saving some $400,000 on receipts of just under one million dollars and boosting profits. Direct labor productivity has increased 15 percent -- from $75 per hour to over $86 per hour in real terms. While sales are still below their high of five years ago, they are on the rise. The company is now in a better position to promise a quality product in a shorter period of time and at competitive prices.

Significantly, one of the fallouts of the turnaround has been a decrease in the labor force. The company has found that it can satisfy current demand for its trimmed down product line with fewer, more productive workers -- it now employs four people on the shop floor, down from a high of nine. That being said, however, without the program *all* jobs would have been lost: according to the president of the company, "We would have

Figure 2.3. Impact of the Program in Increasing Awareness of New Technologies and Innovations



closed down the place if we hadn't gotten help."

Using the model in Figure 2.2, direct technical assistance (SERVICES) provided over a number of months led to adoption of new practices on the shop floor (ACTIONS), which reduced rework and lowered costs (INTERMEDIATE IMPACTS). Reduced costs helped restore the company to profitability (BUSINESS OUTCOME) and ultimately ensured the survival of the firm (POLICY OUTCOME). There is a logical flow from the services provided to policy outcomes.

Actions Taken by Client Companies

The ITES program has led firms to take specific actions. Some of these are fairly routine and broad in scope; others deal with very specific investments in narrow areas of concern.

An apparel manufacturer took steps to clean up the plant and establish a more systematic method for tracking and storing inventory. Using a simple labeling system, the company set up better procedures for ensuring that everything was in a proper place in coded racks. This is turn made it easier to find materials needed during production and to plan when orders needed to be placed to replenish stocks. At the same time, the company reduced the number of suppliers and shifted responsibility for ordering raw materials to a different department. The same company established a modular manufacturing unit within the plant to produce a specific item and cross-trained workers so that they were qualified to undertake a number of different operations.

A manufacturer of quartzware for the semiconductor industry initiated a training program in statistical process control (SPC) The course was conducted by faculty from a local community college at the company's plant. It entailed two four-hour sessions per week for six weeks for all of the plant's 15 workers. During class time, the line was shut down. This represents a significant investment by the company: This one training program accounted for 20 percent of the available hours during this period or more than 2 percent on an annualized basis. The company is now beginning to design and implement its own SPC program. They have set up a charting system, and the plant manager is working with supervisors and operators to identify causes for variances. As part of this system, they now put scrap in specific bins and weigh it as a means to measure and track waste.

These companies learned about the potential for changing manufacturing practices through the

Table 2.2
Actions Taken by Clients as a Result of the Program

Did you take any of the following actions as a direct result of the recommendations offered by the ITES agent or assistance provided by the individuals or organizations to which you were referred?	% responding "Yes"
Reconfigured the layout of the plant	25.9
Purchased or developed other new software	25.1
Implemented Total Quality Management (TQM) program	23.6
Purchased other production equipment	18.6
Implemented statistical process control (SPC)	13.1
Implemented materials resource planning (MRP or MRP II)	12.0
Purchased computer-aided design (CAD) system	8.2
Purchased computer numerical control (CNC) machines	5.5
Implemented computer-aided manufacturing (CAM) system	5.0
Purchased industrial robots	0.6

ITES program. The survey suggests that they are not alone. Figure 2.3 shows that 56 percent of respondents agreed with the statement that the assistance they received increased their awareness of new technologies and other innovations. If respondents with no opinion are excluded, the percentage rises to approximately 72 percent.

As in the examples noted above, increased awareness often leads to specific actions within the firm involving investments in various technologies and / or changes in manufacturing practices. For example, as shown in Table 2.2, one in four survey respondents indicated that they had modified plant layout, implemented a total quality management (TQM) program and / or purchased or developed new software as a "direct result" of the recommendations offered by the ITES agent, or assistance provided by individuals or organizations to which they were referred.

Less than six percent of companies responding to the survey reported purchases of computer numerical control (CNC) machine tools. This relatively low percentage should not be surprising. Although a tremendous amount has been written about the benefits of such technology, these types of tools are not always superior to conventional machine tools, particularly if the plant has already been reorganized to reduce moves and / or if the product being manufactured is a custom item. For example, one of the companies visited as part of this study had undertaken numerous changes on the shop floor, but continued to use non-programmable machine tools in their mold building operations. The president of the company explained that it made little sense to use CNC tools, given the specialized nature of each die. Their operations were based on custom tooling for limited runs; as a result, there was no need for CNC.

While a company may have attributed taking an action as a direct result of services received, a number of factors might have influenced the reported outcome. Some of these relate to the type and intensity of service received under the auspices of the ITES program, others to the characteristics of the firm. A maximum-likelihood logit model is used to estimate the probability of a firm taking specific actions as a result of the services received under the

auspices of the ITES program.[9] The model is used to estimate the Pr(*action*=1)=$F(B_iX_i)$, where F( ) is the cumulative logistic distribution and X_i is the vector of explanatory variables. These variables include:

- CONTACTS is defined as the combined total of meetings and telephone calls that a field agent had with a company as reported in the client survey. It is expected, *a priori*, that the probability of a client taking a specific action will increase, given greater interactions with an agent.
- CONTACTS*DIRECT is defined as the interaction between CONTACTS and DIRECT -- a dichotomous variable that takes on the value one if the client reported receiving direct assistance in the client survey, and zero, otherwise. As pointed out in the preceding section, field agents offer a variety of services. One of the principal differentiating features of these services is the extent to which field agents provide direct assistance to clients in terms of diagnosing problems, providing hand-on engineering assistance, and / or offering advice based on their own expertise and experience. CONTACTS*DIRECT represents the additional effects of contacts with an agent, given that the agent provided direct assistance.[10]
- EMPLOY is defined as the average number of employees at the client's plant between July 1990 and March 1993. Data on client firms were provided by the NYS Department of Labor based on ES-202 files. As noted above, there have been a number of studies that indicate that the size of a firm has a bearing on whether certain technologies are adopted, i.e., larger firms are more likely to adopt technologies than smaller firms.
- PUBLIC is defined as one if the company is publicly held, and zero, otherwise. It is intended as a proxy for a number of firm characteristics, including size and access to capital markets. As pointed out above, previous studies have suggested that the form of ownership is related to management capabilities and firm performance.
- MULTI is defined as one if the company has more than one plant, and zero, otherwise. It is used as another measure of the size of the company, and as a proxy for the opportunity for assistance to be provided to the ITES client by other plants owned by the parent firm. The correlation between publicly held and multiple-plants is positive, but not strong, for the sample of survey respondents (i.e., 0.21).
- INDUSTRY represents a series of eleven dummy variables for different types of industries. Industry groups were created, based on primary SIC codes of the plant, as reported in ES-202 files.[11] The degree of capital intensity, minimum efficient scale, and the types of production processes employed vary by industry. For example, while CAD tools might be used by companies in metal working industries, they are irrelevant to firms engaged in chemical processing. As such, it is important to control for fixed industry effects.

