Money on the Shop Floor:

HOW MANUFACTURING EXTENSION HELPS FIRMS BECOME MORE EFFICIENT

By Eric Oldsman and Douglas Welch

American manufacturers are under constant pressure to reduce costs, increase quality and deliver products more rapidly. While many large corporations have taken steps to enhance their performance, most small manufacturers are still producing products in the same way they have for decades. However, manufacturing extension programs are helping to change this story. This article presents results of a comprehensive evaluation of the New York Manufacturing Extension Program conducted by Nexus Associates, Inc. Drawing on in-depth case studies, it demonstrates that small manufacturers have been able to reduce waste, lower production costs, and cut cycle times as a direct result of services provided by field engineers and other affiliated organizations.

Less than a decade ago, people were rushing to herald the demise of American manufacturers. The foreword of a report published by the Office of Technology Assessment in 1990 was representative of broadly held views: “U.S. manufacturing is in trouble… In industry after industry, U.S. manufacturers have lost out to competitors who are able to make things better -- products with better features and more reliable quality, at lower cost.” The automotive and semiconductor industries were particularly singled out as examples of businesses on the skids.

As was true for Mark Twain, reports of the death of manufacturing in the United Stated have been greatly exaggerated. The success of Intel, Motorola, Hewlett-Packard, Chrysler, Ford, Harley-Davidson and other major manufacturers all speak to the revitalization of American industry. As shown in Figure 1, over the past decade manufacturing output in the United States has grown by more than 20 percent in real terms. While the four percent decline in manufacturing employment during this period is lamentable, it is also a mark of the success of strategies designed to improve production efficiencies. Productivity rose 31 percent between 1985 and 1995 – a gain that outpaced other major sectors of the economy. Corporate profits have also risen, topping $200 billion after taxes in 1995.

The Renaissance for Small Manufacturers is Still to Come

Many manufacturers have gone through a period of major reorganization affecting all aspects of their operations: product design, marketing, accounting, plant organization, supplier management, logistics, labor relations, employee

training, and others. For the most part, these represent changes in business practices and organizational behavior. Companies have learned to use existing assets more effectively. As a result, these manufacturers are producing higher quality products more rapidly and at lower costs.

To some extent, however, the resurgence of American manufacturing has been limited to large corporations. Hundreds of thousands of smaller plants have simply not been part of this success story. For most small manufacturers across the country, the last decade has seen little change except for ever greater pressure to reduce costs. While outsourcing and other factors have shifted production to smaller companies, many small firms are operating far below their potential. As a result of lagging management practices and production technologies, productivity levels among smaller manufacturers were less than two-thirds of that of larger firms in 1992 (Figure 2). Limited financial resources and lack of expertise are major constraints to improvements. Most small manufacturers still need help and they are not getting it from customers or consultants.

Recognizing the importance of manufacturing to the economy and the tremendous needs of smaller firms, a number of states established programs in the 1980s specifically to assist small manufacturers. Building on this foundation, Congress directed the National Institute of Standards and Technology (NIST) -- an agency of the U.S. Commerce Department -- to establish a program to help small manufacturers improve their performance. Beginning with three centers in 1989, the NIST Manufacturing Extension Partnership (MEP) has expanded to include manufacturing extension centers in 50 states and Puerto Rico.

Like most public sector initiatives, manufacturing extension programs are under pressure to demonstrate results to justify continued funding. They are sometimes criticized as ineffective government forays into the private marketplace. The remainder of this article addresses the question of whether these programs make a difference. Specifically, it presents the results of a comprehensive evaluation of the New York Manufacturing Extension Program – one of the NIST-supported extension centers mentioned previously. The evaluation was conducted by Nexus Associates, Inc. – an economics and management consulting firm – at the request of the New York State Science and Technology Foundation. The evaluation covered the period from April 1993 to June 1995 and was based on a detailed review of project records, rigorous statistical analyses of company surveys, and a series of in-depth case studies. Excerpts from these case studies are included to demonstrate the dynamics of the program as well as to illustrate the use of case studies in program evaluation.

