INFORMATION TO USERS

This manuscript has been reproduced from the microfilm master. UMI films the text directly from the original or copy submitted. Thus, some thesis and dissertation copies are in typewriter face, while others may be from any type of computer printer.

The quality of this reproduction is dependent upon the quality of the copy submitted. Broken or indistinct print, colored or poor quality illustrations and photographs, print bleedthrough, substandard margins, and improper alignment can adversely affect reproduction.

In the unlikely event that the author did not send UMI a complete manuscript and there are missing pages, these will be noted. Also, if unauthorized copyright material had to be removed, a note will indicate the deletion.

Oversize materials (e.g., maps, drawings, charts) are reproduced by sectioning the original, beginning at the upper left-hand corner and continuing from left to right in equal sections with small overlaps.

Photographs included in the original manuscript have been reproduced xerographically in this copy. Higher quality 6" x 9" black and white photographic prints are available for any photographs or illustrations appearing in this copy for an additional charge. Contact UMI directly to order.

ProQuest Information and Learning
300 North Zeeb Road, Ann Arbor, MI 48106-1346 USA
800-521-0600

THE EFFECTIVENESS OF MANUFACTURING EXTENSION: ECONOMIC DEVELOPMENT VERSUS TECHNOLOGY-DIFFUSION POLICY?

BY

NATALIE A. DAVILA
B.Sc., Queen's University, 1984
M.A., University of Michigan, 1985

THESIS

Submitted as partial fulfillment of the requirements
for the degree of Doctor of Philosophy in Public Policy Analysis –
Urban Planning and Policy
in the Graduate College of the
University of Illinois at Chicago, 2001

Chicago, Illinois

THE UNIVERSITY OF ILLINOIS AT CHICAGO
Graduate College
CERTIFICATE OF APPROVAL

March 9, 2001

I hereby recommend that the thesis prepared under my supervision by

NATALIE A. DAVILA

entitled THE EFFECTIVENESS OF MANUFACTURING EXTENSION: ECONOMIC DEVELOPMENT VERSUS TECHNOLOGY-DIFFUSION POLICY

be accepted in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

Adviser (Chairperson of Defense Committee)

I concur with this recommendation

Department Head/Chair

Recommendation concurred in:

Members of Thesis or Dissertation Defense Committee

UIC University of Illinois at Chicago

In Memory of Jean Brown
(1912 – 2000)

ACKNOWLEDGMENTS

I have encountered many people who have helped me along the (very) long and winding road it took to complete this journey. While running the risk of turning into one of the Oscar recipients who will simply not get off the stage, it is important to me to thank all of them.

First and foremost, Dave Ranney for his patience, insight, friendship, guidance, and that he did not give up on me (when I had almost given up on myself). My committee members - Joe Persky, Phil Shapira, Rachel Weber, and Wim Wiewel - all of whom have played the role of mentor, colleague, and friend. Other UIC faculty and staff members: Charlie Hoch, Thelma Jackson, the late Rob Mier, and Chuck Orlebeke all deserve a special mention. To my editor, Jeanne Bloom, for her insight and expertise, the long hours spent in order to meet my deadlines, and actually being interested in the topic!

Others who have encouraged me on my academic journey include David Carruthers who made my introduction to statistics fun. If I am half as good a teacher I will be more than satisfied. George McConnell who introduced me to economics. Thanks to my professors at Queens University, Belfast, and University of Michigan, Ann Arbor; especially, James Adams, Severin Borenstein, Victor Hewitt, and Clifford Jefferson who introduced me to the world of public policy analysis.

ACKNOWLEDGEMENTS (continued)

Interviews with policymakers, practitioners, and people working within small and medium-sized manufacturing firms in the Chicago area made this research possible. In particular, I would like to thank staff at the Chicago Manufacturing Center, the Illinois Department of Commerce and Community Affairs, and the Manufacturing Extension Partnership for their full cooperation. Individuals who provided insight and clarity included: Steve Alexander, Lauri Alpern, David Baker, James Carlton, Rosemay Cudzewicz, Demetria Giannisis, Susan Gilbert-Miller, David Gulley, John Hamilton, Dan Luria, Keith McKee, Eric Rinehart, Jack Russell, Helen Squires, and Bob Weinstein.

The Chicago connection - it is hard to put into the words how much the support and encouragement of my friends meant to me during this process, particularly when I was going through difficult times and was having a lot of difficulty staying focused. My new heterodox colleagues at Roosevelt University – your encouragement and support in the final stages were crucial. Special thanks to Dr. Kevin Franke, Julie Putterman, Diane Swonk, and Lumpy - for his unconditional love.

Shifting to another continent, several people have shared this journey we call life with me and for that I wish to thank them. To my grandmother, the late Jean Brown, for innumerable things including introducing me to the world of reading and books. Jackie Shanks, my uncle, for his love of learning and his patience in teaching me – the learning part rubbed off, not so sure about the patience. To my oldest and dearest friends - Stephanie Boyd, Karen McMurray, and Cathy Woods - you are never out of mind.

ACKNOWLEDGEMENTS (continued)

Thanks for your love and support; for sharing the good times and working through the hard times; reminding me not to take myself too seriously; making me laugh (no easy task); and sharing with me many nights on both continents filled with conversation, music, food, and wine. To paraphrase Bob Marley, I give thanks and praise for living in an era that includes telephone and airline deregulation, and the invention of e-mail.

And finally, to President Clinton, the late Ron Brown, and Senator George Mitchell, who did many things to support the peace process in my home country, one of which was to translate the U.S. concept of manufacturing extension to Northern Ireland. They understood that one way to enhance the rhetoric of political support was to supply tools to facilitate economic prosperity for the residents of Northern Ireland.

To all these people, my gratitude.

ND

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

LIST OF TABLES

LIST OF ABBREVIATIONS

AIB	Apparel Industry Board
AISI	American Iron and Steel Institute
ARC	Applied Research Centers
ATC	Advanced Technology Centers
ATP	Advanced Technology Program
BIF	Business Innovation Fund
BIRL	Basic Industry Research Laboratory
CAD	Computer Added Design
CAM	Computer Assisted Manufacturing
CMTC	Chicago Manufacturing Technology Consortium
CMC	Chicago Manufacturing Center
CNC	Computer Numerically Controlled
COMPETE	Coalition for Manufacturing Performance through Technology
DCCA	Department of Commerce and Community Affairs
EDA	Economic Development Administration
EDC	Economic Development Commission
EDI	Electronic Data Interchange
ERP	Economic Report of the President
ESL	English as a Second Language
FY	Fiscal Year
GAO	General Accounting Office
GNP	Gross National Product
GSAC	Governor's Science Advisory Council
HR	Human Resources
IBHE	Illinois Board of Higher Education
IIT	Illinois Institute of Technology
IMEC	Illinois Manufacturing Extension Center
IRMTC	Illinois Regional Manufacturing Technology Center
IRN	Illinois Resource Network
ISAC	Illinois Software Association and Center
ISO	International Organization for Standardization
IT	Information Technology
ITEC	Illinois Technology Center
JIT	Just-In-Time
LIRI	Local Industrial Retention Initiative
LRD	Longitudinal Research Database
MAG	Modernization Assessment Grant

LIST OF ABBREVIATIONS (continued)

ManTech	Manufacturing Technology
MEC	Manufacturing Extension Center
MEP	Manufacturing Extension Partnership
MIS	Management Information System
MMS	Michigan Modernization Service
MOC	Manufacturing Outreach Centers
ModForum	Modernization Forum
MRL	Modernization Retooling Loan
MTC	Manufacturing Technology Center
NCAM	National Council for Advanced Manufacturing
NIST	National Institute of Standards and Technology
NAFTA	North American Free Trade Agreement
NRC	National Research Council
NSF	National Science Foundation
OEM	Original Equipment Manufacturer
OTA	Office of Technical Assessment
OTCA	Omnibus Trade and Competitiveness Act of 1988
PAC	Procurement Assistance Center
PBS	Performance Benchmarking Service
QC	Quality Control
QS	Quality System
R&D	Research and Development
REMI	Regional Economic Models Incorporated
RFP	Request for Proposal
RLP	Revolving Loan Program
SBDC	Small Business Development Center
SBIR	Small Business Innovation Research
SIC	Standard Industrial Classification
SMME	Small and Medium Manufacturing Establishment
SMSA	Standard Metropolitan Statistical Area
SMT	Survey of Manufacturing Technology
SPC	Statistical Process Control
SSC	Superconducting Super Collider
STEP	State Technology Extension Planning
TAC	Technology Advancement Council
TADA	Technology Advancement and Development Act
TCC	Technology Commercialization Center
TCGP	Technology Challenge Grant Program
TDS	Technology Deployment Service
TICF	Technology Innovation and Commercialization Fund
TMA	Tool and Machining Association
TRP	Technology Reinvestment Project

LIST OF ABBREVIATIONS (continued)

UIC	University of Illinois at Chicago
UICUED	University of Illinois Center for Urban Economic Development
UPS	United Parcel Services
WMRC	Waste Management Research Center

SUMMARY

Introduction

Since the 1980s federal and state governments have expanded their roles in applied-technology policy to encourage economic competitiveness and development. While investigating these trends, and comparing the goals and objectives at the national and subnational level, this study focuses on a particular program - the Manufacturing Extension Partnership (MEP). The evolution of the MEP program is examined within the context of existing theories of technological change and economic development.

Research Question

The research focuses on whether the mission of MEP has changed since the program's inception in 1988 and if so, what are the resulting policy implications. Why is this important? I will demonstrate that the MEP system, using the Chicago Manufacturing Center (CMC) as a case study, is not primarily delivering technology-related services to the SMME-client base. This raises the question of legitimacy. From the perspective of public policy and fiscal policy it is important to examine program intent and actual service delivery. Any deviation may suggest that the idea behind MEP is flawed, and a technology-diffusion program cannot be successful with limited public-sector funding. This suggests that the program may need to be redesigned to more adequately account for the realities of economy and the way SMMEs process information and make decisions. This question needs to be addressed directly because of the recent downward trend in manufacturing performance. If this continues, the MEP program and its service delivery is sure to be scrutinized at the federal and subnational level.

Methodology

While starting with an overview of the program at the national level, the study then

focuses on an evaluation of the program as carried out by CMC. CMC is the MEP center serving the six-county Chicago-metropolitan region. This case-study research discusses the conditions that caused program and policy changes that resulted in CMC moving away from a technology-diffusion service provider to a more general-business-assistance resource. Using CMC as a case study, the analysis compares actual results with program mission and goals for 1994-1996 and 1997-1999. The research tests two hypotheses. First, that the type of firm utilizing CMC services changed from firms more likely to adopt technology toward firms interested in more general-business assistance. Second, originally conceived as a technology-diffusion program, over time the MEP program evolved to a more general-business-assistance program. The number of technology-related projects (including assessments) decreased from 91.6 percent to 31 percent, indicating a movement toward the delivery of general-business-assistance services.

Using CMC service-delivery data, research findings are consistent with the hypothesis that CMC is servicing larger firms. Projects are becoming smaller while fees are significantly larger. These statistics indicate that CMC is charging more per project, thereby bringing into question the extent of any cost reduction the client.

This analysis is followed by logit analyses examining client and nonclient characteristics in 1996 and 1997. These two years are selected for comparison for two reasons. One reason was that the trends in service provision within CMC indicate that 1997 marked a change in direction for the center. In addition, 1997 is the first year of reduced federal funding from NIST MEP. Logit models are developed to predict what type of firm is more likely to become a CMC client in 1996 and 1997. Several hypotheses were tested: CMC clients versus nonclients in 1996; CMC clients versus nonclients in 1997; CMC clients in 1996 compared with 1997; and nonclients in 1996 compared with 1997.

Results from the logit analysis support the hypothesis that 1996 CMC clients are significantly different in terms of technology investment than 1996 nonclients, using the upgrading of a machinery and equipment as one measure of likelihood to adopt new technologies. CMC clients in 1996 are more likely to have made recent investments in machinery and equipment than nonclients. This finding is consistent with the original mission of the MEP program. Looking at 1997 data, results indicate that the profile of CMC clients changes, with regard to likelihood to adopt technology, to be more like the general population. The only major statistically significant difference between these two groups is that the 1997 CMC clients are more likely to be located in the city of Chicago than nonclients. With the exception of some tentative results with regard to their location, additional modeling results indicate that CMC clients in 1997 are not statistically different than non-CMC clients in either 1996 or 1997. In sum, the MEP program, as carried out by CMC, moved away from a likelihood to have clients that are more likely to be technology innovative to firms that, if anything, have a less than average propensity to invest in technology.

The next phase of the research supplements the logit analysis by examining in more detail the CMC-client base using several case studies. These case studies are used to illuminate the conclusion reached in this chapter - there is a difference between clients in 1996 and 1997 in their technical sophistication and willingness to modernize through technology. The case-study research supports the hypothesis that the average CMC-client profile changed from the pre-1997 period compared to the post-1996 period. Client firms tend to be more sophisticated, more interested, and willing to adopt new technologies in the first period compared with the second period. In all cases, the CMC intervention would be considered successful using NIST MEP evaluation criteria of increased sales; reduced labor costs; reduced inventory costs; and jobs retained or created. However, the case studies illustrate that this success can be obtained through

a variety of mechanisms, not necessarily technology adoption. Companies that were assisted by CMC prior to 1997 tended to adopt recommendations made by CMC that were technology related. This becomes diluted in the post-1996 clients, who tend to adopt quick-fix solutions that are not technology-based.

The combined findings of the three types of analysis support the hypothesis that, since the inception of the program, encouraged by NIST/MEP, the profile of CMC-client firms and the composition of service provision changed. During the period 1994 to 1996 CMC-client firms tended to be more likely to be adopters of technologies compared with nonclient firms. In this time frame, services delivered tended to be heavily concentrated in technology-related areas. After 1996 a change in firm characteristics and service delivery was observed. CMC clients became indistinguishable from nonclients, while services provided and delivered moved away from being technology focused and became more oriented toward general-business assistance.

Conclusion

The research concludes by presenting specific policy recommendations that would facilitate MEP service centers return to original-program goals and suggests program-design changes to more accurately reflect actual-program outcomes. Recommendations made at the local and state level include:

- CMC should embark on a strategic planning process to help move the organization back to providing services that are consistent with its core capabilities.
- CMC and state and local government officials should analyze the 1998 Illinois Modernization Survey results to provide guidance on organization, policy and program design and direction.

- Once core competencies have been identified, CMC management must decide if they want to remain a nonprofit, government-subsidized program.

- If CMC decides to remain a government-assisted program, CMC staff and management, with the assistance of state and local government program staff, should identify, approach and establish effective partners that would complement their own service delivery.

- Following from this, state and local government officials should reexamine the measurements of success used to evaluate CMC. The goals and mission of the program from the government perspective need to be clearly articulated. Things to consider in designing metrics include how to share credit with partners, how to account for adaptive learning on the part of firms, and varying metrics by type of service.

Recommendations made at the national level include:

- Conduct a nationwide-needs analysis of SMMEs.

- Analyze regional-market conditions by creating an inventory of services currently provided by the private sector and those that are under supplied by the private sector.

- Construct new evaluation metrics that are more comprehensive and capture feedback on adaptive learning, public cost benefit, spill-over effects, and worker benefits.

- Develop some concepts that would provide program mangers with techniques to make a consistent "but for" determination of potential clients.

I. INTRODUCTION

A. Purpose

Since the 1980s federal and state governments have expanded their roles in applied-technology policy to encourage economic competitiveness and development. While investigating these trends, and comparing the goals and objectives at the national and subnational level, this study focuses on a particular program - the Manufacturing Extension Partnership (MEP). The evolution of the MEP program is examined within the context of existing theories of technological change and economic development.

The research focuses on whether the mission of MEP has changed since the program's inception in 1988. The MEP program is comprised of a nationwide network of centers that provide productivity-enhancing services to small and medium manufacturing establishments (SMMEs). The research examines program and policy changes and trends through neoclassical and evolutionary theoretical frameworks. While starting with an overview of the program at the national level, the study focuses on an evaluation of the program as carried out by the Chicago Manufacturing Center (CMC). CMC is the MEP center serving the six-county Chicago-metropolitan region. This case study research elucidates the reasons behind program and policy changes that occurred moving the center away from a technology-diffusion service provider to a more general-business-assistance resource. The research examines the implications for policymakers, practitioners, and stakeholders of the program and policy changes that occurred since the program's inception.

B. Background

Focus on increasing manufacturing productivity is obvious from an individual firm perspective - depending on the degree of market competition - increases in productivity permit

lower costs or higher wages and profits. Productivity from a national perspective is important in maintaining a strong, competitive position in a global economy.

It is argued that strategic national and regional efforts to maintain industrial competitiveness depend on many factors, including; innovation, technology diffusion, and the effective application of technology (United States, 1990). It is also believed that in the long run, technological knowledge is the main source of economic growth and improvement in the quality of life (Organization for Economic Co-operation and Development, 1996).

Productivity growth for SMMEs in the United States is problematic from the following standpoint. From 1967 to 1992, productivity growth, as measured by value added per employee (Kane et al., 1997), for SMMEs averaged 2.1 percent annually compared with 2.9 percent for larger firms. In 1992, the value added per worker at SMMEs was only two-thirds of the value added per employee at large firms, with the gap continuing to widen (Kane et al., 1997).

Several related factors appear to drive the productivity and pay gaps between smaller and larger U.S. manufacturers. For example, SMMEs are less intensive technology users compared with large manufacturers. SMMEs are less likely than larger manufacturers to know about and implement off-the-shelf technology that could increase productivity. Using 1988 data, a study published by the Department of Commerce in 1990, found that small metalworking shops were about half as likely to use computer numerically controlled (CNC) machinery, one-quarter as likely to use personal computers, and one-sixteenth as likely to use robots. SMMEs also lag behind their larger counterparts in awareness and implementation of modern management and shop-floor methods, such as work teams, just-in-time (JIT) and cellular manufacturing, inventory management and control, quality systems, bottleneck scheduling and planned preventative maintenance. SMMEs are also less likely to use progressive workforce practices, including profit sharing and shop-floor training (Cohen and Zysman, 1987; Kane et al., 1997).

Luria (1996) argues that the lagging use of technology and modern management techniques among many SMMEs in the United States creates a vicious cycle. He and his colleagues find that less technology and less modern methods result in lower productivity growth for smaller firms. Lower wages follow, making it more difficult for smaller manufacturers to attract and keep skilled workers, and undercutting the incentive that these firms otherwise might have to invest in labor-saving, productivity-boosting technology (Kane et al., 1997). This often leads larger manufacturing companies that purchase goods from small firms to think of them as only suppliers of simple parts and assemblies. This further reduces prospects for higher wages and investment in technology, as larger firms with considerably more market power are able to squeeze the profit margins of SMMEs.

In the late 1980s, U.S. policymakers were expressing concern about the rate of technology adoption by the country's four hundred thousand SMMEs (OTA 1988; Dertouzos and Solow, 1989). This fear arose because of the link between U.S. technology adoption and industrial performance - slow rates of adoption have a negative impact on industrial competitiveness, regional economies, and the stability of high-wage manufacturing jobs (Shapira, 1990).

The promotion of technology adoption within SMMEs is the core of the MEP program. In response to lagging productivity trends, the MEP program is established to encourage and assist SMMEs to adopt productivity-enhancing technologies, thereby increasing SMME global competitiveness. Omnibus Trade and Competitiveness Act (OTCA), (Public Law, no. 100-418, 1988). At the time when MEP is first proposed U.S. firms are facing stiff competition from overseas competitors in large part due to the increasing value of the dollar, which makes imports

relatively less expensive. The MEP also exemplifies a trend to form partnerships between private and public organizations to provide technology-program services to SMME in the United States (Shapira and Youtie, 1996). MEP is a collaborative initiative between federal, state, and local governments. The National Institute of Standards and Technology (NIST) is the federal sponsor.

The program received modest federal funding during its first few years. However, by 1995 appropriations rose to $105 million. During the period 1988 to 1995, as noted earlier, a stronger dollar led to an increased level of competition, both in terms of imports and exports. In response to this increased competition with foreign manufacturers some domestic manufacturers restructured and through this streamlining were able regain some of their competitive position However, most of the gains in U.S. manufacturing performance occurred among large companies that possessed the resources to reengineer their industrial processes, introduce new technologies and quality methods (Shapira, 1998)

Several movements have occurred within the MEP system. First, at their inception centers focused on technology-diffusion assistance. This gradually shifted to an increased focus on general-business assistance and training. Second, the implications of the sunset clause for federal funding contained in the original 1988 legislation began to be felt by the early funding recipients [1] The federal sunset clause mandated that centers become self-sufficient by the end of their sixth year

[1] The sunset provision will be discussed in more detail in Chapter 3 and Chapter 6.

to a gradual reduction in federal funding over a six-year period, reality took a few years to set in. At the same time as the impact of reduced federal funding on the bottom line became apparent, changes in center behavior began to occur. This behavioral change will be discussed in Chapter 3 and Chapter 6.

C. Central Research Question

Using CMC as a case study, the analysis compares actual results with program mission and goals for 1994-1996 and 1997-1999. The research tests two hypotheses. First, that the type of firm assisted by CMC services changed away from firms more likely to adopt technology toward firms interested in more general-business assistance. Second, originally conceived as a technology-diffusion program, over time the MEP program evolved from technology diffusion to a more general-business-assistance program. Several factors may have caused this to happen. First was reduced federal funding for the program. This caused centers to replace the federal revenue shortfall from other sources, relying especially on client fees. In order to become self-sustaining, centers needed a client base that was much broader than the limited number of SMMEs ready for technology-diffusion assistance. This led to centers offering services that were more in demand rather than those of the original mission that would facilitate technology diffusion. Hand-in-hand with this first point, was a realization that firms needed more than information about newer technologies. Many SMMEs required basic business assistance before they could consider new technology adoption. These factors resulted in a program that experienced an informal (nonlegislative) change in its mission and caused inconsistencies between actual and anticipated outcomes at the program and policy levels.

D. Methodology

Using CMC as a case study, this research tests the hypothesis that the characteristics of firms assisted under MEP changed since CMC's inception. It is hypothesized that initially the program did lead centers to implicitly target companies more likely to adopt new technologies. However, over time, circumstances changed leading centers to deviate from this strategy. This resulted in the program becoming less of a technology-diffusion program and more of a general-business-assistance program.

The database developed for this research links specific firm characteristics of SMMEs in the Chicago area with CMC-client program data. The first component of the quantitative research that employs this database is an examination of trends in CMC's service delivery from 1994 to 1999. This analysis is conducted to determine whether there were significant changes in the type of projects delivered to SMMEs by CMC. This is followed by logit analyses examining client and nonclient characteristics in 1996 and 1997. These two years are selected for comparison for two reasons. One reason was that the trends in service provision within CMC indicate that 1997 marked a change in direction for the center. In addition, 1997 is the first year of reduced federal funding from NIST MEP.

Logit models were developed to predict what type of firm was more likely to become a CMC client in1996 and 1997. Several hypotheses were tested: CMC clients versus nonclients in 1996; CMC clients versus nonclients in 1997; CMC clients in 1996 compared with 1997; and nonclients in 1996 compared with 1997.

The quantitative analyses are followed by six CMC client-firm case studies. The purpose of these case studies is to illuminate the results obtained from the statistical analyses. The case studies consist of three pre-1997 client-firms and three post-1996 client-firms.

The research is also designed to determine whether firms currently assisted through the MEP program are significantly different than the entire population of SMMEs. The hypothesis is that if Manufacturing Extension Centers (MECs) are assisting firms through increased adoption of technology, firms assisted through the MEP program have different characteristics that those of the general population of SMMEs: clients should exhibit a greater likelihood to have adopted technologies compared with nonclients. If there is no statistical difference between the two, the conclusion is that client-firms are not those firms more likely to adopt new technologies, but rather are representative of the general population of SMMEs who have a demand for more general-business assistance.

E. Policy Issues/Relevance

If the analysis does not support the hypothesis that the current operations of the MEP center are focused on assisting firms that are likely to adopt new technology, the mission, goals, evaluation criteria, and impact of the MEP program are in question. If we assume that the current mission and goals of the program remain consistent with the original intent of the MEP program, are the centers operating within the original scope of the program? Is the fact that results indicate that CMC interventions increase firm productivity (Ehlen, 2001) sufficient justification for current service-provision mix to continue, or does the vehicle through which this improved productivity occurs matter? Are the current operations of MEP centers competing

with other existing government-service providers or private-sector consultants? Can service providers specialize in technology-diffusion assistance delivery to a limited, targeted market without relying more heavily on public funding?

There have been many exhaustive analyses evaluating the economic impact of the MEP program on individual firms and state economies (Shapira et al., 1994; Shapira and Youtie, 1995; Shapira and Youtie, 1997; Shapira and Youtie, 1998). All of these economic impact studies demonstrated an overall positive impact of MEP centers on SMME productivity. This leads to the conclusion that the policy initiative is having the desired outcomes, and the end justifies the means. However, these evaluations do not examine the degree to which the program is meeting its mission and goals with regard to its diffusing technology to SMMEs. This is the first study to address this question. From the point of view of good fiscal management, appropriate use of taxpayers money, and to minimize criticism of the program that may lead to elimination of funding, I contend that insuring that a program is being carried out in a manner consistent with its goals and mission is very important.

F. Organization

The outline of the study is as follows. First, background information is provided on the general economic conditions that served as the basis for manufacturing extension. This includes a discussion of market failures with regard to SMMEs and examples of some appropriate public policy options adopted to address these failures. The next chapter reviews theories of technology diffusion and technology policy to set a theoretical context for discussing the history of MEP specifically. The chapter continues with discussion of various theories of subnational economic development and techno-economic development and provides a theoretical basis from which to examine the state of Illinois' technology-policy development. The next chapter provides details

of the federal history of the MEP program and is followed by a literature review of existing research on MEP evaluation.