Table 2.3 shows that the number of contacts is positively related to the probability of undertaking all the actions, except for adopting computer-aided design (CAD) tools. That the number of contacts has a bearing on the probability of companies taking

[9]More precisely, the model attempts to explain the probability of a company taking an action that survey respondents have attributed to the program. A company could have taken the action, but not attributed it to the services received.

[10]DIRECT is not included as a separate variable in the model. Direct assistance only occurs through contacts with companies. It is not possible for a company to receive direct assistance without having contacts with a field agent.

[11]The groups are presented in Appendix A.

Table 2.3
Influence of Factors on Probability of Clients Taking Specific Actions: Logit Results

	Changed plant layout	Installed production equipment	Adopted CAD	Adopted MRP	Adopted SPC	Adopted TQM	Adopted software
CONTACTS	0.087 * (0.031)	0.096 * (0.033)	0.012 (0.047)	0.089 * (0.034)	0.123 * (0.040)	0.167 * (0.057)	0.032 * (0.017)
CONTACTS * DIRECT	0.032 (0.030)	-0.033 (0.027)	-0.001 (0.041)	-0.061 * (0.030)	-0.055 * (0.031)	0.066 (0.047)	-0.006 (0.020)
EMPLOYEES	0.000 (0.001)	-0.016 * (0.008)	-0.000 (0.002)	0.000 (0.002)	0.010 * (0.005)	0.007 (0.005)	-0.000 (0.000)
PUBLIC [a]	-0.074 (1.113)	-0.470 (2.152)	Dropped	-5.005 (4.403)	-12.492 * (5.525)	Dropped	-1.355 (1.086)
MULTI	0.568 (0.798)	1.3 (0.957)	-0.509 (1.252)	-0.595 (1.320)	0.857 (0.984)	-0.369 (1.070)	-0.849 (0.785)
INDUSTRY [b]	Included	Included	Included	Included	Included	Included	Included
INTERCEPT	-2.700 * (0.749)	-1.992 * (0.708)	-1.714 * (0.780)	-2.916 * (0.892)	-4.505 * (1.268)	-5.380 * (1.464)	-0.375 (0.536)
log-likelihood	-39.303	-32.514	-26.606	-27.218	-22.452	-21.968	-53.183
chi^2 (d.f.)	40.44 (14)	31.68 (12)	3.58 (8)	18.62 (11)	25.15 (9)	42.25 (10)	15.1 (15)
Number of observations	98	88	68	86	70	67	99

Source: Estimates based on equation in text. Standard errors are shown in parentheses
* signifies that the coefficient is statistically different from 0 at the 10 percent level.
[a]In two instance -- adopting CAD and adopting TQM -- all publicly-held companies report taking the specified action. Because of the estimation problems that this poses, the variable PUBLIC is dropped in these two models. The 13 observations that led to the problem are excluded as well so as not to bias the remaining coefficients in the models.
[b]All models include separate dummy variables for industries. In some instances, however, certain industry dummies predict actions perfectly. For example, in the case of group 2 -- textiles and apparel -- none of the three companies included in the sample undertook any of the actions. The dummy industry variables and associated observations are excluded.

Table 2.4
Number of contacts needed to induce 50 percent of companies to take actions

Action	Median dose [a] (number of contacts)
Reconfigure plant layout	31
Adopt new software	12
Implement TQM	32
Install new production equipment	21
Adopt SPC	37
Adopt MRP or MRP II	33

Source: Author's calculations based on estimates in previous table.
[a]The median dose is defined in terms of coefficients as: -INTERCEPT / CONTACTS, holding all other variables constant.

specific actions adds credibility to claims of attribution reported in the survey.

It is helpful to interpret the coefficients in terms of an odds ratio defined as $\exp(B_i)$**.**

For example, holding other factors constant, each additional contact with a field agent increases the odds of a company changing the layout of the plant as a result of the program by nine percent and adopting TQM by 18 percent. Furthermore, direct assistance improves the odds of a company adopting TQM, i.e., each contact with a field agent increases the probability of a company taking this action by 26 percent. However, it appears that direct assistance reduces the probability of companies' adopting MRP and SPC. This finding is difficult to explain and may be the result of the model specification.

Of particular interest is the value of contacts when the probability of an action is equal to 50 percent, i.e., the number of contacts required to produce a response in 50 percent of the companies. Table 2.4 presents what is called the *median dose* for each of the specified actions for which the contacts variable is significant. The number of required contacts ranges from 12, for the adoption of new software, to 37 for the implementation of statistical process control (SPC). The relatively low figure for software makes intuitive sense, given the availability of packaged software and after sales technical support provided by vendors. With respect to TQM, the median dose is reduced to 23 contacts if field agents provide direct technical assistance. These numbers are significantly more than the typical number of contacts that actually take place between field agents and companies, suggesting that greater interaction is required to affect the majority of companies participating in the ITES program.[12]

Intermediate impacts

Changes in behavior, or specific actions taken by companies, are intended to improve performance along a number of dimensions. The story told at the beginning of this chapter detailed benefits to a particular firm resulting from various changes that it made to its operations. Discussions with other program participants revealed similar benefits, although not necessarily of the same order of

[12]The median number of contacts is 13; the 90th percentile is 34.