The New York Manufacturing Extension Program

New York has long been a heavily industrialized state, dominated by thousands of small manufacturing plants. There are still 26,000 plants with less than 500 employees currently operating in the state. These plants employ over 660,000 people, accounting for two-thirds of the total manufacturing workforce in New York.

Because of the central importance of manufacturing to the state economy, New York was one of the first states to establish a manufacturing extension program.

Begun on a regional basis in 1985, the Industrial Technology Extension Service (ITES) was expanded statewide in 1990. The program was given a further boost in 1994 through a cooperative agreement between the New York State Science and Technology Foundation and NIST. With these additional funds, the statewide New York MEP integrated all of the activities of ITES, four large regional centers, and the Northeast Manufacturing Technology Center (NEMTC). The four large regional centers are the Industrial Technology Assistance Corp. (ITAC), the University/Industry Public Partnership for Economic Growth (UNIPEG), the Hudson Valley Technology Development Center (HVTDC) and the Western New York Technology Development Center (WNYTDC). The Northeast Manufacturing Technology Center (NEMTC) was one of the original Manufacturing Technology Centers funded by the US Department of Commerce, National Institute of Standards and Technology (NIST). NEMTC was subsequently phased out in the second quarter of 1995 under an agreement between STF and NIST. The current annual operating budget for the New York MEP program is approximately $8 million with funding provided by the state and federal government as well as through fee-for-services.

Although it has evolved over time, the core of the program has remained intact over the past ten years. At the heart of the New York MEP is a regional network of field engineers employed by affiliated not-for-profit organizations who provide technical and managerial assistance to companies throughout the state. Field engineers help diagnose problems and identify opportunities, define an appropriate course of action, and marshal resources required by the company to effect needed changes. At times, field engineers provide general management counseling and technical engineering services based on their own expertise and

experience. However, the more typical approach is for the engineer to serve in a broker capacity, referring companies to appropriate third-party service providers. Working with manufacturers, field engineers may call on state and local economic development agencies, universities, community colleges, and private consultants to provide needed services.

Beginning in 1990, field engineers were charged with the primary responsibility for field activities associated with the Industrial Effectiveness Program (IEP). The IEP is an important resource for the New York MEP. In addition to grants to cover assessment costs, New York manufacturers may be awarded up to $75,000 on a cost-shared basis to implement specific improvement projects through the IEP. Field engineers help companies define projects, complete grant applications, identify consultants, and conduct post-project evaluations. Approximately 10 percent of New York MEP clients have participated in the IEP program.

In addition to this assistance, field engineers organize and participate in seminars and workshops as part of outreach and educational efforts. In some offices, agents are responsible for implementing group projects with several clients at a time, including quality networks. Training programs include education in specific manufacturing technologies or practices, including ISO 9000 preparation and certification.

The program is clearly complex. Services provided to manufacturers under the New York MEP vary considerably with respect to the problems addressed, the magnitude of assistance provided, and the duration of client participation. One of the purposes of evaluation, however, is to identify elements of the program

that are common among successful interactions between field engineers and manufacturing firms. Case study methods are particularly useful in this context.

Case Studies Present a Logical Argument

A good case study is far more than an exaggerated war story, serving simply as a public relations tool. Case studies present an argument that demonstrates program impacts and illustrates *how* they were achieved. In so doing, they offer a detailed description of the logical series of events linking the program to reported outcomes.

