

Michigan Journal of International Law

Volume 6 | Issue 1

1984

Technology Diffusion and the Performance of American Manufacturing: A Proposal for an Industrial Extension Service

Frank Ostroff

Harvard Industrial Policy Project

Follow this and additional works at: <https://repository.law.umich.edu/mjil>



Part of the [Business Organizations Law Commons](#), [Comparative and Foreign Law Commons](#), and the [Science and Technology Law Commons](#)

Recommended Citation

Frank Ostroff, *Technology Diffusion and the Performance of American Manufacturing: A Proposal for an Industrial Extension Service*, 6 MICH. J. INT'L L. 197 (1984).

Available at: <https://repository.law.umich.edu/mjil/vol6/iss1/12>

This Article is brought to you for free and open access by the Michigan Journal of International Law at University of Michigan Law School Scholarship Repository. It has been accepted for inclusion in Michigan Journal of International Law by an authorized editor of University of Michigan Law School Scholarship Repository. For more information, please contact mLaw.repository@umich.edu.

Technology Diffusion and the Performance of American Manufacturing: A Proposal for an Industrial Extension Service

Frank Ostroff *

The purpose of this article is to propose an Industrial Extension Service modeled upon the Agricultural Extension Service, and suggest how it might effectively address certain fundamental problems hindering the performance of the American manufacturing sector. Part I highlights some probable causes of American manufacturing's declining relative performance. Part II discusses why firms may adopt new technology more slowly than would be optimal. Part III considers the model of the Agricultural Extension Service, pointing out those features that make it attractive and those features that would have to be changed in applying it to the industrial sector. Part III also describes early and partial experiments to form such a service, and identifies their limitations. Part IV concludes with an evaluation of the idea and recommends a basic framework for implementation.

I. THE GENERAL PROBLEM

The ability of American manufacturing to compete in world markets is eroding. The balance of trade in manufactured goods has shifted strongly against the United States (U.S.) since the mid-1970s. As recent headlines attest, this trend has worsened in the past two years. In a host of industries—electrical equipment,

*Chair, Harvard Industrial Policy Project; Founding Editor, Working Papers on Industrial Policy (published by the Harvard Industrial Policy Project with the Center for Business and Government at the John F. Kennedy School of Government); A. B. 1982, University of California—Berkeley; M. P. P. 1984, John F. Kennedy School of Government, Harvard University, J. D. (expected) 1987, Yale Law School.

The author would like to note the following acknowledgement:

I am deeply appreciative of the assistance given to me by Professors Dorothy Leonard-Barton and Robert Hayes of the Graduate School of Business Administration at Harvard University and by Dr. Herbert Holloman of Boston University. I am also deeply appreciative of the assistance given to me by Robert Reich of the John F. Kennedy School of Government at Harvard University and, in particular, that given to me by Professor Dorothy Robyn which extended well past that dictated by duty towards that which demonstrated true friendship.

leather and rubber products, motor vehicles, numerically-controlled machine tools, and many others—the share of the market held by U.S. companies declined between 1965 and 1980.¹ The results of this decline have been felt on the corporate bottom line. For much of the past decade, the return on manufacturing assets has been below that on corporate bonds.²

Various explanations have been offered to account for these problems, including an over-valued U.S. currency and non-competitive wage rates. However, these explanations ignore a critical fact. Even with equivalently valued currencies and equally priced inputs of labor and capital, many American manufactured goods would still not be competitive internationally. For example, Japanese automobile manufacturers enjoy a \$1500 landed cost advantage over American companies in the production of similar cars.³ Although lower wage rates constitute an important part of the Japanese cost advantage, the Japanese require 20–25 percent fewer hours of labor and significantly less capital than American firms to build the same car.⁴ In steel, Japanese integrated mills enjoy as much as a \$150 per ton cost advantage over their American counterparts.⁵ Wage levels aside, Japanese integrated steel mills are simply more efficient than U.S. plants, requiring only 8.25 hours to produce a ton of steel, while those in the U.S. require 11.5 hours.⁶

But efficiency and productivity advantages, by themselves, do not explain enough. In some industries, quality of manufacture is the critical factor of competitive success. Here again, the performance of American firms has been disappointing. Japanese automobile manufacturers not only are more efficient than U.S. companies, but usually turn out a higher quality product as well.⁷ This Japanese advantage is found in other industries. David Garvin recently found that Japanese manufacturers of air conditioners had an assembly-line defect rate almost 70 percent lower than that of American manufacturers.⁸ Manufacturers in other countries have long recognized the importance of product quality. European companies such as Volkswagen and Phillips, for example, have made product quality a central part of their competitive strategy for many years.⁹

There are, in fact, a number of strategic dimensions that can be critical to competitive success through manufacturing. Among them are:

- (1) cost efficiency
- (2) product reliability
- (3) delivery cycle

1. For an exhibit showing a variety of industries in which world market share has been lost, see Scott, *National Strategy for Stronger U.S. Competitiveness*, HARV. BUS. REV., Mar.–Apr. 1984, at 80.

2. *Id.* at 77–78.

3. W. ABERNATHY, K. CLARK & A. KANTROW, *INDUSTRIAL RENAISSANCE* 63 (1983).

4. *Id.* at 59–63.

5. N.Y. Times, Mar. 20, 1984, at D4, col. 4.

6. *Id.*

7. W. ABERNATHY, *supra* note 3, at 63–67.

8. Garvin, *Quality on the Line*, HARV. BUS. REV., Sept.–Oct. 1983, at 66.

9. Leonard & Sasser, *The Incline of Quality*, HARV. BUS. REV., Sept.–Oct. 1982, at 163.

- (4) flexibility of product design
- (5) aesthetic appearance
- (6) pace of production.¹⁰

The dimension(s) upon which a firm should base its manufacturing strategy will depend upon both the resources available to the firm and the competitive dynamics of the industry as a whole. Any attempt to redress the problems of America's manufacturers must consider both the capabilities of particular firms and the competitive structure of involved industries.

New process technologies can lead to superior performance in manufacturing. Studies by economists¹¹ repeatedly point to the crucial role of technological advance in both economic growth and productivity increases.¹² Computer aided design and computer aided manufacturing technology (CAD/CAM) increases production efficiency by decreasing design and production time. Continuous casting increases the production pace and decreases costs in the manufacture of steel. Shuttleless looms and microprocessors increase production rates and efficiency in both continuous and small-batch production of textiles.

Advanced process technologies can also improve manufacturing performance in other ways. Shuttleless looms can offer significant increases in product quality. CAD/CAM can increase flexibility in product design and product mix and decrease change-over costs. The particular capability of a technology which will be most important, as well as the choice of technology which should be made, will vary with the competitive characteristics of different industries.