Table 2.5
Intermediate Impacts Resulting From Program Participation

Intermediate Impacts	% applicable	Average benefits [a]
Reductions in scrap / rework rates	50.0	3.4
Reductions in inventory	49.0	3.6
Reductions in manufacturing lead time	49.0	3.7
Reductions in direct labor costs per unit	53.0	3.4
Reductions in materials costs per unit	46.0	2.6
Reductions in energy costs per unit	41.0	2.4
Reductions in indirect labor costs per unit	50.0	3.0
Reductions in other overhead costs per unit	49.0	2.8

Source: Author's calculations based on results of survey of ITES clients. There were 175 observations.
[a]On a seven-point scale, ranging from 1 "no benefits" to 7 "very beneficial"

magnitude.

Consider the following:

As a result of various actions related to workplace organization. the apparel company described earlier has been able to reduce inventories by 15 percent, trim dead stock by 60 percent and reduce stock outs by 50 percent. Moreover, changes in procurement have led to significant reductions in the cost of materials.

While the quartz ware company is still in the process of establishing better quality procedures, it has already seen some tangible benefits. For example, according to the plant manager, scrap rates have been reduced from 30 percent to 25 percent as a result of a better tracking system and more attention being paid to waste. Charting under SPC pointed out a number of specific production problems, leading to remedial actions.

Benefits such as reduced scrap, reduced inventory, and reduced manufacturing lead times are expressed in terms of physical parameters. They can also be expressed in financial terms.[13] These benefits can be thought of as intermediate impacts resulting from the actions taken by companies in response to service received.

As pointed out above, assistance rendered through the ITES program is intended to address a variety of issues within firms. Each interaction may have a different intended outcome. Table reports the percentage of companies indicating that a specific objective was indeed an aim of their involvement in the ITES program. It also presents the mean rating of benefits on a scale of 1 "no benefits" to 7 "very beneficial" for those companies where the objective was applicable.

[13]However, it is not always obvious which components of the product costs will be affected by improvements along physical dimensions. For example, reductions in scrap rates may result in higher material costs per unit of production depending on the cause of problem and the particular solution. If high scrap rates were the result of the use of inferior materials and the solution were to substitute a higher, more costly material, it is conceivable that material costs per unit of production would rise.

While a number of clients reported significant benefits, the average was generally low. Overall, in no instance was the mean greater than four, i.e., the midpoint in the range. On average, clients reported achieving the greatest benefits in terms of reductions in direct labor costs per unit of production. This suggests that services tend to focus and be more successful on measures that enhance labor productivity.

The ability of a company to achieve a certain level of benefits depends upon individual characteristics of the firm, the nature of services received through the program, and the specific behavior changes and actions taken as a result of program participation. Given the use of an ordinal scale, a maximum-likelihood ordered logit model is used to estimate the relationship between benefits reported by companies, actions taken as a results of services received, and firm characteristics. Only the companies indicating that the intermediate impact was an objective of their participation in the program are included in the analysis.

As before, the model includes the number of contacts with field agents, a variable representing the interactions between contacts and direct assistance, and the number of employees.[14] Contacts and direct assistance are included in the model because the type and intensity of services provided by the ITES field agent may have a bearing on the level of benefits accruing to clients. More contacts with a field agent may yield a greater probability of effecting changes within the plant; more contacts may also produce greater benefits, given that certain actions are indeed taken. In addition, the model includes a series of dichotomous variables for the actions specified above.

Tables 2.6 and 2.7 present the results of the analysis.[15] In all cases, the null hypothesis that all of the coefficients, except the intercept, equal zero can be rejected. The coefficient on CONTACTS is positive and significant for reductions in manufacturing lead time and energy costs. CONTACT*DIRECT is also generally positive and highly significant with respect to energy costs.

For the most part, the signs of statistically significant coefficients are positive as expected. For example, Total Quality Management (TQM) is oriented, in part, toward continuous improvement in production processes. One indicator of improvement is a reduction in scrap and rework rates. The analysis demonstrates that clients adopting TQM as a result of participation in the program tend to report greater benefits with respect to reductions in scrap and rework.

Similarly, results demonstrate that companies adopting MRP as a result of services received tend to report greater benefits from inventory reductions. Materials resource planning (MRP) systems provide schedules, manage inventories, and support procurement. MRP systems generate a list of the amount of materials required and the date when they need to be delivered to maintain manufacturing schedules. As such, the adoption of MRP should be associated with inventory reductions.

The results of the analysis also suggest that adoption of CAD leads to reductions in material costs per unit of production. Computer-aided design (CAD) can be used either as a stand-alone tool for designing products, or in an integrated fashion with shop floor production (CAD/CAM). CAD systems provide a means for designers to develop and evaluate several potential designs before production. As part of this process, CAD can be used as a basis for selecting materials offering

[14]The number of employees also provides a means to scale reported benefits. For example, respondents may be reporting benefits of scrap reductions in terms of a decrease in the volume of scrapped parts, rather than a decrease in the scrap rate. Larger firms may have larger volumes of scrap. Including EMPLOY helps to address this problem.

[15]To simply the presentation, cut points are not presented in the table since we are more interested in the sign and magnitude of the coefficients than estimating a particular value of benefits. Cut points are, however, available from the author.

Table 2.6
Influence of Factors on Intermediate Impacts: Ordered Logit Results

Explanatory variable	Scrap /rework rate	Inventory	Manufacturing lead time
CONTACTS	0.0221 (0.0162)	0.0322 (0.0230)	0.0364 * (0.0209)
CONTACTS*DIRECT	-0.1420 (0.8214)	0.6010 (0.8279)	1.2010 (0.8639)
PLANT LAYOUT	-0.1178 (0.9368)	1.4618 (1.0858)	4.2341 * (1.1939)
CNC	0.5985 (1.1847)	1.7458 (1.2217)	2.9563 * (1.4936)
EQUIPMENT	2.3167 * (0.8846)	0.8374 (0.8454)	-1.3258 (1.0456)
CAD	0.1708 (0.9329)	0.7180 (0.9485)	-1.3851 (1.2280)
MRP	1.0987 (1.0725)	2.6740 * (1.2141)	-0.3633 (1.1860)
SPC	-0.7951 (1.2514)	-0.5298 (1.3311)	2.8078 * (1.2387)
TQM	2.4839 * (0.9273)	1.1208 (0.8850)	-0.1525 (0.8873)
SOFTWARE	-0.1542 (0.7230)	0.3996 (0.8239)	1.5402 * (0.7986)
EMPLOY	0.0030 (0.0028)	0.0061 * (0.0023)	0.0069 * (0.0028)
INDUSTRY [a]	Included	Included	Included
Log Likelihood	-74.11	-69.80	-57.80
Chi2 (d.f.)	34.50 (21)	49.45 (21)	61.78 (21)
Number of observations	51	52	49

Source: Estimates based on equation in text. Standard errors are shown in parentheses
*signifies that the coefficient is statistically different than 0 at the 10 percent level.
[a]All models include 10 dummy variables for industry groups.

