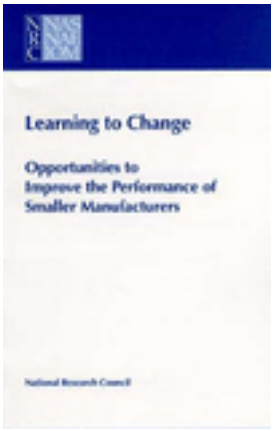

Learning to Change: Opportunities to Improve the Performance of Smaller Manufacturers

Committee to Assess the Barriers and Opportunities to Improve Manufacturing at Small and Medium-Sized Companies, Commission on Engineering and Technical Systems, National Research Council

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LEARNING TO CHANGE

OPPORTUNITIES TO IMPROVE THE PERFORMANCE OF SMALLER MANUFACTURERS

COMMITTEE TO ASSESS BARRIERS AND OPPORTUNITIES TO IMPROVE MANUFACTURING AT SMALL AND MEDIUM-SIZED COMPANIES
Manufacturing Studies Board
Commission on Engineering and Technical Systems
National Research Council

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Preface

In July 1992, at the request of the Director of the Manufacturing Technology Centers Program of the National Institute of Standards and Technology (NIST), the Commission on Engineering and Technical Systems' Manufacturing Studies Board (MSB), in cooperation with the Commission on Physical Sciences, Mathematics, and Applications' Board on Assessment of NIST Programs, established a committee to: 1) identify the major barriers to manufacturing improvement in cost, quality, and timeliness at small and medium-sized companies in a number of discrete component manufacturing industries; 2) determine what means are available to overcome those barriers and which, if any, can be most effectively and efficiently addressed by the NIST Manufacturing Technology Centers (MTC) program; and 3) determine how the activities of the MTCs should be focused to address those barriers to best leverage the resources available.

This charge was developed in the political context in summer 1992. During the course of the study, the national election resulted in a change of administration. The Clinton administration has proposed a substantial increase in federal funding for industrial assistance activities. For this study to be meaningful in the new political context, the proposed plans by the new administration were incorporated into the study and the potentially expanded role of the federal government in providing technical assistance to industry was subjected to critical analysis.

The Congress directed NIST to create the Manufacturing Technology Centers program in the Omnibus Trade and Competitiveness Act of 1988 (U.S. Congress, 1988). The purpose of the program is to speed the transfer of advanced manufacturing technologies to U.S. industry,

particularly small and medium-sized manufacturers, by establishing regional technology transfer centers. Proposals are solicited from qualified institutions and awards made on a competitive basis.

NIST awarded approximately $1.5 million in matching funds to each of three nonprofit organizations in 1988: the Cleveland Advanced Manufacturing Program, the University of South Carolina (later managed by Enterprise Development, Inc.), and Rensselaer Polytechnic Institute (later transferred to the New York State Science and Technology Foundation). Two more centers, the Industrial Technology Institute in Ann Arbor, Michigan, and the Kansas Technology Enterprise Corporation in Topeka, Kansas, were awarded in 1990. In 1992 funds for the latest of the seven centers were awarded to Minnesota Technology, Inc., in Minneapolis/St. Paul and California Community Colleges in Los Angeles.

The Clinton administration has published plans to raise significantly the contribution of the federal government in industrial extension efforts, in part by greatly expanding the MTC program. President Clinton has proposed the creation of a national network of manufacturing extension centers. Federal funds, matched by state and local funding, would go to support and build on existing state, local, and university programs to expand assistance services "to give all firms access to the technologies, testing facilities, and training programs they need" (Clinton and Gore, 1993). Initial efforts to implement this national network have been included in the Technology Reinvestment Project, the multiagency federal program for defense technology conversion, reinvestment, and transition assistance (U.S. Department of Defense, 1993).

The committee has taken these plans into consideration in responding to the NIST request. The committee has assessed barriers and opportunities to improve manufacturing performance in small and medium-sized firms and has determined the most effective role for the MTC program. The committee has also discussed these new plans and initiatives for a national manufacturing extension network and provides some recommendations in that context.

STUDY METHODOLOGY

The process adopted by the committee in response to the NIST request had three primary components: 1) discussions with groups of small and mid-size manufacturing firm managers, owners, and executives during public meetings and workshops held throughout the United States;

2) soliciting the testimony of service providers at full committee meetings and during visits by subcommittees to various assistance facilities; and 3) reviewing appropriate written materials and background information, academic literature, and industry publications.

The committee membership visited, as subcommittees of three to five persons, six of the seven Manufacturing Technology Centers and met with MTC and other industrial assistance program staffs. They also met with more than 75 owners, managers, and executives of small and medium-sized manufacturing companies in eight day-long workshops to discuss the problems and challenges confronting smaller firms and opportunities for helping them improve their competitiveness. Although a majority of the owners, managers, and executives had been involved, to some extent, in state and federally funded programs, the workshop participants were not invited because of their experience with the services of local and regional manufacturing assistance organizations, but rather for their interest and willingness to contribute to the information gathering efforts of the committee. The workshops were held in Minnesota, South Carolina, Kansas, Michigan, Ohio, California, Georgia, and New York between September 1992 and January 1993.

A practical objective of the MTC program is to offer services that facilitate improved manufacturing performance at small and medium-sized manufacturers. The underlying assumption is that small and medium-sized manufacturers would benefit from greater awareness and understanding of advanced manufacturing technologies and practices. However, there has been no comprehensive assessment of the existing technological capabilities of small manufacturers, including the broad variation across companies, or their sources of information on advanced technology. Similarly, there is little comprehensive understanding of the sources of competitive advantage and disadvantage of small and medium-sized manufacturers, so it is difficult to assess the relative effects of programs designed to upgrade their technological capabilities compared to alternative assistance mechanisms. The committee has striven to address these analytical shortcomings by discussing conditions in small and medium-sized firms with owners and managers and those working to provide assistance to the firms; surveys and other literature were also used extensively.

The work of the committee led to several conclusions concerning the modernization needs of small and medium-sized manufacturers and the circumstances they face, the community of service providers that presently assist manufacturing companies, and, in particular, the role of the MTC program. The committee suggests goals for improving the

overall system of assistance to smaller companies and recommends steps for increasing the effectiveness of the MTC program in the context of the needs of small and medium-sized manufacturers, the existing network of public and private industrial assistance providers, and the Clinton administration's plans to create a national network of manufacturing extension centers.

REPORT STRUCTURE

The committee's report is divided into five parts. Chapter 1 examines the importance of manufacturing to the American economy, considers the regional diversity of small and medium-sized manufacturing companies, and describes their crucial influence on the global competitiveness of American products. It also describes the changing requirements for successful manufacturing in the context of increasing global competition, rapid technological change, and new forms of intra and intercompany relationships.

In Chapter 2 the committee describes the barriers to improving manufacturing performance in small and medium-sized companies and opportunities to help the companies overcome those barriers.

There is a broad spectrum of state, local, and federal government programs and various kinds of initiatives that have been undertaken to improve American manufacturing. Within the private sector is a rich source of assistance from consultants, educational institutions, and local programs. These efforts, and the resources that have been deployed to help firms improve their performance in terms of quality, cost, and responsiveness, are summarized in Chapter 3.

The committee was asked to examine the MTC program and evaluate the degree to which MTCs were meeting the needs of small and medium-sized companies. The committee did not rate the performance or success of individual MTCs, but rather looked at them in a programmatic context and evaluated the alignment of smaller manufacturers' needs and services provided by the MTCs. A summary of committee observations and conclusions about the effectiveness of the MTC program is presented in Chapter 4.

Chapter 5 presents the conclusions and recommendations of the committee majority regarding the barriers and opportunities to improve the cost, quality, and timeliness of production in small and medium-sized manufacturers, and appropriate mechanisms and roles for MTCs and other assistance providers. In order to be relevant to current conditions

facing NIST, the committee majority had made these recommendations in the context of plans for an expanded role for the federal government and NIST in creating a national network of manufacturing extension centers.

Chapter 6 presents the conclusions of two committee members concerning the inappropriateness of federal funding of organizations to assist manufacturers.

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LEARNING TO CHANGE OPPORTUNITIES TO IMPROVE THE PERFORMANCE OF SMALLER MANUFACTURERS

Executive Summary

Manufacturing firms—large and small—face massive change and adjustments as they move from a stable, fault-tolerant environment of long production runs to a volatile world in which production runs are short, product characteristics are constantly changing, and defect-free on-time production at decreasing prices is a condition for survival. The necessary changes in the organization of production include everything from the layout of the shop floor to the distribution of authority between managers and workers. The magnitude of these transformations threatens to overwhelm the managerial capacities of firms regardless of their size.

These dramatic changes in the requirements for successful manufacturing are happening during a period of steady increase in the number of smaller industrial firms[1] and a trend toward facilities with fewer workers. Smaller manufacturers play an important role in the competitiveness of American industry. They comprise the bulk of manufacturing establishments, are integral parts of the supply chain for both commercial and defense products, and provide approximately 40 percent of manufacturing employment.

Many of these smaller firms, however, are operating far below their potential. Their use of modern manufacturing equipment, methodologies, and management practices is inadequate to ensure that American manufacturing will be globally competitive.

[1] Typically defined as those with fewer than 500 employees.

This situation has prompted significant public response. State and local governments have created industrial assistance services, the federal government has multiple programs aimed at helping small businesses, and there is strong interest in the Clinton administration in creating a national network of industrial assistance centers (Clinton and Gore, 1993). Expanding the National Institute of Standards and Technology (NIST) Manufacturing Technology Centers (MTCs) program is one mechanism for creating such a national assistance network. Other possible mechanisms, described in the Advanced Research Project Agency's recent Technology Reinvestment Project (TRP) information package, include Advanced Technology Centers at community colleges, industry specific consortia, and expansion of state-based industrial extension services (U.S. Department of Defense, 1993). Although the specifics of a national industrial assistance system have yet to unfold, it is clear that significant resources—the budget for manufacturing extension programs in the TRP is about $180 million for fiscal year 1993—are being mobilized to create a national industrial assistance system.

Given this context—rapid changes in manufacturing, growth in the numbers of smaller manufacturers, and their apparent lag in modernization effort—NIST asked the Manufacturing Studies Board to form a committee to examine the barriers to manufacturing improvement in smaller firms and to identify the appropriate role of the MTCs in addressing those barriers. As part of its study efforts, the committee met with nearly one hundred small manufacturing owners/managers, as well as extension service field agents and managers from Manufacturing Technology Centers (MTCs), state extension programs, universities, and trade associations. In addition to discussing barriers facing smaller manufacturers, both company representatives and assistance providers discussed opportunities to help firms overcome these barriers and to improve significantly their production costs, quality, and market responsiveness.

The conclusions and recommendations of the committee are based on a review of relevant literature and the testimony of experts, practitioners, assistance agents, private sector service providers, and the many manufacturing owners and executives that participated in eight workshops held throughout the United States. The recommendations of the committee reflect the changed circumstances that have resulted from the emergence in early 1993 of substantial additional federal funding for industrial assistance activities, as well as President Clinton's proposals for the creation of a national network of manufacturing extension centers.

PROBLEMS AND CHALLENGES FOR SMALLER MANUFACTURING COMPANIES

Smaller companies confront major problems in responding to increased global competition. These problems encompass a broad range of issues, only some of which relate directly to technology. Inadequate resources—people, money, expertise, information—and insufficient time are reasons that many smaller firms are not improving their manufacturing performance. The idiosyncracies that come from the genesis of entrepreneurial companies are also contributing factors in their resistance to change and slow adoption of more advanced technologies and new organizational structures.

Five fundamental barriers to manufacturing performance improvement in smaller firms were identified and discussed during the workshops hosted by the committee. The barriers are well corroborated in the extensive literature about conditions in smaller companies. The means for helping firms adequately deal with the problems include a combination of approaches undertaken by MTCs, various state assistance programs, and several private sector service providers. A comprehensive response to most of the barriers will require a combination of the approaches discussed.

Barrier 1: Disproportionate Impact of Regulation

The regulatory environment creates a disproportionate burden for smaller firms. National, state, and local initiatives and decisions concerning trade, the environment, employment, work place safety, health care, and liability have a direct impact on the competitiveness of manufacturing companies. Despite efforts to lessen the impact of regulatory actions on small businesses, the amount of time and effort required to comply with complex regulations has become a disproportionate hardship for smaller organizations. One result is that the economic impact of regulatory compliance is much greater as a percentage of capital investment than it is for larger businesses.

Opportunities for improving the ability of smaller manufacturers to cope with regulatory actions include:

- improved dialogue between regulators and smaller manufacturers; one means for improving dialogue between regulators and smaller

businesses would be to provide assistance in identifying and filing appropriate forms and documents required by regulatory agencies;
- timely information to manufacturers about new or modified regulations; and
- reorientation of the strategies of regulatory agencies towards "compliance assistance" rather than "adversarial and punitive."

Barrier 2: Lack of Awareness

Smaller manufacturers are often unfamiliar with changing technology, production techniques, and business management practices. The staff and senior managers of smaller manufacturing companies must devote most of their time and energies to managing the day-to-day operations of the firm. As a consequence those companies are less likely to be aware of the best manufacturing practices, innovative application of new technologies, and fresh approaches to improved production efficiency. With less relevant experience and expertise, their expectations for successfully selecting and effectively assimilating new technology are not high, and so they are less likely to risk investment in new ways of doing things or in major changes to the management structure and relationships within the business.

Opportunities for increasing the awareness of manufacturers to new technologies and best manufacturing practices include providing:

- national benchmarking data for smaller firms, and illustrative cases of best manufacturing practices;
- greater access to video tape libraries that illustrate technologies and implementation problems;
- local and regional forums and workshops;
- low-cost seminars and formal courses on selection, adoption, and management of specific technologies; and
- expanded mechanisms to provide access to equipment for "try before you buy."

Barrier 3: Isolation

Smaller manufacturers are generally isolated and have too few opportunities for interaction with other companies in similar situations. Interaction with other firms is essential to continuous

improvement. These associations seem to be most productive when they occur among companies of similar size and with larger organizations that might be role models for smaller firms. The chance for suppliers to interact with major customers, to benefit from membership in a supplier improvement program or *keiretsu*-like confederation of companies, can significantly increase the chances for smaller firms to improve their performance.

Opportunities for increasing the interaction and exchange of information with other manufacturers in like circumstances include:

- workshops, meetings, site visits, focus groups, forums, and roundtable discussions;
- television and video programs to expose manufacturers to specific problems and the solutions adopted by other firms;
- construction and operation of networks of companies with similar interests and needs to share costs;
- encouraging professional and trade associations to be more active in determining needs and developing appropriate programs for their membership; and
- electronic networks that provide bulletin boards for direct exchange of information and sharing of approaches to common problems.

Barrier 4: Where to Seek Advice

It is difficult for owners and managers of smaller companies to find high-quality, unbiased information, advice, and assistance. When companies need help with technical problems, when they want to replace production or design equipment, or when they want to upgrade the skills and talents of their work force, they are often at a loss for sources of assistance. Searching for help in the public sector often reveals a confusing uncoordinated array of services—universities, economic development groups, technical schools, government agencies—" competing" for clients. Inappropriate choices can waste precious resources and time, a waste that smaller firms cannot afford.

Opportunities for helping smaller manufacturers acquire necessary information and unbiased advice include:

- databases of consultants with relevant references and qualifications, toll-free numbers to provide firms with a single contact for

assistance, and electronic bulletin boards to notify service providers of opportunities in the manufacturing community;
- field engineers that provide small companies a strategic perspective on how they compare to competitors and what changes they need to make to remain competitive in the long term; and
- interpreters and catalysts to communicate the needs of smaller manufacturers to vendors, suppliers, academic institutions, federal laboratories, and government agencies.

Barrier 5: Scarcity of Capital

Operating capital and investment funds for modernization are difficult for small and medium-sized manufacturing firms to obtain. The financial community does not readily understand manufacturing and often perceives loans for new equipment as unattractively high risks. Smaller firms are unlikely to have the capabilities needed to put together proposals for funds in the format familiar to lending officers. The consolidation of banks, with some exceptions, has removed much of the decision making from the communities where many loan officers have traditionally relied on the "known character" of management and owners of the companies in lieu of collateral.

Opportunities for improving access to capital and understanding the requirements of the financial community include:

- local and regional forums and workshops for bankers, regulators, and others who work with manufacturers;
- assistance developing justification for capital improvements in the format and language understood by the financial community; and
- creation of mutual loan guarantee networks among peer companies.

SOURCES OF ASSISTANCE

Fortunately, the efforts of many assistance organizations, educational institutions, and businesses have demonstrated ways to help companies successfully contend with most of these obstacles. With some regional variation, assistance is available in both the private and public sectors.

The private sector offers a number of resources that manufacturers can buy to solve problems, to modernize their production operations, and

to upgrade the skills of their workers. Among these are consultants, suppliers of technology, trade associations and professional societies, and other miscellaneous service providers. The backgrounds and expertise of many consultants are, however, primarily founded on principles relevant to larger corporations; they often fail to appreciate subtle but important differences in smaller organizations. And though many suppliers will provide fairly substantial "proposal engineering" services while competing for a sale, fewer are able to follow through with sustained support and service after a sale to a relatively small customer. There are no precise data available on the number of smaller companies buying private sector assistance.

Numerous initiatives have been undertaken at the federal, regional, state, and local levels to help manufacturers and business in general. For the most part, these initiatives have become overlapping uncoordinated programs, and the effectiveness of many programs has yet to be systematically evaluated or demonstrated. The programs typically operate on fragile financial underpinnings and often compete for funds to support assistance efforts. The availability of public assistance, which is usually dependent on funding by state and local government, tends to vary with the perceived contribution of smaller manufacturing firms to the wellbeing of the local economy, and the best state programs are unable to help more than a few hundred firms per year.

Until 1989, the federal role in providing assistance to small manufacturers was primarily through the Small Business Administration and various defense programs. Beginning in 1989, however, the National Institute of Standards and Technology (NIST) has funded the Manufacturing Technology Centers (MTCs), seven of which are now operating. The MTC program is the primary federal activity in industrial extension providing matching grants for creating centers to enhance "productivity and technological performance in U.S. manufacturing through the transfer of manufacturing technology and techniques . . ." (U.S. Congress, 1988).

EFFECTIVENESS OF MANUFACTURING TECHNOLOGY CENTERS

To understand the challenges facing smaller manufacturers and to determine the nature and effectiveness of MTC activities, the committee held eight workshops throughout the United States, six of them at MTCs. The conclusions of the committee concerning the effectiveness of the

organizations are based on workshop discussions with smaller manufacturers and company representatives who had some experience working with the Manufacturing Technology Centers, as well as conversations with MTC staff and other service providers.

A majority of the committee has concluded that the MTCs are well placed to provide many of the services needed to improve the performance of smaller manufacturers. However, the committee found that the legislative "sunset provisions," which eliminate NIST funding after six years, and the present metrics (cash flow, number of clients, length of engagements, attendance at manufacturing meetings) tend to adversely dominate the missions, attitudes, and behaviors of the MTCs that have been operational for two or more years. While there is an extensive range of services that can be offered by MTCs, the typical long-term strategies to fill the funding gap and comply with performance measures place increasing emphasis on fee-for-service activities.

Many of the needs and opportunities identified by the manufacturers attending the workshops were not project-oriented kinds of assistance but were, instead, concerned with improving access to information and building stronger networks among companies, suppliers, technology developers, regulators, and financiers. These "soft" services were noted repeatedly as some of the most useful and important contributions that could be made by the MTCs as neutral parties. Such services, however, are not easily converted into fees, and their contribution to the accomplishment of the MTC mission is difficult to measure. All of the MTCs provide these kinds of "soft" services to a greater or lesser degree, but they should receive more emphasis despite the lack of clear metrics on which to judge their value. The committee can foresee a situation emerging in which MTCs fail to provide services that would be most useful and effective to smaller firms because the fee income is insufficient, while at the same time competing more with private sector service providers for the business of larger firms.

Each of the MTCs continues to learn how best to serve its customer base and is flexible enough to adapt. The local infrastructure and industrial economy determine to a great degree the characteristics of the MTC organization and its chosen position in the spectrum of support needed by manufacturers in its region. This drives each MTC to develop a unique combination of services targeted at local industrial conditions, and subsequently each evolves a relatively unique relationship with other providers of services and assistance. They are learning how to serve as a hub of information and facilitator of cooperation in their local industrial communities, and how to amalgamate a range of programs into a core set

of useful services. Each MTC, therefore, can be viewed as an experiment or prototype in how to integrate federal efforts in manufacturing assistance with existing private and public assistance resources to meet the demands of very diverse local manufacturing communities.

CONCLUSIONS

The investigations and deliberations of the committee have led to the development of opposing sets of conclusions concerning the appropriateness of a federally funded national system of manufacturing assistance. The majority opinion and recommendations are presented followed by the minority opinion.

Majority Opinion

Based on the committee's discussions with smaller manufacturers and with staff at the MTCs and other industrial assistance programs, a majority of the committee has concluded that a national industrial assistance system is justified. The committee majority has concluded that barriers to manufacturing performance improvement in smaller firms and the opportunities to overcome those barriers, as described by manufacturers in the committee's workshops, define roles for public sector assistance programs.

The majority assessment of the current MTCs is that the MTCs are well-placed to address many of the challenges confronting smaller manufacturers. Within the fragmented network of assistance sources, the MTCs have begun to carve a niche that, at least within their geographic regions, has brought some degree of order to the community and has raised the awareness of smaller companies that useful help is available. The MTCs are still experimenting with different mechanisms for marketing, ensuring responsiveness to the local customer base, working with other sources of assistance, and building the intercompany networks and information resources that many smaller firms need. This process of experimentation and learning should be encouraged and the lessons broadly disseminated. This is the only way to increase effectiveness in a necessarily diverse environment and to keep expectations realistic as the MTC program is expanded and other initiatives begin in the context of a national manufacturing assistance system.

Minority Opinion

Two members of the committee strongly oppose the concept of federally funded assistance to manufacturers through organizations such as the NIST Manufacturing Technology Centers. To a large degree, the disagreement is ideological. In their opinion, government intervention is more costly and less efficient than natural market forces. They feel strongly that this report should not be treated as a blanket endorsement of a national industrial policy. Their interpretation of the results is to resist the temptation of a national cure-all. The full text of the majority opinion can be found in Chapter 6, page 95.

RECOMMENDATIONS

The committee majority offers the following recommendations to help guide the implementation of such a national program.

1. Develop a long-term strategy.

Efforts to create a national *system* of industrial assistance to improve the manufacturing performance of smaller companies should recognize the importance of creating a coherent system and not just increasing the number of assistance facilities and service providers. A long-term strategy for deploying, operating, and funding a national system, in the context of changing economic and political realities, must be developed.

2. Expansion should be governed by "quality, not quantity."

Too rapid expansion of the MTC program or other forms of industrial assistance programs risks compromising service quality for three reasons: 1) attempts to anticipate appropriate needs based on present knowledge and understanding will not be effective, 2) rapid replication of a single uniform model of an assistance center is inappropriate, and 3) the number of organizations available and capable of providing high-quality assistance is relatively small.

Recognizing these constraints, the committee recommends that expansion of the current MTC program and other federal initiatives should be planned carefully with the aim of developing a comprehensive

national industrial extension system within 3 to 5 years, based on a strategy of "learn as we go."

3. A national system of industrial assistance must strive for balance among local responsibility, regional coordination, and national direction, support, and cohesion.

The combination of rapid changes taking place in manufacturing and major differences across industries and localities calls for a system with centralized coordination and decentralized, distributed management and control. National goals and objectives must be tempered by the environment of each locale, and regional efforts should respond as appropriate for their predominant industrial sectors, private and public resource base, and real potential for matching funds. Local and regional programs must have the ability to implement change and to deliver services in the most effective, efficient way for the demands of their local customers.

4. Federal financial support should recognize different needs, abilities, and capacity to apply funds effectively. It should focus on spending modest amounts wisely, with flexibility in the amount of funds for which an organization must apply.

Rigid criteria that constrain competitive awards to high, fixed levels often discourage applications for programs which, appropriately, should be smaller scale efforts. Funding support should fit the abilities of organizations to use the money effectively, and awards should be commensurate with the size of the market for assistance, availability of matching funds, and other resources.

5. Coherent measures and guidelines should be developed for evaluation of federal, regional, and local assistance efforts. For programs that are not performing, remedial action needs to be taken quickly by a local board of directors.

The set of metrics for evaluating accomplishments of the programs must be tied to their missions, and the connections between those metrics and goals must be clear. Evaluation of the services provided to manufacturing clients must be an integral part of the overall judgement process.

This evaluation should be administered by a governing or advisory board with broad membership, particularly local industry participation.

6. A consistent and coherent funding policy, accompanied by appropriate metrics for evaluating performance, should be established to assure a stable assistance environment.

Current MTC funding policies requiring local matching funds and elimination of federal funding after six years can be counterproductive to the goals of a national system of industrial assistance. Self-sufficiency of the MTC organizations, *while not competing with the private sector,* has a low probability of success. Consequently, reliance on user fees alone is not an appropriate basis for supporting necessary assistance activities, and continuing support should be available to manufacturing assistance programs that meet the performance criteria for continued funding.

7. Periodic self-examination of all the elements of a national system for manufacturing assistance is essential to remain flexible and adaptable in the face of rapid changes in the manufacturing base.

Any assistance system must be able to examine its own effectiveness and adjust specific objectives as circumstances change. Periodically, the specific objectives and certainly the metrics for measuring performance need to be reviewed because the issues that will challenge manufacturers in the future are not readily discerned from the environment they face today. Whatever kind of support and performance improvement system is designed must, therefore, incorporate the means for evolving the services and delivery mechanisms to accompany the new challenges and conditions that will confront manufacturers.

8. Long-term political support is essential.

An infrastructure to help significantly improve the manufacturing competitiveness of smaller companies must have consistent support and visibility in the political process that go beyond partisan politics. Strong management of the federal effort is essential. The Department of

Commerce has the appropriate background to understand the issues, formulate a coherent strategic vision, and attract the necessary resources to accomplish the national goal of strengthening U.S. manufacturers. The Department of Commerce should be given responsibility for undertaking the coordination and rationalization of the broad, and largely disjointed, federal effort now under way to help American manufacturers improve their performance and global competitiveness. It is crucial that the resources made available for such assistance efforts, whether through the MTC and other programs at NIST, other programs in the Department of Commerce, or programs in the Department of Defense and other agencies, be applied in an efficient and rational manner to maximize the benefits to American industry.

Because the MTC program is, and will continue to be, a federal-state partnership, and because state governments have been leaders in establishing industrial assistance programs, the need to maintain state political support cannot be understated. By helping to provide the regional and local input essential to effective assistance programs, states play a critical role.

SUMMARY

The purpose of publicly provided technical assistance is not to absolve manufacturers of responsibility for their success. The immediate purpose is to provide attention to the issues and problems that threaten survival of smaller manufacturers by helping them manage the set of challenges with which they are presently confronted. The long-term goals of public support should be to create an environment in which companies can learn to help themselves and encourage the growth and development of private sector resources by identifying needs, defining appropriate services, and strengthening market efficacy.

Improvements in technology and changes in the firm's internal organization of work are but elements in overcoming the challenges and barriers that block or impede the development of globally competitive manufacturing capabilities in smaller U.S. firms. Innovation within our manufacturing companies must be understood as inextricably linked to, and dependent on, macroeconomic initiatives, trade impediments, antitrust concerns, education and training, energy, regulatory actions, public infrastructure, cost and availability of capital, and a host of other external factors and policies that are beyond the immediate control or direction of individual firms.

1

Introduction

A strong and globally competitive industrial base is a principal driver of the American system of commerce and trade, crucial to the growth and continuing prosperity of the U.S. economy, and a vital component of national security. For the past 40 years manufacturing has accounted for 20.0 to 22.5 percent of the U.S. gross national product when measured in inflation-adjusted terms. The manufacturing sector continues to generate four and a half times as many secondary jobs as the retail sector and almost three times as many secondary jobs as the personal and business service sector (Baker and Lee, 1992). In 1990, 18.3 million workers were employed in manufacturing, representing 20.4 percent of the domestic private sector work force (see Table 1). And despite continuing balance-of-trade deficits, in 1991 manufacturers contributed more than 67 percent of American export earnings, compared with 26 percent for services and less than 7 percent for agriculture.[1] Manufacturing remains important to the American economy.[2]

[1] Based on figures taken from Table No. 1314, U.S. International Transactions, by Type of Transaction: 1980 to 1991. Export total for goods and services is $561,192 million (U.S. Department of Commerce, 1992d).

[2] See recent recommendations for ". . .actions that will help ensure that the United States maintains (and builds where necessary) world-class manufacturing industry to support vigorous economic growth and competitiveness" (Competitiveness Policy Council, 1993).

TABLE 1 Manufacturing in the U.S. Economy. Source: U.S. Department of Labor, Survey of Current Business, Bureau of Labor Statistics, April 1992.