The study then examines the history of state-level technology policy development since the 1980s with a focus on Illinois and is followed by a history of the CMC from its inception. This chapter focuses on identifying changes in funding patterns, program, and service development.

A review of applied literature on factors influencing firm performance connects and binds the theories of technological change and economic development reviewed in previous chapters with the subsequent analytical model developed to analyze changes in firms participating in the MEP program. With the context for the study set, the chapter continues by developing and building econometric models to analyze the program as carried out by one of the MEP centers (CMC). The models test factors that predict whether or not a firm used CMC services. The dependent variable is a binomial variable (whether or not a firm used CMC services). Independent variables include those identified in the literature reviewed in the first part of the chapter. As stated above, the hypothesis tested is that until 1997 CMC targeted efforts on those firms more likely to adopt technology. Beginning in 1997, factors arose that caused CMC to drop any targeted focus, leading to a change in the type of firm it served. Analysis of model results and what the findings mean in terms of program success follow. Additional information to supplement this quantitative analysis is provided in the following chapter, where six case studies of firms receiving CMC assistance are discussed.

The final chapter summarizes the major findings of this research. It continues by presenting policy recommendations that would facilitate MEP-service centers return to original program goals and also suggested program design changes to more accurately reflect actual program outcomes. Implications of helping firms that would have helped themselves anyway as well as the concept of economic development targeting are discussed.

What should the policy be? Is the role of government to assist companies that are doing well or try to help those that are struggling? Once these issues are addressed and acknowledged, the program could once again become more targeted, thus making it more efficient by focusing on companies that meet clearly defined program goals.

G. Economic Conditions in the Late 1980s

By 1987 the current account deficit had grown to a staggering $161 billion, 85 percent of which was in manufacturing. Japan was by far the country with which the United States had the largest trading deficit, accounting for some $47 billion (United States, 1988). Several causes for this trade deficit were suggested. They included expansionary fiscal policies, a strong dollar, and lack of competitiveness of manufacturing industries in a global marketplace.

This research focuses on the latter argument. This focus is supported by other research that suggests that "high-level economic trends and policies can not account for the current state of U.S. industry. To understand what has been happening to American productivity, one must know what has been happening on the shop floor, in the laboratory, in the boardroom..." (Dertouzos and Solow, 1989, 3).

OTA (1988) claims that many of the losses in U.S. manufacturing market share occurred before the rise of the dollar and claim that one of the main factors contributing to the trade imbalance of the 1980s was due to the lack of competitiveness caused by a low rate of new technology adoption. Dertouzos and his colleague (1989) also find technological weaknesses, that began as early as 1974, a major factor in deteriorating U.S. manufacturing competitiveness.

The argument for this position is as follows. While the United States was a leader in basic research, U.S. companies lagged behind their foreign counterparts in adopting new technologies. Dertouzos and his colleague (1989) identify transistor radios, color televisions, and CNC machine tools as examples of technological advances first made in the United States which ended up being dominated by foreign manufacturers. The authors found that:

> As firms in other countries have improved their capabilities in these downstream areas, shortcomings have become evident in the performance of American industry in developing new products, engineering them, and manufacturing them...American companies evidently find it difficult to design simple, reliable, mass-producible products; they often fail to pay enough attention at the design stage to the likely quality of the manufactured product; their product development times are excessively long; they pay insufficient attention to manufacturing processes; they take a reactive rather than a preventative approach to problem solving; and they tend to under-exploit the potential of continuous improvement in products and processes. (Dertouzos and Solow, 1989, p. 68).

One reason suggested for the shortcomings in the adoption of technology in the United States is the lack of government involvement in product development, applied research and process. The authors continue:

> Whereas the governments of most other industrial nations have actively and explicitly promoted research and technology for economic development, US policy for science and technology has traditionally

> focused on basic research and paid much less attention to the commercial development and application of new technologies. The latter has been seen as the responsibility of the private sector. ...Recently, as concern about the nation's competitiveness has grown, the government has begun to assume a more active role in supporting the commercialization of technology... Only very recently....has the federal government paid much attention to questions of manufacturability and process technology. (Dertouzos and Solow, 1989, p. 77).

H. Market Failures Affecting Technology Adoption

Given the economic conditions and identification of problems in the 1980s, policymakers faced a tough choice about how to best address the problem of low productivity in SMMEs. Further, any contemplated policy needed to encompass the principles favored by the Reagan Administration, those of free markets and very limited government intervention in the marketplace. The administration was able to overcome the apparent contradiction by placing the focus on correcting the U.S. trade deficit in manufacturing.

From an economic perspective, several nonpartisan, positive economic arguments can be made to support government intervention in the marketplace. These arguments were summarized in a National Research Council (NRC) report (1993). The report finds that SMMEs may lack knowledge about changing technology and production practices for two reasons: (1) lack of information, awareness, or insufficient knowledge of new technologies, and (2) lack of information sharing among firms. The report claims that many SMMEs are unaware of changing technology and suggests that this might be because owners and managers are so busy they do not have time to keep abreast of either new technologies or new applications of existing technologies. The authors claim that this lack of experience may lead managers to be risk averse toward making investment in new manufacturing methods. The NRC finds that many firms perceive innovations as a risk to the solvency of the company, not only because of the financial costs involved, but also because of the resulting disruptions that can interrupt production on the shop floor. As a consequence, capital investment in new technologies are either delayed or

completely avoided. The authors find that SMMEs tend to be isolated, with not many opportunities for networking with similarly situated companies. The lack of information and networking act as impediments to learning and continuous product and process improvement.

At the time the NRC report was published, trends toward original equipment manufacturers (OEMs) applying significant pressure to suppliers to decrease costs and improve quality were the norm (Luria, 1996). These trends led to pressure on suppliers to integrate new technology in their products and to adopt new production techniques such as computer aided design (CAD) and automation. OEMs were forcing smaller firms to take more responsibility for engineering, and product development, while simultaneously requiring SMMEs to adopt OEM quality standards and performance measures.

One finding by the NRC (1993) was that owners and decision makers within SMMEs felt they did not know where to obtain quality, unbiased information, advice, and assistance about improving their production techniques or adopting new technologies. The authors found that firms searching for help from the government were often faced with a confusing, uncoordinated array of services offered by various providers competing for clients. In addition, the NRC suggested that there were few public-sector employees with relevant expertise available for consultation with manufacturing firms.

Based on company feedback, the NRC report (1993) finds that one of the most pressing needs of smaller companies was access to and assistance with the application of off-the-shelf and best practice technologies, such as CAD, CNC machine tools, inventory control and, and shop scheduling. It finds, however, that the number of vendors and products is overwhelming for an owner or manager who is unfamiliar with the technology, often leading to inappropriate choices and wasted resources and time. The companies' responses to the NRC survey indicate that vendors are one of the main sources for diffusion of technology and best practices among

industrial firms. For much of the information that they receive about advances in manufacturing technology, smaller firms are heavily dependent on the knowledge of vendors. Because of the nature of this relationship, these sources may not be objective. Further, private-sector consultants tend to be very expensive and because their expertise is based primarily on work with large manufacturing firms their recommendations are often inappropriate or too costly for SMMEs (NRC, 1993). Private-sector sources of external assistance have difficulty justifying the up-front sales and marketing costs required to enter into the SMME market. These traditional sources prefer to target markets that result in larger accounts and allow the consulting firms to amortize their sales and marketing costs more quickly.

I. Synopsis

The program concept of what is currently termed manufacturing extension is based on the provision of technology-related services that address many of the barriers to improved manufacturing productivity discussed in this chapter. MECs are intended to help SMMEs through an increase in awareness of modern technologies and best manufacturing practices, facilitate interaction between small manufacturing firms, and become a source of reliable, unbiased technology-based information. This research will demonstrate that delivery of these services has been somewhat limited in practice.

Why is this important? I will demonstrate that CMC and the MEP system as a whole are not delivering primarily technology-related services to its SMME-client base. This raises the question of legitimacy. As suggested earlier in this chapter, from the perspective of public policy and fiscal policy it is important to examine program intent and actual delivery. Any deviation may suggest that the idea behind MEP is flawed, and a technology-diffusion program cannot be successful with limited public-sector funding. This suggests that the program be redesigned to more adequately account for the realities of economy and the way SMMEs process information and make decisions. This question needs to be addressed head-on because if the

recent downward trend in manufacturing performance continues, the MEP program and its service delivery is sure to be scrutinized at the federal and subnational level.

II. THEORIES OF ECONOMIC GROWTH, ECONOMIC DEVELOPMENT, AND TECHNOLOGY DIFFUSION

A. Introduction

This chapter examines the theoretical literature on economic growth, technology-diffusion, and economic development. Federal technology policy, including the development of the MEP program, is based on the economic-growth and technology-diffusion literatures. On the other hand, manufacturing extension at the subnational level is firmly based on the economic development literature. Most economists agree that technological advance plays a central role in the productivity in the economy (Nelson, 1996). For this reason it is important to understand how technology advance occurs and affects the rate of advancement. The first section of this chapter focuses on economic growth and its application to technology diffusion. The reduced scope of this review comes with great warning (Bozeman, 2000).[2] Given the vast body of literature discussing technology, from the research and development (R&D) stage through innovation, technology transfer and diffusion, it is prudent to at least attempt to reduce the scope to highlight those topics directly related to technology diffusion and the formulation of policy intended to address these issues. That is not to say that economic theory attempting to describe any of these other processes will be excluded; they are included if they can be applied to diffusion.

[2] Bozeman suggests that "In the study of technology transfer, the neophyte and the veteran researcher are easily distinguished. The neophyte is the one who is not confused. Anyone studying technology transfer understands how complicated it can be. First, putting a boundary on the technology is not so easy. Second, outlining the technology transfer processes is virtually impossible because there are so many concurrent processes. Third, measuring the impact of transferred technology challenges scholars and evaluators, requiring them to reach deep down into their research technique kit bag" (Bozeman, 2000, p. 627).

B. Theories of Economic Growth and Technological Diffusion

A comprehensive theory of economic growth is not developed until after the 1950s. The theme of this early work is based on the neoclassical theory of the firm and production in a competitive industry (Solow, 1956). Firms are assumed to face a set of alternatives regarding the inputs they purchase and the outputs they produce. The firm's only goal is to maximize profits given the external conditions it faces. The economy is assumed to be in equilibrium in the sense that demand and supply are balanced and no firm can improve its position given what other firms are doing. Growth occurs because of an expansion of the supply of factors of production that shift the aggregate supply curve to the right.

However, if constant returns-to-scale and other assumptions are accepted, this neoclassically-based theory does not adequately explain the increase in output per worker experienced because of movements along a production function resulting from increase in capital and other inputs per worker. This increase in output has been accommodated in neoclassical theory by assuming that technical change resulted in a shift of the production function. Technical advance is brought into the standard neoclassical format for economic behavior by hypothesizing that it is a function of past investment. In addition, the standard profit maximization hypothesis has been expanded to account for these investment decisions.

A major contribution to the development of the body of economic growth theory surrounding technical change stemmed from Schumpeter's Capitalism, Socialism, and Democracy (1942). Schumpeter argued that the microeconomic analysis that was dominant in mainstream economics was missing the point by focusing on competition in a static context. He suggested that technical advance was the principal contributor to not only economic growth but also competition in many industries and, in terms of social benefits, competition-induced innovation was vastly more important than competition-induced marginal cost pricing. In contrast to Solow's orthodox views (1956) about the relationship between market structure and

competition. Schumpeter suggested that if innovation was important in a particular industry, a market structure that contained large firms with a reasonable amount of market power was both desirable and inevitable (Nelson, 1996).

A second addition to the theory occurred during the 1960s and 1970s when neoclassical economists began focusing on methods of economic-growth accounting. One source of growth identified for measurement was technical change, and these economists developed production functions that allowed for technical advance.

A third source for renewed interest in economic-growth theory came from within the discipline of agricultural economics and focused on viewing returns to publicly financed R&D as an investment; hence providing a rationale for public investments in R&D (Nelson, 1996). Economists began to explore the reasons for, and the nature of, public finance of R&D (Griliches, 1958). The notion that basic scientific knowledge was a public good became widely accepted and was accompanied by recognition of market failure in the area of applied-industrial R&D.

1. Neoclassical Theory

As mentioned above, interest in technological change has increased since the 1950s (Nelson, 1996; Antonelli et al., 1992). Output in the United States was found to have grown at a rate significantly faster than the rate of increase of a price-weighted index of inputs (Nelson and Winter, 1982), highlighting the significance of technological change as a source of economic growth.

The analytic foundation for the theory that technical advance is an important source of growth is provided by Solow (Solow 1956, Solow 1957). Solow (1957) shows how growth can be attributed to various sources and how to measure technological advance. Firms

are key, productive actors operating with a production function, in part determined by the state of technology that transforms inputs into outputs. Technological knowledge is assumed to be public in this theory. Firms, given product demand and factor supply conditions, chose a point on their production function to maximize profits. This model predicts full employment. Over time, output grows as inputs increase and technologies advance. The neoclassical theory, focusing on marginal activities, predicts that the elasticity of supply with respect to any input equals its share of total factor returns. Proportional output growth due to input growth along the production function equals the sum of input growth. Solow (1957) concludes that the residual is a measure of the production function shift, or technological advance.

This theory is based on several assumptions that warrant scrutiny. The theory assumes perfect information and profit-maximizing behavior by the firm. Accommodation is not made for imperfect information or incompetent management. An inherent weakness in the neoclassical paradigm is that it ignores differences among firms in access to and knowledge about new technologies, and the complex processes often involved in making decisions about what technologies to adopt.

2. Weaknesses of the Neoclassical Model

Upon closer scrutiny of some of the basic assumptions of the neoclassical model additional weaknesses become apparent. First, the model rests on the assumption that at any given time there is a wide range of technological possibilities that firms may chose, including alternatives that no firm has ever before selected. This means that a production possibility may exist through no one has ever used it. This is not very realistic. Exploration of technologies that have not been used before involves innovation. Expanding the neoclassical model to include innovation implies that R&D is an activity whose outcome can be predicted in advance. Therefore, there would be no difference between moving along the production function by

increasing one kind of capital and shifting the production function by increasing capital through R&D investment.

The neoclassical model makes no allowance for uncertainty nor for differences of opinion about the technology that is best. The model also does not allow for externalities of investment and R&D. It assumes the firm retains full control of the knowledge generated through R&D. This is obviously not the case. Although a firm might try to restrict knowledge about its innovation, at the very least other firms become aware that something new was successfully introduced. In other instances, enough is published or is evident to observers to provide information on how they too could adopt such innovation.

Even the amended neoclassical model cannot accommodate the uncertainty associated with attempts to innovate, the public nature of knowledge associated with the outcomes of these attempts, and the diversity of firm behavior that is inherent in a world in which innovation is important. As a result, it can not explain technological advance at the level of the individual firm. In addition, it is not possible to reconcile what is known about technological change at a microeconomic level with the structure used to model technical advance at the sector or macroeconomic level by arguing that the macroeconomic model deals with the average firm. Differences among firms and the disequilibrium in the system are features of growth driven by technological change in the real world.

Traditionally, economists have tended to minimize the differences among individual firms. Nelson (1996) argues that this lack of interest by economists in discretionary firm differences stems from a particular theoretical view of economic activity and the role of behavior of firms which he explains as follows. First, since the initial formulation of the general equilibrium theory, most of the focus has been on how well, given preferences and technologies, an economy allocates resources. Given this focus, by definition there is very limited focus on the

intricacies of how individual firms operate. Second, in explaining firm behavior, neoclassical economists tend to assume that firms, given their objective to maximize profit, face given and known choice sets constrained by technology and have no difficulty in choosing the action that is the best for them. The combination of these two factors lead to an analytic framework that ignores what actually goes on in firms, and supports the idea that firm differences do not matter.

While current versions of the neoclassical model expanded to accommodate technology as an endogenous variable, they have not moved away from the assumptions that a firm's set of choices as given and obvious and that the best choice is similarly clear and obvious. Because of this, the reasons for firm differences in technology or organization are ultimately reliant on the differences in initial conditions that may make the choice sets different. Given the same conditions, all firms will do the same thing.

Over time new bodies of literature arose because of the inability of the neoclassical model to adequately explain economic growth through technological advance (Mansfield, 1968, 1971;). Mansfield's research was one of the first to highlight the importance of uncertainly in the technology adoption process. He argued that firms have considerable difficulty in evaluating new technological developments. In addition, he suggested that there is a considerable variation across firms regarding the time line for adopting new processes, particularly when technology is advancing very rapidly. These two ideas are inconsistent with the neoclassical viewpoint that technological knowledge is a public good and that growth is an equilibrium process.

3. Evolutionary Theory

Evolutionary theory defines all regular and predictable behavior patterns of firms as routine. The term routine includes firm characteristics ranging from: well-specified technical routines for production; procedures for hiring and ordering new inventory; policies regarding

investment, R&D, advertising; and business strategies about product diversification (Nelson, 1996). Evolutionary modeling highlights the similarities among these different sorts of routines.

As far back as Malthus, there has been a long tradition in economics of thinking about economic growth as an evolutionary process. More recently Nelson and Winter (1974; 1975; 1982) introduced an evolutionary theory of productivity growth. In this model, discovery or creation of a new technology is recognized as being uncertain as well as costly. Research and development is often profitable for a firm if the R&D results in a better technology and if competitors are not able to imitate quickly and easily: different firms make different technical decisions, some turn out to be better than others. Over time, productivity grows as new technologies are discovered and applied, as better technologies discovered by some firms are imitated by others, and as profitable firms grow relative to nonprofitable ones. The ability of firms to imitate the technologies of other firms and the extent to which profitability of the firm induces its expansion are treated as variables within the evolutionary model, indicating a formal relationship between R&D spending and new technologies.

This emerging evolutionary theory focuses on firm-specific dynamic capabilities including strategy, structure, and core capabilities (Nelson and Winter, 1982). The concept of strategy in this theory of the firm connotes a set of broad commitments made by a firm that define and rationalize its objectives and how it intends to pursue them. Some of this may be written down (codified), some may not be, but rather is in the management culture of the firm. In contrast to traditional theory, this theory does not assume that these objectives are necessarily profit maximizing. The concept of firm structure is defined in the theory in a fairly general way. It involves how a firm is organized, and how decisions are actually made and carried out. These factors determine what the firm actually does, given its broad strategy. A firm whose strategy calls for being a technological leader that does not have sizable R&D operation, or whose R&D

director has little input into the firm's decision making, has a structure out-of-tune with its strategy.

Nelson and Winter (1982) propose that a firm that works well can be understood in terms of a hierarchy of practiced organizational routines which define lower-order organizational skills, how these are coordinated, and higher-order decision procedures for choosing what is to be done at lower levels. The notion of hierarchy of organizational routines is the key building block behind their concept of core organizational capabilities. At any time the practiced routines built into the organization define a set of things the organization is capable of doing confidently. If the lower-order routines are not there for performing various tasks, or if they lack a practiced higher-order routine for invoking them in the particular combination needed to accomplish a particular job, then the capability to do that job lies outside the organization's core capabilities.

If one thinks within an evolutionary framework, it can be seen that a firm will have an extremely difficult time determining its best strategy. A basic premise of evolutionary theory is that the world is too complicated for a firm to comprehend. There are certain characteristics of a firm's strategy, and of its associated structure, that management can have confidence will enhance the chances that it will develop the capabilities it needs to succeed. There are other characteristics that seem a prescription for failure. However, there is ample room in between, where a firm simply has to improvise. As a result, using a framework based on evolutionary theory, firm diversity is to be expected. It is almost inevitable that firms will choose somewhat different strategies, leading to different firm structures and core capabilities, including R&D and diffusion. Firms will chose different paths - some proving profitable and others not profitable. Firms that systematically lose money will have to change their strategy and structure: develop new core capabilities or operate the ones they have more effectively; or go out of business.

In contrast to neoclassical models, evolutionary theory espouses that technology advance proceeds through an evolutionary process, with new products and processes competing with one another and with prevailing technology. When an industry or a technology is new, firms take a wide variety of approaches to technological innovation. As experience grows, some approaches begin to have better results than others. Firms who have made the best decisions do well, while those that made bad choices do poorly.

Evidence suggests that whether the new technology conforms with the core capability of the firm is important in determining success (Nelson and Winter, 1982). It has been noted that a major change in management and strategy often are necessary if an old firm is to survive in a new environment (Tushman and Anderson, 1987). However, changes in management and strategy may not be sufficient, as structure and core capabilities are far more difficult to change than management and articulated strategies.

4. Weaknesses of the Evolutionary Model

Modeling technology diffusion as an evolutionary process is much more complex than modeling based on neoclassical theory. Under evolutionary theory, the behavior of the firm must be explicitly included in the model. Compared with modeling under neoclassical theory, the pivotal role of decision rules and routines in the evolutionary-process model implies that the analyst must have detailed information about the firm and its organizational characteristics. Evolutionary models are less stable than models used under an equilibrium approach. This leads to a certain lack of predictive power compared with neoclassical modeling. However, Nelson (1996) suggests this approach is favored despite the fact that it is not a fully evolved comprehensive model because:

> Those doing formal growth theory, or reflecting theoretically on the nature of institutions of modern capitalism, have not paid enough attention to the closer-to-the ground theorizing by economists who have been studying the matter empirically. Those doing detailed empirical work and, in the course of that work, presenting a causal story have in general not seen fit to call attention to the often major differences between their account and what is presumed in formal growth theory. As I think back on it, much of my own work during this period can be understood as the result of my growing awareness of the disjunction between formal theoretical work and the empirical studies of the subject matter (Nelson, 1996, p. 6).

C. Diffusion Theories Comparison

1. Neoclassical

Assuming perfect competition, perfect information on technology, and the maximizing behavior of firms, diffusion arises from an unequal distribution of certain key characteristics of firms that are decisive for adoption. Firms have the same information on the new technology, but not the same ability or potential profitability to use it at a given point. Price changes of the new equipment are then the engine of adoption. Firms display the same rational behavior when faced with similar information, although they face different constraints as they have different production conditions and different market positions. This indicates that while the incentive from outside is the same for all firms, the time of technology adoption differs.

2. Evolutionary

Diffusion as evolution emphasizes the role of inertia, past experience, and knowledge on the decision process of firms (Antonelli et al., 1992). Evolutionary theory suggests that routine patterns dominate over rational choice of a new technique. This theory is based on bounded rationality (Simon, 1982), where firms exhibit satisficing behavior as opposed to optimizing behavior. Pure optimization and full rationally do not coincide with firm behavior. According to Simon (1959), entrepreneurs' psychology is very important. Instead of maximizing long-run profits, the entrepreneur may very well value the short term, and be content with a satisficing level of profit or sales: a firm may chose not to adopt a new technology if it considers

the current technology sufficient. The decision maker chooses not to make the investment not because he is risk-adverse, but rather because the change will involve too much trouble organizationally. In contrast to neoclassical theory, with this evolutionary model, information has a cost. This is consistent with Nelson and Winter (1982) discussion of evolutionary behavior where firms are subject to routines and possess skills which determine their behavior – firm variants arise from different habits, rather than from different expenditures to obtain different information.[3] For these reasons, all firms do not adopt new technology instantly and completely.

3. Differences

Classical models of technology diffusion assume that all firms, based on the same knowledge, make decisions about identical alternatives: differences in choice reflect differences in factor price and market conditions. The time and cost involved in learning about new technologies, and their implementation are not taken into consideration in the assumptions of the classical model. This makes no allowance for uncertainty and the proprietary nature of some new technologies. Neoclassical economics, with its focus on market equilibrium, cannot explain the dynamic process of technology diffusion.

There exists a large body of literature on the diffusion of new technology among potential users (Griliches, 1957; Mansfield 1968; 1971; 1972). Although researchers differ on whether the judgments about technology are competent or arbitrary (Griliches, 1957; Ray, 1984), there appears to be agreement that firms differ in the speed with which they become aware of, evaluate and make decisions regarding technology options. If all firms are fully informed about new technology created by one firm in an industry and have full access to it, the innovating firm would have little incentive to develop and introduce new products and processes. Consistent with these research findings, the more recent evolutionary theories of economic growth appear

[3] Evidence supporting this theoretical approach is provided in Chapter 8 where case studies for six firms are presented.

more insightful and realistic (Nelson and Winter, 1974, 1975, 1982). Discovery or creation of a new technology is uncertain and costly: because of these differences in uncertainly, different firms make different technology decisions. Over time, productivity grows as new technologies are discovered and applied, as better technologies discovered by some firms are imitated by others, and as profitable firms grow relative to unprofitable ones. Nelson (1996) claims that there are two conceptually distinct kinds of mechanisms by which the use of a profitable new technology is spread. One is the diffusion of a new technology from firm to firm. The other is the growth of firms that use a superior technology relative to those that do not.

4. Application

Diffusion, rather than innovation, appears to be the dominant mechanism for the spread of a new technology in sectors where the firms are small compared with the market as a whole. These firms are frequently dependent on suppliers, cooperative R&D mechanisms, or government-sponsored programs to provide them with information on technology options.

One reason these firms do not immediately adopt technologies is due to a lack of adequate information to form a judgment. As technology use spreads, information feeds back not only to potential users but to the designers of the product and their competitors This learning process leads to product redesign to improve performance and potential production cost reduction. Some potential users may choose to wait for the second or third generation of a new technology before making the investment. As the product improves and versions of the technology better suited for particular types of users appear, more and more potential users find it profitable to adopt the technology (David, 1975). As time goes on, a new design may come along, causing the product cycle to begin again.

The MEP program provides technology diffusion to SMMEs on different levels. The program facilitates learning among technical experts and firms and programs are often

designed to encourage learning and information sharing among firms. These approaches combine neoclassical optimization and evolutionary theories of technology diffusion.