Table 2.7
Influence of Factors on Intermediate Impacts: Ordered Logit Results

Explanatory variables	Direct labor costs	Materials costs	Energy costs	Indirect labor costs	Overhead costs
CONTACTS	0.0364 (0.0317)	0.0157 (0.0212)	0.0638 * (0.0343)	0.0227 (0.0202)	0.0250 (0.0192)
CONTACTS*DIRECT	1.2094 (0.7943)	0.2937 (0.9741)	4.7847 * (1.7331)	1.1087 (0.9012)	0.4493 (0.9014)
PLANT LAYOUT	0.7668 (0.8984)	-1.4390 (1.1701)	-1.2032 (1.6723)	-0.5157 (1.0803)	-2.0455 * (1.2053)
CNC	0.0819 (1.5467)	1.6306 (1.8907)	-1.0964 (1.8358)	0.7544 (1.7649)	0.3475 (2.0846)
EQUIPMENT	0.6718 (0.8966)	3.3341 * (1.2821)	1.9001 (1.5205)	1.8495 (1.2490)	4.9496 * (1.5688)
CAD	0.2169 (0.9278)	2.4812 * (1.1188)	-1.5167 (1.6645)	0.1078 (1.1883)	2.6379 * (1.1429)
MRP	-1.2690 (1.1209)	0.8625 (1.1792)	-0.4622 (1.7760)	0.7800 (1.2575)	0.1001 (1.2597)
SPC	1.9838 (1.2582)	0.2753 (1.2046)	4.2771 * (1.9402)	2.2305 (1.3863)	0.9403 (1.4092)
TQM	1.0669 (0.9666)	1.2869 (1.0030)	-2.0455 (1.4724)	0.8496 (1.0262)	1.3103 (1.0406)
SOFTWARE	0.3767 (0.7046)	-2.0690 * (0.9655)	0.4998 (1.4293)	-0.4830 (0.8949)	-0.1822 (1.0634)
EMPLOY	0.0027 (0.0024)	0.0041 (0.0029)	0.0055 (0.0045)	0.0020 (0.0022)	0.0071 * (0.0028)
INDUSTRY [a]	Included	Included	Included	Included	Included
Log Likelihood	-73.33	-57.72	-38.91	-56.27	-46.08
Chi2 (d.f.)	45.71 (20)	43.13 (21)	37.73 (20)	51.92 (21)	57.19 (21)
No. of observations	54	51	41	49	50

Source: Estimates based on equation in text. Standard errors are shown in parentheses
* signifies that the coefficient is statistically different than 0 at the 10 percent level.
[a]All models include 10 dummy variables for industry groups.

the best performance relative to costs. This is consistent with the results presented.

There seem to be a number of paths leading to reductions in manufacturing lead times, i.e., the calendar days between the start and end of production, revealing the complexity of achieving this desired outcome. Improving plant layout to facilitate work flow, using CNC tools, adopting SPC, and employing various management and production software, all appear to affect a company's ability to reduce manufacturing lead times.

It should be pointed out that the signs of some coefficients are negative, suggesting that certain actions reduce the level of benefits, other factors held constant. In all but two cases, these results are statistically insignificant. However, the results suggest that the adoption of software reduces benefits with respect to material cost reductions. Similarly, changing the layout of the plant leads to reductions in the benefits with respect to lower overhead costs. While it is possible to construct stories that are consistent with these results, definitive findings await larger samples and more extensive analysis.

Business outcomes

ITES has not collected data on baseline costs or revenues of companies participating in the program. As a result, an attempt was made to obtain relevant data from clients through the survey. Interviews and written comments on the returned questionnaires suggest that it is very difficult for most companies to estimate impacts in dollar terms. The link between services and benefits in some of the examples cited above is fairly clear. However, it is often difficult to establish a sequence of events that links services received to explicit changes in operations and subsequent performance. Assistance is often broad in scope, affecting many variables within a complex production environment. Under these circumstances, it is hard to isolate the impact of specific actions with respect to costs.

Sixty-five companies responded to survey questions on the dollar amount of cost reductions.[16] The reported annual savings resulting from the ITES program for these companies totaled $4.1 million. The distribution is highly skewed. A few companies reported very significant savings; the majority reported little or none. Reported annual savings ranged from zero to $1 million, with a mean of $63,000 (standard deviation: $147,000) and a median value of $8,000.

The significance of these savings to individual companies is unknown. Data on gross or net profit margins are unavailable. Without such data it is impossible to state whether or not reported savings are likely to have a material impact on firms. For example, if a company had a net profit margin of 5% on sales of $1 million, savings of $63,000 (the mean value) would effectively more than double the company's margins. In contrast, the same savings for a $10 million company would have the effect of increasing the net profit margin to 6%. From another perspective, savings could represent the difference between continued losses and profits. If a company were losing $60,000 per year, savings of $61,000 would restore the company to accounting profitability.

One objective of the evaluation is to demonstrate that the program actually contributed to cost savings and to identify causal factors. Of particular interest is the relationship between reported annual cost savings and the number and nature of contacts between field agents and clients. The analysis is based on the following equation:

$$SAVINGS = B_0 + B_1 CONTACTS + B_2(CONTACTS * DIRECT) + B_3 IEP + B_i INDUSTRY_i$$

The variables included in the model are defined as follows:

[16] It should also be noted that many of the non-respondents on this question reported little or no impact in qualitative terms. Although questions concerning profitability were included in the survey, too few companies provided such data to be useful.