U.S. GDP in Constant 1982 Dollars		**Manufacturing Contribution to GDP**	
1989	4,087.6	929.0	22.73%
1980	3,131.7	665.4	21.25%
Manufacturing and Private Sector Non-Agricultural Employment			
Total Work Force (millions)		108.4	
Federal/state/local (millions)		18.6	
Private Sector (millions)		89.8	
Manufacturing (millions)		18.3	
Manufacturing as Percent of Private Sector		20.38	
Manufacturing as Percent of Non-Agricultural		16.88	

SIZE DISTRIBUTION OF U.S. MANUFACTURERS

Since the mid-1970s, there has been a steady increase in the number of small and medium-sized industrial firms, typically defined as those with fewer than 500 employees (U.S. Small Business Administration, 1992 and Organization for Economic Cooperation and Development, 1992). The number of manufacturing establishments in the United States grew from 319,000 in 1980 to nearly 374,000 in 1990.[3] More

[3] An establishment is a single physical location, such as a plant, at which business is conducted or where services or industrial operations are performed. It is not necessarily identical with a company or enterprise, which may consist of one or more establishments. Manufacturing companies with fewer employees (particularly those with less than 100 employees) tend to be single establishment enterprises and larger firms tend to have more than one establishment. This has the effect of increasing the ratio between small and larger firms (U.S. Department of Commerce, 1992a and U.S. Small Business Administration, 1992).

than 98 percent of these establishments are small or medium-sized and they employ about 40 percent of the total manufacturing work force. Nationwide 90 percent of all manufacturing establishments employ fewer than 100 people[4] (U.S. Department of Commerce, 1992a).

While the overall number of manufacturing establishments has been increasing, the trend towards smaller[5] facilities has dominated. During the period 1980–1990, the number of establishments with 1–4 employees increased 38.8 percent and those with 5–9 employees increased 23.2 percent. In contrast, the number of establishments with over 250 employees decreased. (See Figure 1 and Table 3 in Appendix A.)

Although smaller companies are not major exporters of manufactured goods, they nevertheless participate in the export activity of larger American businesses as vital links in the value-added chain that supplies large manufacturers. Because they represent as much as 60 percent of final goods production costs, the components, subassemblies, and parts provided by smaller firms determine to a significant extent the eventual cost competitiveness and quality of America's exports (Industrial Technology Institute, 1991).

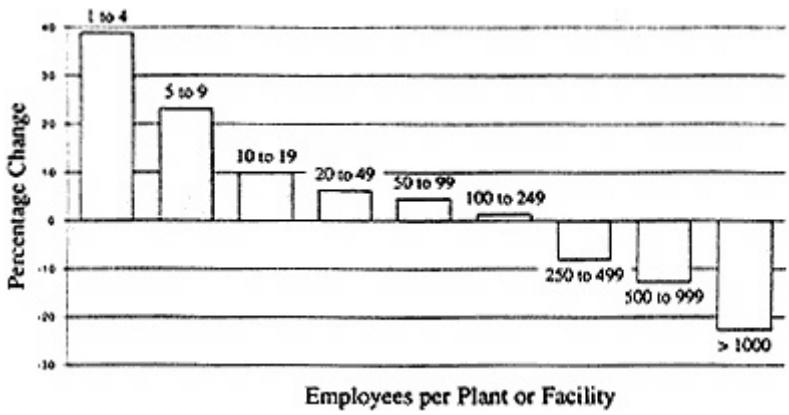

Figure 1 Percentage change in the number of manufacturing establishments of different sizes, 1980–1990. Source: U.S. Department of Commerce, 1992a. various months. See also, Appendix A, page 101.

[4] See Appendix A for a series of tables that summarize establishments by state.

[5] Throughout the remainder of this report "smaller" means less than 500 employees. When finer distinctions are necessary, such as "small and medium-sized," they will be appropriately indicated.

GEOGRAPHIC DISTRIBUTION OF MANUFACTURING

Manufacturing is found throughout the United States, but there are important geographic regions of concentration. An analysis by Case Western Reserve University examined the relationship between the number of high-density concentrations of manufacturing facilities and the cumulative percent of facilities. This analysis found that the 12 largest concentrations account for 70 percent of all U.S. manufacturing establishments, and the 20 largest clusters (or more appropriately, corridors) together account for 87 percent of all such plants (Fogarty and Lee, 1991).

Furthermore, these clusters of manufacturing establishments tend to have particular industrial specializations. For instance, 57 percent of automotive assemblers and suppliers cluster in three different regions: the Great Lakes; eastern Pennsylvania and New York, Delaware, and New Jersey; and southern California. Textiles manufacturing also clusters in the broad region around New York City including eastern Pennsylvania and in southern California, and also has a big presence in southern Florida. The maps in Figures 2 and 3 show that these regions do not follow state boundaries; furthermore, a single industry can have major

Figure 2 The Top Five U.S. Automobile Industry Clusters. The labels for each region indicate the percentage of total U.S. automobile manufacturing establishments contained in that cluster. Source: Fogarty and Lee, 1991.

Figure 3 The Top Ten U.S. Textile Industry Clusters—1990. The labels represent a ranking of the top ten textile clusters. Source: Fogarty, et al, 1993.

importance in more than one geographic region. These patterns of industry location suggest the limits of state actions to assist manufacturing modernization and the potential benefits of a national perspective.

DIVERSITY OF SMALLER MANUFACTURERS

Work force size is a convenient means of categorizing American firms, but that single measure does not convey the diversity and range of attributes found in the manufacturing sector. Many contrasting characteristics of manufacturers influence the ability of firms to help themselves, the kinds of help needed, and the mechanisms for delivering assistance. The concept of the "typical smaller manufacturer" holds no relevance because, at a minimum, one must consider the enormous range of product and market sectors, effects of geographic location, worker demographics, company maturity (years in business), age of equipment, and company ownership.

Product or Market Sector

Obviously the diversity of the markets served by manufacturers is enormous, as are the characteristics of the products and processes needed to serve those markets. A few examples will illustrate the range of diversity and its effects on the competitive strategies and requirements of smaller companies.

The position of a firm in a total production chain affects the demands placed on it and the help available to meet those demands. For instance, a firm supplying Honda must meet rigorous requirements for quality, delivery, and cost, but has access to help through Honda's supplier improvement program. A firm serving final consumer markets may have less rigorous requirements, but is on its own in seeking sources of technical, managerial, and financial assistance.

High-technology firms face different capital and skill requirements than firms in mature industries, but companies making products with greater technological content often have greater access to capital sources. However, even in mature industries such as metalworking, the technology and skills needed to meet increasingly tighter tolerances are becoming more sophisticated and the useful life of process technology is becoming shorter; these firms often have a very difficult time finding capital and skills.

Modernization

Several recent studies have determined that smaller manufacturing companies lag larger firms in modernizing their production equipment, information systems, and skills (Industrial Technology Institute, 1990; U.S. General Accounting Office, 1991; U.S. Department of Commerce, 1989; and Shapira, 1990a). They are less technologically sophisticated, less likely to have adopted more advanced manufacturing technologies, and less likely to invest in upgrading the skills and capabilities of their work force.

Significant numbers of firms still follow outdated methods and employ older equipment and machines despite evidence that more profitable alternatives exist. For example, there may be opportunities to increase productivity with computer control of equipment; however, many smaller companies are unable to justify the investment because it represents a major share of the firm's net worth. A U.S. Census Bureau survey of manufacturers in 1988 found that of the 17 advanced technologies included in the study, numerical and computer-numerical control (NC/CNC) was the only technology in which the usage rate for

manufacturing plants with 20–99 employees was more than half that of plants with more than 500 employees (large firms) (U.S. Department of Commerce, 1989). Figure 4 illustrates a comparison of technology adoption levels by firms according to number of employees per plant or production facility.

Firms associated with the defense industry appear to have overcome these constraints successfully. In a 1991 comparison of the adoption of programmable automation machine tools between defense and non-defense manufacturers, Kelley and Watkins determined that 65.4 percent of the firms in the network of defense manufacturers have programmable automation while only 49.5 percent of the non-defense firms had adopted similar technology. The differences are even more pronounced for smaller firms. For those with fewer than 50 employees the adoption rates for programmable automation tools was 50 percent to 150 percent greater for defense-related manufacturers. It is important to note that the authors attribute these differences to the strength of the support network in defense manufacturing, including specific Pentagon programs to encourage manufacturing investments, the relationships between prime contractors and their suppliers, and the learning opportunities created by cooperation among defense contractors, suppliers, and customers (Kelley and Watkins, 1992).

Company Maturity and Goals

There are broad differences among recently formed companies and those that may be in their second or third generation of business. The difference in the goals, objectives, and overall strategy of these organizations was neatly characterized by Paul Clay, director of the Mid-America Manufacturing Technology Center (MTC) as "investment versus life-style" companies. Investment companies tend to be young, more interested in aggressive growth and expansion, and willing to assume more risk to achieve that growth. They exhibit a greater willingness to adopt change and increase investment in people and training as well as new machinery and equipment. On the other hand, life-style companies view expenditures for new product and process technology as risking personal wealth rather than investing in growth and expansion of capabilities and markets. They are more likely to feel that upgrading worker skills is wasted because the employee is likely to accept a job with another company. Their decisions tend to be personal: "should I buy my daughter a new automobile or should I invest in an NC milling machine."

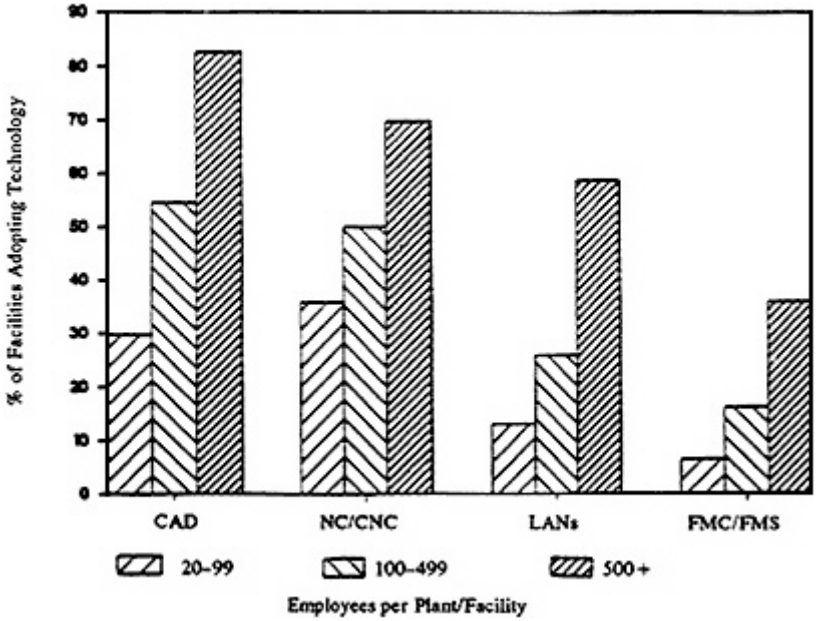

Figure 4 Adoption of Advanced Technology by Size of Plant or Facility.
Source: U.S. Department of Commerce, 1989.

These differences in attitudes and objectives affect the kinds of assistance companies are likely to need or accept. For instance, younger companies need help addressing those aspects of the business that require: 1) access to money such as financing equipment purchases, 2) access to information such as regulatory compliance (e.g., environment, employment, health and safety), and 3) access to knowledge such as establishing appropriate general business management capabilities for long-term growth. Mature firms, in contrast, usually need help making changes: changes in production equipment and practices that no longer are competitive, changes in the management structure and organization of the work place, changes in their relationships with customers and suppliers, and changes in their capabilities to accommodate increased demands from customers—for closer tolerances and improved design capabilities, for example—and increased pressure from competitors in cost, quality, and timeliness.

Not only are the types of problems often different in younger than in more mature manufacturers but also the ability to attract the resources needed to cope with problems can be quite different. For instance, mature companies have less difficulty raising financing and investment

capital than young, fast-growing firms (Dennis, 1992). Firm age also affects the ability to attract qualified people because opportunities for advancement may not be as apparent and rates of pay may not be as good in mature firms (Dennis, 1992).

Worker Demographics

Ethnic diversity and weaknesses in basic literacy skills—ability to read, write, and understand basic arithmetic—influence the effectiveness of the manufacturing work force. In many production facilities, English is, at best, a second language for much of the work force. It is not at all unusual to encounter a smaller manufacturing company that is owned by second generation Americans, has engineers from India, and has a Russian shop floor foreman directing Spanish and Polish speaking production workers. Insufficient communication skills lead to misunderstood directions and inability to read instructions to operate machinery and perform jobs. Some cultural backgrounds mitigate against new ways of organizing production, assigning responsibility for work, accepting direction from female supervisors, or suggesting better ways of accomplishing tasks.

Geographic Characteristics (Urban versus Rural)

Manufacturers in rural areas, in contrast to urban centers, are generally remote from customers, other suppliers, and sources of information and assistance for improving manufacturing productivity. They have less opportunity to interact with other manufacturers and, because there are fewer chances to develop industrial accounts, vendors and suppliers of advanced machinery and equipment are less available as conveyors of new manufacturing knowledge. Smaller manufacturers in rural regions are also more likely to have problems attracting and keeping qualified and technically skilled employees. In many instances, however, a small number of manufacturing firms in a county or region of a state may be major components of the local economic infrastructure. Their success and growth can contribute enormously to the prosperity of that region (Shapira, 1990b). The broad U.S. geographic distribution of manufacturing facilities with less than 500 employees is shown by the map in Figure 5.

Smaller manufacturers in urban areas have their own set of problems. For instance, the local work force in urban areas is often more diverse, and urban tax and regulatory burdens are often much more

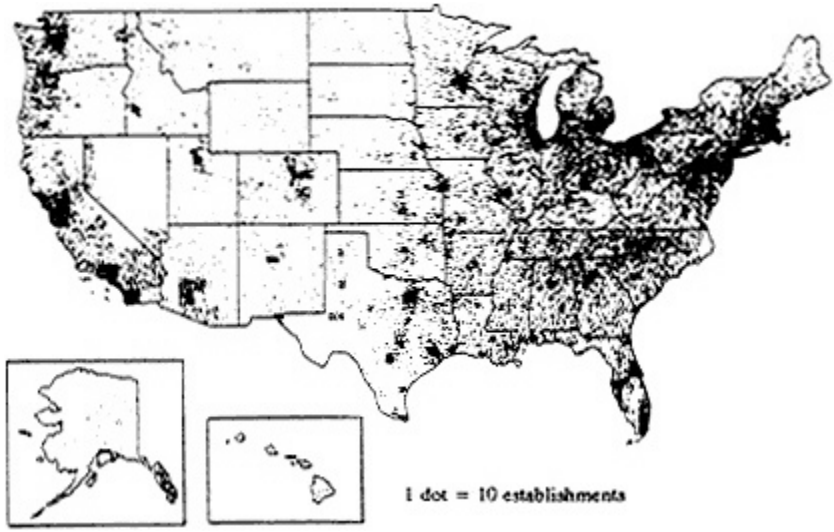

Figure 5 Smaller U.S. Manufacturing Establishments by County: 1987.
Source: U.S. Department of Commerce, 1988.

onerous. Land and utility costs can also be much higher. Although inclose geographic proximity, these manufacturers do not communicate or cooperate because owners often commute from the suburbs and do not participate in local trade associations. This combination of factors can create cost and information access problems as serious as those faced by rural firms, but the solutions will be quite different.

GLOBAL COMPETITION: CHALLENGES CONFRONTING AMERICAN MANUFACTURERS

This diversity of manufacturers greatly affects the operational conditions and resources available to improve their manufacturing competitiveness. Manufacturing firms—large and small—face massive change and adjustments as they move from a stable, fault-tolerant environment of long production runs to a volatile world in which production runs are short, product characteristics constantly changing, and defect-free on-time production at decreasing prices is a condition for survival. The necessary changes in the organization of production include everything from the layout of the shop floor to the distribution of

everything from the layout of the shop floor to the distribution of authority between managers and workers. The magnitude of these changes threatens to overwhelm the managerial capacities of firms regardless of their size.

Today advanced manufacturing technology is an international commodity, available to all.[6] Increased customization of products, greater competition for ever smaller market niches, and shortened product life cycles have significant consequences for manufacturers. The demand for many different products designed and produced to unique customer specifications means the manufacturer must contend with many short production runs. Shortened product life cycles increase the importance of highly responsive production capabilities. Investment in design and mistakes incurred in production become higher percentages of total manufacturing costs as the number of products grows but their individual production life radically decreases. The quality and speed of the entire product realization process are thus rapidly becoming more critical aspects of success for all manufacturers.[7]

Effective response to such a dynamic environment requires new disciplines and entirely new ways of thinking about production. It requires a philosophical revolution in long-held beliefs about relationships, responsibilities, and power. Companies must look for innovative ways of structuring, managing, and organizing work that remove historical impediments to organizational responsiveness. They must change the tenor of the relationships with customers, suppliers, and employees from adversarial to cooperative. Manufacturers must begin using cross-functional team approaches to integrate product and process development activities. They must learn to shift from maximum utilization of machines and equipment to the concept of maximizing system utilization. They must learn to evaluate and selectively apply lean production techniques in the proper circumstances, translate the lessons of single-minute exchange of dies into the appropriate setup situations encountered in their shops, examine the basic skills needed—and understand when—to use statistical process control, and they must recognize the long-term commitment needed to make total quality management and continuous improvement a part of the organization's culture.

[6] The widespread availability of technologies creates new challenges throughout the U.S. economy, not only within the manufacturing sector. An in-depth investigation of the consequences that globalization of technology and its development has for the United States can be found in the *Prospering in a Global Economy* series of studies by the National Academy of Engineering.

[7] Recent discussions of the issues confronting American manufacturers have been presented in studies by the National Academy of Engineering (1988a and 1992a).

To work properly, these disciplines require a new distribution of responsibility and decision-making authority in production operations (Shingo, 1989; Stalk and Hout, 1990; Womack, 1990; National Academy of Engineering, 1992). For example, in bufferless[8] manufacturing, errors are detected immediately by those operating the machines. The amount of work-in-process between manufacturing steps is not large enough to allow quality or production mistakes to be overlooked or ignored until large amounts of scrap product have been generated. However, the machine operators must be authorized and encouraged to make whatever changes are necessary to prevent the errors, and, if errors are detected, to make the adjustments necessary to restore correct production.

Clearly, this approach to work requires a greater synthesis of intellectual skills, problem-solving talents, and manual labor. The knowledge and intellectual capabilities of the entire work force must be harnessed (Kenney and Florida, 1993). This in turn signals a change in educational expectations from episodic training to continuous learning and knowledge enhancement, recognizing the importance of continuously upgrading the skills and capabilities of all members of the manufacturing work force (Tobin, 1993).

In summary, American manufacturers must address three important issues if they expect to achieve significant improvements in quality, cost, and timeliness of production: 1) the manner of structuring work and the relationships among employees, employers, customers, and suppliers; 2) training and education of the entire work force to create an environment that is hospitable to change and new ways of working; and 3) selecting technologies appropriate to the capabilities of the organizational structure and culture of the company.

RESPONDING TO THE CHALLENGES

The degree of improvement in productivity and the adoption of competitive manufacturing practices and new technologies vary widely across American manufacturing firms. An examination of studies conducted over the last ten years shows that the number of American

[8] Bufferless manufacturing is contrasted with traditional methods of maintaining large amounts of work in process (WIP). Minimizing the amount of partially completed products between manufacturing process steps insures that quality problems are immediately visible because defect-ridden products are not stored in WIP. Minimizing WIP, however, requires that greater attention be paid to maintenance of production equipment since there are no buffer stocks to sustain downstream processes if a piece of equipment fails.

firms utilizing globally competitive manufacturing practices and state-of-the-market technologies to survive and grow remains much too low.[9] Conclusions reached concerning the widespread adoption of modern technologies and best practices among smaller companies, in particular, are not very encouraging.

Since the early 1970s the value added per employee among large plants—those with 500 or more employees—has been growing 50 percent faster than those with 20–499 workers. A recent survey found that among manufacturers with 500 or more employees, 93.7 percent reported use of at least one advanced manufacturing technology, compared with 60.9 percent for those with under 100 employees.[10] When durable goods factories with less than 50 employees were examined, more than 85 percent had not introduced a single programmable machine tool (Industrial Technology Institute, 1989). In an unpublished 1989 survey of 150 job shops in and around New York City conducted by the New York Industrial Technology Assistance Corporation, 70 percent had not even begun to use computers in any aspect of their businesses.

These data suggest that smaller manufacturers face additional constraints to mustering effective responses to the challenges confronting manufacturers. First, smaller firms are less likely to have the necessary capabilities—technological expertise, management skills, financial and marketing strength, or capital sources—with which to respond effectively. Second, smaller firms face more risk in attempting technological or organizational change. Because large companies can access greater resources, they are more likely to survive a stumble when adopting a new technology or trying a new production process. They can afford to invest in upgrading worker skills and to investigate new approaches to organizing production operations. These same issues often threaten the

[9] The importance of manufacturing and the need for commitment to substantial manufacturing modernization has received serious consideration since the very early 1980s. From 1982–1985 a series of competitiveness studies of major U.S. industries (automotive, civil aviation, electronics, fibers and textiles, machine tools, pharmaceuticals, and steel) was conducted by the National Academy of Engineering (1985). In 1987, Cohen and Zysman published, *Manufacturing Matters: The Myth of the Post-industrial Economy*, challenging the popular opinion that the United States was moving beyond manufacturing to become a service-based economy. And Hayes and Wheelwright (1984) defined the changes manufacturers had to make if they were to once again compete globally in, *Restoring Our Competitive Edge*.

The present focus on smaller manufacturing organizations is due to relatively recent recognition of the changing demographics that support globally competitive manufacturing economies. See for example, Dobyns and Crawford-Mason, 1991 and *Business Week*, 1992.

[10] The technologies surveyed included several which are not likely to be found in smaller manufacturing firms because size of facilities (e.g., no justification for guided vehicles) or inventory management in lean production environments do not use automatic storage and retrieval systems (U.S. Department of Commerce, 1989).

solvency and viability of smaller firms if they are not accomplished successfully. Consequently, smaller firms place great importance on "doing it right the first time." They may not get a second chance.

A ROLE FOR INDUSTRIAL ASSISTANCE EFFORTS

The large and growing importance of smaller firms in the U.S. manufacturing sector, coupled with evidence that their response to a rapidly changing competitive environment is lagging, has prompted growing interest in providing various forms of assistance to these firms. A wide array of programs and resources, both public and private, is already available. (These programs are reviewed in Chapter 3.)

The Clinton administration has published plans to raise significantly the contribution of the federal government in industrial extension efforts (Clinton and Gore, 1993). President Clinton has proposed the creation of a national network of manufacturing extension centers. Federal funds, matched by state and local funding, would go to support and build on existing state, local, and university programs to expand assistance services "to give all firms access to the technologies, testing facilities, and training programs they need" (Clinton and Gore, 1993).

Initial efforts to implement this national network have been included in the Technology Reinvestment Project, the multiagency federal program for defense technology conversion, reinvestment, and transition assistance (U.S. Department of Defense, 1993). Almost 2800 proposals were received in July 1993, of which 545 were in the area of technology deployment. Technology deployment proposals were solicited in one of four activities: manufacturing extension services, extension enabling services, alternative deployment pilot projects, and technology access services. Additional proposals relevant to industrial extension were sought for the Defense Dual Use Assistance Extension Program (U.S. Department of Defense, 1993). Fiscal year 1993 appropriations for the Manufacturing Extension Programs is $87.4 million; appropriations for the Defense Dual Use Assistance Extension Program is $90.8 million (U.S. Department of Defense, 1993). The proposal conditions require cost sharing of at least 50 percent.

These budgets represent a substantial increase in resources available for public industrial assistance services. A better understanding of the barriers facing smaller manufacturers in their efforts to modernize their operations is a prerequisite for effective use of those resources. Accordingly, the following chapters examine the barriers, opportunities for assistance providers to help firms overcome them, and some of the lessons learned by existing programs, focusing on the MTCs.

2

Improving Manufacturing Performance in Smaller Firms

"The competitive pressures are so great, we haven't been able to raise prices since 1978. We have to emphasize cost reductions and productivity improvements."[1]

Smaller companies confront major problems in responding to increased global competitiveness. These problems encompass a broad range of issues, only some of which relate directly to technology. They include:

- disproportionate impact of regulation;
- lack of awareness and insufficient knowledge of best manufacturing practices and modern technologies;
- isolation and insufficient interaction with other manufacturers;
- where to seek advice and sources of reliable, unbiased information; and
- scarcity of capital and difficulty acquiring sufficient investment funds.

Inadequate resources—people, money, expertise, information—and insufficient time are the bases for many of these barriers to increased manufacturing competitiveness. The idiosyncracies that come from the

[1] The quotations interspersed throughout this chapter are taken from the committee's conversations with owners and managers of smaller manufacturing firms who participated in the eight workshops hosted by the committee throughout the United States during the period of this study.

genesis of entrepreneurial companies are also contributing factors in their resistance to change and slow adoption of more advanced technologies and new organizational structures.

Five fundamental barriers to manufacturing performance improvement in smaller manufacturers were identified and discussed during the eight workshops hosted by the committee; all are well corroborated in the extensive literature about conditions in smaller firms. The committee met with nearly one hundred small manufacturing owners/managers, as well as extension service field agents and managers from Manufacturing Technology Centers (MTCs), state extension programs, universities, and trade associations. In addition to discussing barriers facing smaller manufacturers, both company representatives and assistance providers discussed opportunities to help firms overcome these barriers and significantly improve the cost, quality, and market responsiveness of their manufacturing operations. The following sections describe the ideas raised in these discussions.

BARRIER 1: DISPROPORTIONATE IMPACT OF REGULATION

The Barrier

The regulatory environment creates a disproportionate burden for smaller firms. National, state, and local initiatives and decisions concerning trade, the environment, employment, work place safety, health care, and liability have a direct impact on the competitiveness of manufacturing companies. For smaller firms, the economic impact of regulatory compliance is much greater as a percentage of capital investment than it is for larger businesses.

> *"Compliance with regulations is straining the resources of the company [sales of $7–8 million]. . . last year our entire budget for new investment and new equipment—$500,000—was spent to meet EPA [Environmental Protection Agency] regulations."*

Whereas many large firms spend enormous sums of money for corrective activities and new equipment to comply with complex regulations, smaller firms cannot easily afford or justify such investments. First, the alternatives are limited in many instances because equipment appropriate for their scale of operations and capital budgets

is not available. Second, the fixed costs of regulatory compliance can be a greater burden for smaller firms because they must spread the costs over fewer units of production than large firms. The result of these circumstances is that the attention and resources that should be invested in productivity growth and innovation must instead be directed towards assuring conformance to regulatory actions and insurance for product faults (*Forbes*, 1993).

> *"I believe that there is a need for environmental controls, but we can't read, understand, or interpret the flood of regulatory paper that comes at us. We can't plan for it. . . we just can't keep up."*

Despite efforts to lessen the impact of regulatory actions for small businesses,[2] the amount of time and effort required to stay abreast of and to comply with regulations has become a disproportionate hardship for smaller organizations. A fundamental reason that the regulatory problem is so difficult for smaller firms is that its sources are so numerous and diverse. When federal, state, and local jurisdictions are included, the potential permutations and combinations of regulatory structures are overwhelming. In a survey for the National Federation of Independent Business, respondents said that regulatory problems increased in severity more than any other type of problem over the last five years. The increase in severity varies across states, which indicates that the federal government is not solely culpable (Dennis, 1992).

The circumstances of smaller manufacturers are further complicated by the growing impact of health and employment regulatory action by the government and the largely unknown consequences of major changes in the relationships among the international trading partners of the United States.[3]

[2] *Regulatory Flexibility Act, 1979, Public Law 96-354 [S. 299]*; September 19, 1980. An Act to amend title 5, United States Code, to . . .establish as a principle of regulatory issuance that agencies shall endeavor [consistent with constraints] to fit regulatory and informational requirements to the scale of the businesses, organizations, and governmental jurisdictions subject to regulation. Agencies are required to solicit and consider flexible regulatory proposals and to explain the rationale for their actions to assure that such proposals are given serious consideration.

[3] Smaller manufacturers are particularly concerned about low-wage competition that is likely to result from changes in relationships with Mexico as a result of the North American Free Trade Agreement (NAFTA). For example, see *Wall Street Journal*, March 10, 1993 and March 29, 1993.

"In their eagerness to punish us for relatively innocuous infractions of OSHA [Occupational Safety and Health Administration] rules, inspectors threatened to shut down all of our production operations."

Many companies at the workshops noted that enforcement of regulations is capricious. There was a general sense that regulations are difficult to track so firms may be in violation unknowingly. Companies are convinced that government is intent on detecting violations and fining companies rather than providing any assistance in achieving compliance in a nonthreatening manner. Based on their experiences, smaller organizations are skeptical when someone from the government says, "We're going to help you solve your problem."

"We know that there are some areas of our production operations that are violating EPA regulations, but we're afraid to call the local office and ask questions about the regs. We feel that calling them for help just ends up getting us audited and fined."

Companies have few places to go for affordable advice or help on interpreting environmental regulations. Fear that inquiries about rules and means of complying will result in plant visits and subsequent citations causes many companies to ignore the potential problems.

