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THE IMPACT OF MANUFACTURING EXTENSION PROGRAMS ON THEIR CUSTOMERS: LESSONS FROM AN MTC EVALUATION

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It is important for industrial extension programs to achieve measurable impacts that make a difference to their manufacturer-customers. This is much more than a matter of retaining public support; it is imperative to repairing U.S. manufacturing performance, which since the 1970s has been plagued by a disproportionate slowdown in the productivity and wages of the small and medium-sized shops that have increased their weight in the economy (Foundation for Industrial Modernization, 1993).

Unfortunately, most attempts to evaluate the impact of manufacturing extension (for a review, see Shapira, Youtie, and Roessner, 1994) suffer from at least one of three weaknesses:

- *Subjectivity*. Most program evaluations, no matter how they dress it up, ask clients to report how they *feel* about the services that have been provided.
- *Industry-Ignorance*. Many evaluations don't measure the things that matter in the firms served by extension programs. Metal *stampers* are asked what proportion of their machines are "CNC" (computer numerical control), when the term applies only to metal *cutting*. Tool and die shops are asked about *product* design, when the relevant question is almost always whether they design the *tooling* for their *customers'* products. Alternatively, firms of all kinds are asked the same, overly general questions.
- *Absence of Controls*. Nearly all evaluations are content to ask whether clients are improving, rather than whether they're improving relative to an otherwise-similar control group.

The point about industry-ignorance deserves further emphasis. Good evaluation, we believe, requires intensive knowledge of the industries being served, and one can't know enough about more than a handful. In most of the areas that modernization programs seek to influence -- technology adoption and use, workforce development, shop planning, material selection, and the integration of design and manufacturing -- many of the relevant measures are different in different industries, and even *within* industries. For example, moldmakers don't do

tryout molding or extrusion; diemakers (in the same four-digit SIC as moldmakers) do tryout stamping. Molders use design of experiments to optimize resins; machine shops don't use it to specify steels. Only stampers define tolerances separately for formed surfaces and punched holes. Machine-builders and diemakers only need to worry about machine run time for CNCs, planer mills, and other specialized equipment; high-volume shops need to worry about the utilization of nearly all production machines. Quality assurance is based on statistical sampling in high-volume environments, and on completeness procedures in low. True, some measures -- including the 50 that we use to provide benchmarking reports to other NIST/MEP centers' prospects and clients -- apply across industries. But even there, one has to sculpt comparison groups carefully to be sure that a firm's performance or improvement are being compared to the "right" distribution. Thus it would be wrong to compare -- even on broadly applicable measures such as inventory turns -- job shops and make-to-order companies even within the same industry.

Our goal has been to design and implement an evaluation that redresses these weaknesses.

This paper is the product of two economists fortunate enough to command about 3% of the $35-million, 6-year budget of the Michigan Manufacturing Technology Center (MMTC) for evaluation purposes. Funding for the MMTC is provided by the National Institute for Standards and Technology's Manufacturing Extension Partnership (NIST/MEP), and by a matching grant from the Michigan Strategic Fund (MSF), a state government entity. MSF has earmarked $800,000 of its $13-million match to MMTC evaluation. That supports a two-FTE dedicated staff. The MMTC adds about $20,000/year to allow the associated Benchmarking Service to supply free reports to Michigan manufacturers, and a 1994-96 NIST grant funds a benchmarking service for other NIST/MEP centers that uses the same dataset.

The MMTC -- and thus the evaluation effort -- focuses on five industries: metalforming (dominated by stamping), plastics processing (dominated by injection molding), special tooling, machined parts and assemblies (most often for aerospace, auto, and heavy truck), and powered machine-building. The MMTC does do work with clients in other industries as well, and we include them in the analysis. The sections below outline our approach and results to date.

Methodology

Conceptually, designing an improved evaluation scheme is straightforward. The evaluation effort should measure client improvement on a set of relevant performance metrics, relative to that of a control group. And it should provide continuing direction to MMTC planners and field staff, illuminating questions on the types of intervention that yield the most favorable outcomes.