- SAVINGS is equal to annual cost savings per employee. Cost savings are presented in terms of thousands of dollars per employee.
- CONTACT and DIRECT are defined as above. The model assumes that the relationship between cost savings and contacts is linear.[17]
- IEP is a dichotomous variable indicating whether companies received a grant under the Industrial Effectiveness Program (IEP) to retain an independent consultant. Because of the central role of IEP and the inability of many companies to disentangle its impact from that of other forms of assistance, participation in IEP needs to be taken into account in the analysis of cost savings. As noted in the previous chapter, consultants generally focus on shop floor issues.
- INDUSTRY represents a series of dummy variables for different types of industries, as defined above.

While 65 companies provided data on annual cost savings, 19 observations had to be excluded due to missing employment data. Summary statistics for the 46 remaining observations are presented in Table 2.8.

SAVINGS is skewed left, with a significant percentage of respondents reporting zero savings and a few respondents reporting substantial cost savings as a result of the program.[18] The median is a better measure of the central tendency of the distribution than the mean. As such, a technique known as median regression is used in the analysis. Median regression is similar to ordinary least squares (OLS) regression; however, rather than finding a line that minimizes the sum of the squares of residuals as in OLS, median regression minimizes the sum of the absolute residuals.

The results of the regression are presented in Table 2.9. The coefficient on CONTACTS, while statistically significant, is approximately zero. This suggests that there are essentially no cost savings in instances where the agent did not provide direct assistance. However, if the agent provided direct assistance, each additional contact is worth annual savings of approximately $26 per employee. The coefficient on IEP represents the median cost savings per employee resulting directly from the typical IEP project, all other things being equal. While the coefficients on each of the terms of interest are statistically significant, 76.4 percent of the variance in reported annual cost savings per employee remains unexplained.

Based on these results, the total annual cost savings for the 1300 companies that participated in the program between July 1990 and March 1993 is on the order of $30 million. This figure was arrived at in the following manner. Annual cost savings per employee, as predicted by the model presented above, were multiplied by the actual number of employees within each firm to estimate the annual cost savings for each of the 46 companies included in the analysis. These companies were subsequently divided into four "treatment" groups -- direct assistance and an IEP, direct assistance and no IEP, no direct assistance and an IEP, no direct assistance and no IEP. As shown in Table 2.10, the median cost savings within each treatment group was then multiplied by the total number of companies receiving the specified treatment. Because these

[17]The assumption of a linear relationship may be too restrictive. Cost savings may be subject to diminishing marginal returns with respect to effort expended. For example, in response to a question asking on whether further savings were possible, the president of one company responded, "Let me put it this way. In the first year, we knocked off all of the big barnacles, now we're hand sanding the hull. Its a lot harder now to reap additional savings."

[18]The 25th percentile of cost savings per employee is 0, 50th percentile is $186 per employee, 95th percentile is $3333 per employee and the 99th percentile is $7812 per employee).

Table 2.8
Summary Statistics for Observations Included in Analysis of Reported Cost Savings

SAVINGS ($1000/employee)	
Mean	0.806
Std. deviation	1.654
Median	0.186
CONTACTS	
Mean	18.3
Std. deviation	18.6
Median	15.0
% receiving direct assistance	50.0
% receiving IEP	58.7

Source: Author's calculations based on results of survey of ITES clients and employment data obtained from the NYS Department of Labor (ES-202 files). There were 46 observations.

Table 2.9
Relationship of ITES Services to Reported Annual Cost Savings per Employee ($000): Median Regression Results

	Coefficient
CONTACTS	-0.0007 * (0.0002)
CONTACTS * DIRECT	0.0258 * (.0005)
IEP	0.4409 * (0.0130)
INDUSTRY [a]	Included
INTERCEPT	0.0029 (0.0150)
Raw sum of deviations = 36.42 (about 0.163) Pseudo R-square = 0.236 [b]	

Source: Estimates based on equation in text. Standard errors are shown in parentheses
*signifies that the coefficient is statistically different than 0 at the 10 percent level. There were 46 observations.
[a]All models include 10 dummy variables for industry groups.
[b]The pseudo R^2 is defined as:
1- (sum of deviations about estimated quantile - sum of deviations about raw quantile)

Table 2.10
Estimated Total Annual Cost Savings

Treatment	Number of clients receiving treatment	Median cost savings per company	Total annual cost savings
Direct assistance and an IEP	129.0	75000.0	9675000.0
Direct assistance and no IEP	360.0	35770.0	12877200.0
No direct assistance and an IEP	154.0	47850.0	7368900.0
No direct assistance and no IEP	631.0	0.0	0.0
All treatments	1274.0	23485.0	29921100.0

Source: Author's calculations based on results of model presented in previous table, client survey and analysis of monthly reports.

Table 2.11
Sales and Revenue Benefits Resulting From Program Participation

Business outcome	% applicable [a]	Average benefits [b]
Expansion in customer base	41.0	3.0
Increase in units shipped	45.0	2.9
Increase in sales revenue	47.0	2.8

Source: Author's calculations based on results of survey of ITES clients. There were 175 observations.
[a]Percentage of companies responding that the outcome was an objective of the ITES services
[b]On a seven-point scale from 1 "no benefits" to 7 "very beneficial"

savings are annual, they could be expected to continue for a number of years as companies enjoy the benefit of changes in their cost structure. For example, assuming that cost savings last five years, with a discount rate of eight percent, the net present value of benefits over the entire period would be $200 million.[19]

Beyond quantifying the impact of the ITES program on cost reductions, the survey also sought information on the extent to which clients increased sales and revenues as a result of participation in the program. Table 2.11 presents the percentage of companies indicating that increased sales or revenues was an objective of their involvement in the ITES program. For each business outcome, it also presents the mean rating of benefits received on a scale of 1 "no benefits" to 7 "very beneficial" for those companies where the objective was applicable. The average benefits with respect to sales and revenue tend to be lower than the benefits reported for cost savings.

Using the same approach as described above -- maximum likelihood ordered logit -- an attempt was also made to determine the relationship between reported benefits, firm characteristics, and services received. The analysis showed no significant relationship between reported scores for benefits and any of the explanatory variables.

Sixty-two companies provided information on increases in annual revenues resulting from the participation in the program. Together, these companies reported that annual revenues increased by a total of $3.9 million. Again, the distribution is highly skewed. The range varied from zero to $1 million, with a mean of $63,000 (standard deviation: $205,000) and a median value of zero. Various approaches were used in an attempt to assess the impact of different program components on annual revenue increases. None showed any statistically significant relationships. As such, no attempt was made to estimate the total gross impact of the program in terms of increased revenues.