Opportunities for Resolution or Improvement

Most manufacturers at the workshops agreed that regulations and rules concerning the environment, the work place, and employment are necessary. Their concerns, however, are with the overwhelming increase in complexity and specificity, what they perceive to be capricious enforcement, and the crushing economic burden they represent for small companies struggling against foreign competitors that are not subject to equivalent constraints.

Opportunities to improve the circumstances for smaller manufacturers to contend with regulatory burdens arise primarily through increased awareness of technological means for meeting compliance standards and better coordination among companies and regulation promulgating agencies. The following specific opportunities were identified:

- Timely information to manufacturers about new or modified regulations can help them assess how the regulatory actions will impact their operations and determine alternative means of complying.
- Greatly improved dialogue between regulators and smaller manufacturers is needed to encourage both realistic expectations in the design of new regulations and a realistic pace of compliance given the constraints facing smaller manufacturers.
- Smaller manufacturers could benefit from efforts to articulate clearly the specific problems and constraints they face in complying with regulations. Such a clear articulation could be used not only as information in the regulatory design process, but also in mobilizing university and federal research resources and equipment developers to create effective technological responses appropriate for small firms.
- The strategies of regulatory agencies need to be reoriented towards "compliance assistance" organizations rather than "adversarial and punitive" organizations.
- One means for improving dialogue between regulators and smaller businesses involves offering assistance in identifying and filing appropriate forms and documents required by regulatory agencies.

BARRIER 2: LACK OF AWARENESS

The Barrier

Smaller manufacturers are often unfamiliar with changing technology, production techniques, and business management practices. The staff and senior managers of smaller manufacturing companies must devote most of their time and energies to managing the day-to-day operations of the firm. As a consequence those companies are less likely to be aware of best manufacturing practices, innovative application of new technologies, and fresh approaches to improved production efficiency. With less relevant experience and expertise, their expectations for successfully selecting and effectively assimilating new technology are not high, and so they are less likely to risk investment in new ways of doing things or in major changes to the management structure and relationships within the business.

Companies need to be motivated to improve their performance and seek assistance. Many companies confront survival-threatening aspects of global competition before they recognize the seriousness of the performance gap. For smaller firms this may be too late. Without the

resources and necessary time to accomplish the needed changes, smaller firms can simply disappear from the competitive scene.

This situation can be helped to some extent by broader dissemination of information that explains the competitive challenges confronting manufacturers. Smaller firms, particularly those that are in the supplier chain for larger multinational companies, must understand how global competition can affect their business, even if they do not perceive themselves as exporters or participating in other than domestic markets. Companies hear about world-class manufacturing but they have very little concept of how it applies to them or what it means for them operationally. They need help translating the abstract language of global competition into best manufacturing practices and state-of-the-market technology.

"We know we have to change, but we struggle with implementation."

Even when smaller companies recognize the importance of changing, their circumstances—fewer managerial, technical, financial, and marketing resources than larger companies—present a daunting environment in which to accomplish the needed changes. Their scale of operations prohibits development of customized programs for upgrading the skills and talents of workers.[4] The owners and managers of smaller companies are preoccupied with day-to-day survival. Insufficient time and expertise cause many of them to disregard long-term planning or development of a coherent vision for the company.

Smaller organizations are particularly vulnerable because they are forced to undertake multiple changes and adjustments with little margin for error. They are faced with assimilating the new tools, disciplines, and philosophy of lean manufacturing, embracing new ways of delegating responsibilities, and developing new kinds of collaborative partnerships with customers, suppliers, and employees; often simultaneously and under pressure from their prime customers. Although some suppliers receive help in making the necessary changes from their larger customers, others are struggling on their own. For many of these companies, innovations are perceived as risking the solvency of the company, not only because of the financial costs involved but also because of the resulting disruptions on the shop floor that can interrupt

[4] When smaller companies have devoted time and resources to improvement of worker basic skills, they are generally pleased with the results of their efforts. For case studies conducted at four smaller manufacturing firms during 1991–1992, see Faison, et al., 1992.

production. Consequently, investment in new technologies and other innovations are delayed and avoided.

> *"I know I should be more aware of modern technology, but I just don't have the time to focus on many of the issues in technology that are changing quickly."*

Managers' preoccupations with keeping the company alive and fighting day-to-day problems result in low awareness of new manufacturing developments and inadequate access to timely market information, technology availability, and knowledge of best practices for design and manufacture. When they do decide to adopt new technologies they need help to integrate the technology quickly and effectively without bringing the rest of the business to a halt.

> *"Our biggest work place reorganization problems are with the supervisory people rather than the machine operators."*

Smaller companies need help changing the manner in which they organize work, understanding the importance of upgrading the skills of their employees, and locating the proper means to improve their abilities to function effectively in a rapidly changing environment. For larger companies, transforming organization structures, adopting new ways to accomplish tasks with self-directed teams, and collaborating with customers is so different, so foreign to their company culture, that entire layers of managers must be removed for the changes to be accomplished.

Small companies without extensive management often face even greater difficulties because the decision-making authority has always rested with the owner. Changing the firm's internal and external organizational relationships requires the owner to relinquish some authority to his workers and his customers, which often runs counter to his reasons for owning the business. In many, many cases, only a major crisis of company survival is sufficient to motivate change.

> *"It's impossible to introduce greater worker responsibility or teach modern problem-solving skills when so many of my employees have insufficient math and reading skills."*

Manufacturers increasingly must deal with workers that have insufficient reading skills and are unable to perform simple arithmetic. Mastery of reading and math are increasingly important as workers

operate computer-controlled machinery and equipment that requires understanding instruction manuals, entering data, and maintaining statistical process control information. In numerous parts of the United States the inability to speak English must first be overcome before the organization can begin to consider further efforts to upgrade the skills of its employees. However, managers' commitment to restructure factory operations and to invest in new equipment that requires greater worker participation is often the major motivation for workers to improve reading and math skills (Rimington, 1992).

> *"English is a second language for 60 percent of my production floor employees."*

The benefit of investments in work force education is not always reflected only in upgrading work-related skills. Companies find that the investments they make to develop common communication skills—spoken and written English—are a necessary foundation for any type of improvement program or successful change. Financial commitment to training and education is often perceived by the employees as evidence that the organization is serious about making the changes and improvements necessary to create a more competitive manufacturing company, and not another "program of the month" or cost-cutting measure.

Opportunities for Resolution or Improvement

Despite the difficulties confronting smaller firms, there is evidence that when they make the commitment to change, the changes take place more rapidly than large companies and often with much greater success. Therefore, the problems of gaining access to appropriate information and instilling appropriate knowledge and skills in managers and workers create many opportunities for industrial assistance providers of all types to offer education and information-sharing programs. Key considerations are ease of access and tailoring for smaller firms' needs because smaller company employees have limited time for education programs and may not have appropriate expertise to gain much from programs developed for larger firms. Specific ideas discussed included:

- Nationally disseminated materials and programs can increase awareness of best practice. These would include: 1) benchmarking data for smaller firms to use in evaluating their performance against

companies of similar size; 2) timely publication of illustrative cases of best manufacturing practices on industry, regional, and national bases; and 3) development of case studies that are directly applicable to the circumstances of companies with few resources rather than scaled-down versions of large company "lessons learned." However, major effort is needed to develop methodologies, foundations, and technologies for identifying, organizing, and then deploying best practices to smaller manufacturers.

- Television programs could address issues particularly relevant to manufacturers and could reach a large audience. Providing smaller firms with greater access to video tape libraries that illustrate technologies and implementation problems is a means of increasing knowledge in the manufacturing community.
- Local and regional forums and workshops can introduce and demonstrate new technology, management methods, and market opportunities.
- Low-cost seminars and formal courses on selection, adoption, and management of specific technologies could be made available at times and places convenient for small firm employees.
- Mechanisms could be developed to facilitate access to information sources such as national databases and trade and professional societies.
- Mechanisms that provide access to equipment for "try before you buy" and training of workers could be expanded. Some MTCs already do this for some technologies, such as the computer-aided design (CAD) hardware and software facility at the Northeast MTC. Another example is the teaching factory which, among other services, provides companies with opportunities to use equipment prior to buying it themselves (see Chapter 3).
- Internship programs could be created for high school and university students and teachers to work with smaller manufacturers that would be unable to afford their participation otherwise.

BARRIER 3: ISOLATION

The Barrier

Smaller manufacturers are generally isolated and have too few opportunities for interaction with other companies in similar situations. Interaction with other firms is essential to continuous improvement.

These associations seem to be most productive when they occur among companies of similar size and with larger organizations that might be role models for smaller firms. The chance for suppliers to interact with major customers, to benefit from membership in a supplier improvement program or *keiretsu*-like confederation of companies, can provide enormous opportunities for smaller firms to improve their performance.

A wealth of literature and books on improving manufacturing is available (Schonberger, 1986, 1987; Shingo, 1983, 1988, 1989; Stalk and Hout, 1990; Taguchi, 1989; and Womack, 1990). Some exceptional companies have successfully applied concepts and techniques described in the literature, such as single minute exchange of dies (SMED), *poka yoke* (mistake proofing), work force empowerment, work flow redesign, and improved ergonomics, to cut costs, boost quality, and raise on-time deliveries.[5] But such commitment to improvement is rare. More typically, employees in smaller firms find much of the materials are focused on the solutions adopted by larger firms, or the cases presented may be relevant for other businesses. For many smaller firms the efforts to adjust the techniques and methods presented in books for practical use within their plant requires more time and attention than they can afford.

> *"I've read about SMED and I think I understand the concept of work cells, but I think that talking to people in other companies that have already gone through some of these things would help me understand how to make work place reorganization work in my shop."*

Strikingly, many executives and managers of smaller manufacturing companies have very little association or exchange with other manufacturers within the same or similar industry sectors—even when located in the same community. Therefore, they have insufficient opportunity to trade information about service providers, new practices, and technologies, or to learn from the experiences of companies in similar circumstances. They need to see principles at work in other factories and production settings to better understand operational aspects of implementation. The unknown risk associated with change holds them back.

[5] United Electric Controls, Inc. in Watertown, Massachusetts is one example of such a committed company. This manufacturer of instruments, controls, and sensors received the 1990 Shingo Award for excellence in manufacturing.

"ISO 9000[6] is a problem for us because our customers demand certification but it doesn't add value to the quality of our products or services."

Customers create pressure on suppliers to decrease costs and improve quality. They express their desire for suppliers to integrate new technology in their products and adopt new design and production techniques, such as CAD and programmable automation. Major customers increasingly expect smaller firms to take more responsibility for engineering, to participate in development of new products, and to adopt the same standards and performance measures as the customer uses in their organization. Smaller firms are generally not in control of markets or suppliers, and they have little leverage with suppliers and customers that are often larger and able to dictate terms and conditions.

"Our customers don't understand the impact that JIT (just in time) production has on the suppliers. They just tell us 'do it. . .if you want to continue selling to us.'"

More original equipment manufacturers (OEMs) have come to play an important role improving the performance of their suppliers and vendors; however, these large customers may be so engrossed in changing themselves that they cannot help their smaller suppliers master the required tasks (*Business Week*, 1993). They also tend to make contradictory or at least constantly changing demands as they succumb to the temptation of transferring the costs of adjustment to their weaker partners (Moody, 1992 and Welch, et al., 1992).

Despite the increase in the number of larger firms with well-designed programs for improving the performance of their suppliers, the size of the programs are constrained by the resources which the OEM can justify, so the number of suppliers that each program is able to help is limited. In fact, one principle of supplier relations that the larger firms are adopting is a radical reduction in number of suppliers from whom they purchase materials, parts, assemblies, and so forth. This further reduces the number of smaller manufacturers that are likely to obtain help from major customers (*Wall Street Journal*, March 29, 1993b).

[6] ISO 9000 is a set of standards created by the International Standards Organization for certifying the quality of production. ISO 9000 certification is becoming a standard requirement for companies exporting to the European Community. See Aune and Rao, 1992 and U.S. Department of Commerce, 1992b.

Opportunities for Resolution or Improvement

The manufacturers attending the workshops repeatedly pointed out to the committee that providing occasions (and excuses) for firms within the same, and across radically different, sectors of industry to meet and discuss common concerns and problems were among the most valuable services that a neutral party, such as a MTC, could provide. They felt strongly that the chance for owners and managers to have face-to-face discussions, to exchange information about new methods and technologies, and to hear first-hand how others handled similar business crises was invaluable.[7] Talking with other executives about problems in common is the best way to find out "what works, and what doesn't." Suggested topics included work force training, demographic changes, regulatory compliance, and access to investment capital; sharing stories about solutions attempted and approaches that worked; and comparing ways to respond to so many of the problems facing manufacturers today. For some companies this kind of interaction is sufficient motivation for them to begin significantly attacking their competitiveness problems. Many companies are surprised to learn that they have so many of the same problems and that help is available.

Even when staff and directors of assistance organizations have business and manufacturing backgrounds, their experiences and the problems they faced, in general, are different from what the owners and managers felt they were confronting today. They appreciated the expertise and experience of the assistance groups but they felt that the opportunity to speak with people that shared their same problems and challenges on a daily basis was especially valuable.

Specific ideas to facilitate more interaction among companies included:

- Construction and operation of networks of companies with similar interests and needs can be an effective way to share both costs and experience. Collective or joint activities among groups of companies can include worker training, marketing, production in "virtual enterprises," and cooperative purchasing of health insurance and production materials. "Sharing" consultants among groups of companies that have

[7] Unfortunately, they are less than enthusiastic about paying for such facilitating services. Therefore the paradox for assistance organizations that must be self-funding.

similar problems but are not competitors has been demonstrated successfully.[8]

- Workshops, meetings, site visits, focus groups, forums, and roundtable discussions not only motivate interaction among companies but also can provide entry to local, regional, and national webs of information.
- Some programs to help multiple companies can best be provided by professional societies, trade associations, and other membership organizations. These organizations should be encouraged to be more active in determining needs and developing appropriate programs for their membership.
- Television and video are means of exposing manufacturers to specific problems and the solutions adopted by other firms. Particularly as the technology becomes more readily accessible, video conferences among owners and managers within a region or industry sector could be arranged to share experiences and lessons learned.
- Electronic networks that provide bulletin boards for direct exchange of information and sharing of approaches to common problems will be increasingly valuable as the needed technologies penetrate into smaller companies. Eventually, such networks could be used to organize cooperative purchases and bid opportunities as an effective means of creating a "community" among manufacturers.
- Focus groups that meet on a regular basis to address important sector issues are valuable to manufacturers. Continuous Improvement User Groups (CIUGs), organized by the Midwest Manufacturing Technology Center, are an example. These are groups of companies that hold structured meetings, facilitated by MTC staff, to share experiences, effective techniques, training, and information in implementing continuous improvement of company functions. The CIUGs serve as mutual support systems, encouraging relationships so companies learn to help each other.
- An assistance provider could serve as a neutral convener of groups of suppliers and their major customers (supplier-customer councils) to help resolve different standards of performance and criteria for vendor certification.

[8] In a study for the Cleveland Advanced Manufacturing Program (Helper, 1992), the potential for networks was cited as very high, but the authors caution that their success depends on attention to a number of factors: well-defined plans for establishing the network, organizational support, the size and number of member firms, building trust among members, and availability of a champion who can articulate a vision for the network and who can be responsive to the perceived needs of the members.

BARRIER 4: WHERE TO SEEK ADVICE

The Barrier

It is difficult for owners and managers of smaller companies to find high-quality, unbiased information, advice, and assistance. When companies need help with technical problems, when they want to replace production or design equipment, or when they want to upgrade the skills and talents of their work force, they are often at a loss for sources of assistance. Searching for help in the public sector often reveals a confusing, uncoordinated array of services—universities, economic development groups, technical schools, government agencies— "competing" for clients.

> *"We didn't know where to begin when we started looking for a CAD system. There are hundreds of different ones out there and the vendors all said theirs was best."*

Today, smaller companies predominately need access to, and assistance in applying, off-the-shelf and best practice technologies, such as CAD, numerically controlled machine tools, inventory management, and shop scheduling. However, the number of vendors and products is overwhelming for an owner or manager who is unfamiliar with the technology. Inappropriate choices can waste precious resources and time, a waste that smaller firms cannot afford.

Vendors are one of the most frequently cited sources for diffusion of technology and best practices among industrial firms. Smaller firms depend heavily on the knowledge of vendors for much of the information they receive about advances in manufacturing practice, but these sources are not always viewed as unbiased and concerned with the best interests of the customer. It is easy to be convinced that the solution to a problem is a technology fix. Many companies could benefit from assistance in understanding that "best practice" is not always technology based.

> *"We've tried, unsuccessfully, to find affordable outside experts that can help us create worker teams and build so-called cross-functional skills."*

Consultants with the proper skills and expertise are expensive. Because their expertise is likely based on work with large businesses, their suggested solutions may be too costly and inappropriate for smaller

organizations. It is extremely difficult to justify sales calls on very small manufacturers. Experts for hire, many educational institutions, and other service providers in the private sector tend to concentrate on firms that will result in larger accounts and allow them to amortize their marketing costs more quickly.

> *"We don't feel like we can get unbiased advice from the university (computer science) department because they are given equipment and software by major computer companies."*

Sometimes it is difficult for smaller manufacturers to work with universities because the company may not have staff that is comfortable with university researchers. A frequently cited reason not to work more with universities is that the schedules of the university often do not move quickly enough to satisfy the needs of industry. The training and educational needs of the small business may not match the services that the colleges and universities want to provide.

> *"We want to be sure that (the assistance provider) understands our business before we start spending money and changing the way we do things. If they aren't able to convince my people out there on the floor that they know what they're doing, they're sure not going to convince me."*

Smaller manufacturers are often insecure about locating and selecting the correct assistance and service providers to help them make decisions that will involve expenditure of funds. They want to develop personal relationships and see demonstrated credibility of the individual service providers (field agents) before they are willing to accept their advice.

> *"We believe that the government labs have some of the technology that could help us comply with some very tough EPA regulations concerning solvent-based paints, but we don't know how to get them to listen to us."*

Although there may be fewer opportunities for smaller manufacturers to apply leading edge or advanced technology from government laboratories or universities, there are situations where the skills and capabilities of the laboratories could prove critical to the survival of smaller manufacturing firms. Smaller firms usually have no research staff who could present their needs in a manner that would be appreciated by

the laboratory personnel and they have few mechanisms to demonstrate strongly the importance of their needs to outside researchers. By the same token, smaller firms are unable to participate in most government-sponsored consortia but they would likely benefit from knowledge of research results if they were translated into implementable efforts.

> *"Our greatest disappointment has been the unavailability of skilled shop personnel to operate our equipment when the demand for our products has increased."*

Smaller firms in the same community as major manufacturers have less influence on the course content at local colleges and local technical schools. If their needs differ from the larger businesses, they are likely to have difficulty finding workers with the skills and training they need.

> *"Our employees need hands-on training, but the cost for in-house education can't be justified for the few people directly responsible. . . ."*

Insuring "technology awareness," increasing understanding of how to improve product quality, meeting international standards of excellence, and raising the level of worker talents are difficult issues for smaller firms. Most recognize the importance of tackling these objectives, but the costs of gathering the right information, providing appropriate training, and getting certification to standards such as ISO 9000 are often prohibitive. In many cases, it means hiring extra people or diverting workers and managers away from production, which is just not cost justifiable for most smaller manufacturers.

Opportunities for Resolution or Improvement

The nature of the issues that confront manufacturers are more likely than not to be multifunctional. Situations that are perceived as technology problems may also require that financial issues, worker training, and other elements be addressed. For instance, improving production practices by introducing new machinery and equipment may require transforming the organization of work, which goes hand-in-glove with changes in management practices. Accordingly, the services provided by the organization called upon to help the client should be perceived as an

integrated system of assistance, if not providing all services, at least able to direct the client to appropriate help for each assistance need identified.

The assistance and services available to smaller manufacturers often are not well marketed or coordinated in presentation, including those available from the private sector. The quality of these resources also tends to vary greatly and frequently are based on narrow technology fixes and the set of skills and interests of the assistance organization. Too often they are "hammers looking for nails." Manufacturing requirements planning (MRP), CAD, computer-integrated manufacturing (CIM), and statistical process control (SPC) are examples of technologies that reflect the solutions assistance organizations offer companies. These companies may not have the need for or the appropriate capabilities to use these technologies effectively.

During the workshop discussions, it was evident that firms desire a "one-stop" source of unbiased information and assistance geographically close to the manufacturing community. A number of services such a one-stop source could provide were identified:

- Information on what services, public and private, are available in the community and how to use them is a clear need. A number of mechanisms could be developed to help companies connect with high-quality assistance by knowledgeably linking private and public sector resources with manufacturing clients. These include maintaining databases of consultants with relevant references and qualifications, establishing toll-free telephone numbers to provide a single initial point of contact for firms seeking assistance, and supporting electronic bulletin boards to notify service providers of opportunities in the manufacturing community.
- Field engineers are critical to effective assistance. They provide small companies with a strategic perspective on how they compare to competitors and what changes they need to make to remain competitive in the long term. Among other duties, field engineers 1) help managers define what they need to do next; 2) scope the work; 3) locate resources; and 4) coordinate projects and assess success.
- A reliable, trusted source of market and technology information would improve smaller manufacturers' confidence in their investment decisions. There are opportunities to help firms match their needs with the proper equipment by helping them determine their needs and by providing information to assess and compare available equipment and services.

- Smaller firms with limited resources could benefit from project management services to coordinate and support (but not manage) contracted services between the manufacturing client and private (or institutional) sources of assistance.
- Smaller companies sometimes need specific expertise or technologies that are not available from private sources. Examples include CAD output conversion, access to special equipment that very small firms or start-ups are unable to afford, and very specialized technical questions. Industrial service providers can address these needs either by providing the needed service directly or by linking the client company with an appropriate source of expertise, such as a national laboratory or university.
- Education and training programs are often available from local vocational schools and community colleges, consultants, and associations, but smaller firms may not be aware of what is available or its quality. Examples include courses on ISO 9000 certification, CAD-CAM integration, and electronic exchange of business documents and product engineering specifications. Industrial assistance providers could identify and assess available programs, spur creation of new courses to satisfy company needs, and provide courses in cases where no other source is available, perhaps because of specific technical content.
- Improved linkages are needed among the various components of the technology development and user/manufacturing community. A neutral party such as a public technical assistance provider could act as interpreter and catalyst, communicating needs of manufacturers to vendors, suppliers, academic institutions, federal labs, and government agencies.

BARRIER 5: SCARCITY OF CAPITAL

The Barrier

Operating capital and investment funds for modernization are difficult for small and medium-sized manufacturing firms to obtain. The financial community does not readily understand manufacturing and often perceives loans for new equipment as unattractively high risks. Smaller firms are unlikely to have the capabilities needed to put together proposals for funds in the format familiar to lending officers. The consolidation of banks, with some exceptions, has removed much of the decision making from the communities where many loans have traditionally

relied on the "known character" of management and owners of the companies in lieu of collateral.

> *"The trick is to make enough money to pay for new technologies necessary to achieve quality required by customers."*

The growth in "outsourcing" engineering design and production by large businesses, which they had previously performed in their own facilities, can present smaller manufacturing companies with significant growth opportunities. However, working through the necessary economic justifications for making the investments in technology and people may be outside the capabilities of the smaller manufacturer. The companies may not have the planning and manufacturing know-how to meet such rapidly expanding demands, and they may have difficulty acquiring sufficient capital to meet their commitments. As they assume greater responsibility for product engineering, prior vendor and supplier experience, expertise, and resources may be stretched beyond their means to meet their expanded supplier roles.

> *"You can always finance the hardware; the problem is that the bankers and financiers do not understand the soft costs [e.g., training, programming] needed to make the technology succeed."*

Tightened banking regulations have made banks skittish about investing in small companies, particularly for technologically advanced production machinery and equipment (*All Street Journal*, April 27, 1993). Even when financing is available for capital equipment, funds to develop the skills and competencies required to apply and operate such equipment are very difficult to obtain.

> *"With the influx of large offshore manufacturers, we're afraid we'll lose the investment we've made in training [workers] because they'll take the higher paying jobs with large companies."*

The investment in worker training and upgrading skills and talents is seen by many manufacturers as an extremely risky venture. Other companies, generally larger businesses, are likely to hire the most highly skilled worker because they offer better benefits and sometimes higher salaries that smaller companies are unable to match (*Wall Street Journal*, April 19, 1993).

Opportunities for Resolution or Improvement

Although programs exist to help small firms access capital needed for improvements, they are perceived by the workshop attendees to be insufficient to meet the needs of smaller manufacturers. Significantly expanding such programs, however, raises issues regarding which firms should be helped and which should not, and criteria for choosing. The most efficient market strategy seems to be one of helping banks to understand better the investment needs of manufacturers and to recognize the opportunities available to them if they are willing to devote the time and energy to work with industry. Likewise, smaller firms need to appreciate the constraints and conservative nature of the banking community, which lead to the complex and rigorous process they must endure to acquire funds.

The workshop attendees thought the role of assistance providers in this area to be one of facilitating better understanding and stronger relationships between providers and users of capital. Specific ideas included:

- Educational programs for manufacturers could help build their understanding of the requirements of financial institutions and help them develop justification for their capital improvements in the format and language understood by the financial community. A better understanding of the particular information needed by lending sources to make funding decisions could also lead a small manufacturer to new insights regarding the operation of the company.
- Educational programs for local financial institutions could strengthen their understanding of manufacturing technologies, including the whole chain of hardware, software, training, and maintenance needed for effective implementation, as well as technology trajectories and competitive trends in specific industries. Appropriate education could, for example, help overcome lenders' reluctance to accept advanced manufacturing technology as collateral due to the perception of a limited resale market for such equipment. Such programs could also raise lenders' appreciation of the importance of manufacturing in their communities.
- Assistance providers could facilitate creation of mutual loan guarantee networks among peer companies. Programs in some European countries offer models.

Other ideas discussed by the workshop participants related to broader government policy to raise the supply and lower the cost of capital for smaller manufacturers. Ideas such as the creation of a national fund to make equity investments in smaller manufacturers were discussed; similar funds to provide bridge loans and subsidies to encourage upgrading production equipment were also mentioned.

IMPLICATIONS FOR MANUFACTURING ASSISTANCE

This set of barriers to improved manufacturing performance and the ideas raised to help firms overcome them are familiar to the many organizations and companies striving to provide assistance to smaller manufacturers. The efforts of many assistance organizations, including the MTCs, educational institutions, and businesses have demonstrated ways to help companies successfully contend with most of these obstacles. In some cases, the "solutions" are prototypes, still in the embryonic and experimental stages of development. Some, such as flexible manufacturing networks,[9] were first adopted in other countries but have been shown to be effective means for improving the performance of American firms as well. Still others have been deployed on only a limited scale and remain "islands of assistance best practice."

In some assistance organizations a "project orientation" has been the favored approach for delivering services to client companies. The service providers answer technical questions, furnish the information needed to solve problems with production processes, and help select computer systems or train workers to operate new machinery. The project approach, however, is severely limited in the number of clients that can be helped, because the assistance is provided on a one-on-one basis.

There are many opportunities for assistance organizations to leverage their assistance resources and offer help in ways other than one-on-one contacts. In fact, some of these may prove to be even better mechanisms for quickly improving the performance of smaller manufacturers than individually provided help.

[9] Flexible manufacturing networks in the United States are still in the experimental stages of development and evaluation. It is likely to be several years before their success is substantively documented. See Piore and Sabel, 1984; Sabel, et al., 1987; Ruxton, 1990; and *The Entrepreneurial Economy Review*, 1991.

Other concerns, such as regulatory burdens and access to capital, can be addressed to only a limited extent by manufacturing assistance organizations. Effective solutions to these barriers will require participation by government and regulatory agencies, constituencies that have not historically perceived their role as contributing to the improved performance of smaller American industrial firms.

3

Improving Manufacturing: Sources of Assistance for Smaller Companies

The previous chapter presented many of the problems facing smaller manufacturers: maintaining technological parity vis-a-vis competitors, learning about and adopting new business management principles and practices, justifying and locating financial support for growth and modernization, responding to the marketing opportunities and threats presented by the movement to increased globalization, and understanding an increasingly complex and expanding base of regulatory actions and constraints. This chapter describes some of the many institutions, agencies, programs, initiatives, and organizations that are intended to help manufacturers improve their performance in the areas of quality, cost, and responsiveness.

With some regional variation, assistance is available in both the private sector—consultants, equipment suppliers, customers—and in the public sector—educational institutions, state industrial extension services, and various federal programs. The availability of public assistance, which is usually dependent on funding by state and local government, tends to vary with the perceived contribution of smaller manufacturing firms to the well-being of the local economy. The best state programs usually help no more than a few hundred firms per year. There are no precise data available on the number of smaller companies buying private sector assistance (Clarke and Dobson, 1991). Based on the committee's discussions with company owners and managers, and a review of available surveys and other research, the committee is convinced that many thousands of smaller manufacturers could benefit from outside assistance to cut costs and improve quality and timeliness.

PRIVATE SECTOR ASSISTANCE

The private sector offers a number of resources that manufacturers can buy to solve problems, to modernize their production operations, and to upgrade the skills of their workers. Among these are consultants, suppliers of technology, trade associations and professional societies, and other miscellaneous service providers. While not providing direct assistance, the trade press and industrial expositions and conferences also serve as important sources of information on new technology and management techniques.