The devil, as always, is in the details. Some of the issues that required early resolution included the following:

- *How would we entice firms to provide the needed data?* The data we seek -- detailed metrics on operational performance -- is closely guarded by firms. What inducements and/or safeguards can we provide to encourage participation?
- *How would we characterize the intervention?* The projects that the MMTC carries out with particular firms are tailored to the needs and desires of those firms. Their content and intensity vary widely, depending on the interests of firm managers and on the problems diagnosed by MMTC field staff. The evaluation effort seeks to make constructive statements relating the type of intervention to resulting outcomes.
- *What are relevant outcome metrics?* Here we need to consider at least two different levels of desired outcomes. The State of Michigan's interest is in *social* outcomes -- increased sales and employment, and improved productivity and wages. But the outcomes most directly attributable to a particular project may be quite different -- reducing scrap or achieving faster setup times, for example.

- *How would we develop and pilot test the data collection instruments and methods?* Collecting data on manufacturing performance requires more than the usual careful crafting of survey questions. Technical terminology varies from industry to industry, and even within industries. And firms' management information systems vary hugely in their content and formality. Thus the accuracy and consistency of survey answers is of major concern.
- *How could we optimize the robustness and validity of the experimental design?* Sample selection bias -- among both clients and survey participants -- will certainly impact the statistical analysis. But perhaps the biggest issue affecting the experimental design stems from the heterogeneity of the interventions. Does the MMTC in effect represent many distinct types of interventions? If so, the number of clients for any one type may be few, endangering our ability to make statistical assertions.

Our approaches and methods for dealing with these issues are highlighted in the sections that follow.

Soliciting Firm Participation

Getting firms to participate in survey research efforts is always difficult. For this project, we anticipated even more than the usual reticence, for at least two reasons. First, the data required is, as already noted, precisely the kind firms hold closest to the chest. This reluctance would likely be most severe among control group members with whom, by definition, MMTC has no relationship. Second, the number of needed data elements is large, and would require non-trivial effort for firms to compile and report.

Clearly, a successful data collection effort required that we offer participants something of significant value, something that would justify their effort, and overcome their preference for secrecy.

The concept we developed was to package the data collection effort as a "Performance Benchmarking Service." Participants would receive detailed, customized reports showing how their own performance compared against that of other firms in their industry. That is, we would offer detailed feedback from the database itself as the deliverable that would entice participation. By invoking the term "benchmarking," we hoped to piggyback on the heightened interest in comparative performance analysis now evident in the trade literature.

Evidence of this interest in benchmarking abounds. An example is provided by the June 1994 issue of *Production* magazine, which devoted five articles to the subject (Vasilash, 1994a-b and Bergstrom, 1994a-c). Further, the International Benchmarking Clearinghouse -- part of the American Productivity and Quality Center in Houston -- publishes a bibliography with dozens of benchmarking titles for the interested manager. Xerox Corporation is generally credited with coining the term and popularizing the concept, after launching its own effort in 1979. A thorough exposition on the practice of Benchmarking, written by one of the Xerox project leaders, appeared in the January through May 1989 issues of *Quality Progress* (Camp, 1989).

We felt this approach had the additional benefit of giving firms an interest in providing *accurate* data. If we merely paid for participation, for example, we risked nonchalant or careless data compilation. (We have received some much-appreciated outside validation of our Benchmarking Service strategy. The Service was named winner of the 1993-94 Silver Award for Benchmarking Excellence in the Applied Research Category by the American Productivity and Quality Center.)

Screens for Selecting Metrics

The Benchmarking Service approach has also helped us cultivate relationships with participating firms that have influenced our selection of metrics. The MMTC evaluation features constant back-and-forth with the companies that complete our five annual, 12-page industry-specific questionnaires. Panel members participate in annual polls on the relative importance of metrics. Even though not every metric they want is included, their voice is an essential ingredient in the selection

process. A metric continues to be used only if four requirements are met:

1. The metric must be something that is plausibly amenable to change as a direct or indirect result of extension program intervention. Otherwise, a change over time in its value cannot be attributed to the program.
2. The metric must exhibit substantial variance across firms in the same industry. If it doesn't, little change in it is likely.
3. A significant proportion of industry members must agree that a metric is a meaningful differentiator between better and worse performance in their sector.
4. The metric must be statistically correlated, in the common-sense direction, with at least several other metrics. If it isn't, then improving on it probably doesn't matter.