Despite the importance of technological advance to competitive success, the diffusion of new production technologies is lagging in many American industries. In 1981, 17 percent or less of the steel manufactured in the U.S. was continuously cast, compared to 58 percent in Japan.¹³ In a 1976 General Accounting Office study, only 17 percent of the metalworking firms examined had one or more numerically-controlled machine tools in use.¹⁴ Use of automated bonding equipment for integrated circuit assembly is much more widespread in Japan than in the U.S.¹⁵ The U.S. also lags far behind the Japanese in the diffusion and use of industrial robots.¹⁶

Mere use of advanced technologies does not guarantee superior performance. Comparative studies of the U.S. and Japanese automobile industries conclude

10. Abernathy & Clark, *Innovation: Mapping The Winds of Creative Destruction*, Harv. Bus. Sch. Working Paper, HBS 84-32, at 5; Skinner, *The Factory of the Future—Always in the Future*, in *TOWARDS THE FACTORY OF THE FUTURE 88* (American Society of Mechanical Engineers 1980).

11. See, e.g., C. FREEMAN, *THE ECONOMICS OF INDUSTRIAL INNOVATION* (2d ed. 1982).

12. I do not wish to over-emphasize, however, the role of technology. Obviously, there are a variety of management areas and government policies that play an important part in determining the competitive success of a nation's industries.

13. N.Y. Times, Jan. 1, 1981, at 28, col. 1. Continuous casting technology had been commercially available for over 15 years.

14. GEN. ACCOUNTING OFFICE, *MANUFACTURING TECHNOLOGY—A CHANGING CHALLENGE TO IMPROVED PRODUCTIVITY 44* (1976). Numerically-controlled machine tools had been commercially available for at least 15 years.

15. *Pushing for Leadership in the World Market*, BUS. WEEK, Dec. 14, 1981, at 62.

16. See *CREATIVE STRATEGIES INT'L, ROBOTS AND REINDUSTRIALIZATION 267-71* (1982).

that the way technology is managed—much more than the sheer level of technology—is what determines the Japanese competitive advantage.¹⁷ Most American companies that install CAD/CAM or robots do not take advantage of the flexible production capabilities of this new equipment. Instead, they use the equipment to produce goods in long runs, much in the same way that they used their older, dedicated machinery.

There are two changes necessary to improving the competitive ability of American manufacturing. The diffusion rate of new production technologies must be increased. And the technologies that are adopted must be utilized in a strategically effective manner.

II. CHANGING THE ADOPTION RATE OF NEW TECHNOLOGIES

To meet the challenge of improving manufacturing performance in the United States, it is important to understand why firms may be slow to adopt new technologies. This section of the paper presents three explanations of why firms, following only the incentives of the market, may adopt new technology less rapidly than the national interest in industrial competitiveness warrants. These three explanations demonstrate that a new cooperative effort to promote the use of production technologies may be necessary, and establish some criteria for an effective promotional effort.

(1) *Organizational resistance to change may slow the adoption rate of production technologies.* Adoption of technology almost always involves more than insertion of knowledge into a pre-existing set of processes and organizational relationships.¹⁸ New technologies are often seriously disruptive of pre-existing organizational structures. CAD/CAM technology, for example, requires workers to develop new operating skills. Work sequences must be changed because of altered production paths and faster production. New marketing skills must be developed to take advantage of the enhanced capability for product customization. Supplier relationships are disturbed because of reduced requirements for in-process inventory. The value of existing managerial expertise is destroyed since new procedures must be developed for allocating overhead. These are the kinds of changes that are at the heart of Joseph Schumpeter's "theory of innovation and economic development in which 'creative destruction' is the vehicle of growth."¹⁹ However, there are enough points of resistance to all of these disruptions within a firm to make successful change a difficult problem.

In order to overcome this resistance to change, two things are necessary. First, strategies designed to promote organizational change should be used. Second, business assistance must be given to the areas of the firm affected by the adoption of new technology. Helping a machine shop develop a retraining program for workers, for example, may ease adjustment to the use of CAD/CAM equipment.

(2) *Characteristic shortcomings of small and medium-size firms may slow*

17. W. Abernathy & K. Clark, Notes on a Trip to Japan, Harv. Bus. Sch. Working Paper, HBS 82-58, at 22.

18. Abernathy & Clark, *supra* note 10, at 7-10.

19. *Id.* at 9.

the adoption rate of production technologies. Lack of understanding of the capabilities of numerically-controlled equipment is second only to the cost of capital as a barrier to increased use.²⁰ The lack of understanding of technology is a particular problem for small and medium-size firms, many of which may be unaware that a new technology even exists. Small firms employ only a small percentage of the technical workforce in a sector (except in high technology industries).²¹ This lack of technical capability can limit the ability of these firms to find technical solutions to their problems, or to tap into federal research grants and reports. The lack of technical personnel can also place smaller firms outside of the "networks" of technical information (e.g., technical literature, conferences) where firms become aware of new technologies. Given their relatively scarcer technical resources, the technical personnel that small firms do have are usually devoted to "day to day, technically oriented firm production problems rather than ... the search for new technologies."²² Even if smaller firms are aware of the new technologies, they often do not have the research and development capability to do the adaptive engineering and development necessary to make effective use of available technologies given their specific business and technical needs.²³ Finally, smaller firms often lack the management capacity to effectively plan for, and take advantage of, the new capabilities of advanced process technologies.

(3) *Economic factors may also slow the adoption rate of production technologies.* The "standard micro-economic model" to explain the adoption rate of new innovations was developed by Mansfield in the early 1960s. It predicts that the lower the profitability of a new innovation or the proportion of firms using the innovation, the slower the rate of adoption of the innovation will be. In addition, the larger the size of the investment (as a percentage of the total assets of the firms), the slower the adoption rate of the innovation. The adoption rate of the innovation will also vary across industries depending on: how competitive the industry is, the attitude of the labor force toward innovation, the financial health of the industry, and other factors.

Even if use of an innovation would be profitable for a firm, it may not be perceived that way. Uncertainty concerning the technical feasibility of an innovation may inhibit adoption. In addition, individual firms may be unable to evaluate effects of an innovation on profitability, or be unnecessarily "risk-averse." There is a strong incentive for such firms to wait and let other firms be the "guinea pigs" in the adoption of new technologies.²⁴ Unfortunately, many firms may wait so long, that by the time they are willing to adopt a new technology, the opportunity for competitive advantage is lost.