Consultants

Smaller companies report mixed results in working with consultants. The backgrounds and expertise of many consultants are primarily founded on principles relevant to larger corporations; they often fail to appreciate subtle but important differences in smaller organizations. Although some consultants specialize in working with smaller firms, a company may have difficulty locating a consulting source with the right mix of background and expertise. Executives in smaller firms may also have difficulty defining their problems or specifying exactly what they expect of a consultant.

Many smaller companies may be reluctant to engage a consultant on a long-term basis, and those hired for short-term projects may have little or no follow-up responsibility. Furthermore, a small firm may simply disagree with or otherwise fail to implement the recommendations of the consultant.

Consultants secure much of their business through "word of mouth" referrals among clients' peers. But small firms may not have a well enough developed peer network to find satisfactory consultants in this manner. Some manufacturing assistance organizations, including the Manufacturing Technology Centers (MTCs), have developed a cadre of third-party consultants and are able to help firms identify and select appropriate experts. Associations and professional societies often provide this kind of help as well, identifying consultants with appropriate experience and expertise in relatively narrow segments of industry.

Selective use of consultants is a way for industrial assistance providers to broaden and extend their services, especially when their budgets or third-party funding allows them to absorb part of the consultant's fees and expenses that would be billed to the client. The

state of New York, for instance, invests several million dollars annually to provide matching funds to companies to hire consultants.

Vendors and Suppliers of Technology

Technology vendors and suppliers include machine tool builders and producers of capital equipment, sources of computer hardware and software, materials and component manufacturers, and so on. Many of these companies offer relatively extensive applications engineering assistance to their customers. The suppliers that offer these services, however, are likely to devote more attention to those companies that represent larger sales accounts.

For example, when presenting the final report on an Air Force project that developed automation technology for small subcontractors, a senior R&D engineer with a leading machine tool company frankly admitted that his company preferred to market the technology to larger original equipment manufacturers (OEMs). The larger companies, he said, were more likely to purchase the products, and in greater volume, while the small firms would have difficulty raising cash to purchase only one or two units, and would generally be more skeptical of the new technology.

Companies developing and marketing products and processes of interest to manufacturers obviously have an inherent interest in promoting their own merchandise and services to the exclusion of those of their competitors. Even second-tier suppliers, such as dealers and distributors, cannot be expected to recommend products and services beyond the lines that they handle. Although many suppliers will provide fairly substantial "proposal engineering" services while competing for a sale, fewer will follow through with sustained support and service after a sale to a relatively small customer.

Most leading suppliers of factory management software systems also have active user groups. These groups constitute special-purpose associations, which provide opportunities for personal networking and for sharing experiences and information above and beyond the application of the common software product.

Substantial differences in the availability of supplier services may exist from one region to another. Manufacturers in Chicago, for example, can examine many different makes and models of machine tools at dealers, distributors, and working installations in the immediate

metropolitan area. A similar company in Arkansas may need to travel hundreds of miles to look at the same array of equipment.

In general, smaller manufacturers often need help finding the right equipment and vendors for their operations, as well as help implementing it; some industrial assistance providers are filling this role in various ways. For instance, the Great Lakes Manufacturing Technology Center (GLMTC) secures loans of equipment from suppliers and permits clients to try it at the GLMTC facility without the pressure of a sales environment. A similar concept is employed by "teaching factories" in several locations (see page 66).

Supplier Chains

Many smaller manufacturers are suppliers to large manufacturers of products such as automobiles, aircraft, computers and office equipment, appliances, machine tools, and other industrial equipment. These final product assemblers may spend 50 to 80 percent of final product cost on purchased inputs (Welch, et al., 1992). In such situations, the viability of the small firm will depend on the nature of its relationships with its large customers and on the strategies adopted by the large partners. Likewise, the purchaser can come to depend heavily on the performance of the companies constituting its supplier chain (Shapira, 1990b).

As members of a supply network, smaller companies feel increasing pressure to improve significantly the quality of the products they provide, to shorten radically engineering cycle time, to increase product performance, and to improve shipment schedules for smaller lot sizes, all while continuing to reduce prices. In a study of relationships between major customers and smaller manufacturers, Kelley and Watkins found that close links between supplier firms and their customers help spur suppliers to adopt more advanced technology and that the efficiency of the smaller firms increased the more frequent and intensive their interactions with the technical and managerial staff of their customers. These interactions appear to augment the limited engineering and management capabilities of small organizations. A comparison of smaller firms within such a supplier network to counterparts operating outside estimated a 15 percent cost advantage for those that were part of the supplier network (Kelley and Watkins, 1992).

The purchasing groups in many large companies have begun to change the historically adversarial relationships with suppliers. They now help suppliers understand their purchasing needs and meet their

requirements for cost, quality, and delivery. However, the manner in which these customer-led programs are implemented and the kinds and amount of assistance provided to suppliers vary broadly. Some limit their involvement with suppliers to periodic reviews of anticipated production and new product development plans, seeking input for improvements to products as well as presenting new opportunities for supplier participation. Others have comprehensive programs to help vendors and suppliers meet company mandated quality, delivery, and cost requirements (Moody, 1992). One attribute that most of the supplier improvement programs have in common is significant reduction in the number of firms from whom they purchase materials, components, parts, and subassemblies (Welch, et al., 1992).

Unfortunately, the majority of these customer-led efforts address only the first-level suppliers and in most instances the assistance provided to suppliers addresses only the aspects of the business that are directly related to items they are buying. Other areas of the supplier's business, which might benefit from interaction with the customer, are unlikely to receive attention. And companies at the second, third, and fourth level do not, for the most part, receive much help from their customers. Many niche market producers do not fit into a supplier chain at all, so have no access to help from large companies.

Professional and Trade Associations

There are over 6,000 professional societies and trade associations in the United States, not including the many local and regionally based organizations. Virtually all of these groups are not-for-profit corporations, governed by boards elected from their membership.

At the national level, most of these organizations have relatively modest operating budgets and a small paid staff; locally, there is typically no paid staff, but a rotating cadre of member volunteers who plan and implement local activities. Revenue streams are typically based on membership dues, meetings and conference fees, publishing sales, trade shows and expositions, and, in some cases, grants. Some associations also sponsor programs for group purchases of insurance and other benefits which return a royalty fee to the organization.

Professional societies are organizations of *individuals* in a common occupational field or with common occupational interests. Members of these groups may be employed in companies of any size, and services and benefits of membership are usually aimed at the worker rather than

their employer. The Society of Manufacturing Engineers (SME) and the American Society for Quality Control are two large professional societies that address issues of industrial modernization and competitiveness.

Trade associations are composed of *company* memberships, although in practice, especially among associations oriented towards smaller companies, relations are often confined to one (usually the owner or chief executive) or a few management personnel in the member firm.

No two associations or societies provide an identical mix of benefits and services to their members, but there are a number of activities that are common to many:

- Meetings and conferences are perhaps the most common denominator of all membership organizations. Programs for these events usually focus on management education or technical subjects, but many participants believe that the greatest benefit of such meetings and conferences is the opportunity to meet and share experiences with their peers. A high level of informal networking often arises among participants at these events.
- Educational programs are offered in a wide range of forms, including seminars and tutorials, correspondence courses, audio and video cassettes, books, and informative articles in newsletters and magazines. Some associations and societies sponsor courses through local chapters in conjunction with community colleges or other educational institutions. Some groups offer scholarships to attract talented students to their field of study. The SME, for example, has been instrumental in gaining recognition of manufacturing engineering as a distinct engineering discipline at the university level. The SME and other groups also offer a variety of professional certification programs.
- Publishing is another common activity of membership organizations. Virtually all publish at least a periodical newsletter or magazine. Many produce directories of members that serve as marketing tools. Some publish technical manuals or reference materials appropriate to their fields. Some develop and publish standards, guidelines, or recommendations for technical practices. Publishing activities of these groups are often closely linked to related educational activities.
- Advocacy efforts of one kind or another are often a major function of associations and societies. These kinds of activities range from public relations "image" campaigns to active lobbying at both the legislative and regulatory level. Many membership organizations maintain a Political Action Committee to contribute to supportive candidates for elected office.

Advocacy efforts are often the only evidence of membership groups seen by government officials and bureaucrats. While advocacy is the sole (or principal) function of some groups (including the highly visible National Association of Manufacturers), most groups recognize that these kinds of activities are only one aspect of being the voice of the profession or industry.

- Information services are another common benefit of membership groups. The data for these services are often gathered through membership surveys concerning wages and salaries, operating costs, safety, sales levels, technical or business practices, and so on. The Association for Manufacturing Technology operates a comprehensive information service for its member companies, staffed by professional research librarians. Even associations with less formalized information services will usually attempt to respond to the requests of members for sources of obscure standards or technical information.

Books and Periodicals

There are innumerable books, newsletters, journals, and other published materials concerned with changing and improving management structures, implementing lean production, uncovering foreign manufacturing secrets, adopting statistical process controls, developing worker teams, and applying total quality management. These are, in general, a basis for intellectually understanding the different means of achieving competitiveness. They provide guidelines for aspects of the problems confronting manufacturers but cannot be embraced as cookbook solutions to the problems that challenge companies today.

In the abstract, the problems confronting smaller firms may be similar. Their proper solution, however, requires an awareness and appreciation of the particular constraints, idiosyncracies, and size of each company, adjusted for individual company strengths and weaknesses, as well as the particular characteristics of each industry. Effective application of the world-class manufacturing principles described in the literature therefore requires a great deal of intellectual effort and commitment by the managers of the company who know its situation best.

PUBLIC SECTOR ASSISTANCE

Numerous initiatives have been undertaken at the federal, regional, state, and local levels to help manufacturers and business in general. For the most part, these initiatives have become overlapping uncoordinated programs, and the effectiveness of many programs has yet to be systematically evaluated or demonstrated. The programs typically operate on fragile financial underpinnings and often compete for funds to support assistance efforts. At times the manufacturing community can see only a crazy quilt of disconnected services that appear to be more reflective of the expertise and interests of the organizations offering the assistance than of the client demand from the private sector.

State and Local Initiatives

City and county economic development councils, with certain exceptions, have given less attention to retaining and increasing the success of firms already in the community than to recruiting new companies or new plants to the city or locale. Most states also have extensive efforts to increase the international competitiveness of businesses in their region and to attract new economic development. Many have gone so far as to open trade offices in other countries to lobby foreign firms that may be interested in establishing new facilities in the United States and to increase the amount of exports from firms within their state.

By most measures state governments have made the greatest efforts to help manufacturers become more productive and competitive. With varying success, nearly all of the industrial states have launched programs that offer business practices and technical assistance to local firms. The majority of these efforts draw substantially on university science and engineering faculty to support technology transfer programs modeled after the Cooperative Extension Service supported by the agriculture community for the last 70 years. Others are designed to capitalize on the state's vocational-technical system and community colleges.

A study of the state-funded technology assistance programs by the National Governors' Association identified 42 programs in 28 states (as of 1991) with total funding for fiscal 1991 of $83 million. About half of the programs are administered by universities or community colleges, and the other half by state agencies, quasi-public organizations, or

private nonprofit organizations. The staffs of these organizations tend to be small: the majority have ten or fewer professional staff who are generally technically educated with business experience. The 42 programs served a total of 17,500 clients in 1990. These organizations may provide technical assistance to all types of businesses, but the majority of their clients are manufacturing firms (Clarke and Dobson, 1991).

State programs deliver services in a variety of ways. Most provide technical information in response to specific questions, problems, and requests from manufacturers. Some programs are supported by field agents that visit firms and deliver one-on-one assistance. The most frequently provided support is to improve a process or to solve a problem through use of an existing technology. The programs also help companies identify and select vendors and in some cases help write work specifications for the tasks to be accomplished (Shapira, 1990b). Some go so far as to manage projects for smaller firms that do not have the inhouse expertise.

The programs also try to help firms maintain an awareness of recent technology developments, such as new software and computers or production machinery. They publish newsletters, host workshops, and conduct a wide variety of classroom courses on productivity and quality improvements. Machine tools and computer equipment are sometimes available for demonstrating new production methods and to train workers. Several state programs are discussed in more detail in Appendix B.

Universities

Universities offer a particularly rich source of technical and business practices assistance. Faculty and other members of the university staff are frequently available as consultants and contractors to private industry. When involved in state-sponsored technical assistance programs, faculty are more likely to focus on issues of advanced technologies in contrast to applying off-the-shelf, state-of-the-market technology, although the same is not true for engineering extension specialists. In addition, some university-based assistance efforts use engineering students as field agents, or assistants to field agents, working directly with local firms. These programs have found that, given proper training, students are an effective, affordable resource to assist both public and private service providers.

Assistance from universities, however, is sometimes criticized for being geared more to the academic calendar and academic interests than to the needs of business clients. Faculty tend to focus on quite narrow aspects of particular disciplines and technologies, and to be intent on using summers to conduct research rather than to teach courses for local businessmen. Their orientation or approach to problems is often a scientific investigation with no sense of urgency and no immediate applications. A small business with a pressing problem that may be blocking achievement of quality levels or production goals does not want to hear that the issue cannot be addressed "until the next semester." Other criticisms relate to faculty and students who lack a general understanding of real-world business concerns, especially issues facing smaller manufacturers. Some European engineering schools address this shortcoming by requiring professors to take periodic sabbaticals for relevant experience in industry in order to maintain their credentials.

Technical Schools, Community Colleges, Apprenticeship Programs

Two-year colleges have become a major source of job training and education for American manufacturing companies. In addition to day and evening degree programs, these institutions typically offer a comprehensive array of short courses geared to the needs of the community. In most cases, these colleges will customize a program on demand for some minimum class size (often 12 or 15 students). These customized programs can be presented at the business site or at the college.

However, smaller companies may be at some disadvantage, since the minimum class size may represent a very large percentage of any one company's work force, and on-site programs may conflict with production demands. These colleges may also suffer the handicap of being oriented to a fixed academic schedule, but they have more flexibility in this regard than four-year colleges. Also, as a group, these schools generally have greater flexibility to select faculty with industrial backgrounds, since academic credentials may not be as important as practical knowledge and experience.

Many two-year colleges have successfully worked with local industry to establish programs based on traditional, apprenticeship-type training and education. They offer credit towards a degree for apprenticeship classes, and, with industry support, provide facilities for hands-on demonstration of new, practical manufacturing technology. In some cases the community college has absorved tooling and machining apprentice

training that was formerly done privately by a local industry group. Community colleges in Michigan and Wisconsin, for example, have programs to develop advanced skills in machining, tool and die making, and plastic injection mold building. In many respects, these schools have taken up an educational role that was once filled by vocational-technical high schools and post-secondary institutions.

Federal Programs

An array of federal government initiatives assist small business. Firms, however, perceive these programs to be disjointed and sometimes redundant. Agencies of the federal government have, with some exceptions, viewed assistance to industry as a secondary mission. For instance, the Small Business Administration (SBA) addresses many general business issues that may be of interest to manufacturing firms, but its capacity and abilities depend on regional leadership and the variability of its services reflects frequently shifting priorities. The emphasis of the SBA tends to be on loan guarantees, start-ups, and minority business, with no particular focus on manufacturing.

Federal efforts to help smaller firms have, in general, emphasized development of new mission-related technologies, supported the spin-off or deployment of technology developed in federal research facilities to the private sector, and increased research and development opportunities for smaller companies. For instance, all federal departments and some agencies now have Small Business Innovation Research (SBIR) programs providing set-aside funds to "strengthen the role of smaller firms in meeting federal research and development needs."[1] Cooperative Research and Development Agreements (CRADAs) are another mechanism intended to link the research capabilities of government and universities more closely to industrial and commercial applications by sharing the costs of moving advanced technologies out of the federal laboratories.

[1] The SBIR program, however, has not been utilized by many smaller manufacturers because of its academic, scientific-oriented proposal process. Greater importance needs to be directed towards the development of a user-friendly interface between small companies and federal agencies (Ruxton, 1989).

Federal Laboratories

The federal laboratories are required by legislation to transfer technology to the private sector. For instance, all of the DoE national laboratories now have full-time technology transfer staff and have begun to place some emphasis on reaching smaller firms. A National Technology Transfer Center has been established as an information clearinghouse on technology transfer opportunities in the laboratories and other federal facilities. A consortium of the technology transfer officers in the laboratories has been formed to share information, network, and direct small company clients to appropriate sources. Yet, the majority of successful transactions appears to remain with large corporations that are able to afford for an appropriate researcher to spend extended time at the laboratory with which they have partnered. Smaller firms usually do not employ such researchers and, if they do, cannot afford to be without them while they investigate possible applications of national laboratory technologies.

Many observers have also cited a "cultural gap" between the laboratories and the manufacturing community, especially smaller companies. The dissimilarities are as great as they are many, but to name a few:

- Time horizons for projects in research laboratories may extend over several years; projects in smaller companies are typically very short.
- Laboratory employees tend to have advanced degrees; managers and owners of smaller companies often lack college degrees.
- Smaller companies are pragmatic: they must meet payrolls and deliver, when promised, quality products that satisfy customer expectations. Research laboratories are driven by "funding" to conduct research which may yield uncertain results.

In the post-Cold War environment, reduced demand is resulting in accelerated outreach by the laboratories to smaller companies. For the laboratories to be successful in reaching smaller companies, however, they first must understand the needs of these manufacturing companies and make their capabilities better known among smaller firms. Because efforts to work with smaller companies are just beginning, mutual understanding of the benefits of the laboratories and smaller firms working together can be expected to increase with time.

Department of Defense

The Department of Defense (DoD) has a number of programs that are intended to encourage the development and adoption of new technologies in manufacturing process and product design. The Advanced Research Projects Agency (ARPA) sponsors leading-edge defense research in manufacturing among its many other fields of investigation. Most defense manufacturing initiatives, however, have been managed through the Manufacturing Technology Program, known more commonly as ManTech.

All of the service branches plus the Defense Logistics Agency have ManTech programs that concentrate on helping the defense industry investigate the feasibility of production technologies considered too risky or DoD-focused to be undertaken by manufacturers on their own. This funding of research and development has been supported by DoD since 1947. One of the most acknowledged successes was the design and development of numerically controlled machine tools in the 1950s. Among its suppliers, ManTech spends approximately $150 to $200 million annually to promote shop-floor modernization (U.S. Congress, 1990). The focus, however, of ManTech and DoD in general has been in those areas of manufacturing that directly support the military mission of the Department of Defense—armament, protective apparel, and so on.

A few ManTech programs have specifically addressed smaller companies at the subcontractor level.[2] The Air Force Machining Initiative for Aerospace Subcontractors (MIAS) program set up demonstrations in a handful of smaller firms of shop management software and of untended machining. An exhaustive assessment tool, the Small Manufacturer's Improvement System (Service), or SMIS, was developed under the MIAS program. The Air Force intended that SMIS tools would eventually be commercialized. The developer of the system, however, never successfully commercialized the SMIS consulting activity, most likely because the commercial cost ($50,000) was seen as excessive by the smaller companies it was supposed to serve.

The Navy ManTech Rapid Acquisition of Manufactured Parts (RAMP) program focuses on DoD subcontractors. The purpose of RAMP is to enable suppliers to make replacement parts on demand through automation. The project is closely linked with a multiagency

[2] The Air Force has noted that about 70 percent of a military aircraft is manufactured in companies of 100 employees or less (Ruxton, 1989).

task force developing the next generation of engineering software to describe manufactured parts.

The Navy also has sponsored the Best Manufacturing Practices (BMP) program which evaluates operations, methodologies, and procedures of (primarily) DoD suppliers. Companies that believe that they have developed noteworthy methods are visited by an assessment team that, following a BMP-developed template, prepares a report which is circulated freely. Report results are also available from a database on a publicly accessible computer network. Periodic conferences sponsored by the Navy are held to discuss practices that have been identified as exemplary. The conferences are open to industry for a modest registration fee.

Department of Commerce

The Department of Commerce has several programs to assist smaller companies. Most programs concerned with manufacturing competitiveness are located in the Technology Administration, established under the 1988 Omnibus Trade and Competitiveness Act. The Technology Administration consists of three components: the National Technical Information Service (NTIS), the National Institute of Standards and Technology (NIST), and the Office of Technology Policy (OTP). NTIS and NIST both have roles in helping U.S. manufacturers improve their competitive capabilities. OTP has little immediate relevance to manufacturing competitiveness, since most of its energies are directed towards development of science and technology policy and removal of barriers to the commercialization of new technology (U.S. Department of Commerce, 1991).

The National Technical Information Service was established as a centralized source of information on U.S. and foreign government-sponsored research and development results, business information, and engineering solutions. NTIS is expected to become a gateway through which industry can efficiently learn about markets and locate technical information. For instance, the NTIS Computer-aided Acquisition and Logistic Support/Concurrent Engineering (CALS/CE) Information Center provides a single source of public access to information on advanced manufacturing information technologies.

Over the past decade, the National Institute of Standards and Technology has been the primary federal agency focusing on the technological needs of smaller manufacturers. The Advanced Manufacturing

Research Facility (AMRF) focuses on development of new ways of machining and manufacturing components and products, sensors and control technologies, and software tools to link equipment from different vendors in an integrated system of shop floor control. Most of the AMRF work, however, is too advanced for current production environments and not generally supportable by the technical staff of most smaller companies (National Research Council, 1985).

In addition to the AMRF, NIST has developed an entry-level program suitable for very small companies called the *NIST Shop of the '90s*.During a one-day seminar, participants attend a mix of lectures, videos, and demonstrations of technology that can be implemented at relatively low cost by smaller firms. Although a one-day program has limitations, managers of small shops can seldom get away for longer periods. The program provides a good, if basic, overview and provides hands-on software demonstrations. Suppliers are prohibited from discussing prices or terms of sale during the program and are restrained from making overt sales pitches during their presentations and demonstrations.

The State Technology Extension Program (STEP) is a NIST-administered grant program created by the 1988 Omnibus Trade and Competitiveness Act to improve the use of manufacturing technology, particularly federal technology, by smaller companies. The program has evolved somewhat since the first awards of $1.5 million were made in 1990 to help nine state programs establish mechanisms to access federal technology for smaller businesses. In 1991, awards were made to help eight states develop strategic plans for state-wide industrial extension programs. Six more awards were made in 1992 to help states implement such strategic plans. Federal funding in 1992 was $1.3 million.

NIST also administers the Manufacturing Technology Centers (MTC) program, also created by the Omnibus Trade and Competitiveness Act of 1988, to help smaller manufacturing firms become more technologically competitive. A detailed discussion of the MTCs is the subject of Chapter 4.

Finally, NIST manages the Malcolm Baldrige National Quality Award. In response to a rising national concern with product quality and its implications for the manufacturing competitiveness of U.S. firms, the Malcolm Baldrige National Quality Improvement Act was passed in 1987. The act called for the development of guidelines and criteria that organizations could use to evaluate their quality improvement efforts. It also provided for a Malcolm Baldrige National Quality Award to be given in three categories: manufacturing, services, and small business.

The Baldrige Awards draw attention to the systems aspects of achieving improvements in quality by adopting a management and overall organizational approach rather than investments in production technology alone. The evaluation criteria for the awards have been broadly adopted by many large businesses as a basis for measuring the performance of their suppliers (Garvin, 1991).

National Center for Manufacturing Sciences (NCMS)

The National Center for Manufacturing Sciences in Ann Arbor, Michigan is a not-for-profit manufacturing research consortium of approximately 180 small, medium, and large manufacturing companies. The organization, incorporated in 1986 to improve the U.S. machine tool industry, has an annual budget of approximately $200 million financed by manufacturers, the federal government, and philanthropists. It currently conducts a broad range of production-targeted research and technology transfer activities in support of industry. However, NCMS treats its research findings and internally developed assessment and educational materials as proprietary among its member companies and organizations.

NCMS has recently begun efforts to establish a national network of some 150 "Manufacturing Application and Education Centers." It recently received $5 million from the Air Force to establish the National Center for Tooling and Precision Components (NCTPC) at the University of Toledo. NCTPC plans to place a teaching factory in a facility to be built by the university.

Shared Manufacturing Facilities/Teaching Factories

Shared manufacturing facilities, also referred to as teaching factories, are an increasingly popular concept among the various approaches to industrial modernization. The term "teaching factory" is applied to a variety of facilities, ranging from CAD demonstration centers at universities to flexible computer-integrated manufacturing facilities capable of full-scale part production. Typically, manufacturers and suppliers of state-of-the-market, off-the-shelf machines and equipment loan or donate their products to organizations that provide the physical facilities for the equipment, demonstrate its operation, and train users. Teaching factories offer smaller companies an opportunity to investigate

applications of the technology and evaluate its applicability to their business without purchasing the equipment.

According to the Department of Commerce, there are now 16 teaching factories in operation or pilot operation throughout the United States (see Table 1); another 15 are in the planning stages. In some cases, the teaching factory is jointly owned by local small manufacturers; more typically, they are owned and operated by non-profit organizations, usually universities and community colleges. There is growing interest from profit-making companies who would sell access to the equipment and charge for the training provided.

In addition to teaching basic operations on the equipment, the teaching factories usually permit clients to buy time on the equipment (sometimes at below-market rates) to perform actual production work for customers. In these situations, the employees of the small manufacturer operate the equipment at the teaching factory. When the teaching factory is located at a college or university, students or faculty also use it for research and educational work.

The teaching factory concept is attractive because it offers smaller companies the ability to try new technology without the substantial risk of first making a significant capital purchase. By permitting employees to learn the new systems before the smaller manufacturer acquires its own, a smoother installation at the company can often be expected. Of course, it is presumed that successful clients of teaching factories will purchase their own equipment once they have demonstrated its effectiveness for their specific applications. Obviously this presumption is the incentive for the suppliers, who provide demonstration machinery in hope of selling the same equipment to clients that try it at the teaching factory.

Smaller companies who have the opportunity to use the teaching factories as subcontracting sources may have little motivation to change their low-cost advantage by actually buying their own equipment and weaning themselves from the subsidy. The teaching factories themselves, in the absence of broad acceptance by smaller companies, may be reluctant to turn away the few repeat cash customers that take advantage of the available service. Thus, as clients subcontract for inexpensive time on available equipment, some centers have essentially become subsidized job shops.

Another shortcoming of the teaching factory concept is the need to locate them in areas where the local company demographics are such that a finite range of production equipment is relevant to enough firms. Even for relatively generic technology like machining centers, the range of

TABLE 2 Centers for Shared Flexible Computer-Integrated Manufacturing/Teaching Factories. In Operation or Pilot Operation.

1. FLORIDA	
Orlando	- Valencia Community College
2. IDAHO	
Boise	- Boise State University
3. ILLINOIS	
Rockford	- Rock Valley College
4. ILLINOIS	
Rock Island	- Manufacturing Technology Consortium (Rock Island Arsenal)
5. INDIANA	
Indianapolis	- Electronics Manufacturing Productivity Facility
6. MARYLAND	
Hagerstown	- Hagerstown Junior College
7. MISSOURI	
Rolla	- DemMaTec, University of Missouri
8. NEW JERSEY	
Blackwood	- Camden County College
9. NEW MEXICO	
Las Cruces	- New Mexico State University
10. NEW YORK	
Rochester	- Rochester Institute of Technology
11. OHIO	
Elyria	- Loraine County Community College
12. PENNSYLVANIA	
Bethlehem	- Northampton Community College
13. PENNSYLVANIA	
Meadville	- National Institute for Flexible Manufacturing
14. PENNSYLVANIA	
Monroeville	- Micro-Teaching Factory
15. WEST VIRGINIA	
Huntington	- Robert C. Byrd Center, Marshall University
16. WISCONSIN	
Kenosha	- Great Lakes Composite Consortium

features and capabilities needed by companies can be extensive, and therefore difficult to accommodate in a teaching factory. The rate at which the equipment is updated can also be an important factor to potential users, but is dependent on the available budget or donations. These factors make the design, operation, and marketing of a teaching factory, particularly in the long run, very difficult and problematic.

OTHER MODELS FOR COORDINATED MANUFACTURING ASSISTANCE

Guidelines for structure, organization, governance, and operation of systems of assistance and technology diffusion are available within the numerous state and regional efforts as well as some recent initiatives by the federal government. An often cited model for a coordinated system of assistance is the Cooperative Extensive Service, administered by the U.S. Department of Agriculture and state land-grant universities.

Cooperative Extension Service

The Cooperative Extension Service (CES) is frequently cited as a model on which to base a new federal extension program for manufacturing industry. Established in 1914, agricultural extension has developed into a nationwide system employing more than 9,600 county field agents and 4,600 land-grant university specialists to transfer new agricultural techniques to farmers and to stimulate community development. One-on-one contacts between extension agents and farmers, publications, electronic media, and workshops and training sessions are among the methods used to disseminate information and provide technical assistance. In 1988, 30 percent of the system's $1.1 billion budget came from the federal government. States provided 48 percent of funding, counties supplied 18 percent, and 4 percent came from other sources.