This screening process has resulted, for the MMTC, in the selection of approximately 200 metrics for the metalforming, plastics processing, tooling and low-volume precision machining, machined parts and assemblies, and powered machine-building industries. (Complete metrics lists, by sector, are available from the authors on request.) Approximately half of these are common across the five industries; roughly one-third apply only to a single industry.

We also distinguish among three kinds of metrics:

Performance Measures. These are metrics for which the preferred direction (higher or lower) is clear and unambiguous. Customer reject rate should be as close to 0 as possible. On-time delivery should be as close to 100% as possible. For these metrics, MMTC clients and members of the control group for the client's sector are fed back distribution data indicating the performance that *top, mid-range, and bottom* performers are achieving, as in Table 3.1 on press run time.

Practices. These are continuous (i.e., not yes-or-no) metrics that reflect choices firms make in trying (or not trying) to achieve performance. Hit rate on quotes, for example, may be low because the firm is in a business in which many jobs must be quoted for each order won, or because the firm consistently underbids (perhaps because it doesn't know its true costs). For practices, therefore, we feed back only the distribution of responses, without any characterization of top or bottom, as in Table 3.2 on in-die sensing.

We also include in the Practices category metrics that describe the background or environment in which a firm operates -- Percent of Sales to the Aircraft/Aerospace Industry, for example. These metrics are usually less under the short-term control of the firm, but capture factors that we may need to control for in performing the client versus control analysis.

"Switches". These, finally, are simply yes/no practices. But since we retain these metrics only if they are correlated with at least a few (continuous) practices or measures, we think of them as "switches" that firms either do or do not turn on. Benchmarking participants tell us that they want us to use their responses to determine which switches really need to be turned on and which are simply passing fads or window-dressing. Table 3.3 provides an example from the quality section of a metalforming sector report.

Characterizing the Intervention

The projects MMTC carries out with its clients can be classified into three distinct types:

- *Assessments.* Assessment projects are aimed at diagnosing a firm's weaknesses, and presenting a focused list of recommended actions. MMTC field agents follow a standardized protocol in sleuthing out trouble spots. Obviously, however, the nature of the problems they find -- and thus their proposed solutions -- vary widely. These projects generally do not aid the firm in implementing recommendations. They are typically under three months in duration.
- *Implementation Projects.* These projects provide direct assistance in carrying out improvement activities. They often, but not always, are follow-ons to an earlier assessment. Implementations follow no common format or protocol, and range from aiding in launching employee work teams to assisting with the installation of MRP-II software systems.

Table 3.1

Example of Reporting Format for Performance Measures

Running Time as a Percent of Total Hours in a Year - Average per Production Machine (Q545/[Q513*8760]*100)

Panel Performance: Based on 88 Responses	
Plants in the Top 5% Have Values of at Least	43.4 %
Plants in the Top 10% Have Values of at Least	38.5%
Plants in the Top 25% Have Values of at Least	27.4%
Plants in the Top Half Have Values of at Least	15.4%
Plants in the Bottom 25% Have Values at or Below	6.8%
Your Performance . . . . . 12.5 %	

Table 3.2

Example of Reporting Format for Practices

Percent of Dies with In-Die Sensors (Q625)

Distribution of Panel Member Values: Based on 78 Responses				
10% Said At Least	25% Said At Least	Median	25% Said At or Below	10% Said At or Below
50 %	5 %	0 %	0 %	0 %
Your Value . . . . . 0 %				