While the impact of the program on sales is murky, the majority of companies responding to the survey indicated that their ability to compete was improved as a result of participation in the ITES program (Figure2.4). If companies offering no opinion are excluded, the figure increases to over 70 percent.

Policy Outcomes

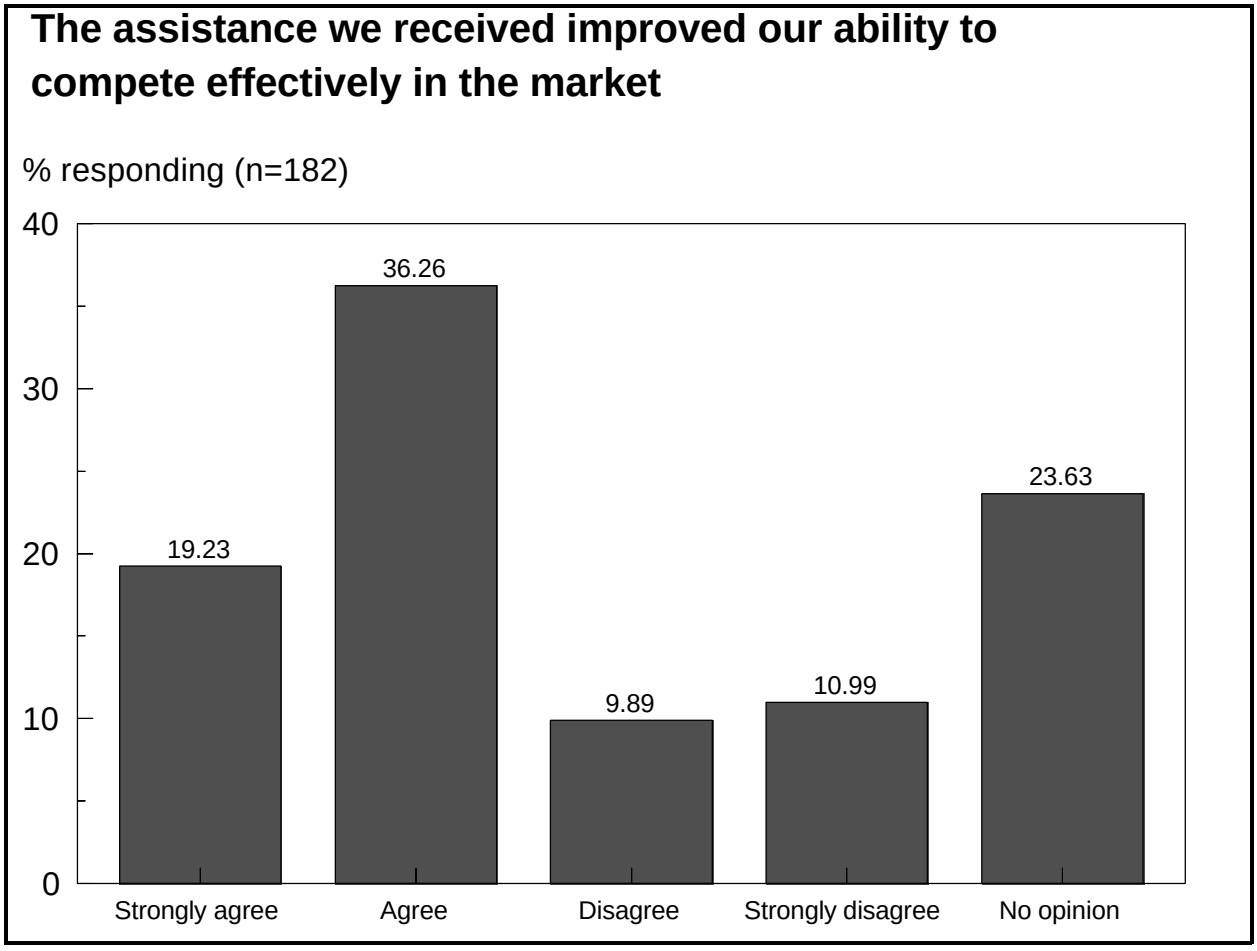
The enabling legislation poses two questions: Has participation in the ITES program resulted in increased employment? Has participation in the ITES program increased the likelihood of companies continuing to operate in New York?[20] As noted above, one of the central issues in evaluation revolves around the need to provide evidence that the same result would not have occurred in the absence of the program. The most plausible way to demonstrate the net impact of the program is through the use of a control or comparison group. To this end, the performance of companies that participated actively in the ITES program was compared to that of companies that were visited by ITES agents, but did not receive any other services. "Active" clients are those that received technical assists, referrals, or participated in projects, including those supported through the IEP, as stated in monthly reports. "Non-active" clients are companies that only received an initial site visit.

The effect of the ITES program on employment within participating companies was tested, controlling for prior employment changes, size of the firm, and regional and industry effects.

[19]These estimates should be treated with caution. It assumes that survey respondents are representative of the entire clientele. However, as noted above, survey results may be biased by non-response.

[20]The lack of available data made it impossible to examine the net impact of the program on productivity -- another objective delineated in the legislation. This is an important measure and should be addressed in future evaluations. It requires information on value-added per labor hour within participating and non-participating companies.

Figure 2.4 Impact of the Program on Competitiveness



The analysis is based on the following model:

$$RELEMP_{post}=B_0+B_1MONTHS+B_2RELEMP_{pre}+B_3EMPLOY$$

- $RELEMP_{post}$ is defined as the percentage change in employment between the first and last quarters of 1992 at the company's plant relative to the average for all plants in the same industry and region.[21] The use of relative changes in employment controls for industry and regional effects.
- MONTHS is a measure of participation in the ITES program. It is equal to the number of months in which activity was reported for the company in 1992 by field agents. If a company did not participate at all during 1992, MONTHS equals 0. The use of a continuous variable, rather than a dichotomous variable, allows the incremental impact of continued participation in the program to be estimated. It also represents an attempt to deal with the complication arising from the

[21]This is not strictly a "post-treatment" measure. Companies do not receive a specified "treatment" during a specified period of time. There is no finish date to the ITES program; in a sense, companies can continue to participate indefinitely.

absence of a "post" treatment measure.