The experience of agricultural extension offers important lessons for an industrial extension service. For three reasons, however, it is neither possible nor desirable to build an industrial extension system based simply on duplicating the agricultural extension model. First, agricultural extension is by no means a perfect system. Agricultural extension has been criticized for focusing too much on costly chemical and mechanical technologies that favor larger agribusinesses, often with damaging social and environmental consequences. The system has also been faulted for

lacking coordination and strategy and for overbroadening its programs into such areas as youth education and suburban gardening. The growth of proprietary research in agriculture, especially in biotechnology, threatens to make obsolete the traditional extension model of public university research with free dissemination. Furthermore, as agricultural technology becomes more sophisticated, the generalist county agents who form the base of the system may increasingly lack the expertise to help farmers effectively.

Second, conditions in manufacturing are usually much more varied and complex than in agriculture. For example, farmers in a given region tend to share common soil, water, crop, climate, and market situations. A single university-based extension delivery system can accommodate these needs. In contrast, smaller manufacturers in a region may have widely differing technologies, products and processes, material needs, and markets. No single approach to manufacturing extension is likely to serve all needs; rather, a variety of models and approaches may be justified, depending on the particular characteristics of the manufacturers and areas being served. At the very least, the agricultural extension model needs adaptation to be useful in the manufacturing sector. But it is also possible that other, quite different approaches to manufacturing technology dissemination need to be considered and tried.

Third, it would be extremely difficult today for the federal government to establish a unified, national system of industrial extension in the same way that a national system of agricultural extension was founded in 1914. Current budget constraints are one obstacle. Another is the fact that many states have already initiated their own industrial extension and technology transfer programs to enhance the technological capability of smaller firms. These programs assist firms in various ways, including deploying technology, product development, work organization, and work force training.

Japanese Kohsetsushi Centers

The Japanese and several European countries have made particular efforts to improve the competitive circumstances of their smaller manufacturers. Their programs suggest a number of alternative approaches that may be appropriate means for helping firms locate necessary resources, assimilate new technologies, upgrade worker skills, acquire machinery and equipment, and access information concerning best practices.

Japan has a large majority of smaller manufacturing firms, and has more than twice as many enterprises with 20 or fewer employees as the United States. The economic and political importance of smaller firms has led to active government support of modernization programs for many years. To encourage adoption of new technology, government financial assistance has been available in the form of direct loans for operating funds or plant and equipment investment, favorable leasing arrangements or installment sales to individual manufacturers or cooperatives of manufacturers, and substantial tax relief that in 1984 allowed smaller firms the option of taking a first year depreciation of 30 percent.[3]

In addition to the system of financial assistance for smaller firms, Japan has a nationwide public system of support that encourages technology adoption and development. An important component of this system is the network of 170 *Kohsetsushi* centers, many founded in the 1920s and 1930s. The centers provide industrial-oriented research services, calibration and testing, technology demonstration and information, training, and problem-solving assistance for smaller Japanese manufacturers. There may be more than one center in each of the 47 prefectures, based upon the extent of industrial concentration. The centers typically specialize in the industries that economically dominate their region, not all of which are manufacturing. The *Kohsetsushi* also administer a national system of qualification and registration for private consultants that assist smaller firms.

The *Kohsetsushi* program receives half of its funds from the national government and half from the prefectures, and the centers generally charge firms a nominal fee for consultations and assistance at the centers or for visits to the production facilities of the companies. The centers are administered primarily by municipal and prefecture governments, and because of their long histories of service are generally well known and used by local manufacturing firms (Shapira, 1992).

The committee believes that the model that exists in Japan suggests several alternative approaches that should be examined when planning a national system of assistance to smaller manufacturing companies, but the Japanese framework is unlikely to be applicable to circumstances of U.S. companies without substantial modifications.

[3] For further discussion of equipment financing options available to Japanese small and medium-sized companies, see U.S. Congress, 1990.

4

Effectiveness of Manufacturing Technology Centers

Although the federal government has many programs to assist manufacturers (see Chapter 3), the Manufacturing Technology Centers (MTCs) program managed by the National Institute of Standards and Technology (NIST) is the primary federal activity in industrial extension targeted at smaller manufacturers. The MTC program provides matching grants creating centers to enhance "productivity and technological performance in U.S. manufacturing through the transfer of manufacturing technology and techniques . . ." (U.S. Congress, 1988). Since 1989, seven MTCs have been established in Cleveland, Ohio; Troy, New York: Columbia, South Carolina; Ann Arbor, Michigan; Kansas City, Kansas; Los Angeles, California; and Minneapolis-St. Paul, Minnesota. Federal funding for the MTC program in 1992 was $17.6 million.

The current MTCs have been established through three rounds of proposal evaluations and awards, in 1988, 1990, and 1992, with the number of proposals falling from 36 to 20 to 16 (National Research Council, 1988, 1990, 1992). Proposals are solicited from qualified nonprofit organizations. NIST provides funding for six years, with maximum funding of $1.5 million, $3 million, $3 million, $2.4 million, $1.8 million, and $1.2 million in each respective year. No NIST money is provided after six years. Applicants are required to contribute 50 percent or more of the proposed MTC's capital and annual operating and maintenance costs for the first three years, and an increasing share up to 80 percent in the sixth year. At least 55 percent of the applicant's share must consist of cash or in-kind contributions of full-time personnel.

NIST evaluates proposals based on: 1) regional need, 2) technology resources, 3) technology delivery mechanisms, and 4) management and

financial plan. (Appendix C is a copy of the 1992 Federal Register notice requesting MTC proposals.) Proposers must demonstrate that they understand the needs of their local manufacturing base and are qualified to meet those needs effectively and consistently. Innovative approaches to meeting the needs of the local industrial community are encouraged; NIST offers no predetermined solutions or expectations regarding modes of operation or specific program offerings.

This approach to the proposal process and conditions for funding are reflected in the current MTCs. Each MTC has a unique combination of services targeted at local industrial conditions (see Table 3). Each has a different relationship with its local cosponsor, typically state government, and has a different combination of financial and in-kind matching funds. Each has a relatively unique relationship with other service providers, such as consultants, community colleges, universities, and other state assistance efforts. Each MTC, therefore, can be viewed as an experiment or prototype in how to integrate federal efforts in manufacturing assistance with existing private and public assistance resources to meet the demands of very diverse local manufacturing communities.

The NIST and the Manufacturing Technology Centers fund the Modernization Forum to capture the lessons gained from these MTC experiments, to accelerate the learning process across them, and to identify areas for joint ventures among the MTCs. The activities of the Forum include national conferences on issues such as technology transfer to smaller manufacturers, an annual conference of MTC staff, joint MTC projects, and initiatives to link the MTCs with state extension programs, universities, and other public sources of industrial assistance. The MTC directors comprise the board of directors of the Modernization Forum, which meets monthly.

OBSERVATIONS REGARDING THE MTCS

Of the eight workshops held by the committee, six were collocated at MTCs. In addition to the workshops, half-day sessions were spent with MTC staff learning about their programs and experiences in working with the local manufacturing communities. (The remaining workshops were held in Los Angeles prior to that MTC becoming operational and in Georgia.) Based on these discussions, as well as conversations with company representatives who had had some experience working with the MTCs, the committee made the following observations:

Manufacturing Technology Center	Date Established	Host Organization	NIST Support ($ millions)		Matching Funds ($ millions)		Industries Served	Service Focus	Clients Served	Field Agents	Economic Impact** ($ millions)
			1993	Cum.	1993	Cum.					
California MTC Hawthorne, CA	Aug. 1992	California Community Colleges	1.5	1.5	1.5	1.5	Aerospace Suppliers	Assessments, improvement planning, TQM, training and technical seminars	Under 30	20 by April 15	N/A
Great Lakes MTC Cleveland, OH	Jan. 1989	Cleveland Advanced Manufacturing Program	1.8	11.6	4.2	15.2	Industrial machinery and equipment, fabricated metal products, electronic and other electrical equipment, instruments and related products, primary metal industries	Networking, direct assistance, manufacturing equipment demonstration and facilities, luncheon forums, workshops, technology transfer events	2096	24	123
Mid-America MTC Overland Park, KS	Apr. 1991	Kansas Technology Enterprise Corp.	3.0	7.5	3.0	7.5	Industrial and agricultural machinery and equipment, fabricated metal products, aircraft, food processing, wood products, and plastics	CAD/CAM, EDI, TQM, process planning. Services include one-on-one consultation, seminars and customized training, industrial networking, and equipment and software demonstration	376	38	17.6
Midwest MTC Ann Arbor, MI	Apr. 1991	Industrial Technology Institute	3.0	7.5	3.0	7.5	Automotive and office furniture. Key supplier sectors include metalforming, machine tools, tooling and machining, plastic processing, energy/environs.	Assessment, improvement planning, technology implementation, quality programs and information exchange	254	28	15.3
Northeast MTC Albany, NY	Jan. 1989	NY State Science and Technology Foundation	1.8	11.6	4.2	15.2	Metalworking, auto parts, plastics industries, and general manufacturing	Technical assistance including CAD/ CAM, quality control, training, demonstrations, and seminars. Operates a Manufacturing Technology Vehicle training van for factory-site demonstrations, a Manufacturing Resource Facility, and two Manufacturing Service Centers	2318	29	42
Southeast MTC Columbia, SC	Jan. 1989	Enterprise Development Inc.	1.8	11.7	4.2	15.3	Metal fabrication, textile industry, all manufacturing industries	Business and manufacturing operation assessments, customized technical training, work force training, technology demonstrations	650	33	61
Upper Midwest MTC Minneapolis, MN	Aug. 1992	Minnesota Technology Inc.	1.5	1.5	1.5	1.5	Computers and non-electrical machinery, fabricated metal products, electrical machinery, plastics and composites.	Change agent to encourage manufacturing companies to identify process and technology improvements and increase global competitiveness. Provide information and access to resources; identify barriers and possible solutions, manage projects; work force, supplier, and network development	638	35	3.6
		Totals	14.4	52.8	21.6	63.7			6977	207	251.9

**Economic Impact is based on estimates by each Manufacturing Technology Center. When this information was collected, the metrics used to measure economic impact were not consistent across MTCs.

TABLE 3 National Institute of Standards and Technology Manufacturing Technology Centers Program summary (February 1993)

The chief characteristic shared by the MTCs is their funding relationship with NIST.

The MTCs differ primarily in the emphasis each places on the roles of technical center and field service assistance. The local infrastructure and industrial economy determine to a great degree the characteristics of the MTC organization and its chosen position in the spectrum of support needed by manufacturers in its region.

Despite the diversity of their management structures, relationships with other organizations, and sources of matching funds, MTC managers and staff seem to agree on what they are and are not about. They are not about doing academic research, doing traditional economic development in the sense of attracting new firms, transferring technology from federal laboratories, or creating Silicon Valleys.

Rather, they are about helping firms to adopt the disciplines required for globally competitive manufacturing and the design capacities needed for collaborative production. Reflective of this orientation is the emphasis placed by field engineers on working with firms to acquire the capabilities to evaluate individual projects rather than on conducting the evaluation themselves. Good projects build such capacities and, above all, increase the likelihood that firms will learn how to adopt other relevant capacities without further assistance.

The expectations and missions for the MTCs appear to have evolved towards a much broader set of initiatives than was originally perceived.

In addition to upgrading the technological competence of smaller manufacturing firms, MTCs are expected to support broader modernization efforts, provide business management assistance, participate in defense conversion and worker retraining, and so on. A well-articulated vision and coherent set of missions, understood and shared by all of the MTCs, was not readily evident.

This ambiguity is natural and reflects the experimental nature of the program and the tremendous amount of organizational experience, knowledge, and innovation to be examined. It also reflects responses to the diversity of the manufacturing economies surrounding each of the MTCs and the likelihood that strategies and missions should differ for each, based upon local circumstances, resources, and needs.

Organizational stability, local commitment, and proper institutional structures are critical underpinnings of a successful program to improve manufacturing competitiveness.

The success of the MTCs depends on well-established communication lines with the various communities they serve and appropriate mechanisms for sufficiently considering customer needs. Based on the performance of the current MTCs, university management is not likely to be as effective as other forms of organization and governance. Likewise, the availability of local organization and support, reflecting grassroots political commitment and accompanied by service and resources in the private sector, appear to be important elements of successful programs.

Recruitment and training of talented, dedicated, skilled, and experienced staff are essential for program success.

The reputation of the MTC and its ability to influence the regional industrial base depends on the trust and credibility established by the field agents with manufacturers in their regions of responsibility. The experience and expertise of senior MTC managers determine the strategies and establish the guidelines to accommodate local constraints and to leverage most effectively the available strengths and resources of each community. Employees of MTCs must understand business fundamentals and appreciate the unique circumstances of smaller manufacturing firms. They should be capable of both assessing areas for improvement and helping firms develop viable solutions.

MTCs in some instances devote a substantial portion of their resources to marketing services and "acquiring projects"; these activities limit the number of companies they can help.

Projects with individual companies are an important part of the MTCs' activities because they build credibility in the community by demonstrating technical competence and ability to deliver promised services. However, this type of one-on-one assistance severely limits the number of companies that can be helped with available resources, even when the amount of time allotted for specific projects with companies is limited, a common practice. To increase the breadth of the customer base, the network of field engineers associated with each MTC should be encouraged to identify problems common to manufacturers in their region that would be amenable to efficient means of assistance, such as

classes and workshops. Changing the instructional focus and content to meet local needs can produce a large impact on many more manufacturers than is possible on a one-to-one basis. For instance, one means of insuring that the assistance provided meets the needs of the smaller manufacturer is for the MTCs to encourage and facilitate participation by smaller firms in establishing the curriculum for local community colleges and technical schools. Furthermore, increasing general awareness of available assistance services with consistent and coordinated outreach efforts at regional and national levels could reduce the need for marketing efforts by individual centers.

Legislative requirements eliminating NIST funding after six years ("sunset provisions") adversely dominate the missions, attitudes, and behaviors of the MTCs.

Although, arguably, state government support would still be forthcoming after six years, the elimination of NIST funding forces MTC managers to devise long-term strategies to fill this funding gap. Typically, these strategies place an increasing emphasis on fee-for-service activities. On the one hand, focusing on services for which customers will pay ensures responsiveness to the client base and provides an easy metric for identifying valuable services and eliminating others. On the other hand, the need to raise funds from paying customers tends to encourage MTCs to focus on the needs of larger companies. These firms often are more willing to pay for services and require less marketing effort for the resulting income than smaller firms. Though still too early in the overall MTC program to tell what will happen after NIST funding ends, the committee can easily foresee a situation emerging in which MTCs fail to provide services that would be useful and effective to smaller firms because the fee income is insufficient, while at the same time competing more with private sector service providers for the business of larger firms.

It is difficult to collect quantitative return-on-effort data on "soft" services.

An extensive range of services can be provided by MTCs, but the present performance metrics (e.g., cash flow, number of clients, length of engagements, attendance at manufacturing meetings) become a strong impetus for them to concentrate on the assistance services for which the clients are willing to pay a fee or for which there are matching funds.

For instance, all of the MTCs place a great deal of emphasis on assessing the current conditions in client firms and determining productive areas for modernization efforts. Clients are charged for this assessment, which often leads to follow-on projects, either with the MTC or another assistance provider. The assessments, therefore, serve as a marketing tool, a source of income, and an easy measure of the number of company interactions.

However, during each of the committee's workshops, less project-oriented kinds of assistance were repeatedly noted by the company representatives as very useful and important to the manufacturers that participated. Examples of MTC services that workshop attendees noted as potentially very useful include activities to facilitate better networking among companies, such as forums, workshops, and company introductions, and activities to provide needed expertise, such as project management services and brokering or matching appropriate private sector providers with smaller clients. Although all of the MTCs provide these kinds of services to a greater or lesser degree, they should receive more emphasis despite the lack of clear metrics on which to judge their value.

There are not currently enough MTCs to have a substantial influence on the performance of the American industrial sector.

The sphere of influence for some MTCs is nowhere near what has been suggested as their domain of regional accountability. Consider the extremes in the number of smaller manufacturing firms in three regions of the country, each of which has a single MTC. California has nearly 45,000 smaller manufacturing firms with fewer than 100 employees. Kansas has about 3,000 firms with 100 or fewer employees. In South Carolina, the Southeast Manufacturing Technology Center has implicit responsibility for all 13 southeastern states.

This range in size of the customer base has important implications for several aspects of the MTC program. First, with 45,000 potential customers, the California MTC cannot reasonably be expected to provide the same level of service or range of activities for the same budget as does the Kansas MTC. Either expectations need to reflect the constraints of available resources, or funding levels should reflect the size of the customer base. Based on the number of customers to be supported and the level of assistance to be provided, multiple MTCs may be required in high-density areas.

Second, selection of MTCs and expectations of their service areas should reflect the difficulty of cooperating across state lines when state

governments are the source of matching funds. Although some MTCs have been successful in arranging cooperation across state boundaries, Cleveland and Minnesota in particular, these efforts are still small. This issue will need to be confronted more directly in the future as the MTC program is expanded.

CONCLUSIONS

Based on the discussions at the workshops with MTC personnel and manufacturers, a majority of the committee has concluded that the MTCs are well placed to provide many of the services needed to improve the performance of smaller manufacturers. (See Chapter 6 for a minority opinion.) Many of the needs and opportunities identified by the manufacturers relate to improving access to information and building stronger networks among companies, suppliers, technology developers, regulators, and financiers. Many of the activities of the MTCs already address these needs, but, for a variety of reasons, these activities are not given the emphasis they deserve.

Some manufacturers perceive the MTCs as just another government program and therefore are reluctant to work with MTC staff; these firms are probably in the minority, however, and can be expected to change their minds over time. Most manufacturers seem to perceive the MTCs as neutral parties without a vested interest in any particular vendor, equipment type, or software package, and as government bodies with access to other government bodies such as state regulatory agencies. The MTCs should capitalize on this perception by playing a far more forceful role in mobilizing networks within local manufacturing communities. Such networks would improve sharing of information, experience, and problems; they could also serve as an effective mechanism for aggregating the concerns of smaller manufacturers to provide a voice in national policy commensurate with their numbers.

Each of the MTCs continues to learn how best to serve its customer base and is flexible enough to adapt. All are learning what they should do in the context of their customer base and their resources and capabilities. They are learning how to serve as a hub of information and facilitator of cooperation in their local industrial communities, and how to amalgamate a range of programs into a core set of useful services. More progress is needed, particularly in building methodologies for effective group learning among companies, but the learning process seems strong.

5

Conclusions and Recommendations

Smaller manufacturers play an important role in the competitiveness of American industry. They comprise the bulk of manufacturing establishments, are integral parts of the supply chain for both commercial and defense products, and provide the vast majority of manufacturing employment. Many of these smaller firms, however, are operating far below their potential. Their use of modern manufacturing equipment, methodologies, and management practices is inadequate to ensure that American manufacturing will be globally competitive.

This situation in which the thousands of smaller manufacturers who comprise the foundations of U.S. industrial strength are slow to modernize their manufacturing operations has prompted significant public response. State and local governments have created industrial assistance services, the federal government has multiple programs aimed at helping small businesses, and there is strong interest in the Clinton administration in creating a national network of industrial assistance centers. Expanding the NIST Manufacturing Technology Centers (MTCs) program is one mechanism for creating such a national assistance network; other possible mechanisms, described in the Technology Reinvestment Project (TRP) information package, include Advanced Technology Centers at community colleges, industry specific consortia, and expansion of state-based industrial extension services (U.S. Department of Defense, 1993). Although the specifics of a national industrial assistance system have yet to unfold, it is clear that significant resources, both federal and other (since 50 percent matching funds are required for all TRP proposals), are being mobilized to create a national industrial assistance system.

Based on the committee's discussions with smaller manufacturers and with staff at the MTCs and other industrial assistance programs, a majority of the committee has concluded that a national industrial assistance system is justified. The barriers to manufacturing performance improvement in smaller firms and the opportunities to overcome those barriers, as described by manufacturers in the committee's workshops, define roles for public sector assistance programs. The committee majority's assessment of the current MTCs is that they are well-placed to address many of the barriers facing smaller manufacturers. In particular, they can create communication networks and facilitate much greater information sharing among companies, technology providers, educators, regulators, and other members of the manufacturing community.

The federal government, through the MTCs, is learning to help firms adjust to the rapid changes taking place in manufacturing. In many respects, the diversity of the MTCs has provided valuable insights into what needs to be done and how to do what is needed. The MTCs have also discovered that some features of the manner in which they are organized are obstacles to further progress. Despite these lessons, it is crucial to emphasize that there is no consolidated model at NIST or elsewhere of how to provide assistance to smaller firms most effectively. As initiatives unfold to create a national industrial assistance system, the need to remain flexible, to fund experiments, and to adapt accordingly must be a guiding principle.

Even if highly successful, it must also be recognized that industrial assistance is not a panacea. Improvements in technology and changes in firms' internal organization of work are elements in overcoming the challenges and barriers that block or impede the development of globally competitive manufacturing capabilities in smaller U.S. firms. Innovation within manufacturing must be understood as inextricably linked to macroeconomic initiatives, trade impediments, antitrust concerns, education and training, energy, regulatory actions, public infrastructure, cost and availability of capital, and a host of other external factors and policies.

RECOMMENDATIONS

With these caveats, but with the full recognition that initiatives to construct a national industrial assistance program are well under way, the committee majority offers the following recommendations to help guide

the implementation of such a program. A dissenting set of conclusions is presented by a committee minority of two members in Chapter 6, page 95.

1. Develop a long-term strategy.

Efforts to create a national system of industrial assistance to improve the manufacturing performance of smaller companies should recognize the importance of creating a coherent system and not just increasing the number of assistance facilities and service providers. Appropriate elements of centralized coordination and control, in conjunction with decentralized and distributed management and direction, are needed to create an efficient, comprehensive *system* of assistance resources.

Although many of the elements of a national industrial assistance system exist, and initial steps at coordination and cooperation are developing—for instance, through NIST's State Technology Extension Partnership (STEP) program—the reality of a cohesive national system is a long way off. To be effective, a national system of industrial assistance must become an integral part of the manufacturing community, which requires continued support over many years. A long-term strategy for deploying, operating, and funding a national system, in the context of changing economic and political realities, must be developed. The goal of the system should be to ensure that assistance is available to any company that requests it.

2. Expansion should be governed by "quality, not quantity."

A national system of assistance can only be successful if it is supported by and responsive to the customer base, and manufacturers will only support it if they believe the advice they get is high quality. With the long-term objective in mind of providing access to assistance for any manufacturer who wants it, the emphasis must remain on ensuring that high-quality assistance is provided.

Too rapid expansion of the MTC program or other forms of industrial assistance programs risks compromising service quality for two main reasons. First, the complexity and constant change confronting manufacturers means that attempts to anticipate appropriate needs based on present knowledge and understanding will not be effective. Rapid replication of a single uniform model of an assistance center will not

work. Second, the number of organizations available and capable of providing high-quality assistance is relatively small. A mechanism is needed to initiate the development of future assistance centers by building on the experience and lessons learned from current MTCs and other programs.

Recognizing these constraints, the committee recommends that expansion of the current MTC program and other federal initiatives should be planned carefully with the aim of developing a comprehensive national industrial extension system within 3 to 5 years, based on a strategy of "learn as we go."

3. A national system of industrial assistance must strive for balance among local responsibility, regional coordination, and national direction, support, and cohesion.

The combination of rapid changes taking place in manufacturing and major differences across industries and localities calls for a system with centralized coordination and decentralized, distributed management and control. To remain responsive to customers in the manufacturing base, local and regional programs must have the ability to implement change and deliver services in the most effective, efficient way for the demands of their local customers. It is critical that any national system of industrial assistance accommodate the complexity, diversity, and economic idiosyncracies for each location served. It must permit the development of alternative models that best address those unique qualities and differences. There is no one model or organizational structure that will suffice as a template suitable for all situations. National goals and objectives must be tempered by the environment of each locale, and regional efforts should respond as appropriate for their predominant industrial sectors, private and public resource base, and real potential for matching funds (Fogarty et al., 1993).

Within this organizational structure, there are clear roles appropriate for federal, regional, and local components of the system.

The federal role must be to provide a stable funding environment, to facilitate learning among local and regional providers, to nurture new providers in areas with unmet needs, and to provide services that are best done at the national level. Specific examples of appropriate federal activities include:

- Provide funding for resources that are best developed nationally, such as marketing to build awareness that assistance is available, training and certifying extension agents, developing and refining educational materials and programs for clients, and creating a consistent set of performance metrics for assistance centers.
- Develop a national benchmark database and identify a relevant suite of metrics for evaluating and comparing the performance of manufacturing companies within and across industry groups.[1]
- Develop comprehensive information resources, such as databases, software, and computer-based tools for training, tracking, and evaluation, and electronic bulletin boards to provide user-supported problem resolution.[2] Investment in the development of a suite of assessment tools and methodologies is one example where resources are duplicated but where the opportunity exists for significant benefits of scale if these resources are made broadly available. For instance, the Industrial Technology Institute has constructed an extremely comprehensive Manufacturing Assessment Methodology, or MAM Tool Kit, that its staff uses with clients.

  These kinds of tools also contribute to the creation of a common set of terms and language for both service providers and the clients they service. Considering that there is likely to be increasing communication among members of the manufacturing community and the assistance organizations, the need for a dictionary of standard terminology would be an appropriate goal of the assistance system.
- Serve as a clearinghouse for company needs and convey them to appropriate sources of help. A specific example is the use of federal laboratories to help smaller firms comply with pending environmental regulations on solvent-based paints.
- Facilitate cooperation among regional and local programs by convening workshops and conferences and creating electronic linkages. Such cooperation should encourage sharing of problems and solutions

[1] The Foundation for Industrial Modernization has recently undertaken, with the Midwest Manufacturing Technology Center, an effort to identify the data and information needed to properly measure and compare the performance of smaller U.S. manufacturing companies, considering the technology used, their productivity, and their ability to respond quickly to customer requirements. See, Foundation for Industrial Modernization, 1993.

[2] An example of such a network is TECNet, a database for small and medium-sized companies that includes information " . . . about government regulations and programs, requests from large firms for bids and quotations, directories of used equipment for sale, import-export information, and training opportunities." See Rosenfeld, 1992.

encountered by assistance providers to speed the learning process nationwide.

- Provide a linkage between smaller manufacturers and other federal policies that may affect their business, including regulatory, trade, research and development, and tax policies.

The role of the regional component is to ensure the development of a cohesive system of assistance in the area represented. The genesis of such a system begins with identification of the problems whose solutions are crucial to regional industrial success, followed by development of relevant strategies and plans for addressing those issues. The range of activities and mix of organizational expertise should reflect the principal industries of the area and be informed by regional interests, issues, and concerns. The system's strategies, direction, and oversight should be provided by members of the community within the geographic constraints of the organization's charter.

Regional centers should:

- Supply the necessary coordination, standards, and administrative facilities to minimize duplication and inconsistency of programs and structure among the local service organizations.
- Support scale efficiencies by pooling the needs of the local assistance network in areas such as computer services and databases, and by organizing and sponsoring regional events in areas of broad industry interest (e.g., ISO 9000).
- Provide common legal, accounting, reporting, evaluation, and marketing support required for each service group.
- Function as contract administrators for federal agencies and ensure compliance with the terms and conditions of federal funding awards.
- Recruit and educate (with federal assistance) new service providers (field agents, service center directors).

Note that "regional" can mean a single state or an area more or less than a state. For states with very high manufacturing density, "regional" may refer to one geographic area within a state. Likewise, a region may be industry-sector defined, in which case it would probably cross state boundaries. In those cases, attention must be paid to insuring equitable coordination and representation of interests that extend across state lines.

The role of the local assistance program is to help firms develop their own capacity to grow and improve (as exemplified by the tenets of continuous improvement and total quality management). The responsibilities of local assistance organizations include offering a clearly delineated menu of services and facilities appropriate for the local industrial economy, partnering with and brokering of existing local services to solve companies' specific problems, encouraging private sector provision of needed services, helping manufacturers define needs by assessing performance and identifying improvement potential, providing leadership for the local manufacturing community, and working with the regional organization(s) of which it is a component to fill the needs of its community in the best and most efficient manner possible.

Success at the local level depends significantly on the ability to integrate diverse local conditions in terms of industry needs, demographics, and available resources to create a service organization that fits the situation, rather than wholesale adoption of a "national model." The details and emphases of each local assistance network are contingent on the circumstances of each locale. For instance, agent-provided problem-solving (technical fixes) may be the only practical means of assisting smaller firms when local vendors and consultants are not available to the client firm. In contrast, regions that have a high density of smaller firms are more likely to have an accompanying industrial infrastructure. In those cases, the local assistance organization will be most effective by devoting its efforts towards identifying and coordinating the needs of smaller manufacturers with suppliers of assistance in the private sector, facilitating linkages and information exchanges among companies sharing similar problems, and providing services to groups of manufacturers addressing common challenges.

Local assistance providers must balance the "push" of education and programs that promote new strategies and performance criteria for manufacturing against the "pull" of customer-specified requests, predominantly technical fixes and short-term problem-solving. The assistance efforts must be concerned with addressing the improvement of all processes throughout the firm and not focus just on those that take place on the factory floor.