Table 3.3

Example of Reporting Format for Switches

Quality Actions			
	% Yes	**Number Answering**	**Your Answer**
Q.628. Routinely use statistical quality assurance (SQA) methods such as SPC to monitor and chart variations in significant process or product characteristics	82.4	91	Yes
Q.630. Routinely analyze SPC/SQA data using computers or Datamytes	72.5	91	Yes
Q.632. Use quality data to automatically (with no operator) shut off or adjust machines if chart values exceed certain limits or the process is trending	9.1	66	No
Q.636. SPC charts usually done by production workers monitoring their own work	66.3	89	No
Q.637. Regularly display quality data where operators can easily see it	73.0	89	Yes
Q.638. Engaged in a Total Quality Management (TQM) or similar program	60.7	89	No
Q.639. Do studies to find sources of recurring errors	74.2	89	Yes
Q.619. Routinely use gauges in quality assurance	97.8	90	Yes
Q.620. Use non-contact gauges in quality assurance	31.8	88	No
Q.624. Operators perform gauging	93.4	91	No
Q.627. Has one or more coordinate measuring machines	50.0	90	No
Q.606. Plant is ISO 9000-certified	1.1	92	No

- *Group Projects.* Besides one-on-one projects done with individual firms, MMTC also carries out several group projects. Participants pay an annual membership fee, and meet periodically to discuss issues of mutual interest and tackle common problems. Most of these projects are packaged as "Continuous Improvement Users Groups" (CIUGs). CIUGs focus on identifying and implementing those high benefit-to-cost activities that can reduce scrap and increase productivity in a plant without requiring large capital investments.

These distinctions and terminology are used and recognized within the MMTC. Thus the information for each project is readily available.

One important analytical question is whether project efficacy varies by type. Do assessment projects, merely by providing guidance in problem/solution identification, yield beneficial results? Or is some direct involvement in implementation required? Are group projects, with their opportunities for economies of scale and for shared learning, a more cost-effective means of delivering assistance and, if so, for which kinds of assistance? Our approach to addressing these questions is discussed in the analysis section below.

Besides project type, however, the analysis must consider the subject or content of a project. We classify project content in two ways. First, we identify the types of firm actions that can be directly tied to the MMTC project. These are the purchases or activities that a firm might choose to pursue as a result of an MMTC recommendation, or as part of an MMTC implementation project. The most common types of actions associated with MMTC projects are listed in Table 3.4.

MMTC project files -- proposals, final reports -- as well as interviews with field staff, allow us to assign a list of associated actions to each project.

Further, we classify projects according to the *types of benefits* that firms expect to accrue as a result of their actions. Of course, virtually all goals might be reduced to the desire of owners or managers to increase profits or net worth. But particular projects tend to focus on one or a few operational goals. For example, a firm might desire to reduce lead times in the belief that quicker response is an important marketing asset -- one that could lead to more business, and thus better financial outcomes.

At least within MMTC's target sectors, we have found that project goals or hoped-for benefits can be collapsed into just a few categories, those presented in Table 3.5.

MMTC project files again provide a ready source of information. Often, the goals are expressed directly by the client, and captured in the "statement of the problem" section of the MMTC proposal. Or, if an opportunity is identified by the field agent, then they make the case for their recommendation by outlining the associated benefits.

Note that the lists of project actions and goals lead naturally to the definition of outcome metrics. Finally, of course, we measure *how much* intervention occurred (measured by project cost) and the time that has elapsed since the start date of the intervention.

Issues in Experimental Design

From the start, we faced a good deal of uncertainty regarding several key factors that could determine the success or failure of the project. Most stem, at bottom, from fears about effective sample size or response rate. Some were at least partially under the control or influence of the Evaluation team: the Performance Benchmarking Service approach was designed to boost response rates, for example. But others reflected uncertainty about the nature of the work -- specifically, the number and types of interventions -- that the MMTC would be doing. Our approach has been to try to anticipate potential problems and build in fall-back options. Further, we planned from the start on the need for mid-course corrections. In this six-year effort, years one and two have been effectively used as "working pilots," simultaneously testing our experimental approach and providing the data for early evaluation analysis.

Table 3.4

Common Actions Resulting Directly from MMTC Intervention

Technology-Related (i.e., adoption or increased use of):
Computer-Aided Design (CAD)
Computer-Aided Manufacturing (CAM)
Computers, computerized machine controllers, or shop floor data collection devices
Electronic Data Interchange (EDI) for CAD or math data
Electronic Data Interchange (EDI) for order processing or billing
In-process inspection equipment
Software for inventory control, shop floor control, scheduling, etc.
Workforce-Related:
Employee suggestion program
Employee training -- quality concepts
Employee training -- other
Use of employee work teams
Other:
ISO-9000 certification program
Modification of plant layout

Table 3.5

Common Goals of MMTC Projects

Growth in sales
Growth in export sales
Higher labor productivity
Reductions in inventories
Reductions in manufacturing lead time
Higher on-time delivery performance
Shorter machine setup times
Fewer customer rejects
Lower scrap

This section outlines what we feel are the most fundamental of the issues associated with experimental design, and how we are dealing with them.