To be effective, this narrative needs to be grounded in a model of the dynamics of the program. The New York MEP evaluation is based on the model presented in Figure 3. Companies participating in the New York MEP program receive a variety of services either directly from a field engineer or through another third-party service provider. These services are intended to encourage companies to adopt new business or manufacturing practices such as implementing quality assurance programs, reorganizing plant layouts or establishing new information systems. It is hoped that changes in practices will result in enhanced manufacturing performance and subsequent improvements in business performance. However, the intent of the program extends beyond making individual companies more profitable. Improved performance of individual companies is intended to lead to public benefits by generating additional income and employment within the state. The case studies that follow paint a detailed picture of the relationships between each component of the model.

The New York MEP evaluation included the preparation of five case studies of companies believed to have benefited significantly from their participation in the program. The companies were selected from a pool of manufacturers nominated by New York MEP field engineers. The case studies were prepared according to a standard protocol following the model presented in Figure 3. They draw on information obtained from program records and interviews with the principal field engineer, consultants, and company representatives. Interviews with company officials typically lasted two or more hours and included a tour of the plant to observe changes undertaken as a result of services provided to the company. Additional follow-up interviews were conducted by telephone.

Although these cases were drawn from different industries, they share certain elements as illustrated in summaries of three of the five case studies presented in the next section.

The New York MEP has Helped Companies Improve Production Processes and Lower Costs

Buerk Tool and Machine Co.

Founded in 1919, Buerk Tool and Machine Co. is a family-run, precision machine shop with 14 employees. The company originally designed and manufactured special purpose machinery and printing presses. However, this segment of their business has declined in the face of stiff competition in the industry. Work in this area is limited primarily to spare part production and general repair. In response, the company has turned to producing various machine tool components for approximately 30-35 original equipment manufacturers (OEMs) in Western New

York. Its strategy has been to service an existing customer base rather than to develop new business.

In early 1995, the president of the company recognized that his plant was struggling. The shop floor had long been choked with scrap and obsolete equipment. With an upswing in orders, layout problems were further aggravated by additional work-in-process inventories cluttering the shop floor. At this point, the president contacted the Western New York Technology Development Center (WNYTDC) for assistance. WNYTDC is one of the Regional Affiliates of the New York MEP.

WNYTDC staff provided over 80 hours of direct technical assistance to Buerk Tool over the course of five months for a total charge of $2800. The assistance focused on assessing machine utilization, analyzing work flow, designing alternative plant layouts, and developing better procedures for housekeeping and tool and materials storage. Recommendations were supported by evidence demonstrating the effectiveness of similar changes at other facilities. In addition, the WNYTDC referred the company president to a seminar on information systems for manufacturing firms.

Some of the most significant changes are summarized below:

- **The layout of the 23,000-square-foot shop floor has been changed significantly**. The new layout reflects the movement of typical jobs through the shop rather than the long-standing practice of placing similar machines together. In addition, a new overhead door will allow more direct travel of work through the building and avoid the dual use of a single bay for both receiving and shipping. The new layout is designed to

reduce the movement of an average job by approximately 30 percent. Every eliminated movement through the shop will reduce the time and cost required to complete a job. To implement the new layout, roughly 20 of the company's 50 machine tools need to be moved, sold or junked. All told, some 1,360 square feet of floor space have been freed up for productive uses, representing savings of $6,800 per year.

- **The company has adopted improved procedures for material handling, housekeeping, and tool storage**. The company has taken steps to organize raw material and work-in-process inventories, removing the clutter between machines. New procedures for clearing work surfaces and storing tools has made it easier to find tools needed for particular jobs. These changes have helped to increase throughput and on-time delivery rates. They are also expected to improve overall shop safety.

- **The company is also implementing several changes to its information systems.** This includes the installation of a local area network (LAN), bar coding for the traveler sheets that accompany specific jobs through the shop, and the use of new job tracking software.

In 1995, Buerk Tool achieved record sales of $1.4 million, an increase of 20 percent over the previous year. The president of the company attributes 85 percent of the increase to the efforts of WNYTDC. He reports that the increase in effective capacity enabled the company to take on additional orders. Employees have also profited; each received a 15 percent bonus and a five percent wage increase this year.