D. Technology

To determine what, if any, public policies should be implemented to facilitate technology diffusion, it is crucial to define the term technology. Technology is defined by Metcalfe as "the ability to carry out productive transformations: it is an ability to act, a competence to perform, translating materials, energy and information in one set of states to another more highly valued set of states" (Metcalfe, 1995).

Employing Metcalfe's definition there are three interdependent dimensions of technology: knowledge; skills; products and processes. In principle, policies can be designed to influence each of these aspects of technology independently, although in most circumstances the three are jointly addressed. For firms that develop new and improved products in search for competitive advantage, the product and process dimension is the central concern. The skills and knowledge underpinning a technique are a concern of firms; but these dimensions are produced by a wider set of institutions.

Vincenti (1990) suggests that there is no satisfactory classification of knowledge for innovation. However, two important distinctions are often made: basic knowledge and applied knowledge. Fundamental, basic, or pure knowledge is distinguished from applied and engineering knowledge - a distinction based on the nature of the knowledge. Fundamental knowledge is usually defined in terms of the laws of natural phenomena and their empirical verification by replicable, experimental methods. Applied knowledge is more specifically focused on particular generic productive transformations and may or may not be capable of verification of scientific means.

Metcalfe (1995) suggests that the codification of knowledge may be more or less explicit. Different kinds of knowledge have different costs of translating them into technological codes. Such costs are fixed outlays relative to the use of the information, and when average fixed costs are high it is not likely to prove cost effective to transform knowledge in a codified form. Therefore, Metcalfe concludes that knowledge once produced is not going to be freely available to all that demand access to it. As the uncodified component of knowledge increases, the significance of learning by observation increases. Accumulation of knowledge occurs more through experience and communication. It is increasingly more verbal and likely to occur through personal contact. Metcalfe suggests that this leads to the accumulation of tacit knowledge connected to trial-and-error methods: to learning by doing, by using, and by being linked to specified activities carried out by specific organizations.

The significance for policy is that any technology policy or program draws on different kinds of knowledge created in different institutions and accumulated by different mechanisms. The integration of the relevant information and the variety of modes of acquisition are crucial. Technology policies should be based on an understanding of these different sources of knowledge, the different motivations and methods, that underpin the acquisition of knowledge.

The creation and application of technology serve different economic functions. A detailed knowledge of customer needs is crucial to the innovation process. The failure to incorporate this specialized knowledge partly explains the poor results of major government-sponsored civilian-technology programs (Metcalfe, 1995). Innovation is neither technology push nor demand pull, rather it is a subtle and varying blend of the two (Freeman, 1984; Mowery and Rosenberg, 1979).

This decentralization marks the evolutionary nature of economic change. The process of market competition is essentially a creative process of discovery and it is counterproductive to

conceive of such a process in the context of perfect knowledge and perfect foresight (Hayek, 1948). But, equally, policymakers are part of the same discovery processes and are subject to the same limitations as the individuals that they seek to influence.

1. Technology Policy in an Equilibrium World

The chief focus of existing technology policy is based on market incentives to induce innovation by profit-maximizing firms. Under this model, knowledge production is characterized by indivisibilities, uncertainty, appropriability, externalities, and public-good dimensions (Dasgupta, 1988). These characteristics lead to the general presumption of market failure, in the sense that market incentives do not produce optimal allocation of resources to innovate. From this follows the general case for policy intervention. As the sources of market failure are to a considerable extent interdependent, policy prescription may be particularly troublesome (Stoneman and Vickers, 1988). In addition, given that conflicting forces are at work, more specific frameworks are needed to provide explicit policy recommendations.

In neoclassic economic theory the problem of technology policy appears as the identification and adoption of maximizing economic equilibrium. Left to itself, the market mechanism will generally fail to produce the best possible allocation of resources to R&D. The source of inefficiency rests in inappropriate incentive mechanisms or in the imperfect distribution of information across economic actors. Firms always do the best they can, but they face some form of constraint. The central policy option becomes one of changing incentives.

In this optimizing world, the optimizing policymaker seeks to maximize social welfare through developing policies that also permit individual actors to maximize their personal welfare. These criteria define the arena of policy choice. In this instance, the policymaker is considered to be a fully informed social planner who can identify and implement equilibrium policies.

While market failure in an equilibrium world is the rationale behind policymaking, the prevalence of market failure in the real world provides limited insight on how the theory can be used to develop public policy. Theory predicts that firms may spend too little or too much on innovation, generate those innovations too early or too late, or generate innovations that are too similar or too different. The nature of the policy advice, therefore, depends on the specifics of each case. However, the more detail required by the policymaker, the more costly it is to produce the necessary information. At the extreme, the constraints the policymaker faces become indistinguishable from those of the private-sector decision maker the policy is designed to influence.

2. Technology Policy as Evolution

Firmly rooted in the behavioral theory of the firm, evolutionary-technology policy is focused on le· ning capabilities, adaptive behavior, and the interactions between these behaviors and various economic-selection mechanisms. Whether it is because of the organization, the individuals involved, or circumstances; no two firms can be expected to innovate in the same way. This tendency towards technological diversity is a defining characteristic of the evolutionary approach. There is no simple connection between economic and social welfare and these characteristics of innovation and diffusion. Metcalfe (1995) suggests that while progress is desirable in so far as economic wealth is desirable, the incidence of evolutionary progress is uneven, and that the benefits and costs fall unevenly and unexpectedly.

Most significantly, under an evolutionary approach there is no longer a role for the optimizing policymaker. Uncertainty, ill-defined choice sets, and bounded rationality put the policymaker in same position as the firms which policy seeks to influence. Improvements in

technology are the best one can hope for and the way to encourage such improvements is by increasing the learning capabilities of all the institutions involved in the process.

Evolution is a change that occurs endogenously, without reference to adjustment to some equilibrium state. This means moving away from a view of competition based on price toward viewing competition in terms of those decisive cost and quality advantages that arise from innovative behavior. It entails a shift from perceiving competition in terms of states of equilibrium characterized by different market structures, to competition as a process of change premised on the existence of the different behavior of firms and other economic agents (Nelson and Winter, 1982). In an evolutionary world, a central purpose of policy becomes that of stimulating the technical and innovative capabilities of economic system - enhancing the learning processes in firms and other institutions to generate variety in behavior. The evolutionary economic processes are almost by definition open ended and unpredictable. Although the emergence of new ideas is unpredictable, the process that translates them into coherent patterns of change is not. A pivotal role of technology policy and policymakers is translating these.

The evolutionary policymaker adapts rather than optimizes. The central concern is the innovation system - the operation of the set of institutions within which technological capabilities are accumulated. The policy problem is defined in terms of the dynamics of innovation in a world characterized by immense complexity. Moreover, just as individuals operate under the constraints of localized, imperfect, and uncertain information so does the adaptive policymaker. There can be no presumption that the policymaker possesses a superior understanding of market circumstances or technological information. Rather, the policymaker may demonstrate superior coordinating ability across a range of diverse institutions. Technology policies can fail just as easily as the technology strategies of firms. The issue becomes how well policymakers use their experiences to learn and adapt. Given the emphasis on adaption and policy by trial-and-error, two observations can be made. First, the value of limited policy

experiments to guide the learning process (Tassey, 1982) and second, as an integral part of every program, the importance of rigorous and consistent evaluation of policy (Georghiou, 1989). As this research will show, MEP has been exemplary in exhibiting these two characteristics.

There is also the question of how policy interacts with the agents it seeks to influence. Many routes are often available to deliver a given policy to its intended recipients but little is known about their relative advantages (Metcalfe, 1995). For example, a framework which makes firms compete against each other (targeted) will produce different outcomes from a policy which is available to all who are willing to join the queue (as a right) for public support.

3. Differences

For evolutionary policymakers, adaptation and learning displace neoclassically based equilibrium and optimization as organizing criteria. Under the neoclassical theory, policymakers, subject to the same rigorous standards of behavior that are applied to firms, are placed in the untenable position of developing policies that maximize societal- and firm-economic welfare. In contrast, the task of the evolutionary policymaker is more realistic. The adaptive policymaker is assumed to operate with localized, imperfect, and uncertain information. The policymaker is not assumed to have a superior understanding of technological information - expectations are based on the policymaker's ability to coordinate activities across institutions and ability to learn from experience.

E. Theories of Economic Development

The MEP at the federal level is based on the theoretical foundation in the technology-diffusion literature. At the state and local level its theoretical base is found in the economic development literature. This next section discusses various theories of economic development, how they develop over time, and how they apply to manufacturing extension.

1. Traditional Theories

Traditional theories of economic development are generally based on the trickle-down philosophy that suggests that benefits of economic growth and expansion will trickle down to improve conditions of the poor. They are firmly rooted in neoclassical theory, in spite of the fact that neoclassical economic theory does not offer a significant spatial dimension.

Goldstein and Lugar (1993) define neoclassical economic theories as those focusing on market responses to changes or differences in prices, thereby assuming that markets operate competitively. All factors of production are assumed to receive the value of their marginal products as compensation for the services they provide. The paradigm used historically for justification and development of economic development policies is not dissimilar to that used traditionally for justification of technology-policy development at the federal level. One caveat, the unit of analysis is now subnational rather than national.

The primary theoretical justification for what are considered traditional supply-side policies for economic development grew out of the neoclassically based industrial-location theory introduced by Tiebout (1962) and further developed by Thompson (1965). This theory suggests that economic growth in a region is determined by the location of economic activity within that region. Operating within the neoclassical framework, what determines firm location is profit maximization and cost minimization in proportion to revenue, accounting for market characteristics. Firms operate where marginal product per dollar of all factors of production is equal thereby ensuring optimal resource allocation.

While early location theory focuses almost exclusively on minimizing transportation costs, the theory has evolved significantly since then. In its most basic form, the location-theory model postulates that the best location is almost always on the cheapest transport link between markets of raw materials. Theoretical advances incorporate production-cost factors

and other noncost factors. These include labor, land, capital, energy, taxes, market size, regional amenities, and technological capabilities. Application of this least cost principle is also expanded to the analysis of investors - not just seeing to site a new plant but also in terms of relocation when they would search for a location where the returns-on-capital investment might be maximized because of site-specific characteristics.

In general, studies prior to 1960 indicate that basic cost factors were the dominant determinants of industrial location patterns (Blair and Premus, 1993). More specifically transportation, access to markets, access to material inputs, the availability and cost of labor are considered the most significant (Blair and Premus, 1993) cost factors. More recent empirical studies indicate that, as the economy and technology becomes more complex, the list of significant location factors expands to include technical competence of the labor force, state and local taxes, regional business climates, quality-of-life factors and other regional difference (Blair, 1995). While traditional cost factors continue to be the most important locational criteria for many industries, they have declined in relative importance as other locational factors become more important (Blair and Premus, 1993).

Exhaustive studies were conducted to determine the most important costs facing the firm when making a location decision and the most effective tools that subnational units of government can employ to make their region more attractive.[4] Out of the theory came industrial-attraction strategies, economic development strategies used almost exclusively until the 1980s in communities throughout the United States. The basic assumption underlying this smokestack-chasing-attraction strategy was that a community could make its location more attractive to companies by offering incentives and subsidies to reduce the cost of doing business, as discussed in the location theory.

[4] See Bartik (1991) for additional summary of research findings.

There are many supply-side policy tools that localities devised to help reduce the cost of doing business in their region in order to make it more attractive for firms to locate there. These include tax concessions (property, income, sales, utility), employment creation and retention subsidies, capital grants, loans, and interest subsidies.

2. Strengths and Weaknesses

Location theory is one of the better-developed branches of urban economics. While proven to be a valuable analytical tool, it does possess several weaknesses and/or limitations. First and foremost, location theory is rooted in neoclassical economics where the sole goal of investors is to maximize profits. While this is not an uncommon assumption in economic theory, it is important to recognize that investors may have alternative motives. These could include making decisions that are safe from criticism or that have a high probability of earning at least a minimum threshold profit (Blair and Premus, 1993). Recent analysis of business decisions suggests that many executives may be more concerned with short-run outcomes than maximizing profits over the long run (Blair and Premus, 1993).

Blair (1995) claims that inertia is perhaps the strongest, and often unrecognized, locational factor. One reason why inertia may play such a strong role is that the economic and social structures of an area may evolve to reinforce the initial locational choice. The firm supports the community and the community develops in ways that support the firm (Norgaard, 1984). In other words, a firm develops ties to other producers, buyers, and employees that may be severed if the firm relocates. The business ties may even be cemented by personal friendships. This suggests that building cooperative working relationships among firms and with local governments can be a powerful economic development strategy (Blair, 1995).

Additional shortcomings of such supply-side strategies include uncertain impacts of particular investment incentives, the ease with which competitor jurisdictions can match

subsidies for mobile capital in a bidding war, economic decline continues in some states even during decades of vigorous efforts to lure and keep industry through supply-side devices, and that in spite of government offering location-theory-based incentives the private sector fails to invest in R&D and additional business formation.

From the policy perspective, it is difficult to determine how public-sector officials actually make decisions on the type and level of cost-reducing incentives to provide private-sector firms. What is clear is that political factors such as public opinion are often weighed into the calculation and become part of the bargaining process between businesses and subnational government (Blair, 1995).

Finally, one serious limitation of location theory today is that modern technologies and telecommunications alter the significance of specific locations for the production and distribution of goods. However, the contribution of location theory to local economic development is the realistic parameters it places on the development process.

3. Demand-Side Strategies

The 1980s witnessed somewhat of a paradigm shift at the subnational level. Governments became increasingly more reliant on what became known as demand-side, new wave, or entrepreneurial strategies to facilitate economic development (Eisinger, 1988). Eisinger identified states as being entrepreneurial if they adopted demand-side strategies as opposed to supply-side strategies.

Supply-side strategies were developed by states that recognized various shortcomings of the supply-side approach to encouraging private investment for development. These new strategies were based on the idea that anticipating or stimulating demand forces in the market would offer more effective economic development results (Eisinger, 1988). However,

these alternative strategies based on demand-side concepts required government to play a more entrepreneurial role in the economic development process.

> How is it possible, the capitalist asks, for government bureaucrats, who venture nothing of their own, to assess the market and the risks as accurately as the individual who puts his or her money on the line? ...Such a question assumes, of course that the entrepreneurial impulse is driven only by the profit motive, and that, lacking the possibility of private gain governments embodied by their bureaucratic and elected functionaries can not or will not understand all that is at stake in a venture into the market or do what is necessary to increase the chances of success. But in fact the public stakes in market ventures are increasingly clear to state and local governments and they lie less in the prospect of profit than in jobs and taxable resources. To secure these ends, state and local government have begun to make serious efforts to develop the financing, investment and marketing skills necessary to function in the world of entrepreneurship. (Eisinger, 1988, p. 228)

The policies of the entrepreneurial state are drawn primarily from economic-base theory. Once again, this theory finds itself firmly embedded in the neoclassical paradigm. While Tiebout (1962) first developed this theory, it is expounded on by Thompson in his 1965 publication. Economic-base theory suggests that the determinants for economic growth are directly related to the demand for goods, services, and products from areas outside the local economy. Such demand for final exports will generate local wealth and employment. Under the export-base theory, policymakers must have a strong understanding of the structure and dynamics of the market. One assumption of the model is that once new and expanding markets are captured, jobs will be generated in the export sector. This in turn leads to a local employment-multiplier as subsidiary businesses form to provide services to the export workers. The economic-base model relies heavily on a sectoral approach to economic development. The approach concentrates on transactions within the economic system rather than the failures and inadequacies of the system in which the transactions are taking place. One criticism, raised by Thompson (1965) is that the relationship between the proportion of employment in the basic (export) sector and secondary jobs is unstable. In addition, there is considerable debate over

what is considered basic and what is considered nonbasic. In other words, what sectors support and attract others. However, from Eisinger's perspective (1988), for purposes of economic development what is important is that there is a relationship between the two, not the direction of causality.

Eisinger (1988) identifies one major practical adaptation of export-based theory to address market expansion rather than just increasing the export of goods. This focus assumes growth not just through the injection of exogenous income to pay for export goods but also by offering goods that stimulate the spending of indigenous income. One further adaptation of the model is the role of government spending. This model assumes that government spending has an associated multiplier and thus helps promote growth. In addition, drawing from Schumpter (1942), Eisinger (1988) suggests that in order to stimulate demand whose location is not yet known, export-based demand-side policies can encourage innovation.

4. Policy Implications

The state's role is to identify, evaluate, anticipate, and even help to develop and create these markets for private producers to exploit; aided, if necessary, by government as subsidizers or coinvestors. The policies of the entrepreneurial state are geared to these functions (Eisinger, 1988).

Policy tools identified as new wave or demand side include generation of venture capital for selected new and growing businesses, the encouragement of high-technology research and product development to respond to emerging markets, and the promotion of export goods produced by local businesses to capitalize upon new sources of demand.

5. Strengths and Weaknesses

In terms of the economic-base model several weaknesses can be observed. First, critics contend that it places too much emphasis on exports and overlooks other important factors that can lead to growth. As indicated in other parts of this research, growth can be generated through increases in productivity, investment from outside the region, or by substituting domestic production for goods that were previously imported into the region.

Second, the multiplier associated with increased production of export goods is based on the assumption that when the export sector expands the demand for local services increases and the increase in demand will be sufficient to induce an increase in the supply of these services. However some local services may not be able to respond quickly to this increase in demand (Blair, 1995). If exports increase but the nonbasic sector does not increase, then the multiplier will not adequately reflect the impact of changes in exports.

Third, feedback effects are not accounted for in the simple export-base model.[5] While this is not so much of a problem for a small region, if the region is large the feedbacks can be significant (Blair, 1995).

Eisinger (1988) claims that these demand-oriented policies are perceived by state and local government officials as a break with past practice. However, interviews with senior economic development policymakers in Illinois do not necessarily agree that the distinction in policies made by Eisinger is clear cut.[6] Given that the paradigm in which these policies are placed falls within the neoclassical framework - with a focus on optimal resource allocation,

[5] Feedbacks occur when one region's actions cause another region to increase its purchases from the subject region. Regional interdependence creates feedbacks. Actions of large regions may create feedback effects from other large regions (Blair, 1995).

[6] Interview with Marley, David [pseud.], senior DCCA official. Interview by Natalie Davila. Chicago, Illinois, 19 April 19 2000. Bowie, Robert [pseud.], senior DCCA official. Interview by Natalie Davila. Springfield, Illinois, 21 April 2000.

perfect information and profit maximization - the extent to which demand-side policies are fundamentally different in substance may be questionable.

However, if we agree with Eisinger that the 1980s did witness a shift from supply-side to demand-side policies that are fundamentally different, it raises the following question. Under such demand-side policies the criteria of success by which policymakers and implementers are judged does not appear to have changed. Given this framework, the job of the policymakers under this new paradigm becomes increasingly more unattainable.

6. Correcting for Market Failure

Shortly after Eisinger's (1988) well-received theory of the entrepreneurial state, Bartik (1990) published a paper that was the first to explicitly identify market failure as an approach to subnational economic development.

In this 1990 paper Bartik discusses the assumptions underlying such an approach and applies it to a wide variety of economic development policies. As such, the market-failure approach cuts across the distinction made by Eisinger, and identifies policies from supply-side and demand-side theories as market-failure correction strategies.

Bartik's (1990) logic for advocating a market-failure classification goes as follows. The goal of regional economic development is to increase the wealth of a metropolitan area or state by providing direct assistance to business. However, the distinction often made between traditional and new wave policies provides only vague policy guidance. Bartik (1990) suggests a market-failure approach to economic development policies, the goal of which is to correct private market failures. Market failure is caused by impediments to the formation or operation of markets. If benefits exceed costs from some change, gains from trade should cause markets to change: market failure occurs when this does not happen. Application of a market-

failure approach to economic development policymaking encourages the expansion of benefits that private markets fail to recognize. Under this approach, policies will be efficient if nonmarket benefits exceed program costs.

Bartik (1990) identifies several types of market failure at the subnational level. They include unemployment, underemployment, fiscal benefits, agglomeration economies, human capital, research and innovation spillovers, imperfect capital markets, and information in general.[7] Compared with both traditional- and demand-side approaches, he identifies several strengths and weaknesses of this approach. With regard to strengths, such policies focus on what the private markets cannot or are not doing. In this sense, market failure makes meeting the "but for" condition often associated with evaluation of economic development programs much easier to document.[8] This leads to the second strength. It is relatively easier to measure and document potential costs and benefits associated with market-failure policy decisions. However, market failure approaches still face the difficulty of quantifying nonmarket benefits and costs. Second, the approach in and of itself does not account for the distributional effects of such policies. Finally, subnational policies fail to account for the impact its policies have on other regions of the country. Bartik (1991) suggests, based on his previous research (Bartik, 1990), that subnational economic development policies that provide positive spillovers will have an overall positive effect on the national economy.

However, once again, this approach is placed within the paradigm of the neoclassical model. What the author is doing is applying different criteria to categorize economic development policies that do or do not have certain characteristics. The goal of efficiency and profit maximizing are still the driving forces. Bartik's contribution (1990, 1991) to the literature is helpful for several reasons. First, it provides a useful conceptual framework

[7] See Bartik (1990) for more detail.

[8] The "but for" condition raises the question of whether or not the activity would have occurred "but for" the government involvement.

for analyzing subnational economic development policy. In addition, it employs a language that is more common in the federal-policymaking arena. We can therefore begin to compare apples to apples. At the federal level, because of the partisan nature of posturing and aversion to anything labeled targeting or industrial policy, the adoption of market failure becomes a major criterion acceptable to both parties. Certainly correcting market failure to increase competitiveness was the mantra of both parties as they voted on OTCA, (Public Law, no. 100-418, 1988).

7. Third Wave

Seven years after the publication of The Rise of the Entrepreneurial State (1988) Eisinger published a paper focusing on state economic development policy learning in the 1990s (Eisinger, 1995). He identified a new direction in subnational economic development strategies termed "third wave." This idea was first discussed by Pilcher (1991) and Ross and Friedman (1990). These new strategies were differentiated from entrepreneurial programs in terms of their more extensive scale and scope.

Third-wave programs are primarily responses to the lack of scale and accountability of the entrepreneurial programs. This new strategy seeks to reduce the role of state government to an institution that enables institutions, firms, and communities to develop the means to help themselves. Third-wave programs emphasize seeding, leveraging, and general capacity-building functions.

Eisinger (1995) suggests that it is often difficult to distinguish between entrepreneurial-state and third-wave policies. While they often operate on the same principles, entrepreneurial programs are designed to provide firms with more specific programmatic direction than the general capacity building of the third wave. Programs identified as third wave include investment in job training and education, industrial-modernization initiatives, support of

community-level economic development planning, and encouragement of industrial clusters of firms for the purpose of pooling resources to achieve higher levels of international competitiveness than each firm could manage on its own.

Eisinger (1995) concludes his analysis by stating that while this was occurring in some states, movements away from entrepreneurial programs toward third- wave programs were not dominant across all states. However, particularly useful is his concluding discussion about policy learning and policy consolidation. Eisinger (1995) claims that policy changes in the 1990s were a product of policy learning. He suggests that this learning came from political signals rather than program administration experience. If policy change comes via experience, policymakers have an opportunity to modify or adjust the program. Such policy learning may come about either informally, through anecdotal evidence and the experiences of program administrators in the field, or through formal evaluations and audits. Eisinger's survey of state development agencies provides no estimate of the importance of anecdotal evidence in policy learning.

Eisinger's survey (1995) of forty-eight states finds that only thirty-four conducted some kind of monitoring activity and only eight states conducted evaluations that recommended program modifications. This suggests that the policy-learning feedback loop in most states contains little information about program operations that is based on any sort of systematic program scrutiny. In the absence of any correlation between program evaluation and program change, Eisinger goes on to hypothesize what might have caused the observable changes in economic development programs and strategies that occurred throughout the country during the 1980s and 1990s. He suggests that policy change in state economic development is occurring primarily because of a change in strategic calculations by state-elected officials. Eisinger acknowledges that this is not an easily testable proposition, but suggests that it is consistent with changes occurring in economic development. Political factors identified as shaping this trend

include the economic recession of 1990/91, leading states to divest from programs that did not have immediate results. He suggests that political survival during fiscal hard times dictates that states employ resources that provide the maximum visible effect using the least resources. The author claims that philosophy is responsible for the program terminations, budget cuts, recruitment wars, and third-wave programs observed in the mid-1990s.

8. Recent Theories

In recent years, there are some modest developments in the literature on theories of state-technology policy. Goldstein and Lugar discuss the application of theory related to high-technology economic development (Goldstein and Lugar, 1993). They conclude that at the subnational level high-tech program development is not based on any particular theory of regional development. They suggest that this arises because policymakers have difficulty linking abstract or not well-specified theories to a particular course of action. However, the authors suggest neoclassical theory lends itself to application in the area of manufacturing extension, for many of the reasons discussed earlier - specifically the authors mention increasing global competitiveness. Goldstein and Lugar (1993) suggest that modernization programs tend to be micro in orientation and are very similar to other nonhigh-tech economic development programs though having a stronger focus on technology as an important input factor. The authors claim that while many programs have a strong foundation in one theoretical paradigm, they often overlap several theoretical policy approaches. In addition, they find a huge gap between existing theory and practice in the arena of high-tech economic development.

Goldstein and Lugar (1993) conclude by suggesting that existing theories of economic development need to be made more relevant to the technology-policy domain. In addition, development of systematic approaches to evaluation should be developed to facilitate the building of empirical databases across states that would allow contingent theories of

subnational high-tech policies and programs to be tested to determine what works under various conditions.