As much as practical, services should be provided to groups of manufacturers sharing common problems to satisfy collective needs, such as rationalizing standards across several large OEM customers. For example, Beech Aircraft and many other OEMs now require electronic data interchange with suppliers and vendors. Coordinated efforts are

needed to develop common standards and protocols to eliminate the need for smaller firms to make multiple hardware and software investments.

The local assistance providers must also endeavor to encourage private sources of assistance. Because of manufacturers' desire to have a "one-stop shop" source of assistance, the local component of a national assistance system could function as a broker of other assistance providers. It could provide referrals to companies of providers with appropriate expertise for specific problems and keep private assistance providers abreast of the kinds of problems raised by manufacturers. The Upper Midwest MTC plays this brokering role in its region.

It is important that the local industrial assistance center not function as a subsidized competitor in the market. For many of the services that should be provided by the organizations, such as facilitating networks, convening forums, supplying information, and encouraging practitioner interaction, manufacturers are often unwilling to pay fees that are sufficient to support the service organization. Conversely, many of the services that could be supported by fees are already provided by private consultants and other businesses. Local assistance providers must learn to balance these conditions so that they do not displace private service providers through subsidized competition but remain vibrant and responsive to their customer base. The appropriate balance is likely to be unique to each locality.

On an operating level, the committee believes the best way to achieve the requisite balance of local responsibility, regional coordination, and national direction and support is for the federal government, as a condition of funding, to require that assistance organizations conform to "governance principles." Arguably, the current requirement in both the MTC and the TRP program for matching funds is such a governance principle aimed at ensuring local or regional commitment to the industrial extension organization. Other examples of governance principles might be to have representatives of local industry serve as the organization's board of directors, and to demonstrate that existing service providers, such as universities, community colleges, consultants, and industry organizations, support and will cooperate with the organization. While allowing the necessary flexibility in local strategies and operations, applying these kinds of governance principles can ensure that local assistance centers remain responsive to their customers and encourage them to build on available strengths rather than creating duplicate, fragmented assistance resources.

4. Federal financial support should recognize different needs, abilities, and capacity to apply funds effectively. It should focus on spending modest amounts wisely, with flexibility in the amount of funds for which an organization must apply.

Rigid criteria that constrain competitive awards to high, fixed levels often discourage applications for programs which, appropriately, should be smaller scale efforts. Funding support should fit the abilities of organizations to use the money effectively. Awards should be commensurate with the size of the market for assistance, availability of matching funds, and other resources.

A two-stage funding approach should be adopted to support and encourage strong proposals. Substantial effort is needed to organize properly and present a coherent strategy for local or regional development. "Seed" grants to assist in development of comprehensive plans, identify and catalog resources, determine goals and objectives, design organization structures, and review similar efforts would improve applicants' chances for success in obtaining major funding. Such support may also help stimulate new programs by state and local governments or by private industry groups. The STEP program provides some support for development and implementation of state-wide extension programs, but greater provision is needed to help organizations mobilize the resources and support necessary to operate an MTC effectively prior to receiving a full MTC award.

5. Coherent measures and guidelines should be developed for evaluation of federal, regional, and local assistance efforts. For programs that are not performing, remedial action needs to be taken quickly by a local board of directors.

The set of metrics for evaluating accomplishments of the programs must be tied to their missions, and the connections between those metrics and goals must be clear. Counting the number of projects undertaken— the number of doors knocked on—provides almost no evidence of influence on improved manufacturing capabilities. Evaluation of the services provided to manufacturing clients must be an integral part of the overall judgement process. This evaluation should be administered by a governing or advisory board with broad membership, particularly local industry participation.

The committee believes that a positive evaluation of assistance organizations should reflect financial success by their manufacturing clients. The measures adopted, however, must be informed by the differences in objectives, jurisdiction, and availability of quantitative and qualitative data for each component of the system.

Furthermore, publicly funded assistance organizations should improve the capabilities and infrastructure of the local and regional industrial economy and not compete unfairly with or replace commercial sources of assistance. The success of the assistance organization in accomplishing the development and improvement of private sector capabilities can be measured by the growth in numbers of service providers and the creation of easily identified linkages among groups in the manufacturing community. In fact, a declining demand for public sector assistance can be an indication of private sector self-sufficiency.

The complexity of performing effective evaluations of MTCs and other industrial assistance programs should not be underestimated. Although an independent advisory board with local membership, which is therefore cognizant of local conditions, is the best approach to evaluation, issues such as composition of the board, specific sources of information and questions to be asked, and reasonable expectations all need to be addressed.

6. A consistent and coherent funding policy, accompanied by appropriate metrics for evaluating performance, should be established to assure a stable assistance environment.

Current MTC funding policies requiring local matching funds and elimination of federal funding after six years can be counterproductive to the goals of a national system of industrial assistance. There may be examples of regions with significant industrial concentration that do not qualify for state matching funds but nevertheless should have a MTC. Similarly, there may be compelling circumstances in which **priority should be given to regions of geographic industrial concentration and demonstrated or special industry needs**, perhaps due to defense conversion or major trade adjustments (such as NAFTA); these regions may or may not have access to matching funds. Federal funding should be made available in such cases, though it is critical that specific criteria be established for reducing matching-fund requirements.

Self-sufficiency is another difficult issue needing reassessment. Many of the activities instrumental in improving the proficiency of smaller

companies—facilitating networks, convening forums, supplying information, encouraging practitioner interaction—do not generate adequate income to sustain the organization. While it is reasonable to expect that the rigors of market competition should be applied to the MTCs, self-sufficiency of the programs is contingent on offering services for which manufacturers will pay; in many but not all cases, these are services for which a private provider exists. Therefore, self-sufficiency of MTCs, *while not competing with the private sector,* has a low probability of success. Consequently reliance on user fees alone is not an appropriate basis for supporting necessary assistance activities, and **continuing support should be available to manufacturing assistance programs that meet the performance criteria for continued funding.**

7. Periodic self-examination of all the elements of a national system for manufacturing assistance is essential to remain flexible and adaptable in the face of rapid changes in the manufacturing base.

Any assistance system must be able to examine its own effectiveness and adjust specific objectives as circumstances change. Periodically, as the economy, technology, needs of manufacturers, and the positive influence and effects of the assistance program itself are felt, the specific objectives and certainly the metrics for measuring performance need to be reviewed. The issues that will challenge manufacturers in the future are not readily discerned from the environment they face today, characterized by complexity, interdependence, widespread availability of technology, and intense global competition. Whatever kind of performance improvement system is designed must, therefore, incorporate the means for evolving the services and delivery mechanisms to accompany the new challenges and conditions that will confront manufacturers. This system must provide an efficient means to respond in a timely manner.

8. Long-term political support is essential.

An infrastructure to help significantly improve the manufacturing competitiveness of smaller companies must have consistent support and visibility in the political process that go beyond partisan politics. Manufacturers will not support a program that is perceived to be the latest fad or an outlet for political favors.

Strong management of the federal effort is also essential. The Department of Commerce has the appropriate background to understand the issues, to formulate a coherent strategic vision, and to attract the necessary resources to accomplish the national goal of strengthening U.S. manufacturers. The Department of Commerce should be given responsibility for undertaking the coordination and rationalization of the broad, and largely disjointed, federal effort now under way to help American manufacturers improve their performance and global competitiveness. It is crucial that the resources made available for such improvements, whether through the MTC and other programs at NIST, other programs in the Department of Commerce, or programs in the Department of Defense and other agencies, be applied in an efficient and rational manner. By recommending that the Department of Commerce be given such a leadership role, the committee is drawing attention to the need to maximize the benefits to the customers of these various government programs, U.S. manufacturers.

Because the MTC program is, and will continue to be, a federal-state partnership, and because state governments have been leaders in establishing industrial assistance programs, the need to maintain state political support cannot be understated. By helping to provide the regional and local input essential to effective assistance programs, states play a critical role.

CONCLUSIONS

The majority of the committee concludes that, viewed in their totality, existing sources of industrial assistance provide a portfolio of services to help improve the competitiveness of smaller manufacturers. However, this existing set of programs, institutions, and businesses is organizationally fragmented and limited in scope of services and reach of clientele. Within this fragmented network of assistance sources, the MTCs have begun to carve a niche that, at least within their geographic regions, has brought some degree of order to the community and has raised the awareness of smaller companies that useful help is available. The MTCs are still experimenting with different mechanisms for marketing, ensuring responsiveness to the local customer base, working with other sources of assistance, and building the intercompany networks and information resources that many smaller firms need. This process of experimentation and learning should be encouraged, and the lessons broadly disseminated. This is the only way to increase effectiveness in

a necessarily diverse environment, and to keep expectations realistic, as the MTC program is expanded and other initiatives begin in the context of a national manufacturing assistance system.

Realistic expectations are critical to effective policy in this area. The purpose of publicly provided technical assistance is not to absolve manufacturers of responsibility for their success. And the intent of assistance organizations is not to become a collection of subsidized consulting firms competing with private sector providers. Rather, the goal should be to provide immediate attention to the issues and problems that threaten survival of smaller manufacturers by helping them manage the set of challenges with which they are confronted: regulatory compliance, upgrading worker skills, assimilating new technologies, meeting quality expectations, and organizational restructuring.

This broad set of challenges requires a diverse set of assistance programs. Some companies may need help finding sources for appropriate work force education and training. Some may need help identifying opportunities to improve current production processes. Others may need help selecting vendors and suppliers for new machinery, computers, and software, and some may need help gathering the data and completing the documentation to support capital investments and expansion. There will also be situations in which companies will require more extensive hand-holding to learn how to use effectively the modern methods and best practices they have been encouraged to adopt and the technologies in which they have invested.

The public policy objective should be to provide the means and motivation for companies to build their own capacity for finding and using improved business and production methods and for sustaining an awareness of new technology and market information. In the long-term, public support should create an environment in which companies can learn to help themselves and encourage the growth and development of private sector resources by identifying needs, defining appropriate services, and strengthening market efficacy.

6

Minority Opinion

Mr. Robert A. Pritzker and Mr. Paul D. Rimington, as members of the Committee to Assess Barriers and Opportunities to Improve Manufacturing at Small and Medium-Sized Companies, disagree with the opinions of the committee majority that a national industrial assistance system is justified. To a large degree, the disagreement is ideological. However, it was not until late in the project that we discovered a mutual belief that federal government intervention or "help" is more costly and less efficient than natural market forces. Our view did not alter the project schedule or goals (1) to identify major barriers, (2) to determine the means to overcome those barriers in the context of the NIST Manufacturing Technology Centers, and (3) to identify how the MTCs could best be focused. As a result, our minority opinion was not the basis for any fact finding related to the project.

In their opinion, the committee's charge implies that there is a need for a national policy. The minority opinion feels strongly that this report should not be treated as a blanket endorsement of a national industrial policy. Our interpretation of the results is to resist the temptation of a national cure-all.

Although our minority opinion is not written based on the data gathered, it does provide an alternative perspective derived from substantial industrial experience and expertise and also draws on our participation in committee meetings, discussions during workshops with smaller manufacturers, and conversations with Manufacturing Technology Center staff.

Our perspective is summarized in the following points:

1. **Establishing public sector organizations to assist smaller manufacturers is not an effective means of improving the competitiveness of manufacturing in the United States.** Sufficient private sector resources are available to smaller manufacturers that are willing to make the commitments necessary for improving their competitive capabilities. These include, but are not limited to:
   - **suppliers** that are happy to demonstrate their new machines, products, or technologies and teach buyers to use them;
   - **customers,** particularly larger ones, are more and more demanding of high quality and will assist suppliers in various forms of quality improvement. Even the second and third tier of suppliers are influenced by the quality requirements of the subcontractors so that one large customer can influence hundreds of smaller supplier firms.
   - **industry groups,** such as the thousands of trade associations in the United States, sponsor seminars and meetings to discuss problems unique to their industry and to educate their members;
   - **consultants,** in addition to large consulting firms such as Arthur Anderson and McKinsey, there are thousands of very small firms with modest costs but great expertise;
   - **universities and community colleges,** besides working directly with companies, also furnish individuals who provide direct consulting services, hold seminars and classes, and offer other forms of assistance to smaller firms;
   - **published materials,** as a source of information about new activities, already exceed the time business people have available to read and digest; about the last thing they need is to receive more of these mailings.
   - **special business groups,** such as the Young Presidents' Organization, disseminate considerable information to smaller businesses; and
   - **professional societies** such as the Society of Manufacturing Engineers (SME), American Society of Mechanical Engineers (ASME), and so forth.
2. **The Manufacturing Technology Centers (MTCs) have not proven their ability to substantially influence the overall competitive performance of U.S. industry.** There is a dearth of metrics for properly evaluating the success of this and other federal and state funding spent to date. The MTCs are a series of small-scale experiments investigating

various ways of assisting manufacturing companies, but anecdotal evidence should not be the sole basis on which to conclude that they have demonstrated that they are the best means of improving the competitiveness of U.S. manufacturing companies.

3. **There is insufficient talent available to the public sector for adequately staffing a national system of manufacturing assistance.** It is likely that those people initially employed and trained by the assistance centers would subsequently be hired by companies offering higher wages and benefits.
4. **The MTCs would constantly be in doubt as to long-term survival.** The MTC program would be extremely expensive and we believe that it would have great difficulty securing the local components of the funding for long periods.
5. **The MTCs tend to be in direct competition with small consulting companies.** We believe the government does not wish to compete with private sector service providers but the present structure of the MTCs encourages such competition.
6. **MTCs are not a particularly good manner of achieving technology transfer.** It is difficult for the government to know what is the best technology for a given situation, and if the small businessperson does not know much about the appropriate technology, the project is likely doomed.
7. **MTCs offer no help in alleviating the regulatory burden of manufacturers.** The single biggest assistance that government could provide to manufacturers is to reduce the amount of regulation to which smaller manufacturers are subject and really incapable of handling.

APPENDIXES

A

Manufacturing Establishments by Size and State

The two tables in this appendix summarize "Number of Employees" data from the Bureau of Census, County Business Patterns. The tables contain the number of establishments grouped by size of employment. For example, cells under the column heading "1–4 means the total number of establishments in a particular state that has at least one employee and no more than four employees. The "Percentage of Establishments" columns reflects the distribution of the facilities according to the same size groupings.

Each table is arranged in order of the total number of manufacturing establishments in each state from highest to lowest totals. The "Change 80–90" reflects percentage changes during the period 1980–1990 in the number of establishments according to the size groupings of employees, and the change in proportion of the total that each size category represents. Table 2 consolidates the three smallest size groupings shown in Table 1.

STATE	Number of Establishments										Percentage of Establishments								
	1-4	5-9	10-19	20-49	50-99	100-249	250-499	500-999	> 1000	Totals	1-4	5-9	10-19	20-49	50-99	100-249	250-499	500-999	> 1000
California	15,909	8,344	8,302	8,403	3,850	2,693	795	300	194	48,880	32.5	17.1	17.2	17.2	7.9	5.5	1.6	0.6	0.4
New York	10,091	4,900	4,550	4,622	2,055	1,361	428	164	118	28,289	35.7	17.3	16.1	16.3	7.3	4.8	1.5	0.6	0.4
Texas	7,326	3,877	3,248	3,059	1,440	1,149	406	177	99	20,781	35.3	18.7	15.6	14.7	6.9	5.5	2.0	0.9	0.5
Illinois	5,230	3,054	3,136	3,377	1,781	1,390	465	205	90	18,740	27.9	16.3	16.7	18.0	9.5	7.4	2.5	1.1	0.5
Pennsylvania	5,024	2,934	2,948	3,252	1,772	1,389	517	219	98	18,153	27.7	16.2	16.2	17.9	9.8	7.7	2.8	1.2	0.5
Ohio	4,672	2,969	3,120	3,273	1,773	1,415	475	171	129	18,017	25.9	16.5	17.3	18.2	9.8	7.9	2.6	0.9	0.7
Florida	6,392	3,116	2,491	2,255	934	653	189	80	41	16,151	39.6	19.3	15.4	14.0	5.8	4.0	1.2	0.5	0.3
Michigan	4,292	2,739	2,866	2,906	1,372	1,027	310	110	112	15,734	27.3	17.4	18.2	18.5	8.7	6.5	2.0	0.7	0.7
New Jersey	4,341	2,367	2,232	2,366	1,294	907	261	107	61	13,936	31.1	17.0	16.0	17.0	9.3	6.5	1.9	0.8	0.4
N. Carolina	3,268	1,839	1,827	1,804	1,204	1,125	481	264	84	11,716	28.1	15.7	13.9	15.4	10.3	9.6	4.1	2.3	0.7
Massachusetts	3,186	1,654	1,808	1,868	929	704	218	108	48	10,723	29.7	17.3	16.9	17.4	8.7	6.6	2.0	1.0	0.4
Wisconsin	2,757	1,612	1,597	1,611	945	729	296	141	49	9,737	28.3	16.6	16.4	16.5	9.7	7.5	3.0	1.4	0.5
Georgia	2,850	1,538	1,432	1,511	827	798	327	141	55	9,479	30.1	16.2	15.1	15.9	8.7	8.4	3.4	1.5	0.6
Indiana	2,268	1,458	1,463	1,623	987	807	292	115	59	9,092	25.2	16.0	16.1	17.9	10.9	8.9	3.2	1.3	0.6
Washington	3,048	1,444	1,199	1,100	508	336	109	38	30	7,812	39.0	18.5	15.3	14.1	6.5	4.3	1.4	0.5	0.4
Missouri	2,366	1,345	1,243	1,229	597	549	197	81	38	7,677	31.2	17.5	16.2	16.0	7.8	7.2	2.6	1.1	0.5
Minnesota	2,563	1,376	1,147	1,158	611	478	177	74	41	7,625	33.6	18.0	15.0	15.2	8.0	6.3	2.3	1.0	0.6
Tennessee	2,248	1,037	1,096	1,133	693	679	280	127	52	7,345	30.6	14.1	14.9	15.4	9.4	9.2	3.8	1.7	0.7
Connecticut	2,035	1,135	1,058	1,085	514	404	147	66	28	6,474	31.4	17.5	16.3	16.8	7.9	6.2	2.3	1.1	0.4
Virginia	2,016	1,117	977	963	480	486	186	98	56	6,401	31.5	17.5	15.3	15.4	7.5	7.6	2.9	1.5	0.9
Oregon	2,500	1,154	944	886	406	324	98	36	11	6,359	39.3	18.1	14.8	13.9	6.4	5.1	1.5	0.6	0.2
Alabama	1,994	1,065	928	881	478	480	215	96	41	6,198	32.2	17.5	15.0	14.2	7.7	7.7	3.5	1.5	0.7
Colorado	2,157	973	693	620	265	191	55	24	26	5,004	43.1	19.4	13.8	12.4	5.3	3.8	1.1	0.5	0.5
S. Carolina	1,333	772	665	677	404	460	262	118	36	4,747	28.1	16.3	14.4	14.3	8.5	9.7	5.5	2.5	0.8
Arizona	1,706	851	701	651	298	174	58	24	22	4,483	38.1	19.0	15.6	14.5	6.6	3.9	1.2	0.5	0.5

TABLE 1

STATE	Number of Establishments										Percentage of Establishments									
	1-4	5-9	10-19	20-49	50-99	100-249	250-499	500-999	> 1000	Totals	1-4	5-9	10-19	20-49	50-99	100-249	250-499	500-999	> 1000	
Maryland	1,318	742	712	644	345	293	108	35	22	4,217	31.3	17.6	16.9	15.3	8.2	6.9	2.5	0.8	0.5	
Kentucky	1,171	640	666	640	379	362	159	65	27	4,109	28.5	15.6	16.2	15.6	9.2	8.8	3.9	1.6	0.7	
Oklahoma	1,383	722	653	523	258	223	82	28	12	3,884	35.6	18.6	16.8	13.5	6.6	5.7	2.1	0.7	0.3	
Louisiana	1,323	697	640	563	272	233	73	35	18	3,854	34.3	18.1	16.6	14.6	7.1	6.0	1.9	0.9	0.5	
Iowa	1,084	602	593	596	343	258	116	43	33	3,670	29.5	16.4	16.2	16.3	9.3	7.0	3.2	1.2	0.9	
Arkansas	1,151	606	555	489	277	266	141	61	27	3,595	32.0	16.9	15.4	13.6	7.7	8.0	3.9	1.7	0.8	
Mississippi	1,085	646	526	486	311	321	147	69	17	3,588	30.2	18.0	14.7	13.0	8.7	8.9	4.1	1.9	0.5	
Kansas	1,084	566	548	524	292	225	77	26	21	3,367	32.2	16.9	16.3	15.6	8.7	6.7	2.3	0.8	0.6	
Rhode Island	958	519	451	436	185	136	40	19	7	2,753	34.8	18.9	16.4	15.8	6.7	5.0	1.5	0.7	0.3	
New Hampshire	829	418	369	317	173	133	44	25	8	2,316	35.8	18.0	15.9	13.7	7.5	5.7	1.9	1.1	0.3	
Maine	925	385	301	269	144	110	45	25	11	2,215	41.8	17.4	13.6	12.1	6.5	5.0	2.0	1.1	0.5	
Utah	672	386	363	318	165	127	48	18	11	2,108	31.9	18.3	17.2	15.1	7.8	6.0	2.2	0.9	0.5	
Nebraska	591	362	298	292	146	121	48	34	8	1,898	31.1	19.1	15.7	15.4	7.7	6.4	2.4	1.8	0.4	
Idaho	749	298	262	231	86	78	20	11	9	1,744	42.9	17.1	15.0	13.2	4.9	4.5	1.1	0.8	0.5	
West Virginia	596	300	303	242	118	100	34	20	8	1,723	34.7	17.4	17.6	14.0	6.8	5.8	2.0	1.2	0.5	
New Mexico	558	254	200	171	85	42	10	9	4	1,313	42.5	19.3	15.2	13.0	5.0	3.2	0.8	0.7	0.3	
Vermont	539	237	184	170	90	59	17	2	4	1,302	41.4	18.2	14.1	13.1	6.9	4.5	1.3	0.2	0.3	
Montana	580	261	170	109	52	30	7	4	0	1,213	47.8	21.5	14.0	9.0	4.3	2.5	0.6	0.3	0.0	
Nevada	440	193	145	137	63	32	12	7	0	1,029	42.8	18.8	14.1	13.3	6.1	3.1	1.2	0.7	0.0	
Hawaii	360	222	178	134	54	34	4	4	0	986	36.4	22.5	17.8	13.6	5.5	3.4	0.4	0.4	0.0	
South Dakota	204	144	112	113	69	50	21	5	1	799	25.5	18.0	14.0	14.1	8.6	6.3	2.6	0.8	0.1	
Delaware	196	113	110	127	56	53	19	13	12	699	28.0	16.2	15.7	18.2	8.0	7.6	2.7	1.9	1.7	
North Dakota	229	140	99	85	31	29	10	3	0	626	36.6	22.4	15.8	13.6	5.0	4.6	1.6	0.5	0.0	
Wyoming	226	114	70	53	22	22	0	0	0	507	44.6	22.5	13.8	10.5	4.3	4.3	0.0	0.0	0.0	
D.C.	177	95	77	65	25	11	4	0	5	459	38.6	20.7	16.8	14.2	5.4	2.4	0.9	0.0	1.1	
Alaska	210	71	69	42	23	19	9	0	0	443	47.4	16.0	15.6	9.5	5.2	4.3	2.0	0.0	0.0	

TABLE 1

STATE	Number of Establishments										Percentage of Establishments								
	1-4	5-9	10-19	20-49	50-99	100-249	250-499	500-999	> 1000	Totals	1-4	5-9	10-19	20-49	50-99	100-249	250-499	500-999	> 1000
1990	120,364	64,645	60,235	60,091	30,471	24,101	8,531	3,649	1,883	373,970	32.2	17.3	16.1	16.1	8.1	6.4	2.3	1.0	0.5
1989	111,732	62,518	59,328	59,965	30,832	24,347	8,799	3,679	1,966	363,166	30.8	17.2	16.3	16.5	8.5	6.7	2.4	1.0	0.5
1988	111,669	63,005	59,815	59,993	30,478	23,759	8,619	3,624	1,944	362,906	30.8	17.4	16.5	16.5	8.4	6.5	2.4	1.0	0.5
1987	120,793	63,234	60,178	59,919	29,759	23,290	8,397	3,534	1,914	371,018	32.6	17.0	16.2	16.1	8.0	6.3	2.3	1.0	0.5
1986	110,665	60,710	58,536	58,720	29,624	23,407	8,445	3,534	1,987	355,628	31.1	17.1	16.5	16.5	8.3	6.6	2.4	1.0	0.6
1985	111,046	61,319	58,978	58,984	29,936	23,346	8,583	3,618	2,053	357,863	31.0	17.1	16.5	16.5	8.4	6.5	2.4	1.0	0.6
1984	107,764	60,044	57,613	58,195	29,593	23,192	8,597	3,680	2,062	350,740	30.7	17.1	16.4	16.6	8.4	6.6	2.5	1.0	0.6
1983	111,647	60,805	57,365	56,398	27,777	21,704	8,039	3,426	1,959	349,142	32.0	17.4	16.4	16.2	8.0	6.2	2.3	1.0	0.6
1982	94,441	56,110	55,893	56,634	28,590	22,635	8,422	3,819	2,188	328,932	28.7	17.1	17.0	17.3	8.7	6.9	2.6	1.2	0.7
1981	90,877	53,068	54,476	56,179	28,370	23,121	8,902	3,923	2,354	321,290	28.3	16.5	17.0	17.5	8.8	7.2	2.8	1.2	0.7
1980	86,702	52,470	54,784	56,568	29,153	23,797	9,285	4,182	2,436	319,377	27.1	16.4	17.2	17.7	9.1	7.5	2.9	1.3	0.8
Change 80-90	38.8	23.2	9.9	6.2	4.5	1.3	-8.1	-12.7	-22.7	17.1	18.6	5.2	-6.1	-9.3	-10.7	-13.5	-21.5	-25.5	-34.0

TABLE 1

STATE	Number of Establishments								Percentage of Establishments								
	1-19	20-49	50-99	100-249	250-499	< 500	500-999	> 1000	Totals	1-19	20-49	50-99	100-249	250-499	< 500	500-999	> 1000
California	32,645	8,403	3,850	2,893	795	48,386	300	194	48,880	66.8	17.2	7.9	5.5	1.6	99.0	0.6	0.4
New York	19,541	4,622	2,055	1,361	428	28,007	164	118	28,289	69.1	16.3	7.3	4.8	1.5	99.0	0.6	0.4
Texas	14,451	3,059	1,440	1,149	406	20,505	177	99	20,781	69.5	14.7	6.9	5.5	2.0	98.7	0.9	0.5
Illinois	11,422	3,377	1,791	1,390	465	18,445	205	90	18,740	60.9	18.0	9.6	7.4	2.5	98.4	1.1	0.5
Pennsylvania	10,908	3,252	1,772	1,389	517	17,838	219	98	18,153	60.1	17.9	9.8	7.7	2.8	98.3	1.2	0.5
Ohio	10,781	3,273	1,773	1,415	475	17,717	171	129	18,017	59.8	18.2	9.8	7.9	2.6	98.3	0.9	0.7
Florida	11,999	2,255	934	653	189	16,030	80	41	16,151	74.3	14.0	5.8	4.0	1.2	99.3	0.5	0.3
Michigan	9,897	2,908	1,372	1,027	310	15,512	110	112	15,734	62.9	18.5	8.7	6.5	2.0	98.6	0.7	0.7
New Jersey	8,940	2,366	1,294	907	261	13,768	107	61	13,936	64.2	17.0	9.3	6.5	1.9	98.8	0.8	0.4
N. Carolina	6,754	1,804	1,204	1,125	481	11,368	264	84	11,716	57.6	15.4	10.3	9.6	4.1	97.0	2.3	0.7
Massachusetts	6,848	1,868	929	704	218	10,567	108	48	10,723	63.9	17.4	8.7	6.6	2.0	98.5	1.0	0.4
Wisconsin	5,966	1,611	945	729	296	9,547	141	49	9,737	61.3	16.5	9.7	7.5	3.0	98.0	1.4	0.5
Georgia	5,820	1,511	827	798	327	9,283	141	55	9,479	61.4	15.9	8.7	8.4	3.4	97.9	1.5	0.6
Indiana	5,209	1,623	987	807	292	8,918	115	59	9,092	57.3	17.9	10.9	8.9	3.2	98.1	1.3	0.6
Washington	5,891	1,100	508	336	109	7,744	36	30	7,812	72.8	14.1	6.5	4.3	1.4	99.1	0.5	0.4
Missouri	4,986	1,229	597	549	197	7,558	81	38	7,677	64.9	16.0	7.8	7.2	2.6	98.4	1.1	0.5
Minnesota	5,086	1,158	611	478	177	7,510	74	41	7,625	66.7	15.2	8.0	6.3	2.3	98.5	1.0	0.5
Tennessee	4,361	1,133	693	679	280	7,186	127	52	7,345	59.6	15.4	9.4	9.2	3.8	97.6	1.7	0.7
Connecticut	4,228	1,065	514	404	147	6,378	68	28	6,474	65.3	16.8	7.9	6.2	2.3	98.5	1.1	0.4
Virginia	4,110	963	480	486	186	6,247	98	56	6,401	64.2	15.4	7.5	7.6	2.9	97.6	1.5	0.9
Oregon	4,598	886	406	324	98	6,312	36	11	6,359	72.3	13.9	6.4	5.1	1.5	99.3	0.6	0.2
Alabama	4,007	881	478	480	215	6,061	96	41	6,198	64.6	14.2	7.7	7.7	3.5	97.8	1.5	0.7
Colorado	3,823	620	265	191	55	4,954	24	26	5,004	76.4	12.4	5.3	3.8	1.1	99.0	0.5	0.5
S. Carolina	2,790	677	404	480	262	4,593	118	36	4,747	58.8	14.3	8.5	9.7	5.5	96.8	2.5	0.8
Arizona	3,258	651	298	174	56	4,437	24	22	4,483	72.7	14.5	6.6	3.9	1.2	99.0	0.5	0.5