"Before and After:" Panels versus Retrospective Data Collection. The overriding purpose of the evaluation is to gauge the relative *improvement* of MMTC clients versus non-clients. Thus the data must reflect performance at two (or more) points in time. One approach is to build a panel dataset: to revisit the same firms over time, thus building a record of how firms progress and change. At first, the dataset would be dominated by control group firms; then, as the number of MMTC clients grew, more clients would join the panel. The panel data approach has two advantages. First,

firms need be asked only about the very recent past; they need not provide retrospective data that might be less accurate. Second, because individual firms can be tracked over time, panel data provide a superior means of examining what *actions* or *practices* lead to improved performance. Of course, the risk in relying on panel data is that the possibilities for non-response are dramatically increased.

Our initial approach was a hybrid. We planned to solicit participation from the same firms annually, including all past MMTC clients. But we also include retrospective questions, asking about performance two years earlier, in all survey instruments.

Heterogeneity in Interventions and Outcomes. Because of the wide variety of interventions -- ranging from ISO 9000 short-courses to full-blown operations assessments to projects doing CAD/CAM for hot tub mold design -- the experiments are "thin," i.e., even though there may be 100 or more significant interventions in each program year, there are often only a few of a given type. This makes it particularly hard to test the no-improvement null hypothesis on industry-specific measures, where the counts for a particular intervention type is often one.

Evaluation as a Self-Biasing Intervention. By providing non-clients with a valued deliverable that identifies their strengths and weaknesses vis-a-vis other, similar manufacturers, the Benchmarking Service leads many members of the control group to change their behavior and, therefore, to become less like the underlying population they are supposed to represent. Indeed, we know from our annual participant polls that roughly half of the controls credit their benchmarking report with motivating at least one improvement action (often, the action of starting to track certain metrics). On the other hand, MMTC clients also receive benchmarking reports; so while benchmarking may constitute an intervention, it is the same intervention in the client as in the control group. Still, it is probably correct to label our approach an evaluation of the *additional* impact of MMTC services beyond the provision of a benchmarking report.

Double Selection Bias. The MMTC evaluation approach probably has a double selection bias -- in clients and in benchmarking participants generally, neither of which may be representative of the underlying small manufacturer population. We are only now beginning to measure that by calling a random sample of manufacturers recruited, but failing to sign up, for the control group to see whether, and if so how, different they are from those that took part. We are hopeful that, if there is bias, it is substantially the same bias in the client and control groups, i.e., that both differ from the underlying population in the same way. Discussions with MMTC field staff, with staff from the Cleveland-based Great Lakes MTC, and with metalforming and tooling trade association personnel all incline us to think that the client group is biased toward poorer-than-average performers and that the control group may be as well, the best firms often seeing little reason to participate.

A Description of the Database

The dataset contains responses to approximately 300 questions by more than 550 U.S. manufacturers with fewer than 500 employees. These raw data are transformed into approximately 200 metrics, values for which are also stored in the database. Table 3.6 describes the subset of the observations that pertain to the time period 1991 to 1993. Clients are those for which the MMTC was paid to provide at least one week of staff time of service during the 12 months ended October 15, 1994. (Note: the MMTC's program year runs April 1 through March 31; the idea was to select projects that began late enough -- after 10/15/92 -- that they could not plausibly have influenced calendar 1991 data, and ended early enough to have influenced calendar 1993 performance.)

As noted earlier, we include a metric for one of two reasons: either it is essential to the evaluation effort, or it is popular among Benchmarking Service participants and thus increases the perceived value of the benchmarking report. Luckily, the overlap between these two goals is substantial.

The following tables provide sample lists of the types of metrics contained in the dataset. Table 3.7 presents definitions for the social outcome measures of most interest to state and federal funders.