A new cooperative effort to promote the use of new technologies could help overcome these impediments. To be effective, this effort should increase infor-

20. GEN. ACCOUNTING OFFICE, *supra* note 14, at 45.

21. CENTER FOR URBAN ECONOMIC DEV., FACILITATING FEDERAL TECHNOLOGY TRANSFER TO SMALL AND MEDIUM SIZED BUSINESSES AND STATE AND LOCAL GOVERNMENTS 10 (1984).

22. *Id.*

23. *Id.* at 11.

24. R. NELSON, M. PECK & E. KALACHEK, TECHNOLOGY ECONOMIC GROWTH AND PUBLIC POLICY 102-9 (1967)

mation concerning new technologies and promote organizational change to overcome the resistance of firms to their adoption and effective use. Attempts to increase information should aim to increase technical understanding and awareness of innovations, decrease uncertainty concerning technical feasibility and effects on profitability, and aid adaptation to the specific characteristics and needs of firms. Business assistance for areas of the firm affected by the use of new technology should also be given.

III. EFFORTS TO TRANSFER TECHNOLOGY

In response to the problem of lagging adoption of technology, a number of people have proposed establishing an industrial extension service, modeled after the successful Agricultural Extension Service,²⁵ a strategy briefly attempted in the 1960s. This section will look analytically at the Agricultural Extension Service as a model for an industrial technology transfer mechanism. It will also look at direct efforts to transfer industrial technology and describe some of their achievements and limitations. Finally, this section will examine the current "infrastructure" of productivity organizations in the U.S. and identify some of the areas where improvements are necessary.

A. *The Agricultural Extension Service*

The Agricultural Extension Service (AES) is probably the best known and most successful effort in the United States to transfer technology to industry. Studies of the great productivity increases of American agriculture almost all point to the critical role played by the AES.²⁶ The AES model consists of three main components: a research subsystem consisting of fifty state agricultural experiment stations and the U.S. Department of Agriculture; county extension agents, who work with farmers at the local level; and state extension specialists who link agricultural researchers and county agents.²⁷

The AES was established by the Smith-Lever Act of 1914.²⁸ The support of the railroads in the early 1900s was critical to the early successes of the Extension movement, which preceded passage of the Act. The railroad operators, recogniz-

25. J. Herbert Holloman, formerly Japan Steel Industry Professor of Technology and Policy at MIT and currently Director of the Center for Technology and Policy at Boston University, has been a leading proponent of the idea of applying the Agricultural Extension Service model to other industries. See, e.g., Heaton & Holloman, *Diffusing Technical Knowledge: A National Imperative*, TECHNOLOGY REV., Oct. 1983, at 13; see also CENTER FOR URBAN ECONOMIC DEV., *supra* note 21. For a pessimistic view of applying the Agricultural Extension Service model to other industries, see Rogers, Aveland & Bean, *Extending the Agricultural Extension Model* (Sept. 1976) (preliminary draft).

26. See, e.g., Rogers, Aveland & Bean, *supra* note 25, at 45.

27. "[T]he researchers and extension specialists are located in state agricultural universities, and have similar levels of expertise (both are usually Ph.D.s in agriculture). So the agricultural extension model is actually an integrated system for the innovation-development process." E.M. ROGERS, *DIFFUSION OF INNOVATIONS* 159 (3rd ed. 1983).

28. Smith-Lever Act, Pub. L. No. 95, ch. 79, § 1, 38 Stat. 372 (1914) (codified at 7 U.S.C. §§ 341-48 (1976)).

ing that an increasing percentage of rail shipments consisted of farm products, saw a strong correlation between increased farm productivity and their own prosperity. The railroad operators gave financial support for farm demonstrations, distributed educational bulletins and presented exhibits of farm products. The demonstration trains were particularly important; agricultural experts, usually from the land grant colleges, would travel the countryside, giving lectures and demonstrating new farming techniques. In 1911, three years before the Smith-Lever Act was passed, 62 trains carried 740 lecturers over 35,000 miles to an audience of over one million people.²⁹

Today, there are over 15,000 employees of the Extension Service. Funding comes from federal, state and county government and in 1975 totalled over \$450 million.³⁰ In addition to its record of success, several features of the Agricultural Extension Service make it attractive as a model for accelerating the adoption of technology in other industries.

(1) *The research subsystem provides a continuous source of new knowledge which is useful to increasing productivity.* There is a constantly expanding data base of new technology and processes that extension agents can use to help farmers improve production methods. Agents are kept abreast of new developments and have access to the research subsystem for technical solutions to particular problems that may arise.

(2) *The Extension Service uses an active transfer system to convey information about new technologies.* Technology transfer mechanisms can be divided into two basic modes: active systems in which active transfer agents, like county agents, bring together researchers and clients, and passive systems in which the user has sole responsibility for obtaining information through formal or impersonal media.³¹ Passive systems have a few obvious advantages. Since they do without the high labor overhead of active systems, they are relatively cheap to operate and maintain. And with the advent of computer information processing, users can theoretically find their way through the data bases of passive systems to find solutions to their technical problems.³²

For the purposes of accelerating adoption of new manufacturing technologies, however, passive systems have significant drawbacks. First, the same lack of technical expertise that keeps smaller, unsophisticated firms from introducing new processes severely limits their ability to make use of passive information systems. Some sort of technological "translator" is required to help smaller firms understand new research developments. In the Agricultural Extension Service, this "translator" function is taken up by the county extension agent, who can confer with the state specialist on the more difficult problems. Passive systems, like the National Technical Information Service, usually depend upon the user to adapt the information to his specific needs—again, something which is

29. J. Killacky, *The Cooperative Extension Service: An Historical Overview* 16 (April 1982) (qualifying paper submitted to Harvard Univ. Graduate School of Education). This paragraph draws heavily on pages 15–16 of Killacky's paper.

30. Rogers, Aveland & Bean, *supra* note 25, at 26, 30.

31. NAT'L SCIENCE FOUND., *THE PROCESS OF TECHNOLOGICAL INNOVATION: REVIEWING THE LITERATURE* 164 (May 1983).

32. *Id.* at 164–65.

beyond the capacity of many firms. Also, continual exchange of information between the technical source and information seeker is usually required to ensure that the correct problem is being addressed.³³ Finally, the tendency of smaller firms to devote their technical personnel to day-to-day operations limits their ability to stay on top of information in technical data bases.