TABLE 2

STATE	Number of Establishments								Percentage of Establishments							
	1-19	20-49	50-99	100-249	250-499	< 500	500-999	> 1000	Totals	1-19	20-49	50-99	100-249	250-499	< 500	500-999	> 1000
Maryland	2,772	644	345	293	106	4,160	35	22	4,217	65.7	15.3	8.2	6.9	2.5	98.6	0.8	0.5
Kentucky	2,477	640	379	362	159	4,017	65	27	4,109	60.3	15.6	9.2	8.8	3.9	97.8	1.6	0.7
Oklahoma	2,758	523	258	223	82	3,844	28	12	3,884	71.0	13.5	6.6	5.7	2.1	99.0	0.7	0.3
Louisiana	2,660	563	272	233	73	3,801	35	18	3,854	69.0	14.6	7.1	6.0	1.9	98.6	0.9	0.5
Iowa	2,279	598	343	258	116	3,594	43	33	3,670	62.1	16.3	9.3	7.0	3.2	97.9	1.2	0.9
Arkansas	2,312	489	277	288	141	3,507	61	27	3,595	64.3	13.6	7.7	8.0	3.9	97.6	1.7	0.8
Mississippi	2,257	466	311	321	147	3,502	69	17	3,588	62.9	13.0	8.7	8.9	4.1	97.6	1.9	0.5
Kansas	2,200	524	292	225	77	3,318	28	21	3,367	65.3	15.6	8.7	6.7	2.3	98.5	0.8	0.6
Rhode Island	1,928	436	185	138	40	2,727	19	7	2,753	70.0	15.8	6.7	5.0	1.5	99.1	0.7	0.3
New Hampshire	1,616	317	173	133	44	2,283	25	8	2,316	69.8	13.7	7.5	5.7	1.9	98.6	1.1	0.3
Maine	1,611	269	144	110	45	2,179	25	11	2,215	72.7	12.1	6.5	5.0	2.0	98.4	1.1	0.5
Utah	1,421	318	165	127	46	2,077	18	11	2,106	67.5	15.1	7.8	6.0	2.2	98.6	0.9	0.5
Nebraska	1,251	292	146	121	46	1,856	34	8	1,898	65.9	15.4	7.7	6.4	2.4	97.8	1.8	0.4
Idaho	1,309	231	86	78	20	1,724	11	9	1,744	75.1	13.2	4.9	4.5	1.1	98.9	0.6	0.5
West Virginia	1,201	242	118	100	34	1,695	20	8	1,723	69.7	14.0	6.8	5.8	2.0	98.4	1.2	0.5
New Mexico	1,012	171	65	42	10	1,300	9	4	1,313	77.1	13.0	5.0	3.2	0.8	99.0	0.7	0.3
Vermont	960	170	90	59	17	1,296	2	4	1,302	73.7	13.1	6.9	4.5	1.3	99.5	0.2	0.3
Montana	1,011	109	52	30	7	1,209	4	0	1,213	83.3	9.0	4.3	2.5	0.6	99.7	0.3	0.0
Nevada	778	137	63	32	12	1,022	7	0	1,029	75.6	13.3	6.1	3.1	1.2	99.3	0.7	0.0
Hawaii	758	134	54	34	4	984	4	0	988	76.7	13.6	5.5	3.4	0.4	99.6	0.4	0.0
South Dakota	540	113	69	50	21	793	5	1	799	67.6	14.1	8.6	6.3	2.6	99.2	0.6	0.1
Delaware	419	127	56	53	19	674	13	12	699	59.9	18.2	8.0	7.6	2.7	96.4	1.9	1.7
North Dakota	468	85	31	29	10	623	3	0	626	74.8	13.6	5.0	4.6	1.6	99.5	0.5	0.0
Wyoming	410	53	22	22	0	507	0	0	507	80.9	10.5	4.3	4.3	0.0	100.0	0.0	0.0
D.C.	349	65	25	11	4	454	0	5	459	76.0	14.2	5.4	2.4	0.9	98.9	0.0	1.1
Alaska	350	42	23	19	9	443	0	0	443	79.0	9.5	5.2	4.3	2.0	100.0	0.0	0.0

STATE	Number of Establishments								Percentage of Establishments							
	1-19	20-49	50-99	100-249	250-499	< 500	500-999	> 1000	Totals	1-19	20-49	50-99	100-249	250-499	< 500	500-999	> 1000
1990	245,244	60,091	30,471	24,101	8,531	368,436	3,649	1,883	373,970	65.6	16.1	8.1	6.4	2.3	98.5	1.0	0.5
1989	233,578	59,965	30,832	24,347	8,799	357,521	3,679	1,966	363,166	64.3	16.5	8.5	6.7	2.4	98.4	1.0	0.5
1988	234,489	59,993	30,478	23,759	8,619	357,338	3,624	1,944	362,906	64.6	16.5	8.4	6.5	2.4	98.5	1.0	0.5
1987	244,205	59,919	29,759	23,290	8,397	365,570	3,534	1,914	371,018	65.8	16.1	8.0	6.3	2.3	98.5	1.0	0.5
1986	229,911	58,720	29,624	23,407	8,445	350,107	3,534	1,987	355,628	64.6	16.5	8.3	6.6	2.4	98.4	1.0	0.6
1985	231,343	58,984	29,936	23,348	8,583	352,192	3,618	2,053	357,863	64.6	16.5	8.4	6.5	2.4	98.4	1.0	0.6
1984	225,421	58,195	29,593	23,192	8,597	344,998	3,680	2,062	350,740	64.3	16.6	8.4	6.6	2.5	98.4	1.0	0.6
1983	229,837	56,366	27,777	21,704	8,039	343,755	3,426	1,959	349,142	65.8	16.2	8.0	6.2	2.3	98.5	1.0	0.6
1982	208,444	56,834	26,590	22,635	8,422	322,925	3,819	2,186	328,932	62.8	17.3	8.7	6.9	2.6	98.2	1.2	0.7
1981	198,441	56,179	26,370	23,121	8,902	315,013	3,923	2,354	321,290	61.8	17.5	8.8	7.2	2.8	98.0	1.2	0.7
1980	193,956	56,568	29,153	23,797	9,285	312,759	4,182	2,436	319,377	60.7	17.7	9.1	7.5	2.9	97.9	1.3	0.8
Change 80-90	26.4	6.2	4.5	1.3	-8.1	17.8	-12.7	-22.7	17.1	8.0	-9.3	-10.7	-13.5	-21.5	0.6	-25.5	-34.0

TABLE 2

B

Selected State and Local Programs

Many state programs, such as the Quality Management Consortia program at the University of Texas at Austin, rely largely upon university teaching faculty, with some assistance from students at the graduate or undergraduate level. Others, such as those at the Georgia Institute of Technology or PENNTAP at the Pennsylvania State University, have full-time staff devoted to business and technical assistance; they rely on faculty or students only when appropriate. These three programs are briefly described here to demonstrate the range of models followed by states and universities to assist manufacturers in their states.

QUALITY MANAGEMENT CONSORTIA (QMC)

A somewhat different assistance strategy was recently organized (June 1992) at the University of Texas at Austin. The Quality Management Consortia (QMC) focuses on providing education in, and deployment of, quality principles and programs in smaller manufacturing and high-technology service organizations. The QMC is a joint program of the Graduate School of Business and College of Engineering, and is based on the concept of grouping companies together in a consortium for shared formal learning experiences and for continued sharing of knowledge and experience through networking. Each consortium is a group of 12 to 15 small and medium-sized companies who commit to a two-year program of on-campus education and on-site implementation of total quality management concepts. Every year each company contributes a

significant amount of funds, based on a formula relating sales and number of employees, to the program. Every month the companies each receive a minimum of 50 hours of implementation assistance by graduate business and engineering students who are paired in teams to provide the assistance. These teams offer a balance of business practice and technology implementation skills to improve the performance of the participating manufacturers. In addition to classroom education and training, and student implementation assistance, each company receives consulting visits by faculty and other professionals. The projects undertaken by the graduate student assistance teams have concentrated on evaluation and analysis of production processes and accompanying management procedures, development of training programs for professional staff, and creation of strategic planning processes. These activities reflect the management emphasis of the program, rather than the traditional engineering type of problems undertaken by university technical assistance programs.

GEORGIA TECH INDUSTRIAL EXTENSION SERVICE

The Industrial Extension Service (IES) at the Georgia Institute of Technology is one of the oldest programs based on the concepts of industrial extension and technical assistance. Created by the Georgia Assembly in 1960, the IES evolved from several Georgia Tech-based, federal-and state-supported programs. Two such programs were the Engineering Experiment Station (today the Georgia Tech Research Institute) which focused its energies on industrial research projects and development of accompanying technologies, and the Industrial Development Branch which worked to attract industry to Georgia communities by matching the needs of target industries with the resources of specific industrial sites. The first IES field office was opened in 1961, and between 1964 and 1966 an additional six offices were established to bring the "problem-solving skills of IES much closer to the communities and industries they served." Today, IES has a network of twelve field offices from which technical professionals provide industrial problem-solving skills to smaller firms, primarily rural based. In 1988 the industrial extension program provided nearly 1000 firm-specific assists, as well as providing support for community economic development and information requests. About 70 percent of the problems are solved directly by the field staff. For the rest, the field agents help the clients secure the proper expertise or assistance from Georgia Tech, the private

sector, or other state or federally funded efforts. The field staff are predominately engineering professionals with business experience and training (Shapira, 1990c).

PENNSYLVANIA TECHNICAL ASSISTANCE PROGRAM (PENNTAP)

Pennsylvania established the PENNTAP industrial technology extension service in 1965 to provide engineering and technical assistance to all types of business and industry (not just manufacturing concerns) throughout the state. It has concentrated, as do most technical assistance programs, on those firms that do not have or cannot financially justify full-time engineers or have the time to resolve technical problems inhouse. The technological designation has been broadly applied to problems of smaller firms: helping them select appropriate technologies for new or upgraded products, suggesting changes to increase process efficiencies, and providing linkages to other economic development assistance providers. PENNTAP does not solicit clients, and its services are provided at no cost to firms throughout Pennsylvania. The number of full-time PENNTAP employees is surprisingly small. One engineer is based at each of four Pennsylvania state universities in the primary manufacturing regions of the state, and two technical specialists and a librarian are located at University Park.

C

Federal Register Notice and Procedure for MTC Selection

Federal Register / Vol. 57, No. 10 / Wednesday, January 15, 1992 / Notices

National Institute of Standards and Technology

[Docket No. 920104-2004]

Manufacturing Technology Centers

AGENCY: National Institute of Standards and Technology (NIST), Commerce.

ACTION: Notice of the availability of funds; notice of meeting.

SUMMARY: In accordance with the provisions of the Omnibus Trade and Competitiveness Act of 1988, 15 U.S.C. 278k, the National Institute of Standards and Technology is announcing the availability of funds and requesting proposals to establish two additional Manufacturing Technology Centers. In addition, NIST is announcing a public briefing for potential applicants to further discuss the program and answer questions concerning the application and selection process. (Catalog of Federal Domestic Assistance No. 11.611 "Manufacturing Technology Centers Program.")

DATES: 1. Closing Date. Proposals must be received at the address below by April 14, 1992.

2. The applicants' briefing will begin at 9:30 a.m. on February 7, 1992.

ADDRESSES: 1. Applicants must submit one signed original plus fourteen (14) copies of their proposal along with the Standard Form 424 (Rev 4-88), Standard Form 424A (4-88), and Standard Form 424B (4-88) to: Director, NIST Manufacturing Technology Centers Program, Building 222, room B212, National Institute of Standards and Technology, Gaithersburg, MD 20899. Plainly mark on the outside of the package that it contains an "MTC Proposal."

2. The applicants' briefing will be held in the Administration Building (Green Auditorium), National Institute of Standards and Technology, Gaithersburg, MD.

FOR FURTHER INFORMATION CONTACT: Kevin Carr at (301) 975-5020 (voice) or (301) 926-2934 (fax).

SUPPLEMENTARY INFORMATION:

Background

The National Institute of Standards and Technology (NIST) will provide assistance for the creation and support of Manufacturing Technology Centers. Such Centers shall be affiliated with any United States-based nonprofit institution or organization, or group thereof, that applies for and is awarded financial assistance in accordance with the procedures set forth in 15 CFR part 290. Individual awards shall be decided on the basis of merit review.

The objective of the Centers is to enhance productivity and technological performance in United States manufacturing through:

(1) The transfer of manufacturing technology and techniques developed at the Institute to Centers and, through them, to manufacturing companies throughout the United States;

(2) The participation of individuals from industry, universities, State governments, other Federal agencies, and, when appropriate, the Institute in cooperative technology transfer activities;

(3) Efforts to make new manufacturing technology and processes usable by United States-based small- and medium-sized companies;

(4) The active dissemination of scientific, engineering, technical, and management information about manufacturing to industrial firms, including small and medium-sized manufacturing companies; and

(5) The utilization, when appropriate, of the expertise and capability that exists in Federal laboratories other than the Institute.

Manufacturing Technology Centers are established and operated via cooperative agreements between NIST and the award-receiving organizations. To date, NIST has awarded funding for five Centers. These Centers are the Southeast Manufacturing Technology Center (SMTC) in Columbia, South Carolina, the Great Lakes Manufacturing Technology Center (GLMTC) in Cleveland, Ohio, the Northeast Manufacturing Technology Center (NEMTC) in Troy, New York, the Mid-America Manufacturing Technology Center in Overland Park, Kansas, and the Midwest Manufacturing Technology Center in Ann Arbor, Michigan.

Request for Proposals

Contingent upon the availability of FY 92 and future year funding, NIST plans to establish two additional Centers with maximum NIST funding levels of $1.5M, $3.0M, $3.0M, $2.4M, $1.8M, $1.2M for years 1 through 6, respectively, for each Center. Applicants are required to contribute 50 percent or more of the proposed Center's capital and annual operating and maintenance costs for the first three years and an increasing share of 60, 70, and 80 percent in years 4, 5, and 6, respectively. The continuation and level of NIST funding from year to year will be at the discretion of NIST based on such factors as satisfactory performance and the availability of funds.

The competition is open to proposals based on any of the major discrete part manufacturing technology disciplines in which NIST has technical expertise (for example, mechanical parts, electronics assembly, composites). Geographical location, physical size, concentration of industry, and economic significance of the service region's manufacturing base will be factors in the evaluation of new proposals. A proposal for a Center located near an existing Center may be considered only if the proposal is unusually strong and the population of manufacturers and the technology to be addressed justify it.

NIST will provide all qualified proposals to a Merit Review Panel organized by the National Research Council (NRC) which will evaluate the proposals in accordance with the evaluation and selection criteria below as extracted directly from 15 CFR part 290. NIST will consider the findings of the NRC Merit Review Panel in its final selection. NIST anticipates making the selection and announcement of the award receiving Centers by [date to be insert by NIST immediately prior to publication].

Applicants' Briefing

NIST will conduct a public meeting to present an overview of the Program and to allow interested parties and potential applicants to discuss program issues with Institute staff. Representatives from existing NIST Centers will be available at the briefing to answer any questions concerning their respective programs. The meeting will be held at the Institute at the location and time shown above. No advanced registration or fee for attendance is required. Organizations are invited to send a one page fax of the names or approximate number of persons planning to attend to the fax number listed above in order to permit NIST to anticipate attendance.

Proposal Requirement Highlights. Applicants should refer directly to 15 CFR 290, which contains the guidelines for the application, qualification, selection and establishment of Centers. Applicants should particularly note:

- There is a 25 page limitation on the basic proposal text;
- Appendices, or other relevant information, in support of the basic proposal, should be submitted as a separate volume;
- The applicant is required to contribute 50 percent or more of the proposed Center's capital and annual operating and maintenance costs for the first three years and an increasing share of 60, 70, and 80 percent in years 4, 5, and 6, respectively;

• At least 55% of the applicant's share must consist of cash from various sources or in-kind contributions of full-time personnel;

• The Center must focus its activities on transferring new manufacturing technology rather than on performing research and development;

• Each Center shall be affiliated with a U.S.-based nonprofit institution or organization which has submitted a qualified proposal for a Center Operating Award under these procedures; and,

• Support may be provided by NIST for a period not to exceed six years.

Proposal Evaluation and Selection Criteria

In making a decision whether to provide financial support, NIST shall review and evaluate all qualified proposals in accordance with the following criteria, assigning equal weight to each of the four categories.

(1) *Regional Need.* Does the proposal define an appropriate service region with a large enough target population of small- and medium-sized manufacturers which the applicant understands and can serve, and which is not presently served by an existing Center?

(i) Market Analysis. Demonstrated understanding of the service region's manufacturing base, including business size, industry types, product mix, and technology requirements.

(ii) Geographical Location. Physical size, concentration of industry, and economic significance of the service region's manufacturing base. Geographical diversity of Centers will be a factor in evaluation of proposals; a proposal for a Center located near an existing Center may be considered only if the proposal is unusually strong and the population of manufacturers and the technology to be addressed justify it.

(2) *Technology Resources.* Does the proposal assure strength in technical personnel and programmatic resources, full-time staff, facilities, equipment, and linkages to external sources of technology to develop and transfer technologies related to NIST research results and expertise in the technical areas noted in these procedures?

(3) *Technology Delivery Mechanisms.* Does the proposal clearly and sharply define an effective methodology for delivering advanced manufacturing technology to small- and medium-sized manufacturers?

(i) Linkages. Development of effective partnerships or linkages to third parties who will amplify the Center's technology delivery to reach a large number of clients in its service region.

(ii) Program Leverage. Provision of an effective strategy to amplify the Center's technology delivery approaches to achieve national impact as described in § 290.3(e).

(4) *Management and Financial Plan.* Does the proposal define a management structure and assure management personnel to carry out development and operation of an effective Center?

(i) Organizational Structure. Completeness and appropriateness of the organizational structure, and its focus on the mission of the Center. Assurance of full-time top management of the Center.

(ii) Program Management. Effectiveness of the planned methodology of program management.

(iii) Internal Evaluation. Effectiveness of the planned continuous internal evaluation of program activities.

(iv) Plans for Financial Matching. Demonstrated stability and duration of the applicant's funding commitments as well as the percentage of operating and capital costs guaranteed by the applicant. Identification of matching fund sources and the general terms of the funding commitments. Evidence of the applicant's ability to become self-sustaining in six years.

(v) Budget. Suitability and focus of the applicant's detailed one-year budget and six-year budget outline.

Supporting Information Packet. NIST has prepared a supplementary information packet which contains: a copy of 15 CFR part 290; background information on the existing Centers and the NIST Automated Manufacturing Research Facility, the Manufacturing Engineering Laboratory, the Electronics and Electrical Engineering Laboratory, the Computer Systems Laboratory, and the Materials Science and Engineering Laboratory; Standard Form 424 (Rev 4–88), Standard Form 424 (4–88), and Standard Form 424B (4–88); and OMB Circular A–110. Information packets are available upon request from the information contact above. Requests via a one page fax to the above number are preferred. Please include name, mailing address, and telephone number.

Paperwork Reduction Act: This notice contains a collection of information requirements subject to the Paperwork Reduction Act which have been approved by the Office of Management and Budget under control number 0693–0005 for use through September 30, 1992.

Other Requirements, Requests, and Provisions: Applicants who have outstanding accounts receivable with the Federal Government may not be considered for Manufacturing Technology Centers Program funding until the debts have been paid or arrangements satisfactory to the Department are made to pay the debt. The Manufacturing Technology Centers Program does not involve the mandatory payment of any matching funds from a State or local government, and does not affect directly any State or local government. Accordingly, the Technology Administration has determined that Executive Order 12372 is not applicable to this program.

Section 319 of Public Law 101–121 prohibits recipients of Federal contracts, grants, cooperative agreements and loans from using appropriated funds for lobbying the Executive or Legislative Branches of the Federal Government in connection with a specific contract, grant, cooperative agreement or loan. A "Certification for Contracts, Grants, Loans, and Cooperative Agreements" is required to be submitted with any application for funding under the Manufacturing Technology Centers program. Applicants for funding are subject to Government-wide Debarment Suspension (Nonprocurement) requirements as stated in 15 CFR part 26. In accordance with the Drug-Free Workplace Act of 1988, each applicant must make the appropriate certification as a "prior condition" to receiving a grant or cooperative agreement. A false statement on any application for funding under the Manufacturing Technology Centers program may be grounds for denial or termination of funds and grounds for possible punishment by a fine or imprisonment. Awards under the Manufacturing Technology Centers program shall be subject to all Federal and Departmental regulations, policies, and procedures applicable to Federal assistance awards.

Dated: January 8, 1992.

John W. Lyons,

Director, National Institute of Standards and Technology.

[FR Doc. 92–996 Filed 1–14–92; 8:45 am]

BILLING CODE 3510–13–M

National Institute of Standards and Technology — U.S. Department of Commerce

PROCEDURES FOR THE SELECTION AND ESTABLISHMENT OF NIST MANUFACTURING TECHNOLOGY CENTERS

(Part 290, Title 15 of the Code of Federal Regulations, as published in the Federal Register on September 17, 1990.)

Authority: 15 U.S.C. 278k.

Sec. 290.1 Purpose.

(a) This rule provides policy for a program to establish Regional Centers for the Transfer of Manufacturing Technology as well as the prescribed policies and procedures to insure the fair, equitable and uniform treatment of proposals for assistance. In addition, the rule provides general guidelines for the management of the program by the National Institute of Standards and Technology, as well as criteria for the evaluation of the Centers, throughout the lifecycle of financial assistance to the Centers by the National Institute of Standards and Technology.

Sec. 290.2 Definitions.

(a) The phrase ***advanced manufacturing technology*** refers to new technologies which have recently been developed, or are currently under development, for use in product or part design, fabrication, assembly, quality control, or improving production efficiency.

(b) The term ***Center*** or ***Regional Center*** means a NIST-established Regional Center for the Transfer of Manufacturing Technology described under these procedures.

(c) The term ***operating award*** means a cooperative agreement which provides funding and technical assistance to a Center for purposes set forth in Sec. 290.3 of these procedures.

(d) The term ***Director*** means the Director of the National Institute of Standards and Technology.

(e) The term ***NIST*** means the National Institute of Standards and Technology, U.S. Department of Commerce.

(f) The term ***Program*** or ***"Centers Program"*** means the NIST program for establishment of, support for, and cooperative interaction with Regional Centers for the Transfer of Manufacturing Technology.

(g) The term ***qualified proposal*** means a proposal submitted by a nonprofit organization which meets the basic requirements set forth in Sec. 290.5 of these procedures.

(h) The term ***Secretary*** means the Secretary of Commerce.

(i) The term ***target firm*** means those firms best able to absorb advanced manufacturing technologies and techniques, especially those developed at NIST, and which are already well prepared in an operational, management and financial sense to improve the levels of technology they employ.

Sec. 290.3 Program description.

(a) The Secretary, acting through the Director, shall provide technical and

financial assistance for the creation and support of Regional Centers for the Transfer of Manufacturing Technology. Each Center shall be affiliated with a U.S.-based nonprofit institution or organization which has submitted a qualified proposal for a Center Operating Award under these procedures. Support may be provided for a period not to exceed six years. The Centers work with industry, universities, nonprofit economic development organizations and state governments to transfer advanced manufacturing technologies, processes, and methods as defined in Sec. 290.2 to small- and medium-sized firms. These technology transfer efforts focus on the continuous and incremental improvement of the target firms. The advanced manufacturing technology which is the focus of the Centers is the subject of research in NIST's Automated Manufacturing Research Facility (AMRF). The core of AMRF research has principally been applied in discrete part manufacturing, including electronics, composites, plastics, and metal parts fabrication and assembly. Centers will be afforded the opportunity for interaction with the AMRF and will be given access to research projects and results to strengthen their technology transfer. Where elements of a solution are available from an existing source, they should be employed. Where private-sector consultants who can meet the needs of a small- or medium-sized manufacturer are available, they should handle the task. Each Center should bring to bear the technology expertise described in Sec. 290.3(d) to assist small- and medium-sized manufacturing firms in adopting advanced manufacturing technology.

(b) ***Program Objective.*** The objective of the NIST Manufacturing Technology Centers is to enhance productivity and technological performance in United States manufacturing. This will be accomplished through:

(1) The transfer of manufacturing technology and techniques developed at NIST to Centers and, through them, to manufacturing companies throughout the United States;

(2) The participation of individuals from industry, universities, State governments, other Federal agencies, and, when appropriate, NIST in cooperative technology transfer activities;

(3) Efforts to make new manufacturing technology and processes usable by United States-based small- and medium-sized companies;

(4) The active dissemination of scientific, engineering, technical, and management information about manufacturing to industrial firms, including small- and medium-sized manufacturing companies; and

(5) The utilization, when appropriate, of the expertise and capability that exists in Federal laboratories other than NIST.

(c) ***Center Activities.*** The activities of the Centers shall include:

(1) The establishment of automated manufacturing systems and other advanced production technologies based on research by NIST and other Federal laboratories for the purpose of demonstrations and technology transfer;

(2) The active transfer and dissemination of research findings and Center expertise to a wide range of companies and enterprises, particularly small- and medium-sized manufacturers; and

(3) Loans, on a selective, short-term basis, of items of advanced manufacturing equipment to small manufacturing firms with less than 100 employees.

(d) ***Center Organization and Operation.*** Each Center will be organized to transfer advanced manufacturing technology to small- and medium-sized manufacturers located in its service region. Regional Centers will be established and operated via cooperative agreements between NIST and the award-receiving organizations. Individual awards shall be decided on the basis of merit review, geographical diversity, and the availability of funding.

(e) ***Leverage.*** The Centers program must concentrate on approaches which can be applied to other companies, in other regions, or by other organizations. The lessons learned in assisting a particular target firm should be documented in order to

facilitate the use of those lessons by other target firms. A Center should build on unique solutions developed for a single company to develop techniques of broad applicability. It should seek wide implementation with well-developed mechanisms for distribution of results. Leverage is the principle of developing less resource-intensive methods of delivering technologies (as when a Center staff person has the same impact on ten firms as was formerly obtained with the resources used for one, or when a project once done by the Center can be carried out for dozens of companies by the private sector or a state or local organization.) Leverage does not imply a larger non-federal funding match (that is, greater expenditure of non-federal dollars for each federal dollar) but rather a greater impact per dollar.

(f) ***Regional Impact.*** A new Center should not begin by spreading its resources too thinly over too large a geographic area. It should concentrate first on establishing its structure, operating style, and client base within a manageable service area.

Sec. 290.4 Terms and schedule of financial assistance.

(a) NIST may provide financial support to any Center for a period not to exceed six years, subject to the availability of funding and continued satisfactory performance. Awards under this program shall be subject to all Federal and Departmental regulations, policies, and procedures applicable to Federal assistance awards. NIST may not provide more than 50 percent of the capital and annual operating and maintenance required to create and maintain such Center. Allowable capital costs may be treated as an expense in the year expended or obligated.

(b) ***NIST Contribution.*** The funds provided by NIST may be used for capital and operating and maintenance expenses. Each Center will operate on one-year, annually renewable cooperative agreements, contingent upon successful completion of informal annual reviews. Funding cannot be provided after the sixth year of support. A formal review of each Center will be conducted during its third year of operation by an independent Merit Review Panel in accordance with Sec. 290.8 of these procedures. Centers will be required to demonstrate that they will be self-sufficient by the end of six years of operation. The amount of NIST investment in each Center will depend upon the particular requirements, plans, and performance of the Center, as well as the availability of NIST funds. NIST may support the budget of each Center on a matching-funds basis not to exceed the Schedule of Financial Assistance outlined in Table 1. The remaining portion of the Center's funding shall be provided by the host organization.

Table 1. Schedule of NIST Matching Funds

Year of center operation	Maximum NIST share (percent)
1-3	50%
4	40%
5	30%
6	20%

(c) ***Host Contribution.*** The host organization may count as part of its share:

(1) Dollar contributions from state, county, city, industrial, or other sources;

(2) Revenue from licensing and royalties;

(3) Fees for services performed;

(4) In-kind contributions of full-time personnel;

(5) In-kind contribution of part-time personnel, equipment, software, rental value of centrally located space (office and laboratory) and other related contributions up to a maximum of 45 percent of the host's annual share. Allowable capital expenditures may be applied in the award year expended or in subsequent award years. These restrictions on host contribution apply to all awards issued or extended after September 30, 1990.