Table 3.8 lists some of the operational *performance measures* that describe how well a firm carries out its internal activities. (We list here only those measures that apply across sectors, and not any sector-specific measures.) These metrics are the ones that are plausibly most amenable to change as a result of MMTC interventions.

Finally, Table 3.9 presents examples of what we earlier defined as *practices* -- indicators of a firm's strategy or production choices. These metrics are of interest for the evaluation because they capture the *actions* that firms might take as part of an assistance project. They are especially important in answering questions that can provide program guidance to MMTC: what types of activities (and, by extension, what types of projects) are associated with improved performance?

A Summary of Analytical Results

For each of 20 key performance measures that could be defined across all sectors in which the MMTC served clients, the evaluation team examined the following questions:

Issues in Experimental Design

From the start, we faced a good deal of uncertainty regarding several key factors that could determine the success or failure of the project. Most stem, at bottom, from fears about effective sample size or response rate. Some were at least partially under the control or influence of the Evaluation team: the Performance Benchmarking Service approach was designed to boost response rates, for example. But others reflected uncertainty about the nature of the work -- specifically, the number and types of interventions -- that the MMTC would be doing. Our approach has been to try to anticipate potential problems and build in fall-back options. Further, we planned from the start on the need for mid-course corrections. In this six-year effort, years one and two have been effectively used as "working pilots," simultaneously testing our experimental approach and providing the data for early evaluation analysis.

- Does the relative performance of MMTC clients depend on the *type of project* performed (e.g., assessment, implementation, users group)? On the *level of effort* devoted to that client? On the *elapsed time* since project completion? On the *subject matter* or *content* of the project?
- Have MMTC clients been *more likely to take improvement actions* (e.g., form employee work teams, expand use of computer-aided design) than the non-client group?

In addition, the analysis aimed to uncover the types of projects and improvement activities that lead to the outcomes most beneficial to the state of Michigan and its firms: increased sales, increased employment, and increased worker productivity and wages.

Results are summarized in Table 3.10. They include these three findings:

- Clients show somewhat larger increases in inventory turns, training expenditures per employee, percent of shop-floor workers in teams, on-time delivery, and use of computer-aided design than otherwise-comparable non-clients. Similarly, clients achieved greater reductions in manufacturing lead time, machine setup times, and scrap rate.
- While statistically weak, MMTC clients show somewhat stronger sales and employment growth than non-clients. The result seems to hold especially for clients of assessment projects.
- MMTC clients show a *smaller* increase in the use of computer-based equipment and shop floor terminals than do non-clients. The use of computer-based equipment and technologies is a strong predictor of labor productivity. And labor productivity, in turn, is a strong predictor of profitability. Specifically, each 10 additional percentage points in the proportion of employees regularly using computers on the job is associated with an additional $2,700 in

value-added per employee, which in turn is associated with about 0.4 percentage points of additional pre-tax profit margin.

This last result is similar to one found in the analysis of clients' 1990-92 improvement vis-a-vis controls as well, and one that and continues to be a serious program design and management concern. Many MMTC projects do not focus on the area that analysis indicates could yield strong gains in productivity and profits -- the more widespread use of computers on the shop floor or, more to the point, on projects that might bring it about, e.g., CAD adoption, on-machine CAM programming, computer-assisted production planning, in-process sensing, statistical analysis of process control data, etc.

The evaluation analysis summarized above is being used to inform adjustments in the match between proposed projects and clients' "presenting problems." Field staff hiring is also beginning to be influenced by the findings as well. However, many in the MMTC remain skeptical of evaluation findings, citing high client satisfaction.