Numerous studies have confirmed that passive information systems do not work well when evaluated by volume of technology adopted. Studies of various technology sharing programs operated by NASA, the Department of Commerce, and others all come to this conclusion.³⁴

Active systems, on the other hand, have distinct advantages in accelerating the adoption of technology. Virtually all empirical studies have concluded that face-to-face communication has a strong positive effect on technology dissemination and adoption.³⁵ Some of the reasons for the superiority of active transfer systems are the interpersonal "linkage" between technology producer and user;³⁶ the ability of the diffusion agent to absorb information and translate its applications to specific firms; and the ability of the dissemination agents to legitimize the use of the technology. Dissemination agents in the AES are backed by the resources of the research subsystem and the expertise of the research specialists. This lends technical credibility to the innovation, and reduces uncertainty concerning effects of its use;³⁷ the ability of the extension or dissemination agent to act as an exchange medium between the source of information (usually the state specialist) and the user, and to deal interactively with problems that may occur during the implementation of an innovation.

(3) *Local involvement in diffusion efforts help ensure effectiveness of technology transfer.* The AES is typical of centralized diffusion systems where the innovation flow is "top-down" from experiment station to extension agents to individual farmers. However, through county planning councils, individual farmers participate in the planning of extension efforts.³⁸ This gives program constituents an important sense of "ownership" of research results and ensures that problems addressed are those felt to be most pressing by farmers.

(4) *Extension agents act as "change agents."* As the AES has evolved, the assumption that it was sufficient for the county agent to grasp the content of agricultural innovation has disappeared. It is now assumed that the county agent must effectively communicate information concerning innovations and motivate the farmer to adopt them. Since 1954, agents have been trained in communication skills and received social science training emphasizing the diffusion process and behavior change.³⁹ Extension agents have come to see themselves as "change

33. CENTER FOR URBAN ECONOMIC DEV., *supra* note 21, at 26.

34. NAT'L SCIENCE FOUND., *supra* note 31, at 167.

35. See NAT'L SCIENCE FOUND., *supra* note 31, at 159-60 (citing a list of studies).

36. Research shows that potential users generally prefer, and make more effective use of, information given directly by people rather than media. *Id.* at 160.

37. Rogers defines the agent as having "competence credibility...the degree to which a communication source or channel is perceived as knowledgeable and expert." See E. M. ROGERS, *supra* note 27, at 328.

38. See Rogers, Aveland & Bean, *supra* note 25, at 28.

39. *Id.* at 39.

agents" and to think in terms of "innovators, laggards, opinion leaders, and stages in the innovation-decision process."⁴⁰ An agent might help a client understand the need to change his behavior, motivate interest in innovations, or help translate intent into action.⁴¹ An agent might now choose an "opinion leader" in a particular region, motivate that particular farmer to adopt an innovation, and then, through the workings of peer pressure and identification, watch that innovation quickly spread. Given the unwarranted resistance of many manufacturing firms to innovation, this capacity to communicate effectively the benefits of innovation and motivate behavior change is one of the most compelling arguments for extending the Agricultural Extension model to industrial manufacturing sectors.

There are, of course, differences between agriculture and manufacturing that must be addressed before the Agricultural Extension model can be used in other areas.

(1) *Rivalrous competition in manufacturing might impede the effectiveness of extending the Agricultural Extension model.* Differential access to technical knowledge does not give any particular farmer an advantage over another in selling his crop. Farmers are not in "rivalrous competition" with one another.⁴² A county agent usually faces no opposition if he wants to use a particular farmer's field to demonstrate a new planting technique. Moreover, there is little opposition to technical advice given to other farmers in the region. But in manufacturing, firms are often in direct competition. Thus, individual firms may object to having their workplace used as a demonstration site for a new manufacturing process. Opposition may also develop to giving technical advice concerning manufacturing processes which grant rival firms competitive advantages.

(2) *Extension agents might be "spread too thin."* The amount of knowledge required could place tremendous pressure on the extension agents. AES agents deal only with a single industry whose problems are fairly similar. The problems of corn farmers in a particular region, for example, will be much alike.⁴³ An industrial extension agent, on the other hand, may have to deal with different problems across very dissimilar industries.

(3) *There may be opposition to increased government intervention in research and technology transfer.* The government role in basic research has been accepted for some time now. But there has been traditional opposition to government involvement in applied research for industrial purposes other than agriculture. If the government were to become more involved in promoting development and transfer of applied industrial research, ideological opposition may develop.

(4) *The task of extension would be made more difficult by the greater need to adapt technology for specific firms.* This point is related to point two above. Little adaptation is required of agricultural innovations. Lettuce on one farm behaves

40. *Id.* at 40.

41. E.M. ROGERS, *supra* note 27, at 117.

42. R.R. Nelson, *Government Stimulus of Technological Progress: Lessons From American History*, in GOVERNMENT AND TECHNICAL PROCESS 466 (R.R. Nelson ed. 1982).

43. Rogers, Aveland & Bean, *supra* note 25, at 117.

much like lettuce on other farms within a particular region. However, innovation like CAD/CAM must be adapted to the specific characteristics and needs of different firms in order to be used effectively. Demands on the resources of an industrial extension effort would increase as a result.

B. *The State Technical Services Act*

The State Technical Services Act (STS) was a failed attempt in the 1960s to apply portions of the Agricultural Extension model to manufacturing industries. Personality conflicts between leading proponents of STS and members of Congress reportedly played a major role in the program's termination in 1970. However, lessons can still be drawn from STS's short tenure.

The Office of State Technical Services began as the "Civil Industrial Technology Program" within the U.S. Department of Commerce in 1962. The original aim was to stimulate research in lagging industries by giving direct grants for research and development to manufacturing companies. Funding for fiscal year 1963 was only \$1.6 million.⁴⁴ However, opposition to "allocation of Federal funds for research in the private sector in competition with private dollars" developed almost immediately.⁴⁵

In response to this opposition, Department of Commerce officials "turned their attention to increasing industrial productivity through improved utilization of existing technology."⁴⁶ To avoid criticism, STS was "conceived as a state program operating primarily out of land grant colleges, with state funds matching the federal dollars and state agencies establishing program priorities."⁴⁷

Many of STS's activities were based on existing programs in approximately 14 states.⁴⁸ The programs emphasized "consulta[tion], trouble-shooting, and short training courses, and made use of field agents to help with client problems."⁴⁹ Although STS received a three-year legislative authorization, its appropriations were "far below authorized levels."⁵⁰ Only \$10 million was spent during the three and one-half years of STS's operation.⁵¹

According to one commentator, STS affected a variety of groups, many of whom became directly involved in shaping the program. Among the groups were the Association of Land-Grant Colleges, the industrial development agencies in the states, a number of federal agencies including the Department of Agriculture, the Economic Development Administration, the Small Business Administration, and a variety of business, professional and engineering organizations.⁵²

In its evaluation of the program, Arthur D. Little, Inc., a major consulting firm, judged STS a qualified success. It found that the program had a positive

44. *Id.* at 111.