Sec. 290.5 Basic proposal qualifications.

(a) NIST shall designate each proposal which satisfies the qualifications criteria below as a "qualified proposal" and subject the qualified proposals to a merit review. Applications which do not meet the requirements of this section will not receive further consideration.

(1) ***Qualified Organizations.*** Any nonprofit institution, or group thereof, or consortium of nonprofit institutions, including entities which already exist or may be incorporated specifically to manage the Center.

(2) ***Proposal Format.*** Proposals for Center Operating Awards shall:

(i) Be submitted with a Standard Form 424 to the above address;

(ii) ***Not exceed 25 typewritten pages in length for the basic proposal document*** (which must include the information requirements of paragraph (a)(3) of this section); it may be accompanied by additional appendices of relevant supplementary attachments and tabular material. Basic proposal documents which exceed 25 pages in length will not be qualified for further review.

(3) ***Proposal Requirements.*** In order to be considered for a Center Operating Award, proposals must contain:

(i) A plan for the allocation of intellectual property rights associated with any invention or copyright which may result from the involvement in the Center's technology transfer or research activities consistent with the conditions of Sec. 290.9.

(ii) A statement which provides adequate assurances that the host organization will contribute 50 percent or more of the proposed Center's capital and annual operating and maintenance costs for the first three years and an increasing share for each of the following three additional years. Applicants should provide evidence that the proposed Center will be self-supporting after six years.

(iii) A statement describing linkages to industry, government, and educational organizations within its service region.

(iv) A statement defining the initial service region including a statement of the constituency to be served and the level of service to be provided, as well as outyear plans.

(v) A statement agreeing to focus the mission of the Center on technology transfer activities and not to exclude companies based on state boundaries.

(vi) A proposed plan for the annual evaluation of the success of the Center by the Program, including appropriate criteria for consideration, and weighting of those criteria.

(vii) A plan to focus the Center's technology emphasis on areas consistent with NIST technology research programs and organizational expertise.

(viii) A description of the planned Center sufficient to permit NIST to evaluate the proposal in accordance with Sec. 290.6 of these procedures.

Sec. 290.6 Proposal evaluation and selection criteria.

(a) In making a decision whether to provide financial support, NIST shall review and evaluate all qualified proposals in accordance with the following criteria, assigning equal weight to each of the four categories.

(1) ***Identification of Target Firms in Proposed Region.*** Does the proposal define an appropriate service region with a large enough population of target firms of small- and medium-sized manufacturers which the applicant understands and can serve, and which is not presently served by an existing Center?

(i) ***Market Analysis.*** Demonstrated understanding of the service region's manufacturing base, including business size, industry types, product mix, and technology requirements.

(ii) ***Geographical Location.*** Physical size, concentration of industry, and economic significance of the service region's manufacturing base. Geographical diversity of Centers will be a factor in evaluation of proposals; a proposal for a Center located near an existing Center may be considered

only if the proposal is unusually strong and the population of manufacturers and the technology to be addressed justify it.

(2) ***Technology Resources.*** Does the proposal assure strength in technical personnel and programmatic resources, full-time staff, facilities, equipment, and linkages to external sources of technology to develop and transfer technologies related to NIST research results and expertise in the technical areas noted in these procedures?

(3) ***Technology Delivery Mechanisms.*** Does the proposal clearly and sharply define an effective methodology for delivering advanced manufacturing technology to small- and medium-sized manufacturers?

(i) ***Linkages.*** Development of effective partnerships or linkages to third parties such as industry, universities, nonprofit economic organizations, and state governments who will amplify the Center's technology delivery to reach a large number of clients in its service region.

(ii) ***Program Leverage.*** Provision of an effective strategy to amplify the Center's technology delivery approaches to achieve the proposed objectives as described in Sec. 290.3(e).

(4) ***Management and Financial Plan.*** Does the proposal define a management structure and assure management personnel to carry out development and operation of an effective Center?

(i) ***Organizational Structure.*** Completeness and appropriateness of the organizational structure, and its focus on the mission of the Center. Assurance of full-time top management of the Center.

(ii) ***Program Management.*** Effectiveness of the planned methodology of program management.

(iii) ***Internal Evaluation.*** Effectiveness of the planned continuous internal evaluation of program activities.

(iv) ***Plans for Financial Matching.*** Demonstrated stability and duration of the applicant's funding commitments as well as the percentage of operating and capital costs guaranteed by the applicant. Identification of matching fund sources and the general terms of the funding commitments. Evidence of the applicant's ability to become self-sustaining in six years.

(v) ***Budget.*** Suitability and focus of the applicant's detailed one-year budget and six-year budget outline.

Sec. 290.7 Proposal selection process.

Upon the availability of funding to establish Regional Centers, the Director shall publish a notice in the ***Federal Register*** requesting submission of proposals from interested organizations. Applicants will be given an established time frame, not less than 60 days from the publication date of the notice, to prepare and submit a proposal. The proposal evaluation and selection process will consist of four principal phases: Proposal qualification; Proposal review and selection of finalists; Finalist site visits; and, Award determination. Further descriptions of these phases are provided in the following:

(a) ***Proposal qualification.*** All proposals will be reviewed by NIST to assure compliance with Sec. 290.5 of these procedures. Proposals which satisfy these requirements will be designated qualified proposals; all others will be disqualified at this phase of the evaluation and selection process.

(b) ***Proposal review and selection of finalists.*** The Director of NIST will appoint an evaluation panel to review and evaluate all qualified proposals in accordance with the criteria set forth in Sec. 290.6 of these procedures, assigning equal weight to each of the four categories. From the qualified proposals, a group of finalists will be selected based on this review.

(c) ***Finalist site visits.*** NIST representatives will visit each finalist organization. Finalists will be reviewed and assigned numeric scores using the criteria set forth in Sec. 290.6 of these procedures assigning equal weight to each of the four categories. NIST may enter into negotiations with the finalists concerning any aspect of their proposal.

(d) ***Award determination.*** The Director of NIST or his designee shall select awardees for Center Operating Awards

based upon the rank order of applicants, the need to assure appropriate regional distribution, and the availability of funds. Upon the final award decision, a notification will be made to each of the proposing organizations.

Sec 290.8 Reviews of centers.

(a) ***Overview.*** Each Center will be reviewed at least annually, and at the end of its third year of operation according to the procedures and criteria set out below. There will be regular management interaction with NIST and the other Centers for the purpose of evaluation and program shaping. Centers are encouraged to try new approaches, must evaluate their effectiveness, and abandon or adjust those which do not have the desired impact.

(b) ***Annual reviews of centers.*** Centers will be reviewed annually as part of the funding renewal process using the criteria set out in Sec. 290.8(d). The funding level at which a Center is renewed is contingent upon a positive program evaluation and will depend upon the availability of federal funds and on the Center's ability to obtain suitable match, as well as on the budgetary requirements of its proposed program. Centers must continue to demonstrate that they will be self-supporting after six years.

(c) ***Third year review of centers.*** Each host receiving a Center Operating Award under these procedures shall be evaluated during its third year of operation by a Merit Review Panel appointed by the Secretary of Commerce. Each such Merit Review Panel shall be composed of private experts, none of whom shall be connected with the involved Center, and Federal officials. An official of NIST shall chair the panel. Each Merit Review Panel shall measure the involved Center's performance against the criteria set out in Sec. 290.8(d). The Secretary shall not provide funding for the fourth through the sixth years of such Center's operation unless the evaluation is positive on all grounds. As a condition of receiving continuing funding, the Center must show evidence at the third year review that they are making substantial progress toward self-sufficiency. If the evaluation is positive and funds are available, the Secretary of Commerce may provide continued funding through the sixth year at declining levels, which are designed to insure that the Center no longer needs financial support from NIST by the seventh year. In no event shall funding for a Center be provided by the NIST Manufacturing Technology Centers Program after the sixth year of support.

(d) ***Criteria for annual and third year reviews.*** Centers will be evaluated under the following criteria in each of the annual reviews, as well as the third year review:

(1) The program objectives specified in Sec. 290.3(b) of these procedures;

(2) Funds-matching performance;

(3) The extent to which the target firms have successfully implemented recently developed or currently developed advanced manufacturing technology and techniques transferred by the Center;

(4) The extent to which successes are properly documented and there has been further leveraging or use of a particular advanced manufacturing technology or process;

(5) The degree to which there is successful operation of a network, or technology delivery mechanism, involving the sharing or dissemination of information related to manufacturing technologies among industry, universities, nonprofit economic development organizations and state governments.

(6) The extent to which the Center can increasingly develop continuing resources--both technological and financial--such that the Centers are finally financially self-sufficient.

Sec. 290.9 Intellectual property rights.

(a) Awards under the Program will follow the policies and procedures on ownership to inventions made under grants and cooperative agreements that are set out in Public Law 96-517 (35 U.S.C. Chapter 18), the Presidential Memorandum on Government Patent Policy to the Heads of

References

Aune, A. and A. Rao. 1992. ISO 9000 Standards, A Baseline for Excellence: Target (September/ October):23–29.

Baker, D., and T. Lee. 1992. Employment Multipliers in the U.S. Economy. Washington, D.C.: Economic Policy Institute. December 7. Photocopy.

Business Week. November 30, 1992. Quality: Small and Midsize Companies Seize the Challenge—Not a Moment Too Soon. 66–75.

Business Week. March 22, 1993. Cut Costs or Else: Companies Lay Down the Law to Suppliers. 28–29.

Clarke, M. K., and E. N. Dobson. 1991. Increasing the Competitiveness of America's Manufacturers: A Review of State Industrial Extension Programs. Washington, D.C.: National Governors' Association.

Clinton, W. J., and A. Gore. 1993. Technology for America's Economic Growth: A New Direction to Build Economic Strength. Washington, D.C. February 22. Photocopy.

Cohen, S. S., and J. Zysman. 1987. Manufacturing Matters: The Myth of the Post-industrial Economy. New York: Basic Books, Inc.

Competitiveness Policy Council. 1993. Forging the Future: Report of the Manufacturing Subcouncil to the Competitiveness Policy Council.

Dennis, W.J., Jr. 1992. Small Business Problems and Priorities. Washington, D.C.: The NFIB Foundation.

Dobyns, L. and C. Crawford-Mason. 1991. Quality or Else: The Revolution in World Business. Boston, Mass.: Houghton-Mifflin.

Entrepreneurial Economy Review. 1991. Networking as State Law: The Elements of Oregon's New Program. (Spring):32.

Faison, T. E., M. P. Vencill, J. W. McVey, K. M. Hollenbeck, and W. C. Anderson. 1992. Ahead of the Curve: Basic Skills Programs in Four Exceptional Firms. A Report of the Project on Corporate Decision-Making and Basic Skills Training in Small and Medium-Sized Firms, of the Southport Institute for Policy Analysis, Washington, D.C.

Fogarty, M. S., and Jar-Chi Lee. 1991. A Manufacturing Industry Cluster Approach to Technology Deployment . Center for Regional Economic Issues Program Paper Series. December 6. Cleveland: Case Western Reserve University.

Fogarty, M. S., S. J. Gage, and Jar-Chi Lee. 1993. Expanding the MTC Program: Economic and Design Considerations. Center for Regional Economic Issues Program Paper Series. June 25. Cleveland: Case Western Reserve University.

Forbes. March 1, 1993. A Little Guy in Brooklyn. 90–91.

Foundation for Industrial Modernization. 1993. Modernization Metrics: A Call for Knowing Where We Stand on Technology, Productivity, and Agility. Washington, D.C.: Foundation for Industrial Modernization.

Garvin, D. A. 1991. How the Baldridge Award Really Works. Harvard Business Review (Nov.–Dec.):80–93.

Hayes, R. H., and S. Wheelwright. 1984. Restoring Our Competitive Edge: Competing Through Manufacturing. New York: John Wiley and Sons.

Helper, S. R. 1992. Lessons for Networks: A Report to the Cleveland Advanced Manufacturing Program. Center for Regional Economic Issues Program Paper Series. September 9. Cleveland: Case Western Reserve University.

Industrial Technology Institute. 1991. Accelerating the Adoption of Technologies for the Manufacturing Enterprise.

Industrial Technology Institute. 1990. The Michigan Foundation: A Study of the Modernization Process in Michigan's Small-and Medium-Sized Manufacturers. Prepared for the Michigan Modernization Service by L. Ewing, M. Grueber, D. Luria, and E. Wiarda, with A. Baum, P. Cardiff, M. Fleischer, and N. Jennings.

Industrial Technology Institute. 1989. Smaller Firms Lag in Technology Use. TechnEcon 1(Spring):7–9.

Kelley, M. R., and T. A. Watkins. 1992. The Defense Industrial Network: A Legacy of the Cold War. Carnegie Mellon draft report. August. Photocopy.

Kenney, M., and R. Florida. 1993. Beyond Mass Production: The Japanese System and Its Transfer to the U.S. New York: Oxford University Press.

Moody, P. E. 1992. Take Down the Walls: Target (September/October): 8–16.

National Academy of Engineering. 1992. Manufacturing Systems: Foundations of World-Class Practice. A Report by the Committee on Foundations of Manufacturing. Washington, D.C.: National Academy Press.

National Academy of Engineering. 1988. The Challenge to Manufacturing: A Proposal for a National Forum. Washington, D.C.: National Academy of Engineering.

National Academy of Engineering. 1985. The Competitiveness Status of U.S. Industry—An Overview. Washington, D.C.: National Academy of Engineering.

National Research Council, Manufacturing Studies Board. 1992. Proposal Evaluation for Manufacturing Technology Centers. Washington, D.C.: National Academy Press.

National Research Council, Manufacturing Studies Board. 1990. Proposal Evaluation for Manufacturing Technology Centers. Washington, D.C.: National Academy Press.

National Research Council, Manufacturing Studies Board. 1988. Proposal Evaluation for Manufacturing Technology Centers. Washington, D.C.: National Academy Press.

National Research Council, Manufacturing Studies Board. 1985. Reactions of Small Machine Shop Owners to the Automated Manufacturing Research Facility of the National Bureau of Standards. Washington, D.C.: National Academy Press.

Organization for Economic Cooperation and Development. 1992. Technology and the Economy: The Key Relationships. Paris: Organization for Economic Cooperation and Development.

Piore, M. J., and C. F. Sabel. 1984. The Second Industrial Divide. New York: Basic Books, Inc.

Rimington, P. 1992. How We are Learning to Let Go. Target (July/August):4–5.

Rosenfeld, S., with P. Shapira and J. T. Williams. 1992. Smart Firms in Small Towns. Washington, D.C.: The Aspen Institute.

Ruxton, W. E. 1990. A National Association's Role in Local Manufacturers' Networks. Paper presented at Technology Transfer Society's Conference on Technology Transfer in a Global Economy, Dayton, June 28.

Ruxton, W.E. 1989. Testimony before the Subcommittee on Exports, Tax Policy, and Special Problems of the U.S. House of Representatives Committee on Small Business. October 2.

Sabel, C. F., G. Herrigel, R. Kazis, and R. Deeg. 1987. How to Keep Mature Industries Innovative. Technology Review (April):27–35.

Schonberger, R. J. 1986. World-Class Manufacturing: The Lessons of Simplicity Applied. New York: The Free Press.

Schonberger, R. J. 1987. World-Class Manufacturing Casebook: Implementing JIT and TQC. New York: The Free Press.

Shapira, P. 1992. Lessons from Japan: Helping Small Manufacturers. Issues in Science and Technology. (Spring):66–72.

Shapira, P. 1990a. Helping Small Manufacturers Modernize. Issues in Science and Technology. (Fall):49–54.

Shapira, P. 1990b. Modernizing Manufacturing: New Policies to Build Industrial Extension Services. Washington, D.C.: Economic Policy Institute.

Shapira, P. 1990c. Modern Times: Learning from State Initiatives in Industrial Extension and Technology Transfer. Economic Development Quarterly 4(August):186–202.

Shingo, S. 1989. A Study of the Toyota Production System from an Industrial Engineering Viewpoint. Cambridge, Mass.: Productivity Press.

Shingo, S. 1988. Non-Stock Production: The Shingo System for Continuous Improvement. Cambridge, Mass.: Productivity Press.

Shingo, S. 1983. A Revolution in Manufacturing: The SMED System. Cambridge, Mass.: Productivity Press.

Stalk, G., Jr., and T. M. Hout. 1990. Competing Against Time. New York: The Free Press.

Taguchi, G., E. A. Elsayed, and T. C. Hsiang. 1989. Quality Engineering in Production Systems . New York: McGraw-Hill Book Company.

Tobin, D. 1993. Re-Educating the Corporation: Foundations for the Learning Organization. Essex Junction, VT: Oliver Wight Publications.

U.S. Congress. 1990. Making Things Better: Competing in Manufacturing. Office of Technology Assessment. Washington, D.C.: Government Printing Office.

U.S. Congress. 1988. Omnibus Trade and Competitiveness Act of 1988, Public Law 100–418, Section 5121.

U.S. Congress. 1979. Regulatory Flexibility Act, 1979, Public Law 96–354, Section 299.

U.S. Department of Commerce. 1992a. County Business Patterns, 1990. Economics and Statistics Administration, Bureau of the Census. Various months. Washington, D.C.: U.S. Department of Commerce.

U.S. Department of Commerce. 1992b. Questions and Answers on Quality, the ISO 9000 Standard Series, Quality System Registration, and Related Issues. Revised July 1992. Gaithersburg, Md.: National Institute of Standards and Technology.

U.S. Department of Commerce. 1992c. Statistical Abstract of the United States. Bureau of the Census. Washington, D.C.: Government Printing Office.

U.S. Department of Commerce. 1991. Technology Administration: Strategic View. A review of the activities of the Technology Administration at the end of the first year. November. Washington, D.C.: Government Printing Office.

U.S. Department of Commerce. 1989. Current Industrial Reports: Manufacturing Technology 1988. Bureau of the Census. May. Washington, D.C.: Government Printing Office.

U.S. Department of Commerce. 1988. 1987 Census of Manufacturers. Bureau of the Census. Washington, D.C.: Government Printing Office.

U.S. Department of Defense. 1993. Program Information Package for Defense Technology Conversion, Reinvestment, and Transition Assistance. Technology Reinvestment Project. Arlington, Va., March 10.

U.S. Department of Labor. 1992. Survey of Current Business. Bureau of Labor Statistics. April. Washington, D.C.: Government Printing Office.

U.S. General Accounting Office. 1991. Technology Transfer: Federal Efforts to Enhance the Competitiveness of Small Manufacturers. GAO/RCED-92–30. November. Washington, D.C.: General Accounting Office.

U.S. Small Business Administration. 1992. The State of Small Business: A Report of the President transmitted to the Congress. Washington, D.C.: Government Printing Office.

Wall Street Journal. April 27, 1993. Tough Guys: 'Regulators From Hell' Frighten Some Banks But Also Win Praise .

Wall Street Journal. April 19, 1993. German-owned Maker of Power Tools Finds Job Training Pays Off: Stihl's 4-year Apprenticeship at Virginia Unit Yields Skilled, Productive Staff.

Wall Street Journal. March 29, 1993a. Manager's journal: NAFTA Creates Jobs for Joe and Jose.

Wall Street Journal. March 29, 1993b. Some Suppliers Rethink Their Reliance on Big Business—Pressure is Felt Most by Small Companies that Have One Giant Client.

Wall Street Journal. March 10, 1993. Age of Angst: Workplace Revolution Boosts Productivity at Cost of Job Security.

Welch, J., L. Cook, and J. Blackburn. 1992. The Bridge to Competitiveness, Building Supplier-Customer Linkages. Target 8(Nov.–Dec.):17–29.

Womack, J. P., D. T. Jones, and D. Roos. 1990. The Machine that Changed the World. New York: Rawson Associates.

Bibliography

Bast, J. H., and H. A. Domicone. 1992. The Causes and Nature of Organizational Change and Development of Small- and Medium-Sized Manufacturing Concerns in the Cincinnati Tri-State Area: An Empirical Investigation. Prepared for the Institute for Advanced Manufacturing Sciences, Inc. January. Cincinnati: University of Cincinnati.

Batt, R., and P. Osterman. 1993. A National Policy for Workplace Training: Lessons from State and Local Experiments. Economic Policy Institute, Washington, D.C.

Chisman, F. P. 1992. The Missing Link: Workplace Education in Small Business. The Southport Institute for Policy Analysis, Washington, D.C.

Combes, R. S. 1992. Origins of Industrial Extension: A Historical Case Study in Georgia. M.S. thesis. Georgia Institute of Technology, Atlanta.

Economist. March 6, 1993. Survey: The Japanese Economy. 12–15.

Feller, I. 1992. Recent Theoretical and Organizational Approaches to U.S. Technology Policy. Pp 117–131 in Technology and U.S. Competitiveness: An Institutional Focus, W. H. Lambright and D. Rahm, eds. New York: Greenwood Press.

Feller, I. 1992. Lessons from the American Experience with Technology Utilization and Technical Assistance Programs for Small and Medium-Sized Manufacturing Firms. Paper based on statement by Dr. Feller in his testimony to the U.S. House of Representatives, Committee on Science, Space, and Technology, Subcommittee on Technology and Competitiveness, Hearings on U.S. Manufacturing Capabilities, February 27.

Feller, I. 1987. Technology Transfer, Public Policy, and the Cooperative Extension Service-OMB Imbroglio. Journal of Policy Analysis and Management 6(3):307–327.

Feller, I., P. Madden, L. Kaltreider, D. Moore, and L. Sims. 1987. The New Agricultural Research and Technology Transfer Policy Agenda. Research Policy 16:315–325.

Fogarty, M. S., and Jar-Chi Lee. 1992. Manufacturing Industry Clusters as a Logical Way to Structure Technology Deployment. Center for Regional Economic Issues Program Paper Series. February 27. Cleveland: Case Western Reserve University.

Giancola, D. J. 1991. Heat in Ohio: The Difficult Birth of an American Network. Entrepreneurial Economy Review 9(Spring): 19–23.

Glasmeier, A. K. 1992. Plenary session comments from the 1992 Appalachian Regional Commission annual conference. Enhancing Manufacturing Competitiveness: Strategies for Appalachia in the 90s. Baltimore, Maryland. (November): 11–13.

Hatch, C. R. 1991. The Ties That Bind: Networks and the Making of Denmark's Competitive Edge. Entrepreneurial Economy Review 9(Spring): 13–18.

Industrial Technology Institute. 1992. What Detroiters Need to Know to Participate in the New Manufacturing Economy. Prepared for the Joyce Foundation by ITI in conjunction with Detroit Public Schools and Wayne County Community College.

Industrial Technology Institute. 1991. Manufacturing Extension and Technology Transfer: An Analysis of Program Practices, Impacts, and Policy Issues. Submitted to NDMTP Task Force by Industrial Technology Institute, Ann Arbor, in support of Subgroup on Technology Transfer and Manufacturing Extension Services .

Industrial Technology Institute. 1989. TechnEcon 1(Fall):1–13.

Luria, D., R. J. Cole, and A. Baum, with E. Wiarda, C. Treado, and Mr. Grueber. 1992. When Industrial Policy Arrives: The Allocation of Manufacturing Extension. December 22. Ann Arbor: Industrial Technology Institute.

MacNabb, R. R. 1993. Manufacturing Technologies in U.S. Industry: A MAPI Survey on the Use of Advanced Technologies and R&D in Manufacturing. February. Washington, D.C.: Manufacturers' Alliance for Productivity and Innovation.

McKenna, J. F. 1993. Youth's Got a Friend in Pennsylvania. Industry Week (February 1): 16–20.

McMillion, C. W. 1992. Manufacturing in America: A Quantitative View. A Report for the U.S. Competitiveness Policy Council, Washington, D.C.

MDC, Inc. 1992. Greater Expectations: The South's Workforce is the South's Future. Report of MDC, Inc. and its Advisory Panel on Southern Workforce Development. Chapel Hill, N.C.: MDC, Inc.

Mishel, L., and R. A. Teixeira. 1991. The Myth of the Coming Labor Shortage: Jobs, Skills, and Incomes of America's Workforce 2000. Economic Policy Institute, Washington, D.C.

National Academy of Engineering. 1993. Mastering a New Role: Shaping Technology Policy for National Economic Performance. Series on Prospering in a Global Economy. Washington, D.C.: National Academy Press.

National Academy of Engineering. 1992. Time Horizons and Technology Investments. Committee on Time Horizons and Technology Investment. Washington, D.C.: National Academy Press.

National Academy of Engineering. 1991. National Interests in an Age of Global Technology. Series on Prospering in a Global Economy. Washington, D.C.: National Academy Press.

National Academy of Engineering. 1991. People and Technology in the Workplace. Washington, D.C.: National Academy Press.

National Academy of Engineering. 1988. The Technological Dimensions of International Competitiveness. A Report by the Committee on Technology Issues that Impact International Competitiveness. Washington, D.C.: National Academy Press.

National Institute of Standards and Technology, Manufacturing Technology Centers Third Year Review Panel. 1992. Manufacturing Technology Centers: Broad Programmatic Issues. Washington, D.C.: Government Printing Office.

National Research Council, Manufacturing Studies Board. 1991. The Competitive Edge: Research Priorities for U.S. Manufacturing. Washington, D.C.: National Academy Press.

National Research Council, Manufacturing Studies Board. 1991. Improving Engineering Design: Designing for Competitive Advantage. Washington, D.C.: National Academy Press.

National Research Council, Manufacturing Studies Board. 1986. Toward a New Era in U.S. Manufacturing: The Need for a National Vision. Washington, D.C.: National Academy Press.

National Science Foundation. 1992. A report of the Workshop on Fundamental Research in Manufacturing for National Competitiveness. March. Ann Arbor: University of Michigan.

Oishi, O., and P. Eng. 1993. Total Quick Die Change: A Management Strategy. MetalForming (April):20–27.

Rosenfeld, S. A. 1991. Rural Perspectives: Linking Networks and Economic Development. Entrepreneurial Economy Review 9(Spring):28–31.

Ross, D. 1991. The Politics of Network Policy. Entrepreneurial Economy Review 9(Spring):33–34.

Ruxton, W. E. 1991. Talking Networking: an interview with William E. Ruxton. Entrepreneurial Economy Review 9(Spring):24–27.

Sabel, C. F. 1989. Flexible Specialisation and the Re-emergence of Regional Economies. Pp. 17–70 in Reversing Industrial Decline? Industrial Structure and Policy in Britain and Her Competitors , P. Hirst and J. Zeitlin, eds. New York: St. Martin's Press.

Shapira, P., J. D. Roessner, and R. Barke. 1992. Federal-State Collaboration in Industrial Modernization. July. Atlanta: Georgia Institute of Technology.

Simons, G. R. 1992. The Federal Manufacturing Technology Center Program: What Works and What Doesn't.

Suri, R., J. L. Sanders, P. C. Rao, and A. Mody. 1993. Impact of Manufacturing Practices on the Global Bicycle Industry. Manufacturing Review 6(March): 14–24.

Tornatzky, L. G., and D. Luria. 1991. Technology Policies and Programs in Manufacturing: Toward Coherence and Impact. In Strengthening Corporate and National Competitiveness Through Technology, B. Gold, ed., special issue of Journal of Technology Management. In press.

U.S. Department of Commerce. 1992. Overcoming the Competitive Barriers Facing Smaller Manufacturers: An Analysis of the Need for the Manufacturing Excellence Partnership. Gaithersburg, Md.: Technology Administration, National Institute of Standards and Technology. Photocopy.

U.S. Department of Defense. 1992. Adjusting to the Drawdown: Report of the Defense Conversion Commission. Washington, D.C.

U.S. Department of Energy. 1993. DOE Program Solicitation for Small Business Innovation Research. Office of Energy Research. March. Washington, D.C.: U.S. Department of Energy.

U.S. Department of Energy. 1992. DOE New Technology. Office of Scientific and Technical Information. January. Washington, D.C.: U.S. Department of Energy.

U.S. Department of Energy. 1992. Program Solicitation for Small Business Innovation Research. Washington, D.C.: U.S. Department of Energy.

Wall Street Journal. April 13, 1993. We Need to Measure, Not Count.

Wall Street Journal. March 29, 1993. Marketing and Media: Glenn Jones to Offer Cable TV Network on Computer Science.

Wall Street Journal. March 22, 1993. U.S. firms Are Seen Taking Wrong Steps on the Global Road—Study of 43 Companies Uncovers Few Ties Between Changes and International Success.

Wall Street Journal. March 19, 1993. Job Retraining Linked Closely to Employers Works in Cincinnati: Students Get a Fresh Start, Firms Get Technicians Who Are Clearly Eager.

Wall Street Journal. March 18, 1993. Firm Finds Ways to Grow Without Expanding Staffs.

Wall Street Journal. March 18, 1993. The False Promise of Defense Conversion.

Wall Street Journal. March 17, 1993. White-collar Blues: Like Factory Workers, Professionals Face Loss of Jobs to Foreigners.

Wall Street Journal. March 16, 1993. Price of Progress: 'Re-engineering' Gives Firms New Efficiency, Workers the Pink Slip.

Wall Street Journal. March 11, 1993. Firms Use Contract Labor and Temps to Cut Costs and Increase Flexibility.