Conclusions: Use of Analysis Results for Program Improvement

The unsavory finding on computer usage is not the only perplexing finding of the evaluation team analysis. We find clear connections between actions in the areas of data tracking and housekeeping and improved quality and delivery performance, between computer use and productivity, and between productivity and profits. But if clients show relative improvement on key performance measures, and if the MMTC is encouraging them to take actions that should help them improve on others, why don't they show strong improvement relative to the controls in sales, employment, and sales per employee? Our hypothesis has three elements:

1. Firms progress (unevenly) from *"chaotic"* toward being more *"transparent."* Some continue on and get *"systematic"*: not only are they tracking various aspects of their operations, but they have procedures in place to use the results of such tracking to make continuous adjustments. Some firms adopt technology and become more *"modern"* (unfortunately, some that do aren't yet *systematic* or even *transparent*, viz. the 1980s MRP II debacle). Finally, a relatively small proportion of shops are able to get to a state we term *"distinctive,"* in which -- at least for a while -- some unique process capability and/or product enables them to stand out. While these dimensions -- systematicity, modernity, and distinctiveness -- are not independent or orthogonal, it *is* possible for firms to score highly on one of two and low on the rest; indeed, companies' strategies may even be thought of as a conscious mix of the three.
2. The vast majority of small and medium-sized manufacturers in the key MMTC sectors are suppliers of either tooling or intermediate inputs to traded-goods sectors (auto, machinery, aerospace, and office furniture) that face heavy international and/or home-market competition. As a result, they face daunting pressure to reduce quotes. They seek, and receive, assistance from the MMTC in areas that help provide short-term cost reduction -- essentially the ingredients of the *chaotic*-to-*transparent*-to-*systematic* transition (which helps to explain the popularity of our Continuous Improvement User Groups, with their focus on housekeeping, inventory reduction, and elimination of waste, all low-investment approaches). Relatively few seek help on the costlier, riskier, longer path toward *modern* manufacturing, even though being *modern* is increasingly a precondition for sustainable

Table 3.6

Database Description: 1991 and 1993 Data

Sector	**MMTC Clients Served**	**Controls**
Metalforming	16	77
Plastics Processing	12	82
Machined Parts & Assemblies	12	91
Low-Volume Tooling & Machining	8	55
Machine-Building	5	49
All Other Sectors	15	0
TOTALS	**68**	**354**

Table 3.7

Social Outcome Measures

Social Outcome Measure	**Metric Definition**
Firm size	Annual Sales
Jobs	Total Employees (average FTEs for the year)
Productivity	Value-Added (Sales Less Purchased Inputs) Per Employee
Wages	Payroll Per Employee
Exports	Percent of Sales Exported

*distinctive*ness.[1] Fewer still look to the industrial extension community for help on the direct contributors to being *distinctive* -- product design, concurrent engineering, and materials engineering, among others. To date, then, the MMTC may be helping many shops stay afloat at roughly their current size and in their current product lines, but is not yet providing the "high-end" interventions that could help clients to pull away from the pack. 3. That must change, since arguably the goal of industrial modernization programs, at least from the standpoint of their public funders, should be to move as many firms as possible as far as possible down the path to fully

[1]This analysis applies differently to stampers and molders than to tooling and machine-building shops. The latter are, in some sense, characterologically distinctive, their business based on the craft skills of their managers and employees. The problem for them is that CNC makes machining-as-craft an insufficient differentiator.

Table 3.8

Operational Performance Measures

Operational Outcome Measure	**Metric Definition**
Manufacturing Lead Time	Days from Manufacturing Start to Manufacturing End
Inventory Turns	Ratio of Annual Sales to Typical On-Hand Inventory
Delivery Reliability	Percent On-Time Deliveries to Customers
Quality	Percent of Lots/Jobs Rejected by Customers
Scrap	Percent of Units or Material Scrapped
Setup Time	Average Hours Per Setup, Typical Machine

Table 3.9

Practices

Practices: Continuous Metrics
Percent of Sales to Customers Not Served 3 Years Ago
Percent of Design Hours Logged on CAD Terminals
Training Tuition and Fees Per Employee
Percent of Employees Using a Computer or Machine Controller at Least Once a Week on the Job
Number of Keyboards and Keypads Used for Design/Engineering or Production, Per Employee
Percent of Shop Floor Workers Participating in Work Teams
Percent of Shop Floor Workers Receiving Training in Statistical Quality Concepts, Last 3 Years
Practices: Yes/No "Switches"
Use CAD data to generate machine instructions ("CAD/CAM")?
Send/receive CAD data electronically to/from customers/suppliers?
Do any business communication (releases, orders, invoices billing) electronically?
Purchased CAD or CAE software in past 2 years?
Purchased inventory control, scheduling or shop floor control software in past 2 years?
Changed layout of shop floor in past 2 years?
ISO-9000 certified?
Have a formal statistical quality assurance (QA) program?
Analyze quality data using a computer?

modern distinctiveness. The ultimate test of whether extension programs grow the economy of a region, state, or nation is whether they can change the distribution of firms on the *chaotic*, ..., *distinctive* continuum.