Perhaps the most significant impact has been the change in the culture of the organization. Attitudes have changed throughout the company. All employees are beginning to think about the importance of orderly and efficient production methods and continued shop floor improvements. Although WNYTDC involvement is now "trailing off," the company is confident that it is headed in the right direction.

According to the President, "Without the assistance nothing would have happened. . . We would have continued repeating the same behaviors and expecting new outcomes." Said another employee, "Without the WNYTDC, we would be just plodding along the same as always, some years making money, some years in the red."

Luitpold Pharmaceuticals

Luitpold Pharmaceuticals manufactures and packages roughly 55 generic injectable drugs. The company employs over three hundred people with total annual sales exceeding $50 million. While the company has been successful, it faces an ongoing battle to sustain its position in the market. Competition in the generic drug industry is fierce, based primarily on cost, product quality and an ability to deliver on time. Luitpold estimates that it has roughly six competitors for each of its products. The most significant cost component is materials, which constitute roughly 85 percent of total cost of goods sold. Controlling materials flow and maintaining capacity utilization are, therefore, key to low costs.

Back in 1993, the company's principal concerns related to inefficiencies in production lines. Production inefficiencies had led to high scrap rates as well as excessive work-in-process and finished goods inventories. These problems

were hurting the company's ability to meet earnings projections. In many cases, the company did not have systems in place to monitor production costs and identify problems.

In September 1993, a field engineer from Long Island Forum for Technology (LIFT) – another of the New York MEP Regional Affiliates -- met with company executives. The field engineer convinced Luitpold management that improvements to their manufacturing process were possible. LIFT staff helped the company to secure $75,000 through the Industrial Effectiveness Program to cover part of the cost of an information systems consultant. The total cost for the development and implementation of the system was roughly $340,000 (including $90,000 in company time). The field engineer remained involved throughout the project, attending consultant-client meetings and helping to ensure that the project met the needs of the company.

Working in conjunction with the consultant, the company has adopted an information system to track materials flow and other production data. A key element has been to place information in the hands of the people who control the processes. The new system has enabled the company to identify sources of problems and take appropriate corrective action.

The company has realized significant gains. According to the Vice President of Manufacturing, the adoption of the new system has led to a decrease in scrap rates from 3.4 percent in 1992 to 3.2 percent in 1994, and an overall eight percent reduction in unit costs. Executives of the company estimate that the firm has already realized savings of more than $700,000.

Ithaca Peripherals Incorporated

Ithaca Peripherals Incorporated (IP) was founded in 1983 by two engineers formerly with National Cash Register (NCR). The company manufactures point-of-sale (POS) printers used for the printing of receipts and tickets. IP has four primary product lines that are sold as either discreet units or as components for larger POS systems. The company employs 85 people, nearly one-half of whom are engaged in assembly, stock room and shipping operations.

Most of the company's competitors offer low cost, standard products on a rapid turnaround basis. This requires achieving significant economies of scale through the production of large volumes of printers with standard features. The challenge for Ithaca Peripherals is to achieve the same economies of scale and production cycle time while offering greater customization to their customers.

While the company had grown, it now faced a new set of issues that needed to be resolved. In particular, the company was experiencing a high rate of "first-pass" inspection failures, high costs associated with warranty returns, and high staff turnover. These issues appeared to be linked. Contributing factors included poor plant organization, an inadequate management information system, and an over-reliance on temporary employees.

The University Industry Partnership for Economic Growth (UnIPEG) helped the company secure a grant through the New York IEP program to hire a consultant to work on plant layout and management information systems. The plant reorganization centered on removing bottlenecks and improving material flow. The new information system integrates various departments, providing a basis for more informed decisions on purchasing, sales, and manufacturing.