One major contribution in the development of subnational technology-policy theory is by Atkinson (1991). He suggests that one of the most relevant factors influencing the design and funding of state technology-policy initiatives are existing state political and institutional arrangements. To test this hypothesis, he investigates policymaking processes in six states to determine the factors that contributed to the development of effective state technology-policy efforts during the period 1970 to 1982. Illinois is one of the states examined in the research.[9] The author identifies two models for policymaking. The business-as-usual model is characterized by weak support or even opposition by external interests, lobbying by interests, a strong legislative role, a strong role for the state budget agency, little state planning effort, and a moderate or only minimal commitment to economic development by governors and policy entrepreneurs. The second model is the active-stewardship model. This is characterized by: moderate or strong support from external interests for state policies; policymaking partnerships between interests and the state; executive, rather than legislatively driven policy; a weak role for the state budget agency; a strong planning effort; and a strong commitment to economic development by the governor and policy entrepreneurs. Under these process conditions, policy effectiveness is high. The author found that Illinois fell into the business-as-usual category and as such policy effectiveness was low.

Atkinson (1991) claims that the Illinois Chamber of Commerce and the Illinois Manufacturers' Association were not active in the technology-policy arena, preferring instead to focus on keeping business costs down. This lack of pressure hinders policy development. In addition, organized labor plays virtually no role in technology policymaking. With regard to the role of higher education in Illinois, intense competition between public universities, coupled with

[9] Other states were Indiana, Massachusetts, Michigan, New York, and Pennsylvania.

only minimal efforts to lobby jointly for technology policy, contributes to several programs not gaining approval and others being underfunded. The author specifically identifies the Illinois Technology Commercialization Centers as one such program. Atkinson (1991) suggests that the absence of policymaking partnerships in Illinois led the state to formulate technology policy on a project-specific basis with locally and sectorally affected interests lobbying for particular initiatives. Only those interests with a direct stake in the policy become involved, making it difficult to form coalitions for statewide technology policies. These special interest pressures, coupled with the absence of broader support, led to an underfunded and geographically diffused technology-center program in Illinois.

He also finds that in Illinois, because political rather than planning rationality drives many of the legislature's decisions, short-term, place, and special interests are often favored in policy formation. In particular, legislative action often results in suboptimal pork-barrel dispersion of policy efforts. Moreover, legislators are often loath to support technology policies where the benefit is long-term and the results diffuse. The result is that it is harder to design effective programs that maximize long-term statewide economic development impacts. In Illinois, in order to gain legislative support for the passage of the technology-center program, the administration decided to disperse the centers throughout the state rather than concentrate them at the top three or four universities, as initially intended (Atkinson, 1991).

The role of the budget office in shaping technology policies can be two-fold: the degree to which the office is involved in policy and program oversight and management, and the attitude toward economic development and public policymaking held by budget office management. The author finds that in Illinois, the governor places less oversight on the budget office and allows them a freer reign, creating a tendency to reduce funding for technology programs. In Illinois, budget officers view technology policies as simply one more program area competing for funds, making them more likely to cut technology-policy budgets.

A strong state planning effort involves more than conducting and using formal analysis. It also involves viewing policy as a moderate- to long-term undertaking, engaging in active and sustained dialogue with external interests and promoting a coordinated policy-development process. Planning is important for several reasons. First, the willingness to conduct and use analysis, communicate and develop a long-term orientation means that policy is developed on the basis of rational analysis rather than on ad hoc short-term political factors. Illinois fell into the category of absence of forward-looking analysis. This makes it difficult to mobilize support for technology policy. Without analysis calling attention to the need for moderate- to long-term technology policies, politicians and state agency officials respond to other more immediate issues. Moreover, when economic development is driven by deal-making, less effort is devoted to technology policy and the policy is less-well coordinated and designed. Planning efforts must originate from the governor. If it does not, as is the case in Illinois, then planning is not made the driving force behind policy development.

The author (Atkinson, 1991) recognizes that the governor's commitment to economic development is critical - the stronger the governor's commitment, the greater the effectiveness of a state's technology-policy effort. However, the research does not indicate where then Governor Thompson of Illinois fell on the spectrum of commitment.

Atkinson (1991) finds that individuals play a key role in policy development. In fact, he argues increased activity and commitment to technology policy by individuals (policy entrepreneurs) results in greater policy effectiveness. Policy entrepreneurs play two roles. One is to develop and promote policies. The second it to provide coordination and a long-term integrated view of the state's overall technology-policy efforts. In this role one, or a few people, usually through vision and analysis, ensure that policy efforts follow a unified theme that increases policy coordination and effectiveness. In Illinois, the author finds that policy

entrepreneurialism was low. Key individuals fail to emerge to develop technology policy. In the absence of persons at high levels of government pushing strongly, policies are either not developed or are developed but not well funded.

Atkinson (1991) also identifies an inverse relationship between the degree of effort devoted to industrial recruitment and resources devoted to technology policies. He finds that Illinois spent $80 million to recruit the Mitsubishi Diamond Star facility, while cutting funding for technology programs in the face of tight budgets, suggesting that recruitment dollars could have been transferred to these programs.

Atkinson (1991) examines the perception of the nature of economic distress and restructuring in each of the six states as a factor influencing the success of technology-policy initiatives. The hypothesis he tests is: if policymakers consider economic distress and restructuring a major problem in their state, they will formulate more effective policies than if they do not perceive a serious problem. The results indicate that in Illinois, in spite of the fact that the state was experiencing significant economic distress, policymakers are less concerned about the seriousness of the problem. This results in the state continuing to let short-term political factors guide the development of policy. The author concludes that Illinois continues to develop policy along the business-as-usual mode.

Finally, the author (Atkinson, 1991) addresses the influence of political culture on successful adoption of technology policy. He concludes that in Illinois, different factors related to its individualistic political culture contributed to lower policy effectiveness. In particular, the intense factionalism in the state, much of it based on regional politics, undercut the ability of decision makers to develop policy to serve statewide goals. Additionally, Republicans and Democrats in the state house and senate, and the governor form strong, separate factions. The result is that unified backing and approaches to policy development are few.

F. Synopsis

This chapter began with a review of two main theories of technology diffusion and technology policy: neoclassical and evolutionary. Subsequent chapters of this research will illustrate that the MEP program design fell straight out of neoclassical theories of technology diffusion and was an attempt to correct for certain market failures focused on the availability of technology-related information to SMMEs. The research will argue that MEP legislation has the neoclassical viewpoint of technology diffusion and policy embedded in its design. However, when we look at its implementation, we will see that in reality the evolutionary theory more closely resembles what happened to the program during the 1988-1998 period.

In particular, the role of MEP staff is certainly of an evolutionary nature, as witnessed by attempts to expand the program's coverage to integrate services based on adaptive learning by MEP staff from information and feedback received by both firms and other stakeholders. While this evolutionary approach is admirable from the standpoint of evaluation and learning, it has created some discrepancies. First, the enabling legislation continues to authorize the MEP to deliver services related to technology adoption. These program modifications are based on feedback about what firms are demanding not what is outlined in the legislation and were made without an analysis of whether the "but for" condition is met that would justify a government role in these expanded areas. Second, evolutionary policymakers continue to face neoclassically based program evaluation criteria such as reduced labor costs, increased sales, and reduced inventories, with results expected in the short run (less than one year). Evaluation metrics are not expanded to include measures of adaptive learning on the part of the firm or the employees or longer-term impacts such as changes in firm culture.

The second half of this chapter discussed various theories of economic development, technology and policymaking at the subnational level. Economic development policies shifted

from being supply-side to demand-side driven. A third categorization of economic development policies at the subnational level known as third wave, a term coined during the 1990s, fell into what could be considered an evolutionary theory of economic development. These third-wave policies moved away from the traditional neoclassical paradigm and focused on adaptive learning - both on the part of the firm and the institutions involved in policy development. Eisinger's findings (1995) suggested that this learning is largely informal on the part of the firm and very limited on the part of institutions based on the fact that most economic development departments do not actually use audits and evaluations to modify programs.

Goldstein and Lugar (1993) suggest that if modernization programs have any theoretical foundation, they tend to be based within the neoclassical paradigm. The authors continue by indicating serious weaknesses in existing theory and its application to technology-policy development, advocating development of contingency theories of techno-economic development and policymaking. While taking more of a political slant on technology policymaking at the subnational level, Atkinson (1991) also suggests that the rigid classification of traditional theories lead to a less than full explanation of technology policy and program development. Adaptive learning within the policymaking arena has a huge influence on how policies and programs evolve. Atkinson's findings about policy development in Illinois have serious implications for the ability of technology-related programs to be sustained in the long run whether there is a need for them or not.

This chapter suggests that the MEP program was originally conceived within a neoclassical framework and this is reflected in the neoclassically based evaluation and performance metrics associated with program success. However, as will be seen in the following chapter, the program has evolved significantly over time – consistent with evolutionary theories of, not only technology diffusion, but also policy development. Since the program evolved the performance metrics are not necessarily reflective of actual activities being carried out under the

program. In addition, policymakers continue to be judged using optimizing criteria rather than being judged on more comprehensive criteria based on concepts such adaptive learning, continuous improvement, and resulting program modification. Implications of, and recommendations regarding, this divergence are discussed in the final chapter.

Having outlined the relevant theoretical literature, the next chapter presents the specifics of the MEP program at the federal level. This includes MEP legislation, program development, and implementation.

III. A FEDERAL HISTORY OF THE MANUFACTURING EXTENSION PARTNERSHIP

A. Introduction

This chapter examines the economic conditions leading to the creation and funding of the Manufacturing Technology Center (MTC) program and provides a discussion of program and policy changes from 1987 to 1998. This history ends in 1998, the year the program's sunset clause was removed from the enabling legislation.

The first legislative seed of the current federally funded MEP was OTCA (Public Law, no. 100-418, 1988). Initial funding for what was originally called the MTC program was set at only $2 million annually. This funding increased over time to $111 million in 1998. The program also grew in terms of the number of centers, from three in 1989 to seventy-eight distributed throughout fifty states by 1998.

In 1988, the Office of Technical Assessment (OTA) issued a report - Why Manufacturing Matters? - requested as part of an assessment of technology, innovation, and U.S. trade requested by the Senate Committee on Finance; the Senate Committee on Banking, Housing and Urban Affairs; and the House Committee on Banking, Finance and Urban Affairs. The report suggested some factors that had led to the deteriorating weakness of the U.S. manufacturing sector. The first was that the United States was losing its technological edge thereby reducing its competitiveness. The report compared U.S. civilian spending in R&D with other competitor countries and found it at 1.9 percent of Gross National Product (GNP) in 1985, considerably less than Japan (2.8 percent) and West Germany (2.5 percent).

Evidence is provided in the report (United States, 1988) that suggests that U.S. manufacturers had fallen behind in the practical application of technology; U.S. competitors, in

particular Japan, were found to have gained market share in many sectors by developing and applying technology. The report also claims that high-technology industries cannot compensate for trade deficits in traditional industries; attention needs to be given to improving technology diffusion among firms operating in traditional-manufacturing sectors.

The report (United States, 1988) concludes by pointing out that counting on dollar depreciation to increase exports of U.S. manufactured goods would be a potentially painful and shortsighted strategy. The authors claim that improving manufacturing competitiveness is crucial if the United States is to remain an economic power.[11] The report makes several recommendations regarding the role of government in promoting development and diffusion of new product and process technologies to help improve competitiveness. These include improving education and training workers and managers in new skills, helping firms to export, encouraging investment in productivity-enhancing machinery and qualified people, and providing information about effective ways of organizing production and developing new markets.

President Reagan's 1988 Economic Report includes significant discussion of this U.S. trade deficit and its relationship to manufacturing competitiveness. The report indicates the administration's opinion about the causes of the large trade imbalance: the relative price of foreign-manufactured products sold in U.S. markets fell sharply between 1980 and 1985, largely as a result of the strong appreciation of the U.S. dollar from the beginning of 1980 to early 1985. This increased competition from foreign producers put pressure on U.S. manufacturers to keep their costs and prices down by limiting wage and profit growth and by enhancing productivity growth.

[11] Manufacturing competitiveness is defined as the ability to make high-quality goods at reasonable costs, without sacrificing the U.S. standard of living to get costs down.

When discussing the administration's position on technology policy, the report (President, 1988) suggests that because returns-to-investments in knowledge are difficult to measure, there is no clear guide on the appropriate role for government research policy. The administration's position is that private firms must estimate the appropriate levels of R&D under conditions of greater uncertainty than is common for other kinds of investments. Private firms have incentives to invest the amount that produces the greatest net return. In contrast, the cost of government research is borne by taxpayers, while the benefits accrue to the general public or to particular industries or firms; government is also not bound by investing in R&D in a way that produces the greatest net return. The report (President, 1988) suggests that one major role of government is to encourage private-sector R&D by clarifying and enforcing property rights so that investors can fund such activities in a profitable way.

B. Omnibus Trade and Competitiveness Act of 1988

In 1988 the OTCA legislation was signed into law by President Reagan. Interviews conducted with senior policymakers suggest that the program passed because it was so small in terms of proposed funding that it fell below the radar screen.[12]

Initiatives to assist SMMEs included in the 1988 OTCA were to be housed at NIST.[13] As its mission was to enhance the competitiveness of American industry, NIST was selected to administer this initiative. In addition to maintaining its traditional function as the lead national laboratory for providing the measurements, calibrations, and quality-assurance techniques that underpin U.S. commerce, technological progress, improved product reliability and manufacturing processes, and public safety.

---

[12] Woods, Julie [pseud.], senior federal policy advisor. Interview conducted by Natalie Davila via telephone, 31 March 2000. Boyd, Karen, [pseud.], senior federal policy advisor. Interview conducted by Natalie Davila via telephone, 22 May 2000.

[13] Under this legislation the agency's name was changed from the National Bureau of Standards to the National Institute of Standards and Technology.

The legislation stated that initiatives were needed to assist industry in the development of technology and procedures to improve both the quality of manufactured goods and to modernize manufacturing processes. Other areas to be addressed were product reliability and functionality. There was also a desire to make such modernization cost effective, as well as facilitating the more rapid commercialization of products based on new scientific discoveries in fields such as automation, electronics, advanced materials, biotechnology, and optical technologies. Consensus at the time was that such services were particularly needed particularly by the U.S. SMME sector. This was to be accomplished by funding technology-extension centers.

The legislation authorized the director of NIST to contract with NRC for advice and to commission studies to assist NIST to serve U.S. industry and science. The scope of such studies was specified in the legislation. It included research on the competitive position of the United States in key areas of manufacturing and emerging technologies, and research activities that would enhance competitiveness. Also covered was the identification and assessment of likely barriers to widespread use of advanced manufacturing technology by the U.S. workforce, including training and other initiatives which could lead to a higher percentage of manufacturing jobs of U.S. companies being located within the borders of our country. The first study to be conducted under this initiative was commissioned in 1992 and published in 1993 (NRC, 1993).

Under OTCA, NIST was directed to provide assistance for the creation and support of Regional Centers for the Transfer of Manufacturing Technology. Such centers were to be created in order to enhance productivity and technology performance in U.S. manufacturing firms. Organizations applying for center funding had to be affiliated with a U.S.-based nonprofit institution, with awards being granted based on merit review.

Several objectives were identified in the legislation. These included the transfer of NIST-developed manufacturing technology and techniques to centers to manufacturing companies

throughout the United States. In addition, centers were to encourage industry, universities, state governments, and other federal agencies to cooperate with technology-transfer activities. A third objective was for centers to make new manufacturing technology and processes usable by U.S.-based small- and medium-sized companies. Fourth, centers were to actively disseminate scientific, engineering, technical, and management information about manufacturing processes and product development to SMMEs. Finally, centers were to use the expertise and capability of the federal laboratories.

Center activities identified in the legislation, for the purpose of demonstrations and technology transfer, included establishing automated manufacturing systems and other advanced production technologies based on NIST research. Centers funded under this initiative were expected to disseminate demonstration technologies and research findings, particularly to SMMEs. The initial legislation also indicated that loans would be made available based on a selective short-term basis to help finance advanced manufacturing equipment to small manufacturing firms with less than one hundred employees. However, this initiative was never funded.

Significantly, the legislation created a sunset provision that allowed federal financial support for a maximum of six years for any center. In addition, funding in the initial year was capped at 50 percent of a center's annual capital, operating, and maintenance funding.

In order to receive federal assistance, an applicant had to demonstrate that it could raise 50 percent or more of the proposed center's annual capital, operating, and maintenance costs for the first three years and an increasing share for each of the last three years. Each applicant had to submit a proposal for the allocation of the legal rights associated with any invention resulting from the center's activities. Factors considered in making a decision whether to approve such application and provide financial support were the merits of the application, the quality of

service to be provided; geographical diversity, extent of service, the percentage of funding, and the amount of in-kind commitment from other resources. Specific activities indicated as merits were technology transfer, training, education, and adaptation of manufacturing technologies to the needs of particular industrial sectors.

Each center receiving financial assistance was to be evaluated during its third year of operation by an evaluation panel appointed by the secretary of commerce. Each evaluation panel, chaired by an official from NIST, was to be composed of private experts and federal officials. Each evaluation panel was to measure the center's performance against the objectives specified in the legislation, with funding continuing only if the evaluation was positive. Funding would be continued for years four through six, although at a reduced amount. The legislation clearly stated that under no circumstances were centers to receive funding for more than six years. For fiscal years 1989 and 1990 Congress authorized appropriations of $40 million for this initiative.

The initiative also allowed for technology assistance to be provided to state technology programs throughout the United States if such programs were designed to help businesses, particularly small- and medium-sized businesses, enhance their competitiveness through the application of science and technology. The legislation called for a nationwide study of state technology-extension services to be conducted. NIST planned to enter into cooperative agreements with state technology-extension services to demonstrate methods through which states could increase the use of federal technology by businesses to improve industrial competitiveness or help businesses in their take advantage of the services and information offered by the Regional Centers for the Transfer of Manufacturing Technology. To qualify for a cooperative agreement under this subsection a state had to provide adequate assurances that it would increase its spending on technology-extension services by an amount at least equal to the amount of federal assistance.

In evaluating each application, the following factors were to be considered. The number and types of additional businesses that would be assisted under the cooperative agreement, the extent to which the state extension service could demonstrate new methods to increase the use of federal technology, geographic diversity, and the ability of the state to maintain the extension service after the cooperative agreement expired. States that receive funding could provide services directly or arrange for the provision of any or all of such services by institutions of higher education or other nonprofit institutions or organizations. Funding for this initiative was authorized at $2 million annually for fiscal years from 1989 to 1991.

By 1990 only three centers were funded - Columbia, South Carolina; Troy, New York; and Cleveland, Ohio. Two main supporters of the 1988 OTCA legislation were Senator Hollings of South Carolina and Congresswoman Boehlert of New York. (Troy was located in her district.).

C. Policy Evolution

Science, technology, and its relationship to the economy were given much more significant prominence under the Bush administration, as indicated in President Bush's first Economic Report (President, 1989). The report suggested that the real appreciation of the dollar, and not sagging productivity growth, was the primary source of the deterioration of the international cost competitiveness of U.S. manufacturers during the first half of the decade. Moreover, the report claimed that any such reductions in cost competitiveness were restored for many industries because of the dollar's depreciation. The report claimed that since the beginning of the Reagan era, the federal government had been reorienting direct government involvement in R&D through stimulation of the private sector. The discussion provided in the report gave an economic perspective on the debate on appropriate policies to ensure a continued contribution of science and technology to economic growth.

The administration's argument and position is outlined as follows (President, 1989). In order for society to benefit from investments in R&D, the results must be turned into products, processes, and services. Although science generates knowledge used for commercial applications, that linkage can be difficult to identify and quantify. One approach to quantifying this relationship identifies the use of academic research in industry and the value of the time that such research saves a firm in its innovation process. Based on this measure the contribution of academic research to industry is large; using conservative assumptions, the report suggests that the social rate of return can be estimated at more than 28 percent. However, before society benefits from the full value of R&D spending, the knowledge gained must be converted into products, processes, and services. Therefore, factors that facilitate this conversion are very important, particularly if comparisons of innovative capabilities are to be made. In presenting comparisons between Japan and United States, the report finds that Japanese firms enjoy advantages over U.S. firms with respect to innovations based on technologies originating outside the firm. This contrast shows up particularly in the commercialization stage of the innovation process. In the United States the commercialization of an innovation based on external technology requires more time and about as much money as the commercialization of one based on internal technology. The Japanese firms are able to commercialize innovations based on external technology faster and at less cost than those based on internal technology. Japanese firms have been more likely than U.S. firms to adapt the imitated product significantly and reduce its production costs substantially. Americans seem more inclined to invest heavily in marketing start-up costs, emphasizing marketing strategies rather than technical performance and production costs.

The report (President, 1989) continues by discussing the export orientation of the U.S. economy compared with other countries. It claims that the United States is relatively less export oriented than other industrial nations. During the 1980s, slower growth in high-technology U.S. exports combined with a steady increase in high-technology imports led to a dramatic decline in

the U.S. high-technology trade surplus. The sectoral trade-balance dropped in current dollars from $26.6 billion in 1981 to $3.6 billion in 1985, and to a deficit for the first time of $2.6 billion in 1986. In 1987 the trade balance in the high-technology-products sector became positive again at $0.6 billion. However, U.S. trade performance in high-technology manufactures is stronger than in less technology-intensive products. The U.S. trade balance in nonhigh-technology-manufactured goods continues to deteriorate from an $11. 2 billion deficit in 1981 to a $138.3 billion deficit in 1987.

The Bush administration suggests that a more useful and appropriate government role in the technology arena is to gather information on successful organizational and contractual solutions to the typical problems in cooperative-industry R&D, rather than direct funding. They also advocate intervention at the later stages of the innovation process rather than the existing policy focus on stimulating private investments in R&D through increased incentives provided by taxes, antitrust exemptions, and strengthened protection for intellectual property rights.

In 1990 the OTA published the second in a series of reports discussing how to improve the competitiveness of U.S. manufacturing (United States, 1990). The report examined ways to restore U.S. leadership in manufacturing technology. Although published at the same time as the Economic Report of the President (President, 1990), many of the findings were available at the time the economic report was being compiled (United States, 1988).

The OTA report (1990) suggested that U.S. science and technology policy were traditionally concerned with basic science, health, energy, agriculture, and defense. It was mission oriented rather than diffusion oriented. The report acknowledged that only recently had policymakers given serious thought to a different approach. However, the report claimed that while these changes offered a real departure from the past they were made in a piecemeal

fashion; no comprehensive set of policies was adopted to promote the use of technology for better performance in manufacturing.

One of the policies identified is industrial extension. The report suggests that the U.S. government's industrial-extension program ($2 million appropriation) is not comprehensive. Not only is the program much smaller than competitor nations (Japanese $31 billion), but it is hit-and-miss. Owners of small manufacturing firms are often too busy to find out about technology improvements. Many do not have their own manufacturing engineers either because the engineers cost too much, are not needed full time, or are unavailable where some manufacturing plants are located. In addition, consulting engineering firms are usually more geared to serving large clients than small ones. Many small manufacturers do not trust their ability to find a consultant that will tailor recommendations to the needs of the manufacturer rather than what the consultant has to sell. Finally, the report identifies financing as the biggest hurdle for many small manufacturers. A small firm is less likely than a big one to have the contacts or track record needed to obtain loans or otherwise raise money for modernization. If financing is found, it is often more expensive for small firms.

The report identifies four programs structured to assist small manufacturers adopt technology. They are the Small Business Innovation Research (SBIR) program, the Manufacturing Technology (ManTech) program, the Trade Adjustment Assistance Program, and the MTC program.

The 1990 ERP contains significant discussion about the importance of technology and technological advance (President, 1990). It also claims that the Bush administration advanced policies designed to spur investment in research, innovation, and to provide a more favorable environment for entrepreneurial activity and new business formation.

The report (President, 1990) outlines the theory underlying the administration's approach to technology policy: since potential market size determines the return on innovations and therefore influences investment in applied research, economic growth must be increased. In order to increase economic growth, an idea must be translated into a marketable product or service, applied on a production line, or built into a new machine. Information about the technological advance must be disseminated, and workers must be trained to use it. However, in many cases, it is prohibitively expensive to modify the existing capital stock to embody new technology. Therefore, the rate at which new technology actually increases productivity depends in part on the rate of investment.

The Bush administration supports the idea that federal investment in research should focus on the fundamental advances in science and technology that have broad relevance and that no individual firm or industry would have the incentive to produce on its own. The report (President, 1990) suggests that one way to increase the effectiveness of federal research spending is to encourage the timely transfer of scientific advances to private-sector applications.

According to the 1990 Economic Report of the President (ERP), while some have argued for a broad new federal role that would select specific civilian technologies and finance their development or commercialization by special tax treatment or direct subsidy, the Bush administration is strongly opposed to the idea of such an industrial policy. The rationale is that private decisions are disciplined by careful market evaluations of their prospects while government decisions in contrast are often influenced by noneconomic objectives and based on information supplied by self-interested parties, without regard to taxpayers' cost.

President Bush's 1991 economic report states that one of the most important strengths of the U.S. economy is its flexibility. Flexibility enhances the ability of a market economy to respond to change and, thereby enhances the rewards to innovation. Strong demand for an

innovative new product both rewards the innovator and is the signal that draws additional resources into production to meet the demand. The report suggests that this occur without government planning: market economies are much better at introducing new products to market compared with nonmarket economies. With regard to industrial policy, the claims that subsidies for declining industries prevent the efficient movement of resources among sectors, both within and across the states. Therefore, government policies can maximize the flexibility of the economy by avoiding attempts to thwart the inevitable rise and fall of particular economic sectors and removing barriers to innovation.

In 1991 NIST issued a request for proposal (RFP) to fund additional centers. An additional two MTCs received funding as a result of this solicitation: Michigan and the Mid America Manufacturing Technology Center. The five centers existing in 1991 were to form the backbone of the Modernization Forum (ModForum). The ModForum, created in 1992, was established to ensure the success of U.S. manufacturing firms by assisting the members of the manufacturing-extension community. The ModForum is basically a trade association for SMMEs. It acts independently from the federal government and is free to act as the lobbying arm of the MEP members.