The Evaluation and Benchmarking Team has worked with MMTC leadership and field staff on the design of sector-specific "improvement stories" that outline for prospective clients a linked set of multiple interventions aimed at moving them from wherever they are all the way to -- or as far toward as their talent and interest permit -- *modern* and *distinctive* manufacturing. Figure 3.1 presents the improvement story for one sector.

In this context, targeting a small number of industry sectors is probably essential. First, if the

Table 3.10

How Are Clients Improving Compared to Controls?
Summary for Projects Completed by 9/30/93

Performance Measure (change in:)	*Clients vs. Control Group*
Sales	MORE *•
Pct of Sales to New Customers	MORE •
Pct of Sales Exported	SAME
Employment	MORE *
Set-up Time	MORE •
On-Time Delivery	MORE #
Mfg Lead Time	MORE •#
Inventory Turns	MORE
Scrap (or Yield Loss) Rate	MORE *#
Customer Reject (or Not-Accept) Rate	LESS •
Pct of Shop Workers in Teams	MORE •
Pct of Workers Trained in Quality	MORE *•
Training $ per Employee	MORE *•
Pct of Design Hrs Logged on CAD	MORE •
Pct of Employees Using Computers	LESS
Keyboards per Employee	LESS
Value Added per Employee	SAME

* Statistically weak: 10-20% chance of no difference between client and control.
C Result holds only for certain project types.
Result holds only if improvement was an explicit project goal.

MMTC with its five-sector focus presents the Evaluation team with a bewildering variety of different "experiments," imagine the situation for an extension center with no sectoral focus. Second, at least some industrial targeting is probably a prerequisite to what we have called "social impacts," at least at the national level. For example, helping manufacturers in industries that don't produce traded goods or inputs to traded goods will have less impact than helping those that do. And if the social impact issue is approached purely as a state or regional matter, extension programs could end up being zero-sum for the nation as a whole. Luckily, the U.S. extension system is increasingly overseen by a single, federal entity (NIST/MEP). And since industries cluster (more or less) geographically, government can materially increase the chances that impact on firms will also improve the economy by sitting extension centers in the right places. See Luria, Cole, Baum et. al. (1994) for more on this argument and for the top-priority locations for additional extension centers.

References

Bergstrom, R., 1994a, One Tool, Used Right, Many Solutions, *Production*, June 1994, 58.

Bergstrom, R. 1994b, Industrial Tourism May Make You Happy (But It Isn't Benchmarking), *Production*, June 1994, 60.

Bergstrom, R. 1994c, Old Measures, New Rules, *Production*, June 1994, 62-4.

Camp, R., 1989, Benchmarking: The Search for Best Practices that Lead to Superior Performance, *Quality Progress*, five issues: January, 61-68; February, 70-5; March, 76-82; April, 62-9; May, 66-8.

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

Luria, D., Cole, R., and Baum, A. et. al., 1994, Fixing the Manufacturing Base: The Allocation of Manufacturing Extension, *Journal of Policy Analysis and Management*, 13:3, 571-580.

Shapira, P., Youtie, J., and Roessner, J.D., 1994, Review of Selected Literature on Evaluating Technology Deployment and Industrial Modernization in: P. Shapira, J. Youtie and J.D. Roessner (Editors), *Evaluating Industrial Modernization Programs: Issues, Practices, and Strategies* (School of Public Policy and Economic Development Institute, Georgia Institute of Technology, Atlanta, GA).

Vasilash, G., 1994a, Benchmarking: What it Isn't and Other Observations, *Production*, June 1994, 52-3.

Vasilash, G., 1994b, Benchmarking: A Few Things You Should Think About, *Production*, June 1994, 54-5.

Figure 31:
Improvement Story for Metalforming Sector