45. *Id.* at 111-12.

46. *Id.* at 112.

47. *Id.*

48. *Id.* at 113.

49. *Id.*

50. *Id.*

51. *Id.*

52. *Id.* at 112.

benefit-to-cost ratio (based on positive effects on gross national product, employment, or increased competitiveness of U.S. products), and that the program was “most helpful to small and medium size firms which do not have broad technical and research capabilities.”⁵³

However, major problems severely limited the positive impact that the program might have had. As stated by the General Accounting Office, “[f]ederal funding was too low and too short-lived to produce the structures needed to ensure success.”⁵⁴ The extent of federal expenditures was clearly inadequate to hire and train staff sufficiently, particularly field agents, “who could provide the consistent follow through that is essential to ensure any extension program’s success.”⁵⁵ STS was given neither the resources for more than a few demonstration projects, nor the opportunity to build the same kind of clientele network which currently sustains the Agricultural Extension Service. Finally, the activities of STS were limited largely to information dissemination. The need for adaptive research—the “process of adapting a technique or process to a particular local situation”—limited STS’s ability to help the firms it was designed to serve.⁵⁶

C. Other Technology Transfer Programs

A panoply of programs exist today which try to accelerate the rate at which technology is adopted by industry. The most recent inventory identified 50 government technology transfer programs.⁵⁷ However, most of these programs, like the National Technical Information Service, use passive transfer mechanisms, whose usefulness is limited by the inadequate technical resources of many firms. They offer nothing in the way of adaptive research or strategies to promote organizational change, nor do they act to ensure that technology is used in a way that increases the competitive ability of the adopting firms.

A few federal technology transfer programs, however, do use active transfer mechanisms.

(1) *The Small Business Administration*. In 1979 there were 16 Small Business Administration (SBA) small business development centers around the country (see Appendix 1). However, most SBA centers direct their assistance efforts towards service and retail sectors and have had little impact on manufacturing sectors.⁵⁸

(2) *NASA Technology Utilization Program*. The core of the Technology Utilization Program (TUP) was created in 1961. Six Regional Dissemination Centers at major universities around the country were employed to “screen technical

53. ARTHUR D. LITTLE, INC., PROGRAM EVALUATION OF THE OFFICE OF STATE TECHNICAL SERVICES 8 (Report to the Office of Program Planning, Dep’t of Commerce No. 9-35335, Oct. 1969).

54. GEN. ACCOUNTING OFFICE, GAO Pad-83-22, THE FEDERAL ROLE IN FOSTERING UNIVERSITY-INDUSTRY COOPERATION 46 (1983).

55. *Id.*

56. Rogers, Aveland & Bean, *supra* note 25, at 115.

57. FED. COORDINATING COUNCIL FOR SCIENCE, ENG’G AND TECHNOLOGY, DIRECTORY OF FEDERAL TECHNOLOGY TRANSFER 165 (1977).

58. See GEN. ACCOUNTING OFFICE, SIMILAR BUSINESS ASSISTANCE PROGRAMS OF TWO FEDERAL AGENCIES HAVE POTENTIAL FOR DUPLICATION at ii (1980) (draft).

developments for possible applications, prepare technical briefs and other reports, and assist potential users with problem formulation and information search".⁵⁹ During the first ten years of its operation, funding for TUP was approximately \$9.5 million. In its peak year of 1972, TUP aided 3,100 clients.⁶⁰ While there has been no systematic evaluation of the costs or benefits of the program, industrial users appear to have been satisfied with the program. For example, it is reported that Ford currently saves about \$12 million per year with a NASA-developed computer program for stress analysis in structural engineering.⁶¹ With recent cutbacks in NASA funding, however, the technology transfer program has all but disappeared.

Due to these cutbacks, the program is unlikely to have a significant impact on manufacturing firms today. Several problems, however, limited the effectiveness of the program. First, the technology offered had been developed for NASA's needs rather than the needs of industrial users. Second, little was offered in the way of adaptive engineering to help overcome the first problem. Finally, the predominant users of its products were high technology companies; the program did little to benefit technologically less sophisticated companies. One study concluded that, overall, TUP diffused little technological innovation to its clients.⁶²

(3) *Economic Development Administration University Centers*. In 1979, 31 University Centers offered management and technical assistance to industrial firms. (See Appendix I for list of Centers and fiscal year 1979 funding.) The Centers have small core staffs of permanent professional employees who administer programs and participate in counseling and assisting business clients on management and technical problems. Counseling is provided at no cost in most cases. The Center generally counseled clients with business, business administration, finance, accounting, and marketing problems. Clients were mainly small and medium-size retail, service, and manufacturing businesses.⁶³

As with the other programs, there are serious limitations on the effectiveness of the EDA Centers. First, funding and overall levels of program activity are insufficient for any significant impact to be felt. In 1980, total funding was only \$2.9 million.⁶⁴ All EDA Centers combined work with fewer than 2,000 clients a

59. Rogers, Aveland & Bean, *supra* note 25, at 115.

60. *Id.*

61. *Id.* at 115-16.

62. S.T. DOCTORS, THE NASA TECHNICAL TRANSFER PROGRAM: AN EVALUATION OF THE DISSEMINATION SYSTEM 40 (1979).

63. GEN. ACCOUNTING OFFICE, *supra* note 58, at 2. As an example of the type of engineering/technical assistance that a Center might offer, the GAO described one of the clients of the Georgia Institute of Technology EDA Center:

[A] cellulose insulation manufacturing company needed a flame-retardant chemical mix for its insulation. The services of the Chemical and Material Science Division of the Engineering Experiment Station were used to determine which chemical mixes would work efficiently and meet Federal Specification. A written report was provided which recommended certain mixes.

Id. at 14.

64. *Id.* at 1.

year.⁶⁵ Second, although clients are usually able to speak with individual counselors, little effort is made to initiate client contact or promote organizational change. Finally, the Centers offer different services and there is little coordination or systematic evaluation of their respective efforts.

D. The Current "Infrastructure" of Productivity Organizations

A team of researchers at the Georgia Institute of Technology recently finished a compilation of the different organizations attempting to increase "productivity" in the U.S.⁶⁶ Some of these organizations focus on technology, some on human resources, some on management problems, and some on combinations of all three. (See Appendix 2.) In order to define the universe of organizations included in the compilation, the researchers examined each organization to determine whether it was devoted primarily to productivity improvement in the public or the private sector and whether it had local and national support and visibility, a charter, or other formal authorization.⁶⁷

While 30 different organizations offered some combination of management or technical assistance to private companies, the total number of employees was less than 1,000.⁶⁸ This figure contrasts vividly with the more than 15,000 currently employed by the Agricultural Extension Service.