Implementation of changes, made through the American Technology Preeminence Act of 1991, was seen in 1992. These took effect on 14 February 1992 and led to some significant funding changes for the MTC program. Changes in legislation allowed for the transfer of money from the Technology Reinvestment Project (the administration's defense conversion initiative) to the MTC program. This had the effect of increasing the amount of money available to NIST to expand the MTC program. Two additional centers were added in 1992: California and Minnesota (Public Law, no. 102-245, 1992).

In 1993 an NRC report, commissioned in July 1992, by the director of the MTC program was published. The report was commissioned during President Bush's last year in the White House and was published in the first year of the Clinton administration; significantly the Clinton administration proposed a substantial increase in federal funding for the program. The purpose of this report was:

> 1. To identify barriers to manufacturing improvement in cost, quality, and timeliness at small and medium-sized companies in a number of discrete component manufacturing industries;
> 2. Determine what means are available to overcome those barriers and which, if any, can be most effectively and efficiently addressed by the NIST Manufacturing Technology Centers (MTC); and
> 3. Determine how the activities of the MTCs should be focused to address those barriers to best leverage the resources available. (NRC, 1993, p. vii).

The report identifies five fundamental barriers to manufacturing improvements and various approaches that MTCs could take to help to address these barriers. These barriers include a lack of awareness, isolation, where to seek advice, and scarcity of capital. While these issues were not new, they reinforce the rationale behind the program expansion that was to occur during the Clinton years.

The majority of the NRC committee members conclude that a national industrial system is justified. The report (NRC, 1993) continues by defining roles for public-sector assistance. In order to improve the manufacturing performance of SMMEs, NIST should develop a coherent system of assistance resources. This would allow for a centralization of coordination and control in conjunction with decentralized- and distributed-management system. To be effective, a national system of industrial assistance would have to become an integral part of the manufacturing community, and would require continued support over many years. This recognizes the uncertainty created by the sunset provision in the legislation. The report continues by suggesting the need for a long-term strategy for deploying, operating, and funding a

national system. The authors conclude that the goal of such a national system should be to ensure that assistance is available to any company that requests it.

The authors (NRC, 1993) believe that a national system of assistance will only be successful if it is supported by, and responsive to, the customer base. Furthermore, manufacturers will only support such a program if they believe the advice they are getting is of high quality. From this, the authors suggest that any expansion of the MTC program should be carefully planned, allow three to five years to develop a comprehensive-national-extension system, and be based on a strategy of learning by doing. Here we find direct reference to encouraging adaptive learning and evolution in policy and program development.

The report's authors (NRC, 1993) call for the development of a national system that strives for balance among local responsibility, regional coordination, and national direction; support and cohesion - the federal role should be to provide a stable-funding environment, to facilitate learning among local and regional providers, to nurture new providers in areas with unmet needs, and to provide services that are best done at the national level.

In order to increase applicants' chances for success in obtaining major funding, the report (NRC, 1993) suggests that seed grants be made available to assist development of comprehensive plans for MTCs. This support could also be used to encourage new program development at the state and local level. Other recommendations include a consistent and coherent funding policy, accompanied by appropriate metrics for evaluating performance. This recommendation suggests that the elimination of federal funding after six years could be counterproductive to the goals of a national system. The report finds that there is a low probability of success with self-sufficiency for MTCs that do not compete with the private sector.

In order to remain flexible and adaptable in the face of rapid changes, the authors imply that periodic self-examination of the system is essential. This process of experimentation and learning should be encouraged, and the lessons broadly disseminated. They find that this is the only way to increase program effectiveness and to keep exceptions realistic. In defining realistic expectations, the report (NRC, 1993) suggests that the intent of the program is not to absolve manufacturers of responsibility for their success nor for assistance organizations to become a collection of subsidized-consulting firms competing with private sector providers. Rather, the goal is to provide attention to the issues and problems that threaten the survival of smaller manufacturers by helping them manage the set of challenges they face. Some may need help identifying opportunities to improve current production processes. Others may need help selecting vendors and suppliers for new machinery, computers, and software; and some may need help gathering the data and completing the documentation to support capital investments and expansion. The report advocates a public-policy objective of providing the means and motivation for companies to build their own capacity for finding and using improved business and production methods and for sustaining an awareness of new technology and market information.

Interviews with senior policymakers indicate that President Clinton gave the green light to congressional staffers to develop the MTC into a nationwide system shortly after he took office.[14] This is supported by information contained in the President's first ERP (1993). The report posits that the administration's technology initiatives aim to promote the domestic development and diffusion of growth and productivity-enhancing technologies. They seek to correct market failures that would otherwise generate too little investment in R&D, with programs that avoid government failure.

[14] Woods, interview. Boyd, interview.

According to the report (President, 1993), the administration perceives the goal of technology policy as being the correction of significant market failures and not to substitute the government's judgment for that of private industry in deciding which potential winners to back. A second goal is to design the technology investments that the government itself makes in public goods – national security, public health, education, a clean environment, an efficient transportation system – in ways that maximize the potential external benefits for the nation's commercial technology base. In both cases, technology policy enhances the nation's economic and social welfare. This is not dissimilar to the positions put forward under the Reagan and Bush administrations.

However, the report (President, 1993) continues by suggesting that market failures other than imperfect appropriability contribute to the lack of technology adoption.[15] These include high transactions costs for obtaining information, limited sources of capital, difficulty gaining access to other types of technological know-how developed inside other companies, and the ways different firms have met implementation challenges.

To help remedy these market failures, and so promote more rapid and extensive commercialization and diffusion of important new technologies, the administration expanded the MEP program. The administration anticipated that one hundred centers would be established nationwide by 1997, up from seven at the outset of this administration. To help fund this initiative, President Clinton requested significant program expansion ($87 million) in the first budget for fiscal 1994, to come largely from the administration's Technology Reinvestment Project (the administration's defense conversion initiative). Actual appropriation ended up at $66 million.

[15] Appropriability is concerned with new technologies creating economic and social benefits beyond which the investing firm can capture for themselves.

A very significant year in manufacturing extension is 1994; the ERP for that year provides significant discussion on the MEP program, indicating its prominence in the administration's agenda. The report (President, 1994) gives some insight into what the expectations of the program were at that time. The administration's technology initiatives are designed to promote domestic development and diffusion of growth and productivity-enhancing technologies. The initiatives also attempted to correct market failures that would otherwise lead to too little investment in R&D.

The 1994 ERP continues by making the case that while one goal of technology policy is to correct significant market failures, there are complementary goals that justify intervention. These include enhancing the public good in areas of national security, public health, education, a clean environment, and an efficient transportation system.

In discussing the administration's position on the development and diffusion of advanced manufacturing technology, the report (President, 1994) suggests that efforts to commercialize a new technology often presents firms with many challenges. For example, new manufacturing processes and distribution channels must be developed; workers must be retrained; new suppliers and new customers must be identified. Firms sometimes have difficulty gaining access to types of technological know-how developed inside other companies and also information about how other firms have met implementation challenges. The report suggests that the adoption of advanced manufacturing technology is typically a systems problem; suppliers must be able to sell components that fit into complex automated production systems; buyers must be assured of compatibility among machines, robots, transfer lines, and the like, or they will not adopt the technology. Based on these market failures, and also to promote more rapid and extensive commercialization and diffusion of important new technologies, the administration proposes expanding NIST's MEP program.

> Manufacturing Technologies (MTCs) form the backbone of the program. MTCs offer impartial advice to small and medium sized manufacturers form people with extensive industrial experience. This advice is backed by hands-on technical assistance. MTCs will be linked among themselves to a set of smaller Manufacturing Outreach Centers (MOCs), geared to areas with smaller concentrations of industry. MOCs will be affiliated with technical colleges, vocational schools and the State technical assistance centers. Together MTCs and MOCs will help firms to identify, evaluate, install, adapt, and then commercially exploit appropriate advanced technology in their manufacturing and business operations. The Administration anticipates that 100 centers will be established nationwide by 1997 up from 7 at the outset of this Administration. (President, 1994, p. 197)

During the 104th Congress the MEP program, as well as the entire Department of Commerce, was in danger of losing funding. During this time the ModForum stepped up its lobbying efforts. The ModForum directed its membership to mobilize firms that had been assisted. As a result over three thousand letters were sent to members of Congress from assisted firms. In the technology budget that came out of the 104th Congress, only MEP did not have its funding cut. In fact, the MEP budget continued to increase. The appropriation for MEP increased from $80 million in fiscal 1994 to $104 million in fiscal 1995.

The 1995 ERP further outlines the administration's position on science and technology, and highlights the importance of social objectives. These include:

> The development of cleaner more efficient transportation systems, more rapid and widespread diffusion of technological and managerial innovations to small and medium-sized manufacturers, environmental remediation, and pollution prevention....The Administration's R&D strategy relies on a combination of grant programs in which industry and government share the costs: national initiatives in areas such as manufacturing.... These programs require Federal agencies to work more closely with commercial industry to strengthen the technological underpinnings of the entire economy...Investments in a particular technological breakthrough, may create large economic benefits for the industry as a whole, from which no single producer or subset of producers can be excluded, even through the breakthrough was financed and achieved by others (President, 1995, pp. 165-167).

During 1995 NIST/MEP released their evaluation strategy. It contained six major components including: project-level evaluation; firm-level long-term evaluation; individual center performance; NIST/MEP performance; creation of an integrated continuously improving national service delivery system; and interpreting, verifying and reporting on national program mission and results.

The MEP program is again specifically identified in 1996 ERP. The report states that:

> Half or more of all increases in productivity are due to improvements in technology, and these studies have verified the high total returns to such investment – returns far in excess of those from investments in plant and equipment....As the 21st century approaches, our technology programs must be both strengthened and reoriented to emerging sectors. The Administration has promoted public sector investments in technology through programs such as the Advanced Technology program and the Manufacturing Extension Partnerships (President, 1996, p.33).

A General Accounting Office (GAO) report published later that year suggests the reason MEP assistance focuses on SMMEs was because research by the NRC indicated that these companies lack the resources necessary to improve their manufacturing performance (United States, 1996). This is a peculiar finding since the program started five years before the NRC (1993) was released.

By the end of President Clinton's first term, there were seventy-five MEP centers distributed in every state in the Union. In a period of four years, the program grew from seven centers with an annual appropriation of $17.6 million to a seventy-five-center program with an annual appropriation of $80 million.

In September 1997 the officially chartered MEP National Advisory Board convened for the first time. The board members represented the views and needs of customers, providers, and others interested in manufacturing extension throughout the United States. The intent of the

board was to provide guidance to MEP on key management and policy issues, including evaluation. With regards to NIST/MEP, by 1997 there had been a change of focus within the MEP evaluation community toward continuous improvement of MEP centers (Shapira and Youtie, 1997). Intense lobbying efforts, spearheaded by the ModForum, occurred throughout 1997 to eliminate the sunset clause.

The fiscal year (FY) 1998 appropriation was reduced from the previous year level to $111.04 million. In addition, the Senate Appropriations Subcommittee did not recommend funding for several special thrusts. These included $5.9 million for supply-chain optimization, $2 million for information technology, and $2 million for technology infusion

By 1998, federal manufacturing extension grew into a program that provided a nationwide means of assisting small and midsize manufacturers. The efforts spearheaded by the ModForum to eliminate the sunset provision finally paid off. On 8 October 1998 legislation passed that removed the sunset provision.

It seems appropriate at this point to examine national statistics on the type of projects being delivered by the national MEP system. Table I indicates projects delivery by category over a four-year period.

Table I
National MEP System - Project Delivery by Category

Projects by Category	1995		1996		1997		1988	
	%	#	%	#	%	#	%	#
Business Systems	13	345	11	949	12	1,352	13	1,620
CAD	4	102	3	296	3	353	3	344
Control Systems	1	34	1	122	1	141	1	110
EDI	2	52	2	131	2	176	2	258
Environmental	7	185	6	531	7	764	7	810
Finance	1	26	3	287	3	306	2	295
General/Assessments	5	141	6	531	6	670	3	405
Human Resources	9	238	10	879	11	1,305	12	1,473
Market Development	9	245	9	748	9	1,034	9	1,141
Material Engineering	2	60	2	200	2	259	2	295
Plant Layout	7	188	5	461	6	658	5	626
Process Improvement	10	258	12	1,053	10	1,223	10	1,215
Product Development	7	183	6	540	7	788	8	1,019
Quality	16	420	15	1,271	19	2,222	18	2,234
Robotics	1	34	2	157	1	129	1	123
Other	4	99	6	548	3	364	3	319
Total	100	2,610	100	8,703	100	11,743	100	12,286
Nontechnology Projects	47	1,227	48	4,177	50	5,878	49	6,014
Technology Projects	53	1,394	52	4,508	50	5,854	51	6,198

The data contained in Table I indicate that technology-related projects make up around 50 percent of the projects delivered annually by the MEP system. While this percent has remained fairly constant, two things should be noted. First, the national data mask trends happening in individual centers. Second, since the program has been growing during the period 1995-1998 the absolute number of nontechnology projects delivered nationally has increased from 1,227 in 1995 to 6,014 in 1998. The fact that 50 percent of the services provided by MEP are nontechnology is some indication of the difficulty in encouraging technology adoption in SMMEs given the current program design and delivery mechanism.

D. Synopsis

MEP is clearly a success when one considers that it went from a program with $2 million funding and three centers to ten years later being a national network of MECs in fifty states with

an annual appropriation of $111 in FY1998. In addition, the number of projects delivered has increased from 2,610 in 1995 to 12,286 in 1998, more than a 370 percent increase.

During the first few years of the MEP program the most interesting programmatic development was the fact that the legislation authorizing MEP was passed under the Reagan administration – an administration strongly opposed to industrial targeting and corporate welfare, focused on reducing the role of government in the operations of the free market. During 1988-92 the program received only incremental increases in funding. As this history demonstrates, it was only with the Clinton administration that the system began to evolve into a national network of centers. By 1997 the MEP, with support from state and local governments, had national coverage and was operating with an annual federal authorization of $95 million.

As demonstrated by the legislation, Congress envisaged that NIST's manufacturing centers would transfer to small firms advanced cutting-edge technology development under federal sponsorship. However, two significant things happened. While lobbying for the elimination of the sunset clause, the MEP and MECs had to accept the fact that this many not happen. This caused the national system to explore alternative funding sources and initiatives. In addition, the MEP and its MECs realized that small companies need help with more pragmatic and commercially proven technologies in addition to assistance with operations training, general business management, finance, and marketing. Most centers began to address these issues while, at the same time, trying to promote technology under conditions of steady reductions in federal funding (Shapira, 1998). MEP not only did nothing to prevent the MECs from evolving in this way, but in fact encouraged them to exhibit this behavior. This is evidenced by their acceptance of performance metrics that indicate 50 percent of projects are nontechnology-related and by initiating pilot programs that had little to do with technology diffusion.

Having reviewed the program's history, the next chapter of this research reviews and analyzes strengths and weaknesses of existing MEP evaluation literature.

IV. MANUFACTURING EXTENSION PARTNERSHIP EVALUATION HISTORY

A. Introduction

Given its relatively short history, the MEP program has been subject to extensive, almost exhaustive, evaluation efforts since 1994. Unlike most federal programs, MEP made a commitment to evaluation for purposes of both continuous improvement and accountability to stakeholders. MEP program reporting and evaluation efforts consisted of several components. First, MEP designed a center-reporting system to monitor internal financial and activity performance for benchmarking against other centers. Second, a telephone survey of participating companies conducted approximately ten months after project completion was introduced in January 1996. This survey-measured variables including changes in sales, jobs, labor costs, material costs, inventory costs, and capital investment. For the long term, MEP engaged in a quasi-experimental time series study of the performance of MEP clients versus nonclients using 1987 and 1992 census of manufacturers' data. Another strategy adopted by MEP was to sponsor and conduct qualitative case studies based on a logic model, developed specifically for MEP that linked center services provided to firms to changes in firm performance and, where possible, to regional outcomes (Yin and Oldsman, 1995). MEP also established an evaluation-working group composed of evaluators and information specialists from within the MEP system. This group met several times a year to discuss both center- and national-level evaluation issues relating to manufacturing extension. It provided a forum for center staffs to offer suggestions to MEP about the national evaluation system while MEP staff disseminated information about methodology and results to centers at working group meetings (Shapira and Youtie, 1997; Sears and Blackerby, 1998). Finally, MEP staff and external reviewers held center reviews on an annual basis, the purpose was to provide feedback about a center's operating strengths and weaknesses. The structure for the center review process was formalized in 1999 by the adoption

of the Baldrige Criteria (Malcolm Baldrige National Quality Improvement Act of 1987) to develop guidelines specifically for MEP center operations.

In addition to the efforts described above, during the period 1994-1998 NIST provided funding to support an evaluation workshop project that covered a myriad of MEP program reporting and evaluation topics. These workshops were conducted annually for four years by the School of Public Policy and the Economic Development Institute at the Georgia Institute of Technology. Participants included program and field staff, national and state stakeholders/ sponsors, consultants, academics, and industry (Shapira and Youtie, 1995). Fifty-seven papers were prepared for four workshops held from 1994 to 1998 (Shapira et al., 1994; Shapira and Youtie, 1995; Shapira and Youtie, 1997; Shapira and Youtie, 1998). The main themes of these workshops were to critically examine methodologies used to evaluate industrial modernization, discuss the possible policy implications of such research, and the methods to further the body of knowledge about these evaluation techniques with the goal of identifying and disseminating best practices. In addition, Volume 23, No. 1 of the Journal of Technology Transfer was devoted to the MEP program and its evaluation (1998).

This chapter focuses on the overall program evaluation for industrial modernization, rather than an evaluation of the economic impact of the program; the quantifying impact literature was recently reviewed (Rhodes, 1999). From the outset it should be noted that the research papers tend to begin after the point where program legitimacy is assumed. They tend to be based on the premise that the MEP program should exist and should receive public subsidy.

B. Background

NIST MEP began working on a multipronged evaluation strategy during 1994-95 (Sears and Blackerby, 1998). This strategy was initially built upon the experience of the seven centers funded by NIST during the program's early years. While MEP developed the strategy during the

course of 1994, the main guidance came from the output of the first evaluation workshop. This workshop brought together key policy and evaluation experts from throughout the MEP system and other public programs, to review a draft evaluation strategy and suggest revisions. Another group to contribute to the development of the MEP evaluation strategy was individuals who prepared position papers on key evaluation issues (Sears and Blackerby, 1998). Finally, center directors and evaluation experts met informally to provide guidance on issues of policy and evaluation (Sears and Blackerby, 1998).

By 1998 NIST/MEP made progress in five major areas identified in the 1995-evaluation plan (Sears and Blackerby, 1998). First, data collection systems were in place throughout the system. Second, a system for comparing clients with nonclients was developed and in place. Third, a system for examining impacts beyond the client firm using economic impact analysis was in place. Fourth, systems were developed to enable centers to benchmark their operations and performance against each other. Fifth, a strong infrastructure to support program evaluation work was in place, the workshop series being one of the major components. Noticeably absent from the Sears and Blackerby paper (1998) was any discussion of evaluating the type of client firms assisted, the type of assistance activities, and the distributional implications of such interventions.

This background indicates a receptiveness to program evaluation from the onset, with an effort over-and-above what was required legislatively. The first published evaluation strategy combines quantitative-survey methodology and qualitative-case studies along with an assessment of center performance and high-quality-service delivery and management throughout the system (Sears and Blackerby, 1998). This wide range of evaluation activities appears to be credited with the holistic approach taken by NIST/MEP.

This review groups the MEP evaluation literature into four categories: approaches to evaluation, difficulties in the evaluation of the MEP, federal/state partnership evaluation issues, and directions for future analysis and research.

C. Evaluation

1. Approaches

In the paper, "Current Practices in the Evaluation of Industrial Modernization Programs," Shapira, Roessner, and Youtie (1994) indicate that one approach to evaluation is to relate program operations and outcomes to the goals and objectives detailed in enabling legislation or program mission statements. They suggest, however, that this is only a starting point for evaluation, as goals are broad and it is therefore difficult to measure activities. In the case of MEP, the authors draw attention to the difficulty in interpreting broad goals such as improving manufacturing competitiveness and promoting industrial development. They identify several methods of evaluation based on interviews with program managers and evaluation specialists. These include program monitoring; customer valuation; external reviews and audits; economic and regional impacts; and comparative evaluation using control groups.

When interviewing a broad array of relevant program actors, the authors found customer valuation to be the most useful from the program manager's standpoint. This is no great surprise as customer valuation is proxy for customer satisfaction. While very important, customer satisfaction is a necessary but not sufficient for a government-subsidized economic development program, where the "but for" condition is all-important. However, the interviewees often mentioned the difficulty in addressing this "but for" issue, indicating that it is very difficult to distinguish what caused the impact - exogenous factors or program effects.

This paper by Shapira, Roessner, and Youtie (1994) is included to demonstrate that in the very early stages of the program, evaluation tended to focus on the development of

performance outcome measures to monitor program success. Subsequent data collection would provide information to program sponsors and to review and oversight agencies to encourage further program expansion. Therefore, the focus was not on process evaluation. It is my contention that now that data collection processes and procedures are in place, evaluations need to once again begin to focus on process.

Of the five evaluation methods identified by the authors (Shapira et al., 1994), in theory external reviews and audits lend themselves to examining the question of whether or not the program was actually reaching its intended audience, a question very relevant for the purposes of this research. However, in the case of MEP's application of this approach, these methods tended to focus on finances rather than questioning substantive program performance.

The authors indicate that outside reviewers could focus on process evaluations or impact evaluations or both. Such methods may include comparison of legislative mandates with program goals and services, an issue identified earlier in this paper. Examination of metrics in the absence of consideration of legislative intent, program mission, and goals can lead to a seemingly successful program that now serves a significantly different population than originally intended. It is not only possible that the private market maybe servicing this population, but the program may now be in competition to provide services already available to that population through other service providers.

Mininger's paper (1994), "General Accounting Office Perspectives in Evaluation of Federal Technology Related Programs," discusses the context in which the GAO is commissioned to evaluate federally funded technology-related programs; GAO had conducted an evaluation of the MEP program in 1991 (United States, 1991). The perspective of the GAO is that the administration and Congress have increasingly come to believe that technology-related programs play an important role in stimulating the economy and restoring U.S. competitiveness

in global markets, therefore, there are increasing demands for more and better program evaluations. This was evidenced not only by increasing demands on the GAO to perform such evaluations, but also from enabling program legislation that mandates the GAO conduct performance evaluation (Mininger, 1994). These evaluation tools were used by Congress to monitor program performance and also help decide on future program changes and funding.

One of the first tasks the GAO embarks upon when conducting an evaluation is to review the legislative history to understand the setting, as well as the original purpose and intent of Congress in authorizing and funding the program. This perspective, along with that gained by analyzing the agency's guidance for implementing the program, become important criteria to use later in gauging compliance and actual performance.

The paper (Mininger, 1994) continues by specifically discussing the GAO's evaluation of federal technology-related programs (United States, 1991). In order to evaluate the MTC program, Mininger starts by examining the basic purpose and intent of the program. He finds a mismatch between what was intended and expected of the program, and what actually happened when the program was implemented. One of the assumptions underpinning the MTC legislation is that if small manufacturers could somehow be linked with the NIST and other federal labs, those companies could benefit from the advanced, cutting edge-type technologies being developed there and thus, become more competitive. The GAO find that, for a variety of reasons, this is not happening. First, very little technology is transferred from federal labs to small manufacturers, because they have very little contact with the labs, and, in any event, that is not what most small manufacturers really need. Examining effectiveness using these criteria implies that the program is not very successful.

Mininger (1994) found that most small manufacturing companies were not very sophisticated in terms of technology and needed more basic help to adapt to proven, already

available, off-the-shelf, automated technologies such as CAD and manufacturing systems. This apparently was the message the GAO officials wanted to convey to members of Congress in the hope of helping them reorient their expectations and in authorizing future programs directed at small manufacturers.

In the paper, "Overview of GAO's Study of Companies' Perspectives on Manufacturing Extension Program Services," Mendelowitz (1995) discussed a study that the GAO conducted on companies receiving manufacturing-extension services. The evaluation methodology consisted of four written questionnaires, each tailored to ask about a particular manufacturing program service: quality improvement; plant layout and equipment modernization; product design and development; and environmental and energy services. One goal of the evaluation was to help program mangers identify clients' needs. The survey results were used help identify program services and attributes that clients most valued. This paper confirms that in 1995 the MEP program focus at the federal level was still on technology-related activities.

Reamer's paper, "Institutional Assessment of Technology Program," claims that economic development is fundamentally about institutional development (1995). Elaborating on this idea, the author claims that the goal of economic development is to stimulate the development of smart, flexible, and competitive businesses. He suggests that while industrial-modernization services have an important role to play in the development of competitive firms, to be effective these services must display the same type of characteristics as those they are seeking to stimulate in their client firms - intelligence, flexibility, and speed.

Reamer (1995) recognizes that the MEP stands alone in its up-front, long-term, focused work in designing evaluation metrics. He claims that for most economic development programs evaluation has been an afterthought, and suggests that, in most cases, the fundamental purpose of

evaluation is to assist the stakeholder institution in understanding how it can design and operate effective programs. He continues by stating that the evaluation framework should be designed to generate sufficient information to allow reviewers to be prescriptive on program design, structure, operation, and management of the institution.

Reamer (1995) describes three dimensions of evaluation and suggests several components for a good evaluation. His article discusses appropriateness, one of the least addressed areas in the large compendia of manufacturing-extension and industrial-modernization evaluation literature.

1. Is the program aimed at the right targets with the right number and types of tools? Does the program target its efforts toward the population most in need?

2. How well is the program reaching its targets? This second point encompasses the "but for" question, and asks whether the program is addressing needs that are not adequately being met by the private sector due to some form of market failure. If the publicly supported program does not exist, to what extent would firms find ways to improve operations and performance using other resources?