Following completion of the IEP-funded project, a UnIPEG field engineer led a month-long effort to develop a new manufacturing strategy for IP beginning in August of 1994. Developed in conjunction with a new Operations Director, the plan provided guidance concerning a number of manufacturing issues. It identified several areas for immediate attention, including establishing a process to ensure a better flow of needed information within the organization and refining manufacturing process and inventory control procedures.

Subsequent technical assistance provided by the field engineer related primarily to the development of a quality assurance plan, focusing on first pass yield, on-time delivery, and customer satisfaction. Specific measures for each of these elements were developed and are now posted daily on large charts within view of all manufacturing employees. In addition, a new bar coding system has been adopted to track shipments and code rejected items.

According to representatives of IP, the actions outlined here have resulted in improved manufacturing performance and lower costs. The firm estimated total savings of $30,000 in the first year, due primarily to an increase in first-pass yields and a reduction in warranty returns. For example, IP's most popular printer model averaged 96 percent in first-pass yield in October 1995 -- up from 92 percent in September 1994. Similarly, between 1993 and 1995, warranty returns dropped from 50 percent to 5 percent for one model, and 2.75 percent to 1.5 percent for another model. In addition, improved information has led to better forecasting, resulting in improved materials planning and more efficient scheduling. Inventory turnover is currently running four to six times per year and delays due to missing components have been reduced. The company has been

able to continue to manufacture customized printers without compromising turnaround time or quality.

Ithaca Peripherals is growing steadily. The company is maintaining a stable workforce and is relying less on temporary employees. Labor content is down as a result of more outsourcing of operations such as cable manufacturing and board assembly. However, there has been a net increase in employment. The firm has added 20 people over the past three years. This includes an increase in engineering staff, reflecting increased emphasis on R&D.

The Evaluation Also Demonstrated Significant Economic Impacts

The case studies present the stories of just a few companies out of the almost 1,600 firms served by the New York MEP between 1993 and 1995. While all of the cases provide substantial evidence of significant benefits to these manufacturers, there is still a need to judge the extent to which results can be generalized to the larger population of firms served and to estimate the broader economic impacts of the program.

To this end, the evaluation also included an assessment of the total increase in value-added within the state over a two-year period. The analysis drew primarily on data gathered through a survey of a stratified, random sample of 275 New York MEP clients. The questionnaire asked respondents to supply actual historical data on a variety of company performance measures for the years 1992 and 1994, including annual sales, annual expenditures for raw materials and other purchased inputs, annual payroll and total employment. The change

in performance for New York MEP clients over this period was compared statistically to that of a group of similar manufacturers that had not participated in the program to arrive at an estimate of program impacts.

After taking displacement and multiplier effects into account, the analysis demonstrated that the New York MEP program generated $30 million to $110 million of value-added income in New York State in the two years between 1993 and 1994. Since all costs incurred by clients in implementing changes recommended by field agents or other service providers are already captured in the value-added measure, these figures represent the total *net* economic benefit of the program with respect to the New York economy as a whole. The growth in economic activity led to a net increase of approximately 510 to 1,920 jobs statewide and generated roughly $1.8 million to $6.7 million in additional state tax revenues.

Where Do We Go From Here?

The New York MEP evaluation demonstrates that the program is effective in helping manufacturing firms become more efficient. To a great extent, efforts to streamline and control production more closely have paid off. The lessons from these experiences can be applied to the thousands of small manufacturers that struggle each day to produce and sell their products at a price and quality demanded by their customers.

In each of the case studies, manufacturers reorganized their plants to improve material flow and space utilization. As a result, they were able to reduce the movement of materials from one operation to another leading to greater

coordination as well as reductions in scrap, inventories and production cycle time. Reorganization was not, however, limited to changes in plant layout. Companies must gain control over production processes in order to ensure quality and improve efficiency. Measurement and analysis are critical to this function. Here again, all of the cases involved helping companies establish systems to obtain and use production data as a means to control and improve manufacturing operations. This entailed development of performance measures along with formal quality assurance practices to collect necessary data, identify production problems, and determine appropriate corrective actions.