The range of services offered by these organizations varies. The Oregon Productivity Center offers courses to improve business skills.⁶⁹ Others, like the Manufacturing Productivity Center at the Illinois Institute of Technology, offer training in the use of industrial robots and microcomputers.⁷⁰ The approaches used by these organizations to transfer technology vary as well. The Pennsylvania Technical Assistance Program (PENNTAP), located at Pennsylvania State University, uses the university's resources to solve problems that the client brings to the program.⁷¹ The Georgia Productivity Center, located at the Georgia Institute of Technology, gives greater attention to on-site visits, and relies on an extension agent's own problem-solving expertise.⁷²

The PENNTAP and Georgia Productivity Center programs have experienced some measure of success. Using data based on a 40–50 percent response rate, PENNTAP reported that it had produced benefits totaling approximately \$52 million between 1972 and 1981. PENNTAP funding during that period was approximately \$3.2 million. Thus the benefit-to-cost ratio was 16.2 to 1. Examining

65. This figure was calculated by extrapolating the 336 cases in 1979 for the six EDA University Centers studied by the GAO to all 31 University Centers. Obviously, this extrapolated figure should be used with caution. To my knowledge, no study has actually counted the clients of all 31 University Centers.

66. D. Clifton, R. Yoos, W. Riall, Jr. & A. DeCurtis, *The Productivity Infrastructure of the United States* (Jan. 1984) (U.S. Dep't of Commerce Grant No. 99-05-07129).

67. *Id.* at 13.

68. *Id.* at 23.

69. *Id.* at B-43.

70. *Id.* at B-59.

71. GEN. ACCOUNTING OFFICE, *supra* note 54, at 37.

72. *Id.*

successful interaction between the Georgia Productivity Center extension service and six client firms, Arthur D. Little, Inc. found that 300 jobs had been created or saved by the extension service, resulting in a benefit-to-cost ratio of 22:2.⁷³ Satisfactory evaluations have yet to be performed which would measure the contribution of these organizations to increased manufacturing capability or volume of technology transferred.

Despite their qualified success, the impact of these organizations on the competitiveness of U.S. manufacturing sectors is hampered by a variety of factors.

(1) *Their resources are too limited.* Funding and staffing limitations severely diminish the effect that these programs might have. Studies have shown that when ratios of clients to extension agents substantially exceed 500 to 1, effectiveness diminishes.⁷⁴ According to this standard, almost all agent to client ratios are inadequate for the regions served.

(2) *There are significant gaps in the geographic distribution of these programs.* There are major portions of the country where no organizations offer either management or technical assistance. Whole areas of the country go without active efforts to diffuse new technologies.⁷⁵

(3) *The services offered by these organizations are inadequate.* Some of these organizations promote the use of new technologies. Some of them attempt to improve the management of new and existing technologies. A few even offer competitive analyses of the industries so that new technologies might be used effectively. But virtually none do all three, and none make a serious effort to promote behavioral change on the part of firms or attempt to motivate them to adopt new technologies. Those organizations which attempt to diffuse new technologies rely on "technology push" strategies alone.

(4) *A variety of important factors impede interaction among the organizations.*⁷⁶ Many of these organizations could benefit from the experience and expertise of others. Yet there is little or no coordination or even interaction among them. Some of them state that they are afraid to share information for fear that business will be "swept out from under them if they share their methods and information too easily."⁷⁷ And no objective standards exist against which the procedures of these organizations can be evaluated.

Yet, many of the organizations in the Georgia Institute of Technology study believed that their status would be enhanced through national affiliation. In their view, the advantages that national affiliation would offer include:

increased visibility and recognition; combined resources; a sounding board for new ideas; improved funding prospects; and a means by which performance standards could be defined and productivity awareness raised.⁷⁸

73. *Id.* at 40-41. The methods of calculating benefit-to-cost ratios cited in this paragraph are somewhat questionable. Therefore, final figures should be used with caution.

74. Rogers, Aveland & Bean, *supra* note 25, at 121.

75. CLIFTON, *THE PRODUCTIVITY INFRASTRUCTURE OF THE U.S.* 31.

76. This section draws on D. Clifton, R. Yoos, W. Riall, Jr. & A. DeCurtis, *supra* note 66, at 50-51.

77. *Id.* at 51.

78. *Id.*

IV. CONCLUSION AND RECOMMENDATIONS

There is a pressing need for a substantial new effort to promote the use of advanced manufacturing technologies. American firms are failing to compete successfully along a variety of dimensions—efficiency, quality, flexibility, and others—for reasons having little to do with the exchange rate, cost of labor, or current “state of the economy.” Sophisticated applications of new technologies can improve manufacturing performance in a wide range of industries, but organizational resistance to change, characteristic shortcomings of small and medium-size firms, and other economic factors have slowed the adoption of new technologies to a rate that is not in the national interest. Existing efforts to improve manufacturing are inadequate but point to the potential benefits of a new institutional effort, and the need for additional coordination and funding.

The Agricultural Extension Services model serves as an effective starting point for a program that could substantially improve American manufacturing performance. By using an active mode of technology transfer, organizational change strategies, and local planning councils, the model meets a number of the criteria established in Part II for the effective promotion of new technologies. Applying the AES model to the manufacturing sector would greatly benefit the American economy. The successful application of the model, however, will require thoughtful treatment of a number of problems.

An Industrial Extension Service (IES) would improve the performance of American manufacturing.⁷⁹ The IES would be loosely based on the Agricultural Extension Service model, and would include the use of a research subsystem, extension agents, and research specialists.

The following recommendations will serve as a framework for dealing with the more detailed problems of program design and implementation:

(1) *Industrial Research Centers should be established at major universities around the country to provide a continuing source of new information concerning production technologies.* Research Centers would concentrate research on a limited number of areas chosen by local planning councils. In one region, a Research Center might concentrate on robotics; in another, on problems of the mining industry. In many cases, the Research Centers could be based at schools participating in the EDA University Center Program or already existing state programs. In other cases, the Research Centers would have to be established without the assistance of an existing organization. Research Centers should be distributed in all 50 states on the basis of industrial concentration so that all geographic areas receive adequate services.