3. What factors in the organization and management of an institution explain the appropriateness and effectiveness of current operations?

While several research studies were conducted at the inception of MEP to determine whether or not market failures exist, ten years have elapsed since those studies were conducted. Updates of these studies have not been conducted at the national level to verify that the market conditions still exist. An analysis of the needs of the constituency and the use of program tools has not been conducted recently within the MEP system and is a significant program weakness. How organization success is measured may enhance or inhibit effectiveness.

Measurements of MEP success tend to focus on impact rather than appropriateness - the actual type of service and the type of company served.

Reamer (1995) places an emphasis on institutional evaluation. The type of evaluation he discusses is designed to identify factors that explain levels of appropriateness and effectiveness, and what transforms impact evaluation into improved program effectiveness. He recognizes that the design, effectiveness, and operation of individual programs are an extension of the mission, culture, and personnel of the institutions and concludes that program impact evaluation conducted without an examination of the institution prevents not only a full understanding of the factors behind program effectiveness but also does not provide the information to identify means to improve effectiveness.

Wilkins (1998) discusses a movement within the MEP evaluation community toward measuring overall center performance rather than impact. It is significant because it is one of the first papers to focus on center-level performance as opposed to impact on individual firms. This movement toward continuous organizational improvement continues to exist within MEP today.

In 1995, directors of extension centers in northeastern states began discussing the idea of sharing standardized operating information for purposes of continuous improvement. The group applied for and received MEP funding to support MEP-based evaluation activities, with work beginning in late 1996. Center directors agreed that the project's goal was to examine different business models rather then decide on a unique measure to designate a high- or low-performing center. Early in the process it was evident that many measures would be based on tracking staff time by activity. However, more than 50 percent of the centers were not tracking time in a way to make it useful for benchmark comparison - time was not being tracked or differentiated between project time and other time. Not tracking time in this way indicates that

centers were not then operating in a way that resembled the private-sector-consulting model. However, by 1997 many centers had moved toward tracking project time, indicating a movement toward a more private-sector approach to operations. Not surprisingly, one problem that surfaced during the course of the project was the difficulty in building sustained commitment by centers for project participation. This arose because the project was not required by NIST and did not directly affect the field staff, who only saw it as a drain on their time. In the article on benchmarking (1998), Wilkins concluded by claiming that the project helped centers to verify and clarify problems, and helped highlight the impact a problem might have on other operating factors

2. Difficulties

"Issues in the Evaluation of Technology Modernization Programs" by Irwin Feller (1994) discusses difficulties in evaluating modernization programs. The author discusses the stages programs go through within the political cycle. He claims that in the formative years of a program, selected anecdotes are sufficient evaluation data. As the program develops, within a few years - the length of time varying with any legislatively mandated sunset provisions or the departure of the program founders - political sponsors look for quantitative-program impacts. At the time of writing the author suggests that most state industrial-modernization programs are in the second phase, while the federal program is still in the first. Six years later, it is safe to say that the federal program has moved into the second phase.

The author (Feller, 1994) suggests that challenges faced by a new program are likely to revolve around questions of the appropriateness of public-sector intervention, competing budget priorities, effectiveness, and possibly cost effectiveness. In the case of MEP he claims that the standards of program effectiveness for federal and state technology-development and modernization programs have been rather modest, given that the policy area is an unclaimed domain. Citing the 1993 ERP, the author suggests that this is compounded by the

belief at the federal and state levels that America's economic future rests in technological innovation and manufacturing modernization. To Feller, these ideas indicate reluctance on the part of stakeholders to question the appropriateness of the very recent, industrial-modernization initiative.

The author continues by identifying two distinct communities conducting evaluation studies (Feller, 1994). One is academics and practitioners writing articles on evaluation that appear in peer-reviewed journals. These studies tend to be organized around specific research hypotheses, to devote explicit attention to research design, are more quantitatively oriented, as well as being oriented toward the larger policy arena. The second, and larger, community are those publishing reports designed specifically to address sponsors. These tend to be conducted by consulting firms or ad hoc review panels. Such studies tend to be more process oriented, directed at program rather than policy-level decision makers and more qualitative in orientation. This review will address papers that fall under each category, as the distinction may not be as concrete as the author claims. Both types of research are relevant to looking at the program as a whole to determine whether or not it is fulfilling its policy mission.

The Feller paper (1994) also discusses the "but for" condition. The author suggests that a fundamental issue in program evaluation is the extent to which change in clients' behavior and performance can be attributed to the intervention. However, the author claims that most evaluations lack the elements of quasi-research design that includes a control group. Existing evaluations are for the most part process oriented and serve to offer program managers information about means of improving performance. One major criticism raised about such studies is that they typically lack baseline measures, comparison, or control groups. This article points out weaknesses often found in process-type evaluations.

In his paper, Carlisle (1997) discusses the relationship between technology adoption and economic development, indicating a perceived need to educate economic development professionals about technology and how development really works. However, the author draws attention to the fact that from a political standpoint the interest lies in activities that improve economic development, particularly the quality of job creation, rather than individual-firm competitiveness, technology development, or deployment as an end in itself. In this discussion, Carlisle acknowledges the potential conflict between the national goals of technical innovation and subnational-level goals of local-job creation and retention.

The author (Carlisle, 1997) suggests that there is limited hard evidence that firm-level interactions supported by the public sector have made significant contribution to economic performance. He calls for several standard measures, if evaluations are to have real impact on modernization policy and funding. This involves goal clarification. He suggests that much of the debate about evaluation is about program performance in the absence of a clear sense of policy objectives the program was created to achieve. The divergence and lack of clarity of state and federal needs exacerbate this disconnect.

Carlisle (1997) concludes by suggesting that existing evaluation methods for manufacturing modernization have failed to bring the legislature into the decision-making process in determining the ultimate goal of the programs. Carlisle also claims that the program has not been adequately linked to generally accepted economic development objectives. The author calls for the evaluation and public policy community to begin to clearly articulate how technology is integral to achieving subnational economic development goals.

3. Federal/State Partnership Issues

The following two papers discuss national and subnational linkages and expectations regarding manufacturing extension. Rhoades (1998) claims that manufacturing

extension exemplifies the ambiguity and multiplicity of expectations for publicly funded programs. She focuses on the different expectations of federal and state governments, claiming that states are interested in saving, maintaining, rejuvenating, and/or growing their manufacturing base, and with developing programs that help and sustain state economies. The author states that national objectives do not always seem relevant at the state level. However, she does not indicate what her perception of federal objectives is. She raises the issue that when considering state expectations there are in fact many stakeholders including government agencies, legislators, business groups, educational interests, manufacturing companies, environmental groups, and taxpayers.

Carlisle (1998) presents a paper focusing on the linkage of industrial-modernization evaluation with state policymaking. While acknowledging that the origins of industrial-modernization evaluation were largely federal in nature, they were established based on the supposition that federal funding would be supplied to freestanding centers for a defined period of time. As time progressed, centers would increasingly draw revenues from client firms, becoming self-supporting within six years. However, NIST/MEP strategy depends heavily on existing state technology-deployment infrastructure.

According to the author (Carlisle, 1998), a movement began within NIST/MEP in the late 1990s to gain permanent federal support, an action that was eventually voted on and approved by Congress in late 1998. This new strategy recognized that some federal and state financial support is required on a permanent basis. It also implies that state, as well as federal, goals must drive the development of the system, if it is to flourish. However, while industrial competitiveness and technological leadership may drive federal agendas, most states view technology deployment and modernization as an arm of state economic development policy. This requires that performance be measured in terms of state economic development objectives,

appropriate metrics being beyond firm competitiveness or cost-benefit calculations for a particular program.

Carlisle (1998) suggests that modernization programs have to compete with other economic development programs for funds at the state and local level. Funding success is usually based on demonstrating that the program is contributing to the overall state economy. This implies that state governments view modernization dollars as one element of overall economic development expenditures, and thus the issue is not simply whether or not modernization programs are effective, but how much they add to the state economy, job creation, and wages compared to competing expenditures for state dollars.

The author (Carlisle, 1998) claims that many technology-development programs have done a poor job of clarifying mission and objectives, in designing performance measurement systems tied to those objectives, and in demonstrating how technology will contribute to overall economic development. From a subnational level, there is little interest in technology or modernization as an aim in itself. Its value comes only as an economic development tool.

Carlisle (1998) summarizes some fundamentals that apply to evaluation at the state level. First, in most states, a history of state investment in various forms of technology development has left in place an infrastructure with its own history. There is also an increasing emphasis on evaluating modernization programs in the context of overall economic development strategies and policies. Finally, the environment in which modernization programs vie for limited dollars with other programs and services, including education, environmental protection, and crime prevention is very competitive. These new demands imply that successful programs are those that can demonstrate close links to economic development, that fare well in comparison to alternative expenditures, and that develop a strong political constituency.

D. Directions for Future Analysis and Research

A 1998 paper by NIST/MEP staff identifies areas for future evaluation activity (Sears and Blackerby, 1998). This paper includes provides insights to assist centers become high-performance centers. Also mentioned are evaluation efforts that would contribute to a MEP high-performance system by providing actionable insights to senior MEP management and contributing to a well-understood MEP system by assessing program results and providing them to senior MEP management and centers.

The authors (Sears and Blackerby, 1998) close by presenting future directions for MEP evaluation, given that MEP is at a place where it can build upon data systems put in place in the earlier years and can begin to provide a significant level of useful information about the MEP system to key decision makers. These include case-study work, in instances of failure, as well as success; emphasis on improving the ability of individual centers to effectively design and use evaluation to upgrade management capability; thorough examination of the center-review process; and one-shot studies of special issues. The MEP evaluation plan should also be evaluated in the context of NIST/MEP strategic plan, as it is central to the task of determining the MEP system's success in achieving its strategic goals and objective.

Mininger (1994) discusses the direction future evaluations of the MEP undertaken by GAO should take. One of the components of such an analysis would be how MEP centers identify and define their own goals and objectives, and how they evaluate their own progress. How the program interacts with, complements, or possibly duplicates or preempts other state or privately sponsored programs with the same or similar objectives and directed to the same clients also needs to be investigated. Evaluation should also include first-hand information from companies on their reasons for participating in the program, the kinds of changes made in their manufacturing processes, the savings achieved as a result of their involvement in the program.

their willingness to pay for services, and their views on the timeliness and responsiveness of the services. In addition, the author suggests that future analysis should compare the goals, strategies, and approaches, as well as accomplishments, and relative success to identify best practices. This would help highlight improvements in program implementation.

In a unique contribution to the literature on SMMEs and manufacturing extension, Luria (1997) develops a theory of small manufacturing performance in his paper, "Toward Lean or Rich? What Performance Benchmarking Tells Us About SME Performance, and Some Implications for Extension Center Services and Mission." Looking at Performance Benchmarking Service (PBS) data. Luria finds that more and more SMMEs are forgoing capital investments needed to remain modern and opting to employ unskilled labor and modest capital investment, leading to a divergence in trends between large and small firms. He claims that in spite of the suggestion of partnership among customers and small suppliers, two-thirds of the firms in his dataset were reporting that in 1994 they were quoting each job against five or more competitors, up from less than 50 percent in 1991 and 1992. This indicates an increasing trend toward cost minimization as a small-firm strategy.

Luria (1997) also finds that productivity and wages are flat or falling for almost half of the SMMEs in the database, with this low-road strategy leading to negative impacts on wages and productivity. On the other hand, some 20 percent of SMMEs are becoming more productive and doing so at an annual rate of almost 10 percent. High-road and growing firms have high capital per worker, pay high wages across their workforce, use more technology, and pay more per worker on training. Unlike the low-road firms, the high-road firms are investing in technology and workforce.

The data indicates that high-road firms are declining as a proportion of the SMME population. These high-road firms are also losing market share to the lean-commodity shops.

Luria (1997) explains this as follows. The better performers' higher-capital intensity makes them more vulnerable to swings in capacity utilization. However, part of how most high-road firms amortize the cost of equipment that permits them to make some hard-to-imitate products is by seeking out a base of easier-to-make commodity product customers. However, low-road and lean-commodity shops are able to win this competition, as they are not covering debt repayments for capital investment. The author suggests that as the high-road shops stagnate, shrink, or fail - leading to a dwindling base of modern, distinctive suppliers - more large manufacturers are encouraged to treat all purchased inputs as commodities, and therefore seek even more quotes for each job they subcontract. The likely winners are the worst of the low-road shops and the best of the lean-commodity firms. The clear losers are the shops that do precisely what MEP is trying to encourage: investment, training, and innovation.

The author (Luria, 1997) claims that if most firms can choose among different mixes of wages, skill, technology, training, and basic-management discipline without incurring predictable growth or profitability penalties, markets alone are not offering meaningful incentives for good manufacturing behavior. Luria than asks the question: Could it be that improved small manufacturer performance is a classic public good and hence something that only government policy can address?

Luria (1997) suggests that the most important policy initiative should be a reorientation on the mission and practice of the manufacturing-extension community. Centers operate under certain requirements such as demonstrating that a large number of firms were assisted and that they paid fees for the service. This orients centers to select quick-hit projects or services that are easy to package and sell. This has the effect of inducing centers to offer a mix of services that appeal to low-road shops, since such shops dominate the population. Based on analysis of MEP project data the author finds ISO 9000 certification service to be one of the most prevalent throughout the national system. However, when asked, firms indicate little payoff in terms of

quality or productivity through their certification, although they do indicate a benefit in terms of increased sales. In most instances, firms seek certification as they fear from being dropped by their customers, and those that fear it the most are those with the least capability – the low-road firms.

Using the Michigan Extension Center as a case study the author (Luria, 1997) continues his research by grouping assisted firms into three categories: systematic, modern, and distinctive. Systematic firms are those that track things including: how often faulty parts are made, how long it takes to set up machines to run a new job, and how quickly action is taken in response to equipment breakdowns. Other factors include: evidence of work teams, statistical-quality assurance and other factors associated with improving on cost quality and delivery performance. Firms are considered modern if they have hardware and software that automate the business, scheduling, manufacturing, and functions. The distinctive category covers factors such as having new, proprietary, or design-intensive products; or by having the ability to perform processing that most shops cannot. Examining these results, the author finds firms' scores to be modestly correlated in all three scales. However, about half of the smaller shops have low scores on all three of the scales. Such firms, the low roaders are unsystematic, unmodern, and undistinctive. Approximately 20 percent of the firms have high-modern and distinctive scores, with no consistent trend in the systematic scale. The remainder (approximately 30 percent) are the mirror image of the high roaders, with high-systematic scores, but with many scores almost as low as the low roaders in the modern and distinctive categories.

When looking at manufacturing-extension projects, Luria (1997) finds projects that improve firm score on the systematic scale often result in clients achieving greater sales and employment growth than nonclient. However, only projects that increased scores on the modernization and/or distinctive scales led to increases in productivity, wages, and profits relative to nonclients.

Luria (1997) proposes a change in primary mission of MEP toward nurturing the existing high-road shops and to increase the propensity of other firms to choose that road also. This requires centers to target their efforts to help high-road shops become more systematic; lean-commodity shops to become more modern and distinctive.

Oldsman and Heye (1998) suggest that while MECs should continue to provide efficiency-enhancing services to manufacturers, that they should broaden the focus more toward value creation. Specifically, they cite the work by Luria (1997), suggesting that in addition to helping firms reduce production costs by becoming more systematic, centers should help firms enhance product value by becoming more distinctive. The rationale used to justify this is - in an increasingly competitive and global marketplace, improvements in production efficiencies may be insufficient to ensure the profit growth of small manufacturers, as producers of commodity products are constantly threatened by lower-cost manufacturers in the United States and elsewhere in the world. Manufacturers need to consider ways to escape the trap of commodity production by exploiting advantages in technology and know-how.

Using case-study methodology, the authors (Oldsman and Heye, 1998) discuss an example of a manufacturing firm that took a series of actions designed to increase throughput. They discuss the various consequences of alternative strategies considered by the firm to enhance the value of goods sold rather than lower the costs of production. They conclude that while small manufacturers can benefit from efforts to reduce costs, there are limits to this path. Since most companies produce essentially undifferentiated products, more gains in performance are passed on to customers in the form of lower prices. The challenge for small manufacturers is to keep some of the gains.

Oldsman and Heye (1998) conclude that centers should help companies become more distinctive, as well as more efficient, by helping them determine what it would take to enable them to raise their prices and maintain higher profits. This should be done, not just by boosting productivity through lowering costs, but also by increasing the value placed on their products by customers. To this end, small manufacturers need to pursue strategies that yield distinct, competitive advantages in the market based on new capabilities, higher-product quality and/or improved customer service. This emphasis is far from the original high-tech-service provision called for in the MEP-enabling legislation. However, the authors believe that in the long run the ability of U.S. manufacturers to compete in the global marketplace will be heavily dependent on their capacity to add value. They conclude by suggesting that the more capable centers are in delivering value-enhancing services, the better the chances will be for the growth and prosperity of small manufacturers throughout the country.

Shapira (1998) suggests that not all MEP centers are effective. He claims that some local MEP partnerships were put together hastily for the purposes of grant application, leading to instability in the partnership. In other instances, technically competent but politically weak service providers are subordinated. To this end, he supports continued review and evaluation of MEP centers. He suggests that one issue is to ensure the integrity of the review process, to include independent and highly qualified external reviewers, and to avoid undue political interference when NIST has to make hard decisions about discontinuing funding or recommending organizational changes that affect local centers.

The MEP program is designed to help firms become more efficient, lower production costs, and increase efficiency. However, Shapira (1998) suggests that this can be considered only one part of a strategic approach to manufacturing and technology-based economic development. To help small firms move in directions that will allow them to offer higher wages, the MEP system will need to continue to adjust its service mix to offer assistance that goes

beyond short-term technology-based problem solving. These activities could include: helping small firms develop and sell higher-value products, improvement of the supply chain, and increase networking among companies. This modified-service delivery would include focusing on new product design and development; forging stronger links to R&D centers, financing and marketing specialists; help suppliers and buyers talk to one another; promotion of local networks of small firms to speed up the dissemination of information and encourage collaborative problem solving, technology absorption, training, product development, and marketing. In addition, MEP should continue to sponsor pilot projects to offer specialized expertise in areas such as pollution control or electronic commerce. MEP's strategic approach should be to strengthen efforts to foster manufacturing communities, diffuse emerging technologies, and further integrate federal technology, business development, and workforce training programs. Shapira also suggests that variation in firm density in the centers' service area also needs attention. The program has grown in disjointed stages, reflecting separate rounds of federal funding and variations in the ability of state and local actors to prepare winning proposals and find matching funds. This means there is a mismatch between the allocation of federal resources and the distribution of industry. Competitions targeted to deepening services in these industrial clusters would be a useful next step if more federal funds were forthcoming.

Others support this conclusion, but offer different policy recommendations. The National Council on Advanced Manufacturing (2000) suggests that MEP activities include expanded manufacturing-extension infrastructure that could provide new services to accelerate-SMME-productivity growth (NCAM, 2000). Focus would be placed in such areas as: lean-manufacturing practices; information-technology (IT) based networking; organizational development, including the effective use of human resources; electronic-commerce-demonstration systems; web delivery for on-demand-information acquisition; and standards to enhance quality. Additional resources would allow MEP to diversity the methods to distribute

services to SMMEs. In particular, web-based on-demand information and services can be especially effective in reaching the SMME community.

Luria (1997) argues that the MEP should focus more on the types of service that are value enhancing in nature. Small changes in the value of a product – as reflected in a slightly higher price - can have as much impact on a company's bottom line as fairly significant reductions in costs. Moreover, because value-enhancing services are biased toward growth, as opposed to cost minimization, they are likely to have a greater impact on the regional economy than efforts to minimize costs. He calls for a greater focus on helping companies become more distinctive which requires forging long-term relationships between companies and MECs. While cost-reduction projects tend to concentrate on solving discrete problems, projects that attempt to increase value often involve more integrated-business solutions. By necessity, these types of projects are more extensive, affecting a broad range of business processes, and take longer to implement. To be successful, the field staff needs to have relevant-industry experience in addition to technical qualifications.

The MEP has done remarkably well with limited resources (NCAM, 2000). The backbone of a national-manufacturing-extension system is in place, but expansion is clearly necessary to reach the remaining SMMEs. NCAM calls for additional financial resources to be allocated to the program in order for the system to effectively reach the bulk of SMMEs. The organization suggests that there should be a new matching formula to increase private-sector participation and support for MEP services. The current system is supported by a combination of federal funds, state funds, and company-paid fees for services. Under this new formula, federal and state governments would match each dollar of company-paid fees over a cumulative $100 million raised by MEPs for their services, up to a maximum of $50 million each from states and the federal government. Under this formula total funding would increase from the current level of $250-$270 million annually to about $450 million, enough to build a robust extension service.

NCAM suggests that MEP try to leverage fees from OEMs, so long as the fees were for SMME-supplier-improvement programs. With this formula, the MEPs would continue to receive federal and state assistance, but could leverage additional public resources by providing services demanded and supported by the business community.

NCAM (2000) also suggests that the MEP try to leverage its position as a leader in the provision of services to SMMEs by acting as a credible channel or partner for the delivery of services offered by the myriad of new public, nonprofit, and private products and services aimed at the SMME marketplace.

Luria (1997) makes a rather controversial recommendation when he suggests providing an advantage to mature-capital-intensive shops vis-à-vis other SMMEs - an investment tax credit, for SMMEs in operation since say 1980, that applies only to machinery placed in plants for fewer than five hundred workers. He suggests that many large firms might back this small-business program since nearly fifty thousand small plants are units of companies with more than five hundred employees. The credit's structure would discourage owners from shutting down older plants in favor of new greenfield sites. It would also reduce the risks for lean-commodity shops taking the leap into greater capital intensity.

As discussed previously, better coordination of national programs geared toward technology and business development should be adopted. Luria (1997) claims that the federal government invests more than $3 billion annually in cooperative-technology programs and sponsors at least thirty separate efforts to help industrial enterprises, including small-business development and export centers, industry-university centers, technology-transfer centers, and defense-related-technology centers. Unfortunately, efforts to more logically organize these services confront significant barriers. Agencies and constituencies frequently defend individual programs against cuts or reallocations. Nevertheless, the MEP can play a critical role in

integrating and improving the services offered to manufacturers by brokering agreements with other agencies.

Shapira (1998) reminds us that it is sometimes forgotten that industrial modernization is not an end in itself, but rather a strategy towards achieving more broadly held objectives, such as improving economic competitiveness, regional development, or living standards. Moreover, decisions about continued investment in industrial modernization depend not only on evaluations of the program's component parts, but also on comparisons with the alternative uses of those resources.

E. Synopsis

Four major categories of existing MEP evaluation research are reviewed in this chapter: approaches, difficulties, state and national partnership issues, and future directions. Gaps within the current body of manufacturing-extension-evaluation research are highlighted. These include the unquestioned premise that MEP centers are providing services demanded by the SMME market that the private sector could not or does not supply at a price that SMMEs can afford. While this may have been the case in 1988, such assumptions have not been examined systematically since then. It is my contention that given that the original research is more than a decade old, evaluation needs once again to focus on process, policy mission, and goals.

Evaluation topics drawn from the existing literature and examined in this research include:

- Relating program operations and outcomes to the goals and objectives detailed in enabling legislation or program mission statements.
- Do most SMMEs still need basic help to adapt to proven, off-the-shelf technologies?

- Do MECs display the same characteristics as those they are seeking to stimulate their client firms – intelligence, flexibility and speed?
- Does the program target its efforts toward the population most in need?
- How well is the program reaching its targets?
- What factors in the organization and management of an institution explain the appropriateness and effectiveness of current operations?
- How does the institution influence program effectiveness?
- Is there reluctance on the part of stake holders to question the appropriateness of MEP?
- Can a process-evaluation technique be developed that employs a quasi-research design?
- Can the evaluation and public-policy community articulate how technology is integral to achieving subnational economic development goals? Given that this program is a federal/state partnership, state and federal goals must drive the development of the system.
- Is improved SMME performance a classic public good and hence something that only government policy can address?
- Should the MEP change in favor of nurturing existing high-road shops and to increase the propensity of other firms to also choose that road?
- To help small firms move in directions that will allow them to offer higher wages, should the MEP system be encouraged to continue to adjust its service mix to offer assistance that goes beyond short-term technology-based problem solving?

Policy and program development within the MEP has not clearly articulated the potential conflict between federal and state goals. Addressing this issue is essential for long-term funding of the MEP program. If it does not occur before the economy moves into a recession, the evaluation efforts of state governments will likely focus on which economic development programs are most efficiently fulfilling the goal of job creation and retention. As we will see in the next chapter, an examination of state techno-economic development policy history indicates

that the MEP program in Illinois may be very vulnerable under recessionary economic conditions.

In the early years MEP-evaluation research tends to begin with the assumption that the centers are working with the appropriate client base, providing services that are not being supplied at affordable prices by the private sector, and are delivering services that SMMEs considered important. Having identified some limitations in the literature, it is important to emphasize that the MEP program and its component centers have and continue to be subject, and subject themselves, to more regular, rigorous, and innovative evaluations than other federal- and state-level techno-economic development programs.

The next chapter presents a discussion of manufacturing-extension policy development in Illinois. It begins with a general overview of state manufacturing-extension policy development and continues with a summary of manufacturing-related policies and programs in Illinois since the early 1980s.

V. STATE TECHNOLOGY-BASED ECONOMIC DEVELOPMENT POLICY

A. Introduction

This chapter presents research and analysis on the development of state techno-economic development policy since the 1980s, with a focus on manufacturing extension. After discussing general trends in techno-economic development, two case studies of comprehensive approaches developed in the state of Pennsylvania and the state of Michigan are presented. These case studies are selected, as they are two of the most innovative and widely respected programs developed in this policy area. They also serve as a model for techno-economic development programs throughout the United States, including Illinois. This is followed by a discussion of techno-economic development policy and program development within the state of Illinois.