Another similarity among the case studies was the increased use of information technology for production scheduling, quality control and business planning. All of the cases involved the development of computer systems. In some, this entailed the development of fully integrated management information systems linking sales, purchasing and production. In other cases, the scope was more limited, focusing on machine scheduling and inventory control.

The case studies prove that improvements in manufacturing performance do not necessarily require vast outlays on new technologies or capital equipment. Companies have learned to operate existing equipment more efficiently – they have reorganized their plants to reduce wasted movements, adopted formal quality assurance practices; and, in general, have learned to use information to their advantage. These organizational changes have enabled small manufacturers to strengthen their competitive position in the marketplace.

However, the challenge for manufacturing extension programs and for the companies they serve is to ensure that these gains are sustained over time.

Most small manufacturers supply components and subassemblies to larger final goods producers. The big automotive, aerospace and electronics companies have been relentless in forcing suppliers to meet higher quality standards while simultaneously requiring lower costs. As a result, the chase for higher and higher production efficiencies is never ending.

While manufacturing extension programs should continue to work with companies to reduce costs by becoming more systematic, they should also explore ways to help companies avoid the trap of commodity production. To succeed in the long-run, it may be more beneficial for manufacturers to focus on strategies yielding competitive advantages based on new capabilities, higher product quality, and/or improved customer service. The winning strategy requires making different products than competitors, using more sophisticated manufacturing equipment and information technologies, and investing in highly trained workers. Manufacturing extension programs that help manufacturers move in this direction may best serve the interests of their clients as well as the nation as a whole.

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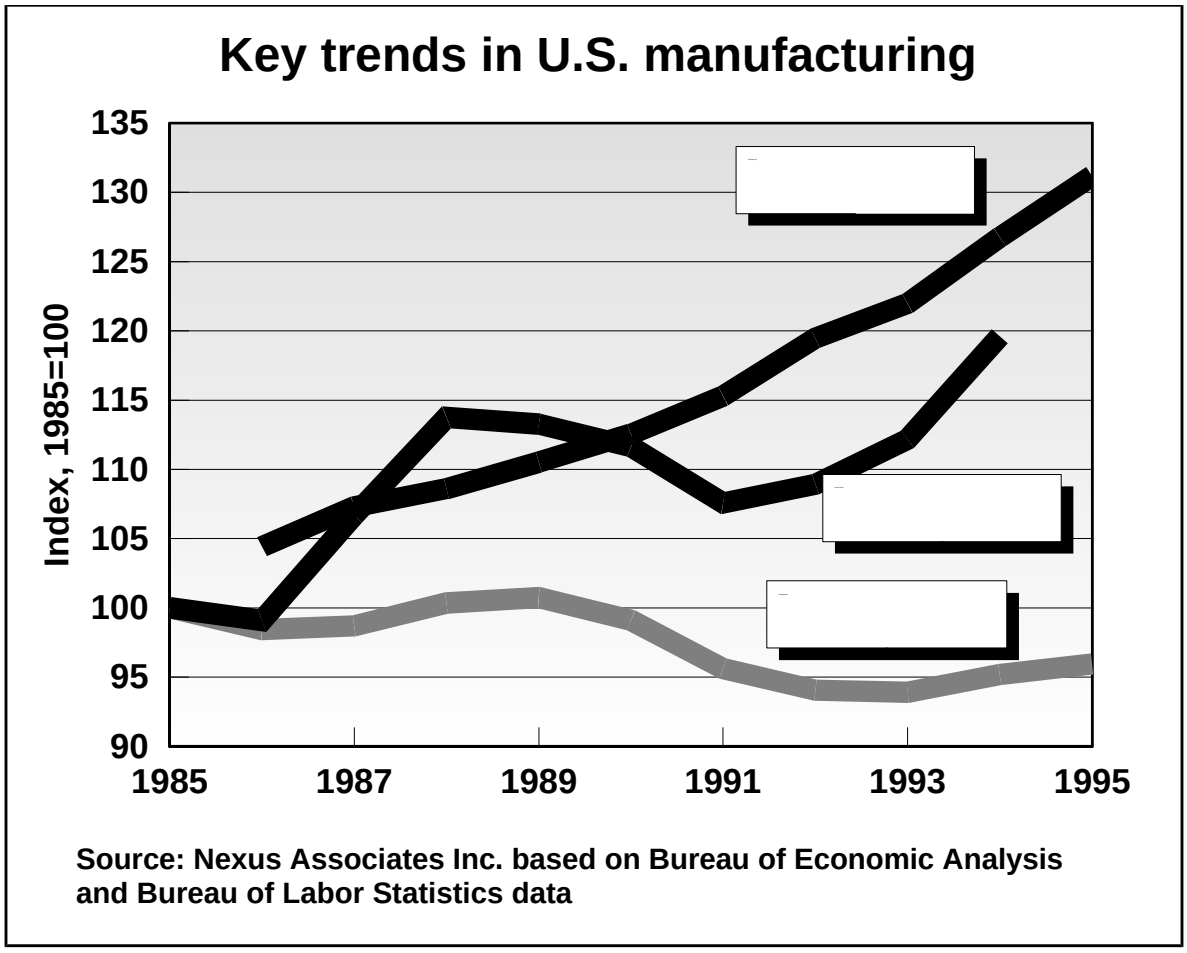
Figure 1.