(2) *The IES should utilize extension agents to actively transfer technology to local manufacturing firms.* Extension agents would increase client understanding and use of new technologies through lectures, demonstrations, and on-site consultations. The qualifications of extension agents backed by a research team and

79. While I highlight the use of the IES to promote the diffusion and effective use of production technologies, it might also be used to improve the performance of small and medium-sized firms in additional management areas. This additional possibility is a legitimate area for policy consideration. See also CENTER FOR URBAN ECONOMIC DEV., *supra* note 21, at 1–13, 79–90, 107–09.

the use of demonstrations would reduce doubts about the technical feasibility of new innovations. The ability of clients to evaluate effects on profitability would be enhanced by agents pointing out the competitive advantages and disadvantages of the innovations. The familiarity of the agent with the client's problems, as well as the use of demonstrations at firms having similar characteristics, would assure clients that use of an innovation would improve profitability. In order to help the firm make the most effective use of its new capabilities, agents would also provide assistance to departments such as personnel, finance, and marketing, that might be disrupted by the introduction of new technologies.

The scope of services should include competitive analysis of industries as well as general business assistance. Mere use of advanced technologies is not sufficient to improve competitive performance. Competitive analysis of an industry would help an agent decide if the use of advanced technologies is appropriate, which technologies should be adopted, and how technologies should be used.

The industrial extension agents should take note of the increasing emphasis the AES has placed on the role of extension agents as "change agents." Through a variety of strategies designed to promote behavior change, individual extension agents could increase the willingness of manufacturing clients to use innovations. Agents would employ organizational change strategies to motivate adoption of technologies and assist clients with adaptive engineering.

Agents should be kept up to date on the latest technologies through conferences and in-house training sessions at the Research Centers. They should also receive ongoing instruction in effective communication and change strategies.

(3) *Research specialists should link extension agents to new technologies and expertise in business analysis.* Technical experts would keep extension agents informed of the latest technological developments. They would also provide answers to complex technical questions and conduct research in response to the requests of local planning councils or client needs. Business specialists would provide the expertise necessary to aid firm departments particularly affected by the adoption of new technology. For example, a staff accountant might help a client develop new procedures for allocating overhead necessitated by the use of CAD/CAM equipment, or a specialist in process planning might help a client develop a more efficient production path for the use of numerically-controlled machine tools. Specialists possessing particular skills in the competitive analysis of industries would be available to assist the extension agents in making recommendations for the effective use of new technologies.

(4) *The program should be given adequate time and funding to attain and prove its effectiveness.* Chronically inadequate funding has limited efforts to transfer technology. Successful application of the extension model to manufacturing will require sufficient funding to provide an adequate range and level of services. In addition, the program must be given adequate time to recruit and train agents and enable agents to develop a clientele network and familiarity with client problems.

During the past decade, the Agricultural Extension Service has received more than \$450 million per year in total funding and continually employed more than 15,000 people. These figures should be considered minimum benchmarks for the Industrial Extension Service. In addition, appropriations for the Industrial Extension

sion Service should be approved for at least a five year period. This time span should be considered the absolute minimum necessary for the program to attain effective operating levels anywhere near that of the Agricultural Extension Service.

Ultimately, program capacity must be sufficient to make a significant impact on the overall performance of American manufacturing. To avoid overburdening the first extension agents, however, program capacity must be expanded carefully; even a five year period may not be sufficient.

(5) *Local planning councils made up of business, government, labor, and the Research Centers representatives should direct local extension efforts toward a limited number of technologies or industries.* This will prevent program resources from being overwhelmed. Cooperative direction of extension efforts will ensure that assistance is directed toward those industries that local interests believe are important and will encourage local support. Cooperative participation by local manufacturing firms will help defuse concern about misguided or unwanted government "intervention."

(6) *To prevent the overburdening of program resources, agents should not be forced to deal with too many clients or too many industries.* Agricultural extension agents deal with a relatively homogeneous group of clients in a single industry. Manufacturing extension agents will need to possess knowledge of a large number of different industries. In addition, manufacturing innovations require more adaptation to individual firms than agricultural innovations. Since the effectiveness of an AES agent declines when the client-to-agent ratio exceeds 500:1, a client-to-agent ratio of 100:1 should be considered an absolute maximum.

(7) *The federal government should take the lead by matching state and county government funds and providing overall coordination of the program.* Federal matching funds for the IES would help ensure adequate funding. Matching arrangements would also ensure that all three levels of government are committed to the program. An appropriate federal agency should also coordinate the efforts of the various Research Centers. Within the current "infrastructure" of productivity organizations, effective methods of providing assistance to client and special technical expertise often go unshared. The federal agency should promote cooperation between the Research Centers and promulgate objective standards by which extension efforts could be evaluated.

(8) *A data network should be established between the Research Centers.* An electronic link between the Research Centers would allow them to share assistance methods and obtain answers to technical problems beyond their particular expertise. Eventually the data network could be expanded to include information in existing passive information systems like the National Technical Information Service.

(9) *A strong effort must be made to obtain the support of interested groups for the idea and methods of an Industrial Extension Service.* One of the lessons of both the Agricultural Extension Service and the State Technical Services Act is that the support of interested groups, particularly those in the private sector, plays a crucial role in determining such a program's success.

It may be difficult to obtain adequate support for applying the extension model

to manufacturing. There is a traditional bias in the private sector against programs that appear to increase government intervention. Certain industries may oppose the program because it assists competing sectors. On the other hand, clients of current productivity organizations and a number of the organizations that participated in shaping the State Technical Services Act would provide a natural political base for establishing an Industrial Extension Service. In addition, a number of the industries whose performance in world markets has deteriorated in recent years—like machine tools and textiles—might also be in favor of the concept.

Adequate support for the program is important to its potential enactment, and confidence in its methods is necessary for it to be fully effective.⁸⁰ Supportive local trade associations and planning councils could help obtain demonstration sites for production technologies and increase participation in IES activities.

The attention now focused upon the effects of exchange rates, labor, and capital costs on the U.S. trade position can be justified only if at least equivalent attention is paid to improving the performance of American industries within the constraints of those economic factors. A carefully planned Industrial Extension Service is an important first step in redressing the current imbalance in both our trade position and the focus of our policy deliberations.

80. It may be difficult to convince some firms of the advisability of some extension methods. For example, firms may not be willing to allow their factories to be used as demonstration sites to be viewed by rivals.