B. Background

Since the New Deal, and up until the 1980s, federal initiatives dominated state government in a variety of areas, including economic development (Osborne, 1990). During this time, significant structural changes occurred throughout the U.S. economy. Many factors have been cited as contributing to these changes, including the information revolution, increased foreign competition, the strong dollar, and offshore-plant investment. These trends led to the erosion of traditional U.S. basic industries and the magnitude of U.S. firm's market share for consumer products. In the 1980s governors were forced to take ground-breaking initiatives because of these economic problems that were compounded by the pressures of the global economy (Osborne, 1990). This was exacerbated by the Reagan administration's reduced activities and funding in areas critical to state economic development.

The need for the industrial base to adopt new technology became increasingly important. From the state perspective, there were two rationales for moving in this direction. First, as was the case for the national government, states wanted to increase their exports thereby increasing their state national product. In addition, and more important for states, was a desire to increase employment for state residents. Such goals required new policies and strategies for states that focused on R&D and technology diffusion.

Osborne (1990) hypothesized that such state efforts could eventually lead to national initiatives. He suggested that some ideas would percolate up and become national policy; others would remain products of laboratories of democracy where states learn from one another. Osborne also predicted that innovative state initiatives would lead to more federal action in the 1990s. Examination of the MEP program indicated that Osborne's hypotheses were in correct.

C. Changes in State Policy Direction

In addition to the many economic changes at the national and international level identified previously in this research, the advent of New Federalism and increased state empowerment, as well as the questioning of the effectiveness of traditional-smokestack-chasing economic development strategies, acted as a catalyst for states to consider different approaches to economic development. As discussed in Chapter 2, by the 1980s states were beginning to develop and innovate new policy directions in a variety of areas including economic development. Moving away from traditional-supply-side programs, the first phase of these new policy innovations was termed demand side or entrepreneurial and was followed by third-wave strategies. Techno-economic development policy was, and continues to be, most frequently considered by states as a subset of economic development policies.

Several new policy areas arose as a result, particularly those focused on small-business assistance. These evolved from general-business assistance at state and local levels to sophisticated entrepreneurial institutes, technological assistance, and financial assistance programs. Cooperative efforts involving governments, universities, chambers of commerce, and others deliver productivity-enhancing services to small businesses were also developed. Other initiatives, focusing more specifically on techno-economic development, include the creation of government/industry/educational consortia. Many states became committed to underwriting the development of new industries based upon the commercialization of research in areas where their university- and industrial-research capabilities were strong and competitive.[9] By the mid-1980s, several states, including Pennsylvania, Ohio, Massachusetts, Indiana, New Jersey, Michigan, and North Carolina initiated what amounts to full-fledged industrial policies with a strong focus on techno-economic development. Components of these strategies included development of R&D capacity, through creation of university research parks, science-based business-development centers such as Pennsylvania's Ben Franklin Partnerships; the creation of new venture-capital funds; and the tapping of state pension funds to help small businesses form and grow. These trends are illustrative of states assuming the role as techno-economic development policy innovators. Most states, including Illinois, followed in the footsteps of states such as Pennsylvania, Michigan, and Ohio.

D. Leading States' Initiatives in Techno-Economic Development Policy

Case studies of the highly acclaimed state-level manufacturing-modernization policies and programs developed in Pennsylvania and Michigan are discussed below. There are several very significant conclusions to be drawn from this discussion. Osborne (1990)

[9] Examples of new partnerships include Pennsylvania's Ben Franklin Partnerships, New Jersey's Advance Science Technology Corporation, Ohio's polymer research program, and North Carolina's Research Triangle.

suggests that state efforts would lead to national initiatives where some ideas would percolate up and become national policy; others would remain products of laboratories of democracy where states learn from one another. For several reasons we can conclude that this is indeed what happened with manufacturing modernization. First and foremost, the fact that then Governor Clinton wrote the foreword to Osborne's book is sufficient evidence that he was aware of subnational efforts in the area of industrial-modernization policy. Second, recognition of state initiatives is provided in not only the OTCA (1988), but also subsequent program development within the MEP. (See Chapter 3.) The evaluation efforts introduced by MEP, and discussed in detail in Chapter 4, are another example of attempts by the NIST to provide a structure that would facilitate learning among states.

1. Pennsylvania

After his election in 1979, Governor Thornburgh commissioned a report, *Choices of Pennsylvanians*, to examine the Pennsylvania economy in detail (Pennsylvania, 1985). The report suggested refocusing economic development efforts away from smokestack chasing and toward the nurturing of new and smaller firms. The report also called for the creation of partnerships between the various levels of government, as well as between the public and private sectors. The study, along with its recommendations, were translated by Thornburgh's administration into

> ...an activist economic agenda....Thornburgh's actual performance was a vivid illustration of the growing divergence between the national Republican party and its governors. But because he adopted the rhetoric of Reaganism, the pubic never noticed (Osborne, 1990, p. 47).

The Ben Franklin Partnership was one program developed based on these two criteria. The partnership was a matching-grant program that offered challenge grants to applied-research university-based projects funded by business. The program was designed to

provide an incentive to get industry and academics interested in working together on research that might result in a marketable product or process.

Although the majority of the research projects involved young, entrepreneurial companies, funding was also available to help older firms adopt new technologies in order to remain competitive. When the partnership was created, a debate raged among advocates of industrial policy over the wisdom of targeting sunrise versus sunset industries. The Thornburgh administration chose to target both. To underscore their across-the-board commitment they adopted the term advanced technology rather than high technology.

The program is operated through four Advanced Technology Centers (ATCs), each in a different region of the state. Each center is affiliated with at least one major university, but every higher-education institution in the region is eligible for grants. Each center focuses on two to four technology areas, depending on the economic strengths of local universities and the regions. A board made up of regional leaders from academia, business, government, and economic development organizations oversees a staff of ten to twenty at each center.

The Ben Franklin Partnership is a model program and it is recognized as such throughout the nation (Osborne, 1990). It is comprehensive, decentralized, acts as a catalyst for significant private investment, and mobilizes major local players in new ways. The program focuses on the commercialization of R&D, the transfer of technology from academia to industry, the generation of risk capital, the birth of new firms, and the integration of advanced technology into mature industries. Osborne claims that the partnership is arguably the best economic development program in the country.

One of the criticisms of this type of programs was using the number of jobs created by each project as the major determinant of funding and criteria for success. Proponents of the partnership claimed it was not designed to create jobs in the short run; it was designed to create new products and processes, to heighten productivity, and to increase the number of start-up companies spun off by universities in the state. They argued that if those goals were met, jobs would follow in the long run. However, the authors suggested that it was dangerous to put centers in the position where their funding is directly related to short-run job creation or retention because such things are difficult to document accurately and honestly (Osborne, 1990). It should be noted that the partnership continues to exist and funding continues to remain partially determined by short-term job creation, with the program continuing to be sold as a jobs program.

2. Michigan

After Governor Blanchard's 1982 election in Michigan, he decided that in order to develop a comprehensive strategy for state economic development, he needed to know more about the state economy. This resulted in the 1984 publication of the *Path to Prosperity* report (Michigan, 1984).

The report (Michigan, 1984) argued that Michigan's future rested upon technological innovation; that new and expanding businesses would be more important than plants recruited from out-of-state, and that the private sector was the engine of growth and innovation. The public-sector role was to encourage and channel private-sector investment by reducing the cost of doing business, encouraging entrepreneurship, filling capital gaps, and investing public dollars in areas such as infrastructure, education, research, technology transfer, and the quality of life.

In one crucial aspect the *Path to Prosperity* (Michigan, 1984) went beyond the *Choices of Pennsylvanians* (Pennsylvania, 1985) study. It carefully distinguished between Michigan's economic base and its local-market economy. The report suggested that the state target its efforts to the economic base and let the local-market economy take care of itself.

Because Michigan's economic base was so heavily dominated by durable-goods manufacturing, the *Path to Prosperity* (Michigan, 1984) argued that its future lay in the development of advanced, automated manufacturing. The report (1984) suggested that a high-wage-manufacturing state like Michigan had three options. It could either drive wages down to attract new industries, shift from manufacturing to services and information industries, or use new technologies to position itself back at the manufacturing frontier. Blanchard selected this third option to pursue in Michigan.

To achieve this third option the report explained that the state's manufacturers would have to go through a technological transformation: its entrepreneurs would have to bring hundreds of new technologies to market: its research universities would have to excel in engineering and industrial technology; its industries would have to pioneer new labor-management relationships: and its governments would have to minimize the disruption caused by the transition from brawn-to-brain. Authors of *Path to Prosperity* (1984) were skeptical of any attempts to pick winners. The only significant targets they identified were advanced manufacturing, new, and small business.

Based on the report (1984), Blanchard's administration decided that the public sector could play a critical role in helping "foundation firms" adjust to the world of automated manufacturing.[17] He began by creating a new Technology Deployment Service

[17] Jack Russell, future president of the ModForum, a lobbying group for the MEP program, coined the term "foundation firms." These were an estimated fifteen thousand Michigan firms with five

(TDS) – a small group of consultants that worked with foundation firms considering installing computer-based-production technologies. The agents assessed the client firm, drew up a report recommending a plan of action, and referred the firm to private-sector consultants if necessary.

This was successful enough that in 1987 Blanchard decided to build comprehensive-industrial-extension service, which could offer an array of services to foundation firms. These services included market-development service; research and analysis program; and education-services program. The new entity was called the Michigan Modernization Service (MMS) and had a mission to help small manufacturers upgrade their production technologies, retrain their workers, and revamp their labor-management systems. The MMS was at the core of what is today Michigan's MEP center.

The two programs examined in this section were nationally renowned and formed the basis for program developments in the area of industrial modernization throughout the country. Illinois was among the states that used the Pennsylvania and Michigan programs for the development of techno-economic policies

E. Techno-Economic Development Policies in Illinois

1. Introduction

The purpose of this section is two-fold. The first is to provide a historical context to technology policy and manufacturing extension in Illinois and to set the stage for how federal- and state-policy initiatives came together to establish the CMC in 1994. The second is to examine the varying degrees of commitment by state government in the techno-economic development policy arena during the 1980s and 1990s.

---

hundred or fewer employees that formed a supply chain that made it possible for the OEMs to function.

2. Background

At the time OTCA (1988) passed, many states already had a headstart in the technology-assistance area. In the case of Illinois, by 1987 the state established twelve technology-commercialization centers housed primarily in higher-education institutions. The efforts of these centers were largely driven by industry demand as opposed to technology commercialization that attempted to find a home for commercializable inventions derived from research coming out of the university/federal research lab system.

Given the history of state involvement in industrial modernization in Illinois, albeit limited, and the extent that the recession had on Illinois' manufacturing base, objectively Illinois seemed like a good candidate to receive NIST funding.

3. Department of Commerce and Community Affairs

The majority of Illinois' technology-policy-related initiatives traditionally were housed within the state's Department of Commerce and Community Affairs (DCCA). DCCA was established on 1 October 1979 by Executive Order Number 79-3. This order reorganized three state agencies into a single department: the Department of Business and Economic Development, the Governor's Office of Manpower and Human Development, and the community-service element of the Department of Local Government Affairs. The purpose of this merger was to bring together in one agency all state-growth services, ranging from business development to community development to job training. This consolidation was intended to produce more effective planning and to improve coordination of related programs (Illinois, 1989b). The hope was that the creation of a consolidated agency would enhance the economic growth in Illinois thereby providing more job opportunities and increased economic vitality for citizens and communities (Illinois, 1981). DCCA's mandates related to economic development included formulation of plans for the economic

development in the state, encouragement of new industries to locate in Illinois, existing industries to grow and expand, and recommendation of legislation relating to the economic development of the state (Illinois, 1989b).

Specific appropriations targeting high-technology initiatives appear for the first time in 1985. They continue through 1991 and are then absorbed into general economic development program appropriations in the Fiscal Year (FY) 1992 Budget. In FY 1992 a significant reduction in DCCA funding occurs. This falls again in FY 1993, and then increases back to the FY 1992 level by 1994. For the next three years total DCCA funding ranges between $700 and $736 million – significantly less that the budget highs experienced in 1990-91 (Illinois, 1981; 1982; 1983; 1984; 1985; 1986d; 1987c; 1988; 1989c; 1990d; 1991).

4. State Techno-Economic Policy History 1982-1999

i. 1982-1990

During the 1982 calendar year Governor Thompson established the Governor's Commission on Science and Technology to cultivate the development of Illinois' high-technology-business sector. This was the first time that high technology was identified as a targeted sector. One of the first major responsibilities of the commission was the development of a biotechnology-research park in Chicago, which had its groundbreaking in 1985 (Illinois, 1986c). The commission was heavily involved in the Technology Innovation and Transfer legislation, passed in 1984 (Illinois, 1986c); establishing the Illinois Software Association and Center (ISAC) to provide resources to the state's software businesses (Illinois, 1986c); and making recommendations to promote Illinois technology resources (Illinois, 1986c). The creation of the ISAC was considered ground breaking at the time as it was a public/private partnerships established to take an active role in encouraging start-ups and ongoing businesses (Illinois, 1984a).

One of the new initiatives specifically highlighted in the state's FY 1983 budget was to target high-technology attraction in anticipation of bringing expanding industry into the state to diversify and stabilize the economy and create employment opportunities (Illinois, 1982). While high technology was not defined in the document, we can see from this very early stage that technology and employment went hand-in-hand at the state level.

An Illinois Task Force was established in 1984 with the mission of bringing the Superconducting Super Collider (SSC) to Illinois (Illinois, 1986c). At this time, DCCA began working to assist the task force and Fermi National Laboratory to put together a proposal for consideration by the U.S. Department of Energy for the $3 billion particle accelerator (Illinois, 1986c).[18] A focus was also placed on technology transfer within the state's university system. Legislation was passed that empowered DCCA to issue grants to universities, research institutions, not-for-profits, and Illinois businesses for the purpose of fostering R&D in high technology and the service sector (Illinois, 1984a). This consisted of four initiatives: university technology transfer; commercialization grants; innovation research; and technology applications.

Technology-transfer grants were designed to build capacity in universities so that they could: market research facilities, publish new technological applications, and computerize their inventories of research resources. The commercialization program provided funding to universities for the establishment of commercialization centers to provide assistance to entrepreneurs - in the adaptation of technologies; prototype

[18] Fermi National Laboratory is a leader in high-energy physics research. The SSC is an instrument that causes protons to collide after accelerating them at nearly the speed of light and causing them to collide. The SSC enables physicists to examine the particle structure of protons at a new level of detail.

development and product testing; securing financing; assistance in production and marketing. Innovation-research grants were made available to businesses to underwrite research or consulting arrangements between Illinois academic institutions and small- or medium-sized businesses involved in developing new technological applications. Finally, technology-application grants were designed as support mechanisms for bridging university resources and the technological needs of businesses and industry (Illinois, 1983). However, in spite of the governor's budget recommendation, DCCA received appropriations only for the commercialization-grants program (Illinois, 1984b). Funding for innovation research was obtained through the Illinois Board of Higher Education (IBHE) (Illinois, 1983).

For the first time, high technology was identified as a line item in the state's FY 1985 budget - $2 million allocation (Illinois, 1984b). That same year the Small Business Bureau was created within DCCA to consolidate programs and services provided to entrepreneurs, small businesses, and high-technology companies (Illinois, 1984b). A DCCA report published around this time gave a sense of the administration's thinking (Illinois, 1986b). The report claimed that smaller firms were more adept at applying technology to new product development, finding new markets, controlling operating costs, and creating more jobs with less capital investment than their larger business counterparts. It also reports that for most midwestern states high-technology-job creation occurred largely through small business.

By 1985 eight Illinois universities were already awarded funds to begin technology-transfer and commercialization activities, using funding that formally established in September 1984 (Illinois, 1987b). Their mission was to investigate institutionally developed and owned technologies or technology-related-product ideas to determine if they could be commercialized (Illinois, 1986a). These centers (I-TEC) also provided a coordinated method for serving small businesses, entrepreneurs, and inventors

with similar technology-related-product ideas. In addition, the centers examined products, product ideas, and advanced many of them toward commercialization. DCCA claimed that this was the first time a framework for applying the intellectual power of the state's higher-educational institutions to the technological needs of the state existed (Illinois, 1986a). One center funded under this initiative was housed at the University of Illinois at Chicago (UIC). Center staff went on to play instrumental roles in the creation of CMC.

Also in 1985, DCCA established two financing programs under the Build Illinois Program - the Business Innovation Fund (BIF) and the Equity Investment Fund (Illinois, 1986b). BIF was designed to stimulate the development, marketing, and commercialization of new, technology-based products or services that had the potential for employment creation and retention (Illinois, 1986a). The fund's proceeds had to be used in cooperation with Illinois universities, colleges, or not-for-profit research organizations to secure technical and management assistance, or otherwise conduct commercialization research activities which would lead to new or improved product or service availability. The fund was not designed to compete with venture-capital firms, commercial-lending institutions, or other sources of capital. However, the criteria on which such a determination would be made were not identified. The fund was targeted at technology-based new business start-ups, or product and service development of existing businesses. The Equity Investment Fund was designed to stimulate the development of technology-based companies by providing equity financing to companies that had significant potential for job creation (Illinois, 1986b).

By 1986 funding for twelve Technology Commercialization Centers (TCCs) located at Illinois universities was available (Illinois, 1986a). In addition, the 1986 budget funded the University Technology Transfer grant program (Illinois, 1985). The purpose of this program was to foster the development of small businesses in the service and

advanced-technology sectors by giving universities the support needed to inventory, catalogue, and computerize information on technologies available in university- and private-research laboratories (Illinois, 1985). The 1986 Building Illinois five-year strategic plan calls called for further expansion of these programs into areas with high potential for high-technology activities (Illinois, 1986b). In addition, plan suggested that the General Assembly of Illinois consider an appropriation of funding for business incubators, business- and industry-related Applied Research Centers (ARC) at major, public and private, Illinois universities.

In 1986 the state appropriated monies to fund a proposal to the U.S. Department of Energy for consideration for the proposed SSC. Illinois appeared well qualified for consideration with Fermi National Laboratory located in Batavia. Funding for this effort was made available through the Building Illinois program. In 1987, the state submitted the SSC proposal to the Secretary of Energy (Thompson, 1987).

For the first time, in 1987 a division was created in DCCA that specifically focused on techno-economic development; the Technology and Innovation Division's mission was to coordinate resources from universities, the government, and the private sector to encourage the incorporation of technology in Illinois' product base (Illinois, 1987a). By 1987 ITECs serviced some 3,420 clients; helped develop 38 commercial projects; created/retained 1,555 jobs; and drawn on $1.67 million from BIF (Illinois, 1987a). In addition, under the Technology Information Transfer and Technology Challenge program, DCCA awarded a grant to enhance an electronic database of university researchers known as the Illinois Resource Network (IRN), which developed the capacity to search throughout the state to find a particular technological expertise (Illinois, 1987a).

DCCA's 1987 strategic plan called for development of a High Technology Center fund seeded initially at $1 million, to be used in support of establishing major research facilities (Illinois, 1987b). The report also called for a reduction in the administrative and delivery costs associated with the Small Business Development Center (SBDC), Procurement Assistance Center (PAC), and the TCC programs through the consolidation of fiscal and field operations and activities. It went on to call for an expansion of the private-sector resources used with the SBDC, PAC, and TCC programs to develop a statewide-promotional campaign aimed at increasing the amount of private-sector donations of volunteer counseling and funds.

In 1988, $5 million was budgeted to encourage the expansion of established high-technology businesses, spur new ventures, and attract others to locate in Illinois. Funding for the SSC proposal development and implementation continued in FY 1988 (Illinois, 1987c). Illinois was selected as one of the finalists, with the final determination made in January of 1989 (Illinois, 1988).

FY 1989 budget identifies two new initiatives under DCCA's high-technology policy (Illinois, 1988). The first is the governor's task force, convened to identify methods to promote growth of the high-technology sector. The second is the technology-transfer and commercialization program. Funding for the commercialization centers was continued, as was the BIF component of the program. Generally, BIF was aimed at helping fund R&D of technology-based products and services that would create or retain jobs in Illinois.

While Illinois lost its bid for the SSC, momentum had built up during the proposal period - business, government, and universities came together around advanced technology (Illinois, 1990d). Governor Thompson turned to Walter Massey, then Vice

President of Research at the University of Chicago, to develop a strategy to make sure that Illinois would be in a position to compete for future federal funds for advanced technology (Illinois, 1989c).

Walter Massey, Stan Ikenberry (University of Illinois), Don Perkins (Civic Committee), and Leon Letterman (Fermi National Laboratory), worked together to help institutionalize a technology-policy framework in Illinois, largely to help leverage federal dollars (Illinois, 1989a). This resulted in the creation of the Governor's Science Advisory Committee (GSAC) composed of leading researchers and scientists. The Illinois Coalition, comprised of top state business and university leaders, was also formally established. The groups jointly reviewed the merits of state-funded R&D and commercialization projects. GSAC evaluated the scientific and technical merits, while the coalition assessed the business and economic development aspects. The two also acted as catalysts, identifying areas of technology concern and bringing the appropriate parties together (Illinois, 1989a). To supplement this effort, Leon Lederman, a Nobel award-winning physicist, was named Science and Technology Advisor to the Governor (Illinois, 1990d).

In 1989 the state of Illinois Office of Auditor General conducted a management and program audit of DCCA's economic development programs (Illinois, 1989b). This was a significant document, as it was used a few years later to justify huge budget reductions and reorganization within DCCA (Illinois, 1990d).

DCCA's Five-Year Plan for 1989 contains the first reference to manufacturing-extension services (Illinois, 1989a). It calls for establishing a technology-transfer program to assist businesses in applying existing technology or acquiring needed resources from research institutions (Illinois, 1989a). This is seen as a complement to

existing extension services offered by the business centers at community colleges. The report recommends that Illinois launch new efforts to foster the development, transfer, and commercialization of new, advanced technologies. The report suggests several specific initiatives. These recommendations include establishing a six-year challenge program funded at $120 million to build on Illinois' existing scientific and technical strengths to improve Illinois' economic future. This funding provides state-matching funds to assist universities, colleges, community colleges, and other nonprofit-research institutions or consortia in attaining large federal R&D grants. In addition, the program was to provide incentive matching grants to promote industry collaborations with universities, colleges, and laboratories for R&D, technology applications, technology and innovation services, and other technological needs.

The report also calls for establishing a new Technology Investment Program as a resource for small- to medium-sized firms that needed help in modernizing their manufacturing technology (Illinois, 1989a). This program would improve the competitiveness of the state's mature, small- to medium-sized manufacturing firms by providing loans for plant modernization. It would also provide grants to mature Illinois manufacturing firms for assessments of business-productivity needs and identification of products, technologies, and processes that can be applied to meet those needs.

Nineteen eighty-nine saw the passage of the Technology Advancement and Development Act (TADA) (Illinois Public Act, 1989). This landmark legislation marked the introduction of technology-transfer programs that emphasize wide dissemination of existing and new technologies, processes, and methods to improve the quality of products and services and the performance of Illinois companies (Illinois Chamber, 1991). New programs legislated under the TADA, based on many of the recommendations in the 1989 five-year plan, were designed to help existing businesses modernize and retool their

operations, while encouraging universities, laboratories, research institutions, and businesses form partnerships to research, develop, and commercialize new technologies (Illinois, 1990a). This legislation conceived of five programs and streamlined existing, technology-venture programs. They were the Technology Challenge Grants Program (TCGP), the Illinois Technology Commercialization Program, the Technology Venture Investment Program, the Modernization Assessment Grant Program (MAG) and the Modernization Retooling Loan (MRL) Program.

Some $1.5 million was made available for leading-edge technology development under the TGCP. In addition, the MAG program provided grants to help firms undertake a general assessment of the efficiency of their operations including suggestions for improvement, as well as providing grants to help firms that need assistance in conducting an in-depth analysis of specific problems. The grant funds were for costs associated with consultant services and other related costs (Illinois, 1989c).

The MRL program provided loans to help companies upgrade their manufacturing operations, thus retaining and, in some places, creating jobs (Illinois, 1989c). This initiative received a $1.2 million allocation (Illinois, 1989c). No grants were made without the approval of GSAC or the Illinois Coalition. One of the first grants made under the MAG program was to the Chicago Economic Development Commission (EDC) to provide funding for assessments of Chicago metalworking firms (Illinois, 1989c). This was significant, as it became the cornerstone for the formation of CMC.

DCCA worked with Leon Lederman, IBHE, and the Illinois Coalition to establish a new challenge fund. TCGP, budgeted at $20 million, was designed to provide state support for efforts to bring federal and private R&D projects to Illinois; to identify new technologies and to develop them for commercialization. The Technology Investment Fund,

budgeted at $10 million, was to make low-interest loans and provide equity support to businesses developing technology-based products or services (Illinois, 1989c).

During this period, the state's TCGP, developed in 1989 under then Governor James Thompson, was the principal-funding source for technology-oriented grants in Illinois. It focused on helping what were perceived as high-tech rather than low-tech industrial sectors. The program had several goals, the first was to respond to unique unique-advanced-technology projects that fostered economic development for which no other source of funding was available. In addition, the program was designed to assist in leveraging major federal and private-sector R&D efforts to promote technology commercialization and technology transfer. The fund was also to be used for technology partnerships performing R&D to be used by industry or partnerships involved in technology transfer or that conducted training and information dissemination directly applicable to industrial commercialization. Finally, the funds were used to assist in needs assessment and evaluation of the status of technology implementation throughout the state (Illinois, 1989c).

One or more RFPs for the program were issued annually. Submissions were reviewed jointly for scientific merit by the GSAC and for business and economic potential by the Illinois Coalition. Recipients were required to provide at least a 1:1 match (Illinois, 1990a).