- $RELEMP_{pre}$ is defined as the relative percentage change in employment between the first and last quarters of 1991, prior to the companies' participation in the program.
- EMPLOY is the number of employees at the companies' plant in the first quarter of 1992. The variable serves to control for the effects of firm size.

For comparison purposes, the analysis focused on ITES clients that were first contacted during or after January 1992; this allowed inclusion of data from the period preceding participation in the program.

Table 2.12 presents summary statistics for the two groups of firms. In the period following participation in the ITES program, mean employment among active clients increased 0.8 percent more than the mean for all establishment in their respective industries and regions. During the same period, mean employment among non-active clients increased 5.3 percent more than the mean for all establishment in their respective industries and regions. The relative growth in employment in 1991 was 5.5 percent and 6.9 percent for active clients and non-active clients, respectively. This difference is not statistically significant at the 10 percent level. Active companies are slightly larger than non-active firms.

The results of the analysis are presented in Table 2.13. Overall, they suggest that participation in the program has resulted in lower labor requirements. While average employment increased by 2.5 percent in 1992, the typical ITES client added 5.7 percent (-0.031 per month of participation x 1.84 months -- the mean number of months of participation) fewer workers than similar, non-participating companies. The impact of other variables is insignificant.

Reduced labor requirements are consistent with the observation that the program has tended to focus on cost reduction, particularly with respect to reducing direct and indirect labor costs per unit of production. Many of the actions taken by companies as a result of participation in the program were productivity-enhancing. Moreover, the case studies suggest that companies find they can produce the same level of output at higher quality with fewer workers. Assuming inelastic demand in the short-run, increased labor productivity may result in lower employment.[22] Over the longer-term, gains in labor productivity might lead to lower relative prices, increased demand for companies' products, and increased labor requirements.

There remains a possibility that results are due to selection bias. Companies choosing to participate actively in the program may differ significantly from those that decide not to participate. Participation in the ITES programs is voluntary, and the program does not have strict eligibility requirements. The reasons underlying a company's decision to participate actively in the program are likely to be associated with factors leading to changes in employment. While the model includes prior employment changes as an explanatory variable, the problem of selection bias is not fully resolved. One solution to this problem is to use instrumental or identifying variables in the analysis. Such variables need to satisfy two conditions: they need to affect the probability that a company participates actively in the ITES program, but have no direct relationship with changes in employment.

The possibility of selection bias was examined using the following model with the same sample of firms as above:

$$\Pr(ACTIVE=1)=B_0+B_1 DISTANCE+B_2 RELEMP_{pre}+B_3 EMPLOY$$

The dependent and explanatory variables are defined as follows:

[22] Studies have demonstrated short-run price elasticities of less than one (Houthakker, 1970.)

Table 2.12

Summary Statistics for Employment Model

Explanatory variables	Active clients	Non-active clients
$RELEMP_{post}$	0.008	0.053
MONTHS	1.840	0.000
$RELEMP_{pre}$	0.055	0.069
EMPLOY	128.991	116.052

Source: Author's calculations based on data from field agent reports and the NYS Dept. of Labor.
There were 210 observations for active clients and 125 observations for non-active clients.

Table 2.13

Results of Regression on Relative Percent Change in Employment: OLS results

Explanatory variables	Coefficient
MONTHS	-0.031 * (0.013)
$RELEMP_{pre}$	-0.001 (0.034)
EMPLOY	-0.000 (0.000)
Intercept	0.067 (0.026)
R^2 = 0.017 F(3,331) = 1.89 n = 335n = 335 R^2 = 0.017 F (3, 331) = 1.89	

Source: Estimates based on equation in text. Standard errors are shown in parentheses;
*signifies that the coefficient is statistically different from 0 at the 10 percent level.

- ACTIVE is a dichotomous variable defined as 1 if the client was active during 1992, and 0 otherwise. A client is considered to be active if it received technical assists, referrals, or participated in projects, including those supported through the IEP.

- DISTANCE is the number of miles between the field agent's office and the client's plant. Specifically, it represents the straight line distance between the centroid of the respective zip code areas. Discussions with field agents suggested that they were more likely to work with companies if they were close to their offices.

- $RELEMP_{pre}$ and EMPLOY are as defined above.

The results of the analysis are presented in Table 2.14. The null hypotheses that all of the independent variables are equal to zero cannot be rejected. Moreover, none of the coefficients are statistically significant. While results suggest that selection bias may not be a major factor, there could be other unobserved differences between active and non-active clients that influence participation and, by extension, relative changes in employment. The issue of selection bias should be explored in more depth in future evaluations.

The legislation also states that one of the aims of ITES is to retain manufacturing firms in New York State. One of the companies visited during the study illustrates how the program can favorably influence the location of manufacturing operations.

The quartzware company mentioned previously was founded in New York in 1967. About fifteen years ago, the owner decided to establish a new production facility in Arizona. The decision to establish operations in Arizona was motivated by a desire to be near customers, reduce costs of operations, and quality of life considerations. While the New York plant continued to operate, it "just sat there" for more than ten years, with little investment in new equipment or training. In 1992, the company was faced with a serious drop in sales. One of the company's major customers unexpectedly canceled a large purchase order; the customer had previously accounted for about 50% of the company's total business. The loss "killed both plants." Lower sales volume could not justify maintaining two plants. Besides the financial situation, customers were calling for higher quality standards. They wanted to see procedures in place to maintain production within tight limits. This included SPC, but also extended to skills certification programs. Customer requirements were also driving the company to consolidate operations. Said the plant manager, "It's easier to get one plant the way a customer wants it." As such, the company is interested in integrating operations into one single plant . The owner has been generally inclined toward closing operations in New York . He felt that the cost of doing business in New York was relatively high in comparison to the other site. However, given the improvements in the New York plant brought about by participation in the ITES program, the company is beginning to shift production to New York. While the final decision has not yet been made, the plant manager in New York stated, "without the assistance, we would have folded up and left a long time ago."