Appendix 1
Location and Fiscal Year 1979 Federal Funding of EDA and SBA Centers

State	Name of College	Center Funding By	
		EDA	SBA
Alabama	Auburn University	\$ 75,000	\$
Arkansas	University of Arkansas	50,000	113,359 ¹
California	California State University	125,000	157,500
"	University of Southern California	175,000	
"	California Polytechnic State University		142,500
Colorado	University of Colorado	100,000	
District of Columbia	Howard University		135,000
Florida	Florida State University	25,000	
"	University of West Florida		154,750
Georgia	Georgia Institute of Technology	50,000	
"	University of Georgia		290,250
Hawaii	University of Hawaii	100,000	
Illinois	University of Illinois	165,000	
Kentucky	University of Kentucky	50,000	
Louisiana	Louisiana State University	100,000	
Maine	University of Southern Maine	100,000	165,000
Maryland	Coppin State College	95,000	
Massachusetts	University of Massachusetts	100,000	
Michigan	University of Michigan	100,000	
Minnesota	Southwest Minnesota State University	25,000	
"	University of Minnesota	100,000	
"	St. Cloud University		150,000
Mississippi	Mississippi Research and Development Center ²	50,000	
Missouri	University of Missouri	100,000	290,000
Nebraska	University of Nebraska		250,000
New Hampshire	University of New Hampshire	100,000	
New Jersey	Rutgers University	100,000	300,000
New Mexico	University of New Mexico	105,000	
New York	State University of New York College	200,000	

Appendix 1 (Continued)
Location and Fiscal Year 1979 Federal Funding of EDA and SBA Centers

State	Name of College	Center Funding By	
		EDA	SBA
North Carolina	St. Augustine's College	100,000	
"	Western Carolina University	50,000	
North Dakota	North Dakota State University	50,000	
Oklahoma	East Central Oklahoma State University	125,000	150,000 ¹
Pennsylvania	University of Pennsylvania		40,000
South Carolina	University of South Carolina		
Tennessee	Memphis State University	50,000	
"	University of Tennessee	50,000	
Texas	University of Texas	100,000	
Utah	University of Utah		150,000
Wisconsin	University of Wisconsin		40,000
Washington	Washington State University	150,000	150,000
Totals		<u>\$2,865,000</u>	<u>\$2,678,359</u>

¹ Awarded in September 1979

² State agency which received grant directly from EDA

Source: GAO, *Similar Business Assistance Programs of Two Federal Agencies Have Potential for Duplication*, 1980 (draft).

Appendix 2
Data in Productivity Organizations

Name	Orientation ¹	Number of Equivalent				Percent of Organization's Efforts				
		Professionals	Staff	Total	Assistance	Education	Publications	Research	Other	
American Center for QWL	HR	22	2	24	.40	0	0	0.60	0	
American Productivity Center	HR/M	40	10	50	.33	.33	.17	.17	0	
Bowling Green Prod. & Gaining Inst.	HR/M	4	1	5	.70	0	.15	.15	0	
Center for Analysis of Prod.—Int. Pers.	HR/M/T	9	20	29	.20	.30	.30	.20	0	
Center for Effective Organizations	HR	5	15	20	.15	.10	.15	.60	0	
Center for Government & Public Affairs	M	5	2	7	.65	.05	.10	.20	0	
Center for Prod. Innovation & Technology	HR/M/T	1	0	1	.25	.50	0	.25	0	
Center for Productivity Studies	HR	2	2	4	.25	.15	.05	.55	0	
Center for Study of Private Enterprise	M/T	7	9.5	16.5	.40	.40	.20	0	0	
Div. of Extension & Public Services	HR/M	32	33	65	0	.70	0	.30	0	
Florida Center for Productivity	T	3	1	4	.25	0	0	0	.75	
Georgia Productivity Center	M/T	110	35	145	.60	.15	.10	.15	0	
Institute for Productivity	HR	15	2	17	.50	0	0	.25	.25	
International Assoc. of Quality Circles	M	6	4	10	.50	.25	.25	0	0	
Management & Behavioral Science Center	M	12	4	16	.25	.25	0	.50	0	
Manufacturing Productivity Center	T	200	50	250	.25	.15	.10	.50	0	
Maryland Center for Prod. & QWL	HR/M	3	3	6	.25	.25	.25	.25	0	
Michigan QWL Council	HR	5	3	8	.50	.30	.05	.05	.10	
National Center for Public Prod.	HR	28	6	34	.10	.60	.20	.10	0	
North Carolina State	T	18.2	12.2	30.4	.20	.50	.06	.21	.03	
Northeast Labor-Management Center, Inc.	M	2	2	4	0	0	0	0	1	
Oklahoma Productivity Center	M	3	1	4	.25	.25	.25	.25	0	
Oregon Productivity Center	M/T	3	1.25	4.25	.45	.20	.15	.20	0	
Organization Behavior Program	HR	4	0	4	.30	0	0	.70	0	
PENNTAP	T	14	3	17	1	0	0	0	0	
Pennsylvania MILRITE Council	M/T	2	1	3	.20	0	0	.80	0	
Productivity Center—GSU	HR	18.5	0	18.5	.03	.03	.04	.90	0	
Productivity Center—U.S. Chamber	M	1.75	2	3.75	0	.99	0	.01	0	
Productivity Center—U. of Arkansas	T	.50	0	.50	.55	.30	.10	.05	0	
Productivity Center of the Southwest	M	12	0	12	0	.80	.10	.10	0	

Appendix 2 (Continued)
Data in Productivity Organizations

Name	Orientation ¹	Number of Equivalent				Percent of Organization's Efforts				
		Professionals	Staff	Total	Assistance	Education	Publications	Research	Other	
Productivity Evaluation Center	T	1	3	4	.05	.20	.25	.50	0	
Productivity Improvement Group	HR	.50	1	1.5	.90	0	0	.10	0	
Productivity Institute	HR	2	0	2	.60	.10	.30	0	0	
Purdue University—CIDMAC	T	5	5	10	0	0	0	1	0	
Quality of Working Life Program	HR	2	6	8	0	0	.05	.80	.15	
RPI Center for Mfg. & Tech. Transfer	T	13	5	18	.70	.30	0	0	0	
State Government Prod. Research Center	HR/M	3	1	4	.65	.10	.10	.15	0	
Texas Center for Prod. & QWL	M/T	11	13.5	24.5	.30	.15	.15	.40	0	
Texas Hospital Assoc. Statewide Prod. Ctr.	M/T	50	50	100	.45	.30	.10	.15	0	
Third Party Studies Program	HR	3	1	4	.25	.25	.25	.25	0	
University of Massachusetts	HR	15	9	24	.30	.60	.10	0	0	
Utah Center for Prod. & QWL	HR/M	3	1.5	4.5	.40	.40	.10	.10	0	
Work in America Institute	HR	9	8	17	0	.33	.33	.33	.01	
Work in Northeast Ohio Council	HR	5	100	105	.25	.25	.25	.25	0	

¹HR = Human Relations; HR/M = Human Relations/Management; M = Management; M/T = Management/Technical; T = Technical; HR/M/T = Human Relations/Management/Technical

Source: Clifton et al., *The Productivity Infrastructure of the United States*, Georgia Institute of Technology, p. C-4.