Source: Nexus Associates Inc. based on Bureau of Economic Analysis and Bureau of Labor Statistics data

Figure 2.

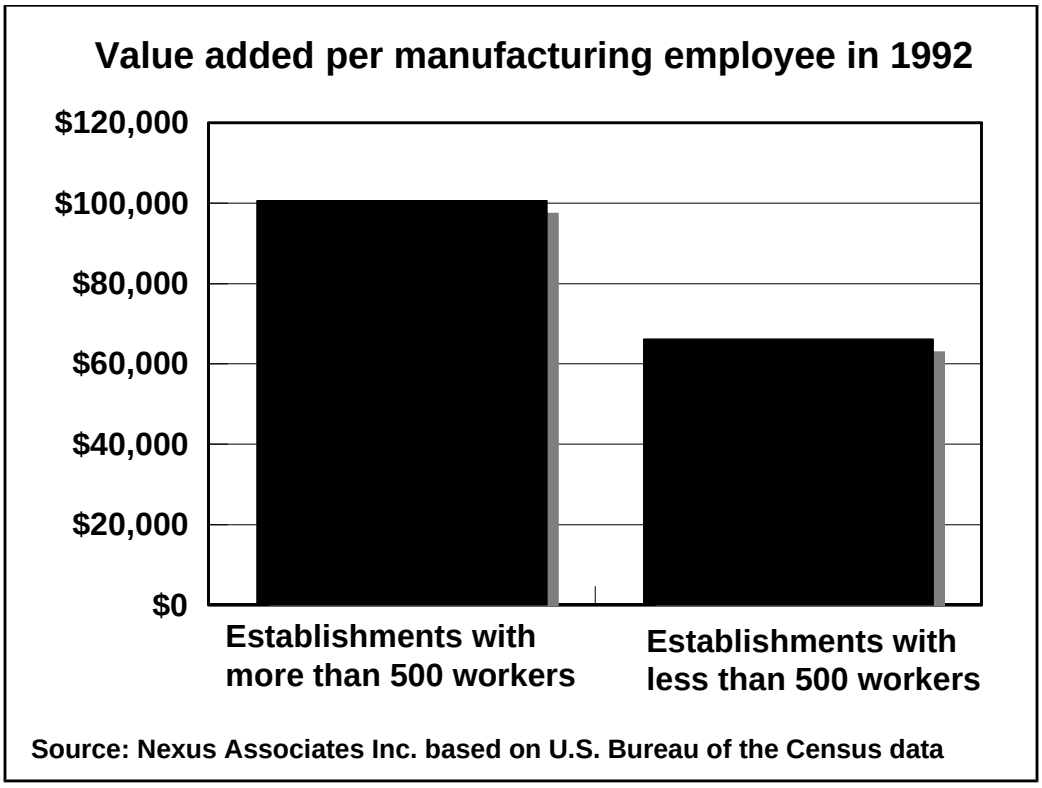
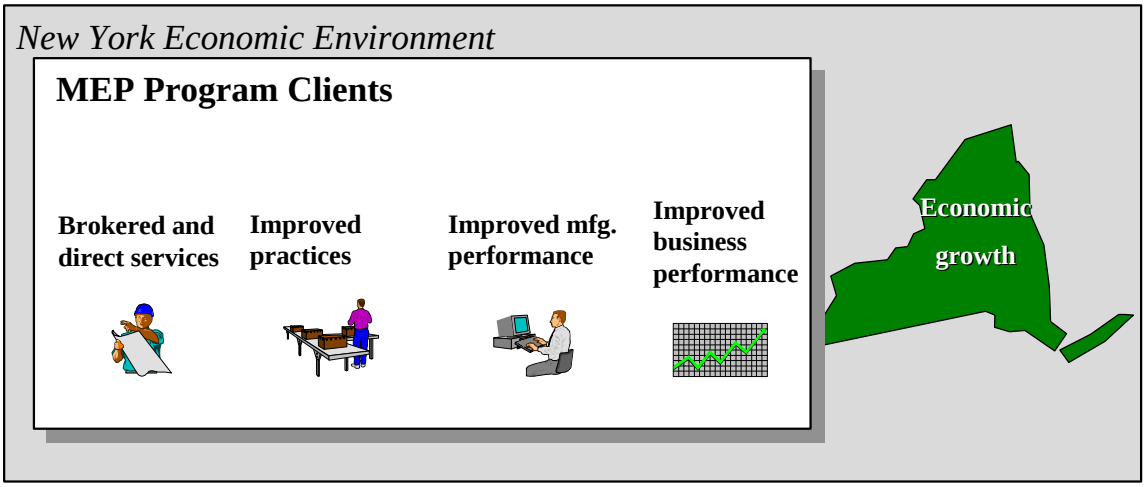

Value added per manufacturing employee in 1992
$120,000
$100,000
$80,000
$60,000
$40,000
$20,000
$0
Establishments with more than 500 workers
Establishments with less than 500 workers
Source: Nexus Associates Inc. based on U.S. Bureau of the Census data

Figure 3. Program Logic Model



Nexus Associates, Inc. is an economics and management consulting firm based in Belmont, Massachusetts. The firm specializes in performance measurement, program evaluation, market research, and economic analysis. Assignments are typically undertaken within the context of strategic planning, organizational development, and process improvement efforts. Since it was founded in 1991, the firm has established a solid reputation for high quality work that meets the needs of its clients on time and within budget.

Nexus Associates has worked with government agencies, quasi-public authorities, not-for-profit organizations, federal laboratories, universities and private corporation both in the United States and abroad. Clients have included the U.S. Department of Commerce, National Institute of Science and technology, Massachusetts Technology Collaborative, New York State Science and technology Foundation, Industrial Technology Institute, Tufts University, World Bank, Inter-American Development Bank, Mexican Government, Hong Kong Government, and General Motors.

Dr. Eric Oldsman -- the founder and president of Nexus Associates --- has more than 20 years of consulting experience. Prior to establishing the firm, he was a senior consultant at Arthur D. Little, Inc. and served as a program officer at PACT, Inc. He holds a Ph.D. in public policy from Harvard University and B.A in economics from Brown University.