This statement is not unique. Approximately 16 percent of companies responding to the survey indicated that they would have ceased operations or moved out of New York State if they had not received assistance through the ITES program (Figure 2.5). An attempt was made to model the probability of survival using various analytical techniques. However, data limitations proved to be a problem -- only one company in the cohort of active and non-active clients used in the analysis presented above went out of business during 1992.[23] As such, the issue of whether the ITES program has increased the survival rate among manufacturers is still an open question.

[23]Cohort data for manufacturers in the State was unavailable from the NYS Department of Labor.

Table 2.14

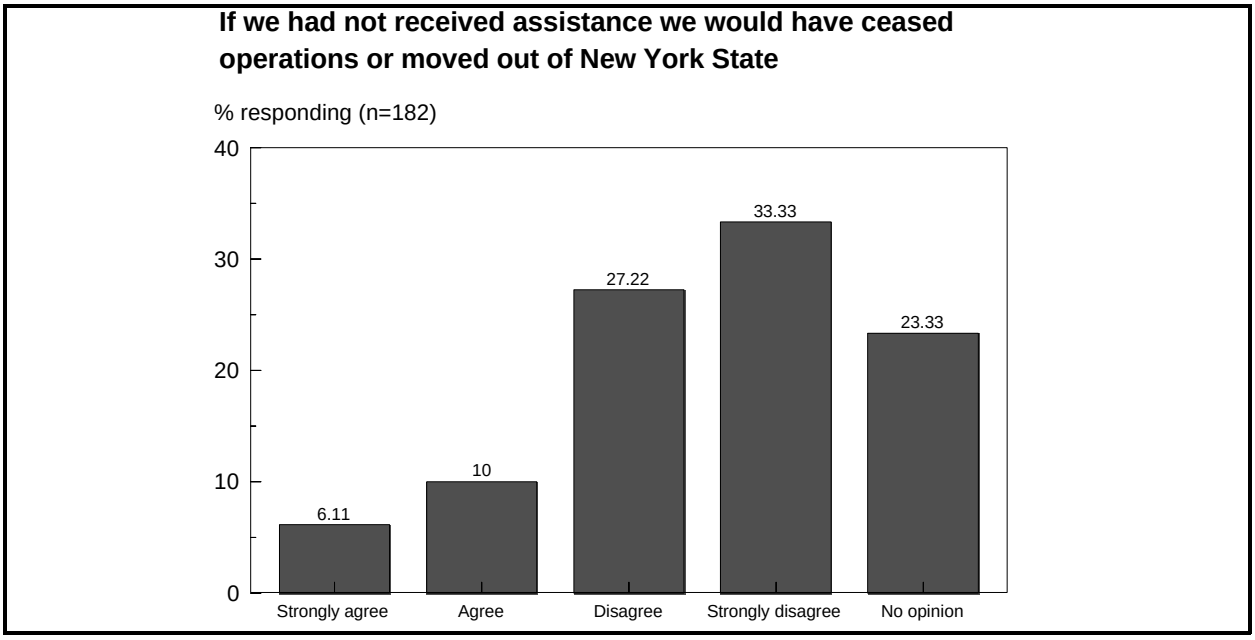
Influence of Factors on the Probability of Being Active: Logit Results

Explanatory variable	Coefficient
DISTANCE	0.0020 (0.0063)
$RELEMP_{pre}$	-0.0456 (0.2092)
EMPLOY	0.0002 (0.0005)
Log Likelihood	-221.111
Chi2 (3)	0.38
Number of observations	335

Source: Author's calculations based on equation in test. Standard errors are shown in parentheses

* signifies that the coefficient is statistically different from 0 at the 10 percent level.

Figure 2.5 Impact of the Program on Business Retention



Conclusions

The evaluation of the ITES program demonstrates that manufacturing extension programs can have a favorable impact on participating companies. As a result of the assistance rendered by ITES field agents and affiliated organizations, companies have undertaken specific investments and modified manufacturing practices. These changes have led to improvements along a number of critical dimensions, including rework / scrap, inventory, and manufacturing lead times. Companies have been able to reduce costs, particularly with respect to direct and indirect labor, and, in some cases, increase revenues.

Companies are more likely to benefit from the program if field agents provide direct assistance. There is a clear relationship between the nature of service rendered and desirable outcomes. Changes and resulting benefits were greatest in cases where the ITES field agents assisted in diagnosing problems, provided advice based on their own experience or expertise, or provided hands-on engineering assistance. The more intensively companies participate, the greater the benefits. Companies that had more contacts with field agents, or were active in the program for longer periods of time, or received grants to retain consultants under the IEP program, have reaped the greatest benefits. Time and the intensity of services matter.

Significantly, it appears that manufacturing extension programs can have a beneficial impact in terms of increased productivity. This dampens demand for labor in the short-term, as companies find that they can fulfill orders with fewer workers. However, with lower costs, participating companies may, in time, be able to secure a larger share of the market for their products. If the rate of growth in output is greater than the rate of productivity growth, companies will add jobs over the longer-term.

A number of implications for the design of manufacturing extension programs flow from the analysis. These are summarized briefly:

- **Focus more on adding value, rather than reducing costs.** The emphasis of the program in New York, and other manufacturing extension programs, is on cost reduction. However, this is only one part of the productivity equation. Perhaps more important is the need to help companies establish a market position where then can command a premium price for their products. Such premiums may be afforded through distinctive features of products or services offered to customers.
- **Focus on direct, long-term assistance.** The probability of companies taking certain actions, and the level of associated benefits, depends upon the nature and intensity of services provided through extension programs. The experience of the program in New York suggests that companies benefit from direct assistance from field agents, with frequent interactions over an extended period of time.
- **Foster cooperation to compensate for the lack of internal economies of scale.** Current programs tend to focus on the provision of services to individual companies. However, it may be desirable to promote greater cooperation among small manufacturers specifically as a means to capture external economies (See Harrison, 1991 and Krugman, 1991).

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Appendix A

Industry Groups Used in Analysis

Industry groups	Primary SIC codes
Group 1	20, 21
Group 2	22, 23, 31
Group 3	24, 25, (except 2514, 2522, 2542)
Group 4	26
Group 5	28
Group 6	308
Group 7	34, 35 (except 357), 37, 2514, 2522, 2542
Group 8	36, 357
Group 9	38
Group 10	27, 29, 30 (except 308), 32, 33, 39
Group 11	Non-manufacturing