Proposals were evaluated on several criteria. These included the relationship of the proposed technology to state-economic growth, qualification of the applicants, and the potential for leveraging federal- or private-research dollars. Other factors considered were capacity to finance the entire project, potential for commercializing the results for the economic benefit of the state, and potential for creating or retaining jobs (Illinois, 1990b).

A document published by DCCA's Bureau of Program Administration in November 1990 gave some clues into the department's thinking about technology initiatives (Illinois, 1990c). At that time, DCCA housed an Office of Business Modernization. The mission of the unit was to provide grants and loans to existing businesses in Illinois, to help these foundation-industrial firms adopt best practices and state-of-the-art machining and equipment for the purposes of increasing productivity and competitiveness. One of the main goals was to insure quality and profitability improvements to Illinois' existing firms through business-modernization financing and services in order to lead to the creation and retention of high-quality jobs and the creation of additional economic wealth in the state.

In 1990 the director of the Illinois Coalition, after reviewing existing state-technology-policy directives, realized that the state's TCGP, originally designed to be the source of matching funds for the state's unsuccessful bid for the SSC project, could be used as matching funds for NIST MTC initiatives.[19] These funds could be used to help define Illinois' SMME needs, a requirement to receive NIST funding. This allowed the state to proceed with an application for a federal State Technology Extension Planning (STEP) grant for $100 thousand, with the TCGP monies contributing a matching $100 thousand. This proposal received STEP funding and the research and analysis defining Illinois' SMME needs was completed in 1993. The project's major partners were DCCA and the Illinois Coalition. The STEP-planning team also included members from the North American Die-Casting Association, the American Foundrymen's Society, and the Tool and Machining Association (TMA). Under this project, the team attempted to inventory activities already occurring throughout the state to assist SMMEs. They surveyed fifty-four

[19] McAdam, Austin [pseud.], senior federal and state policy advisor. Interview conducted by Natalie Davila. 17 March 2000.

universities/community colleges on what each was doing in the area of technical assistance to SMMEs. They also interviewed from four to five clients from each institution, as well as interviewing trade associations about their thoughts on manufacturing extension. A statewide survey of SMMEs was conducted to help define and prioritize impediments to modernization and identify areas were companies needed the greatest. These results allowed the team to classify SMMEs as either modernizers or nonmodernizers, thereby giving the program some definition in terms of targeting. The research also filled one of the main weaknesses in an earlier Illinois' proposal for NIST/MEP funding – a needs analysis of SMMEs in Illinois. It demonstrated need for such centers, as well as prioritizing the types of services SMMEs were most interested in obtaining.

In January 1991, the Governor's Economic Development Policy Task Force issued a report discussing economic development program priorities. The task force found that technology programs represented one-fourth of the state's general-revenue funds appropriated to DCCA, but were buried within the DCCA organization. They suggested that several DCCA programs, including the TGCP, MAG, and MRL programs, provide important seed money directed toward stimulating technology advances in public/private partnerships and modernization of existing facilities (Illinois Chamber, 1991).

The report continues with a discussion that DCCA programs traditionally measured their success by the number of jobs created or retained. The report's authors suggest that success of technologies applied to improve economic performance might not be reflected by employment gains. The task force recommends that appropriate measures be developed for evaluation of new, as well as existing, state-technology programs (Illinois Chamber, 1991).

The task force made several technology-related recommendations. First, establishing a Technology Advancement Council (TAC) to structure long-term technology-policy directions for the governor and the General Assembly of Illinois. TAC would draw members from the GSAC, Illinois Coalition, and others representing technology economic development interests programs (Illinois Chamber, 1991).

TAC's responsibilities were to include coordination with the other policy advisory councils and state agencies administering technology programs. Second, the report contained a recommendation to establish an Office of Advanced Technology within DCCA. This office would have responsibility for coordinating DCCA programs with technology-related programs in other state agencies and conducting strategic analysis to increase the responsiveness of programs to the changing needs of the technology marketplace. The task force also recommended that the office retains the TCGP, the Technology Centers Program,[20] the Office Technology Venture Investment Program, the MAG, and Revolving Loan Program (RLP) program. Taken together, these recommendations highlighted the fragmented nature of technology-related economic development initiatives within state government (Illinois Chamber, 1991).

The report also recommended the creation of a strong technology-transfer program with an emphasis on the small- and medium-sized companies. The report acknowledged that:

> Such a program has already been developed in a proposal submitted to the National Institute for Standards and Technology....This proposal would establish an Illinois Regional Manufacturing Technology Center (IRMTC) with five locations around the state. The idea incorporates using existing state programs and educational institutions to transfer advanced technologies to manufacturers. Included in this program are the important management, marketing,

[20] Previously known as the Technology Commercialization Program.

> exporting and distribution issues vital to these companies. And it will have the capability of providing critically needed training for both the existing and potential work force in the newly adopted technologies (Illinois Chamber, 1991, p. 46.)

In FY 1991, DCCA awarded $12 million under the TCGP, $4 million of which was awarded for ideas originating in industry (Illinois, 1991). The Technology Innovation and Commercialization Fund (TICF) received an appropriation of $1.5 million; however, nothing was expended against the appropriation.

ii. 1991-1997

Technology-policy initiatives created during the Thompson administration were funded largely through TCGP. Fiscal 1992 was Governor Edgar's first budget (Illinois, 1991). He announced that DCCA would undergo major changes; economic development programs in the 1990s would have a different emphasis than those developed during the 1980s. The budget document stated that programs would focus on the retention of existing industries and employment in Illinois (Illinois, 1991). Large business-incentive programs were to be curtailed, while support for small business would continue. Small business was the only initiative to receive increased funding in this budget; technology-related programs suffered an 11 percent reduction.

The focus of technology initiatives in the Edgar budget was very similar to federal goals. Specifically a focus on high-technology initiatives designed to help Illinois firms to compete globally through a commitment to nurture the development and commercialization of technology research (Illinois, 1991). The goal of TCGP was modified to support development of technologies that could enter the market place within five years. The technology-transfer and commercialization programs were to emphasize links of

technical resources and expertise in academic sectors with the research, engineering, and commercialization needs of small business (Illinois, 1991).

In 1992 funding for state-technology-policy initiatives was significantly reduced, causing a shift away from direct funding of projects and toward acting as a catalyst and advisor to proposed private-sector-strategic initiatives. The GSAC, the Illinois Coalition, and DCCA worked together to focus the state's technology activities in the following areas. One was building partnerships among Illinois companies, research institutions, national laboratories, and government agencies. Others included promoting business modernization, assisting businesses seeking to improve their technology, fostering technology transfer, and commercialization. Over time, the program shifted away from emphasizing grants for individual-research projects toward supporting new institutions or building capacity that in turn supports research or technology transfer. To stimulate the transfer of technologies from universities, the TCGP also provided funding to develop an inventory of available intellectual property at the University of Illinois with potential for commercial development (Illinois, 1991).

In FY 1992 the only programs to receive funding were TCGP, TICF, and Section 3 of TADA (Illinios, 1991). The Illinois Coalition, experiencing significant budget cuts as a result of reduced TCGP funding, began to refocus its efforts in three areas: improvement of manufacturing technology in SMMEs; advanced telecommunications; and an effort to save Fermi National Laboratory.

Edgar, through his budget, expressed a desire to get the state out of much of the economic development business (Illinois, 1991). He implemented his philosophy of the role of government in economic development by slashing DCCA's budget. Under Governor Edgar, DCCA became basically a grant-processing agency. Funding for

technology-related initiatives fell dramatically. Funding for TCGP fell to $600. 3 thousand (Illinois. 1991).[21] Funding for the Technology and Commercialization program stood at $1.5 million. while funding under section 3 of TADA was budgeted at $6.65 million (Illinois. 1991). As part of this drive. Governor Edgar dissolved the statewide network of technology centers (Illinois. 1991). While funding pursuant to Article 2 of the TADA, which funded the TCGP program. was not significantly reduced until 1993. the preponderance of FY 1992 funding was in the form of a reappropriation. rather than new dollars. This indicates that dollars that had been obligated in previous years but not expended were rolled over into FY 1992. By 1993. this reappropriation evaporates, leaving a total of $600.3 thousand annual funding.

Funding under Section 3 of TADA remains at a level of $6.65 million during the period 1992-1994 (Illinois. 1991; 1992; 1993c). However. almost no money was expended against this appropriation in 1992 and 1993. The TICF receives significant budget reductions starting in FY 1993 (Illinois. 1992). Actual expenditures for the program in 1992 are only about 25 percent of the allocation. The budget in 1993 is cut by almost two-thirds and the reduction in actual expenditures continues. Although allocations remained the same for 1993 and 1994. by 1995 actual expenditures are minimal.

Nineteen ninety-two saw the president of the Illinois Coalition and staff from the Chicago EDC work together to sell the idea of an MEC to the chairman of the EDC and the commissioner of the City of Chicago's Department of Planning and Development.[22] This effort was to help lead to the creation of the CMC. the first federally funded extension center in Illinois.

---

[21] Interviews with Marley and McAdam indicate that this sum was in fact supposed to be zero and a typographical error caused this amount to remain in the budget.

[22] Baker. David [pseud.]. policy advisor. Interview conducted by Natalie Davila. Chicago. Illinois. 17 May 2000.

During FY 1993, DCCA continued to suffer significant budget reductions forcing changes in program delivery (Illinois, 1993a). DCCA's technology programs previously focused on helping businesses to adopt new technologies or modern-business practices that would make them more competitive. However, reduced funding caused the elimination of most programs along with a shift in application of TCGP. This program shifted from providing grants to individual companies or individual-research projects toward supporting new institutions or trade associations that in turn supported research or technology transfer. During FY 1993 efforts to develop a long-term technology and business-modernization plan of Illinois were initiated, resulting in the state being granted a federal award to continue the work in FY 1994 (Illinois, 1993b).

Illinois submitted two manufacturing-extension proposals to NIST in 1993: one was for a center covering the six-county Chicago metropolitan area (CMTC, 1993), the second covering the balance of the state (Illinois, 1993b). The first proposal was successful and led to the creation of the CMC in 1994 (CMTC, 1993). Although the second proposal was not successful, the state did receive funding from NIST under the STEP program to help plan for such a center (Illinois, 1994b).

The state's FY 1994 budget contains only two pages of discussion about DCCA and its programs, another indication of a much-reduced role for the agency compared with its prominence under the Thompson administration. In FY 1994, DCCA's annual report presents access to technology and modern-business practices as one of the major foundations supporting economic growth and business competitiveness. This belief is somewhat curious, given the almost nonexistent budget for technology initiatives. The report goes on to claim that the focus of the department's technology programs is to assist

businesses seeking to adopt new technologies or modern-business practices that will make them more competitive (Illinois, 1994b).

Governor Edgar in the 1994 State of the State address, unveiled an initiative aimed at developing linkages among the technology base and the manufacturing base in Illinois to increase the technological sophistication of SMMEs. This initiative, known as Project COMPETE (COalition for Manufacturing PErformance through TEchnology), was an approximately two-year effort (April 1994 to June 1996) to build a statewide-manufacturing-modernization system of locally-based manufacturing-extension centers working with industry associations, public and private organizations. This public/private partnership had several objectives. The first objective was to build a manufacturing-modernization-delivery system across the state, a network of local organizations providing technology access and/or manufacturing extension, and to build the capacity of MECs to directly deliver high-quality technical and engineering assistance to firms. A second objective was to fund capacity-building activities including the development of a technical-resource base to facilitate statewide coordination, and to provide support for geographically based MECs and sectoral-extension-service providers (Illinois, 1994b).

COMPETE's major partners were NIST, DCCA, the Illinois Coalition, IBHE, and the seven state-funded regional-extension centers. Other partners included the TMA, the Illinois Manufacturers' Association, and the American Foundrymen's Society. Funding for the initiative was a mix of state and federal funds. COMPETE was funded by revenue from three sources: in 1995, $2.1 million was allocated through the Illinois' TCGP administered by DCCA; $1.4 million in matching funds from federal Technology Reinvestment Project (TRP); and additional matching funds supplied by other COMPETE partners and state agencies (Illinois, 1994b). Revenue from these sources brought the total budget for the project to $4.6 (Illinois, 1994b).

Through the collaborative COMPETE initiative, DCCA hoped to provide firms with access and information about the vendors of industrial-engineering service and modern-business practice in addition to helping state government create common visions and systems of operation. To further this goal, the project provided for facilitation to coordinate existing resources to create a statewide network of organizations involved in manufacturing extension. In addition, funding was made available for local-extension centers and network development to deliver modernization assessments, industrial engineering, and consulting services to manufacturers (Illinois, 1995a).

During the year, DCCA continued to redirect what remained of TCGP away from individual grants to companies or universities and toward new institutions, associations, and networks that supported research and technology transfer. In FY 1994, only the $600.3 thousand line item for challenge-related-technology programs remained (Illinois, 1993c). This budget allocation was used as state-matching funds for the Chicago-area proposal to NIST to fund CMC.[23]

The 1995 budget makes clear that Governor Edgar is a proponent of programs that increase international trade and those that help small businesses. The budget proposes increased funding for the Small Business Center Initiative and introduced financing to set up two new North American Free Trade Agreement (NAFTA) centers in Canada and Mexico (Illinois, 1994b). The budget contains one new technology initiative and retains three existing programs. Section 3 of the TADA continues to be budgeted at $6.65 million, with little expenditure being charged against it. TICF is budgeted at $575 thousand, with little activity being charged against it. Article 2 of the TADA was again funded at $600.3 thousand.

[23] Marley, interview.

In a new initiative, the state made $1.4 million available to match the NIST federal dollars (Illinois, 1994b). These dollars were available for the development of a pilot program bringing together government, business, and academia to build a network of information referral services for SMMEs to access the technical information they need to stay competitive. The 1995 DCCA annual report specified that the mission of this initiative, COMPETE, was to improve the competitiveness of small- and medium-sized manufacturing firms through establishing a statewide network of MECs and other organizations. Building on the NIST MEP model, these regional centers were to be staffed with engineers and professionals with practical experience in the manufacturing workplace (Illinois, 1995a). With access to a wide array of industry experts and the resources of universities, community colleges, and private consultants, the MEC staff could help companies implement improvement plans and projects they need to enhance their competitiveness.

In 1996, the main thrust of DCCA's initiatives continues to be the promotion of exports internationally, again not dissimilar to the thinking at the federal level during the inception of the MEP program in 1988 (Illinois, 1996a).[24] Funding budgeted for the existing four technology initiatives remained at FY 1995 levels, while actual expenditures were only a small percentage of budget (Illinois, 1994b; 1995b). For example, only $1 million of the $6.65 million for the technology recovery fund was expended in 1995; only $70 thousand was spent out of the $575 thousand, budgeted for the TICF (Illinois, 1994b; 1995b).

In 1996, DCCA and the Illinois Coalition completed the COMPETE and STEP projects and submitted them to NIST (Illinois, 1996a). Together with a renewed application to NIST, Illinois received funding for an additional MEC to service the remainder

[24] In Chapter 3, I discuss the intent of the OTCA - to increase global the competitiveness of SMMEs.

of the state, the Illinois Manufacturing Extension Center (IMEC) (Bradley University, 1996; Illinois, 1996a). Again, the $600.3 thousand was used as matching funds required for the proposal and used as seed money to set up six regional centers geographically distributed throughout the state (outside of the six-county Chicago area.)[25]

In FY 1997 an additional $200 thousand, was budgeted for TCGP, renamed the Technology Transfer and Business Modernization program. This increased the line item in the budget to $800.3 thousand (Illinois, 1996b). The purpose of this initiative was defined as giving business better access to most current technology applications. As in the past, the TICF was budgeted at $575 thousand. As in the past, all indicators were that it would not be expended; only $82.4 thousand, of the budget allocation was spent in 1996. The technology-loans component of the TADA was again budgeted at $5.65 million. As in the past, all indicators were that only a small percent would be expended; in 1995 $275 thousand, was charged against the fund, in 1996 $2.8 million was charged against the fund (Illinois, 1995b; 1996b).

iii. 1998 – 1999

No program or budget changes occurred during this two-year period. Although there were two MECs operating in the state, no mention of them was made in either the budget documents or DCCA's annual reports (Illinois, 1997; 1998b; DCCA 1998, 1999). DCCA continued to have a relatively low profile within the governor's budget; the main missions and objectives of the department focused on working with community, local governments, and community organizations to advance economic development and improve the state's competitiveness in the global economy. Areas of assistance provided by DCCA that were highlighted include tourism, energy conservation, alternative-energy technologies,

[25] Marley, interview.

recycling and waste management programs; manufacturing technology is not identified as an area of assistance offered by DCCA (Illinois, 1998a, 1999).

F. Synopsis

Funding in the state of Illinois for technology-related economic development varied dramatically from the 1980s to the 1990s. After achieving significant prominence in the 1990-91 budgets, a change of administration resulted in a reversal of this trend. In 1991, DCCA had a budget of $140 million from state tax sources (Illinois, 1990d).[26] This fell to $27 million in 1992. As part of this massive budget cut, funding for technology centers, MAGs, and MRLs were eliminated (Illinois, 1990d). TCGP, through which all the state's remaining efforts were funded, was cut from a high of $20 million in 1990 to its lowest level of $600.3 thousand in 1993. This trend in reduced funding continued through the end of the 1990s.

Atkinson's (1991) theory of state techno-economic policy development as it is applied to Illinois (see chapter 2) is consistent with policy changes that occurred during 1982-1997. Governor Thompson's focus on the SSC is an example of project-specific technology policy in Illinois. The wide geographic distribution of TCCs is evidence of strong competition among universities that leads to resources being diluted for political purposes. The ability of newly elected Governor Edgar to all but eliminate funding for techno-economic development is strong evidence of the weak support and partnerships in Illinois for technology-policy initiatives, as identified by Atkinson.

The conclusion can be drawn that at a time when federal funding was being made available to states for manufacturing-extension activities targeted at technology diffusion,

[26] General revenue financing is important, as it is the revenue that allows most flexibility in terms of program development. Federal dollars in most cases are available for the administration of federal programs.

policy directions indicate that this was not a priority in Illinois. This conclusion is based on funding reductions being experienced by Illinois technology-related programs during this time. In spite of the hardships being suffered throughout the Illinois economy, federal funding was made available in 1994 to cover the six-county Chicago area only as a result of the City of Chicago providing matching funds. Illinois is the only state where subnational-matching funds came from local rather than state sources. Statewide-MEC coverage was not complete until 1997, making Illinois the last state with a large manufacturing base to receive statewide federal funding under the MEP program.

VI. MANUFACTURING EXTENSION IN CHICAGO

A. Introduction

Founded in 1994, CMC is the MEC serving SMMEs in the six-county Chicago area.[28] The center is supported by a combination of federal, state, and local funding, supplemented by client fees and foundation support.

Efforts to form CMC did not occur overnight. It was the culmination of several disparate activities and major efforts by policy entrepreneurs to assemble Chicago's 1993 application. The activities that led to the formation of CMC include: industrial-policy development under Mayor Harold Washington; State of Illinois funding for commercialization centers in universities; IBHE funding for university and community college collaboration; Economic Development Administration (EDA) funding for manufacturing-firm assessments; and research coming out of the University of Illinois Center for Urban Economic Development (UICUED) that made the case for federal funding to facilitate a nationwide industrial-extension system. Each of these initiatives is discussed below.

In addition to outlining local events that facilitated the creation of CMC, this chapter discusses the various directions CMC has taken in terms of policy and program changes during the first five years of its operation. CMC is a not-for-profit 501c3 corporation, whose original mission was to increase the global competitive advantage of manufacturing and technology-based industries in the Chicago region (CMTC, 1994). The organization serves an estimated sixteen thousand SMMEs in the six-county Chicago-metropolitan area.

[28] This area includes the counties of Cook, Lake, McHenry, DuPage, Kane, and Will.

B. Background

A report published in 1984 by UICUED makes the case for a national-industrial-extension system (UICUED, 1984). The report makes three recommendations to improve technology transfer from the federal laboratories to SMMEs. First, SMMEs should receive coordinated management and technical assistance. Second, third-party-brokering system that would facilitate technology transfer to SMMEs should be developed. Finally, an industrial-extension model should provide access to various information sources, evaluate the commercial potential of innovations, develop user networks, facilitate further product development and financing arrangements.

This report is significant for several reasons. It indicates awareness within the Chicago research community of the potential to develop a national system to facilitate technology transfer from the federal laboratories through the universities and into SMMEs. More specifically, one of the original principal investigators on this research project went on to become Mayor Washington's commissioner of Economic Development.

C. Mayor Washington and Industrial Policy

Industrial-policy development was one of the major initiatives instituted by the Washington administration (Alexander et al., 1987; Giloth, 1989; Reardon, 1990). The administration acted with the belief that local-industrial policy had the power to improve industry conditions and investment. One policy that the administration experimented with was industry task forces. Two industry task forces were formed in 1984 to evaluate the problems of Chicago's steel and apparel industries respectively and to recommend solutions. The Task Force on Steel and Southeast Chicago had a policy committee of twelve members and working groups that contained an additional thirty persons (Alexander et al., 1987). The Apparel and Fashion Task force included many industry members. It had twenty policy-committee members and twenty-three additional persons involved in the work group (Alexander et al., 1987). Representatives

from the industry and its unions, lawyers, academics, and real estate experts sat on each of the task forces. In addition, public-sector involvement shaped the collaborative process. Participation and research of the working groups and policy committees could not have occurred without intensive staff planning and follow up provided by city government (Alexander et al., 1987).

1. Steel and Southeast Chicago Task Force

The catalyst behind the task force creation was the announcement made by U.S. Steel Corporation in late 1983 to close its South Works in Chicago. After two years, the task force reported its findings back to the mayor (City of Chicago, 1986). The task force report identified a multipronged approach to the revitalization of both the steel industry and the southeast side of Chicago. What follows is a discussion primarily focusing on task force recommendations identified to assist the steel industry and its suppliers.

The task force found that the local-steel-industry network remained important to the Chicago area, in spite of the many closures of steel plants. While acknowledging the role of growing competition from other suppliers and materials as a factor contributing to the decline of the local steel industry, the task force report stressed the possibility of reversing both the technology lag and the adverse macroeconomic environment. The report recommended that the city target steel and related industries in its economic development programming, with a major effort to retain existing facilities. Much emphasis was placed on expanded and better-coordinated research on steel technologies and products. The task force also called on the mayor to exert leadership in creating a regional and national political agenda aimed at reversing the harmful effect of macroeconomic policies on basic industry (City of Chicago, 1986).

With regard to technology, the report acknowledged strong international competition in the domestic steel market, that in fact began in the 1960s. Task force research concluded that the success of Japanese and European steel firms in international trade was due in

large part to their willingness to make investments that turn technological innovations into commercial assets. While identifying U.S. strength in the early stages of the R&D process, the task force found that U.S. firms fell short of their overseas counterparts in adopting these new technologies. While U.S. laboratories (university, government, and private sector) consistently led in scientific discoveries, the report suggested that foreign manufacturers would often license a process that had originally been based on an American patent (City of Chicago, 1986).

The task force recommended that an advanced technology center for the Chicago region's basic industries be established. Universities, laboratories, governments, and companies in both Illinois and Indiana were called on to participate in and contribute to this effort. The task force called for the mayor of Chicago to take the lead in promoting this program. They also recommended that the governor of Illinois seek appropriations for initial seed money. The report went on to recommend that Chicago's mayor contact other mayors in the region and ask for their support to create this program. In addition to outreach to the mayors of Gary, East Chicago, and other Indiana cities, the task force suggested that the mayor seek the support of the governor of Indiana, as well as various regional organizations (Chicago, 1986).

The various stages of developing an actual ATP center were outlined in the report (City of Chicago, 1986). First, a consortium of public and private laboratories would be organized to exchange knowledge and develop cooperative projects. Funding would come from many sources: the states of Illinois and Indiana, federal agencies such as the National Science Foundation (NSF), the Department of Energy, and local companies. In addition, government- and private-matching grants would be sought to develop steel and steel-related technologies. A natural spin-off would be the spread of technology information through conferences and seminars. The report identified the Western Pennsylvania ATC, part of the state of Pennsylvania's Ben Franklin Partnership Program that encourages steel-making research in the Pittsburgh area, as a model to follow. The Ben Franklin Partnership program is an independent, not-for-profit

economic development corporation established in 1983 (City of Chicago, 1986). The task force report went on to discuss the possibility of an ATP program developing to include a technology-transfer center (City of Chicago, 1986). The task force suggested that the proposed technical center would be especially effective in meeting small steel users' development needs (City of Chicago, 1986). In the longer run, the creation of a larger research center, modeled on the Institute of Advanced Manufacturing Sciences in Cincinnati that examines and develops machine tool and automation technologies was envisaged.

At the time the task force was working on the report, the American Iron and Steel Institute (AISI) was soliciting proposals to establish a steel-resource center, university-affiliated facility to engage in steel-making research (City of Chicago, 1986). The task force commended the AISI for its interest in establishing this center and urged it to consider the many advantages that a southeast Chicago location would give this research facility. Because considerable expertise in steel production and research is centered in the Pittsburgh area, the report also urged AISI to consider a joint plant where research would benefit steel producers and users in both cities (City of Chicago, 1986).

The many benefits of an advanced-technology facility in southeast Chicago, close to major steel producers and users, were identified in the task force report (City of Chicago, 1986). First, steel makers and steel-consuming industries would benefit from the technical discoveries and applications, while jobs and income would be added to the southeast Chicago economy. Second, the facility would demonstrate that state and local governments and the private sector were committed to retaining a vital, viable steel industry in the Chicago region. Finally, the facility could be a first step toward a joint Illinois/Indiana approach to basic industry; many transactions between suppliers and customers cross the border, as do many manufacturing workers.

The task force recommended that the city of Chicago's EDC, an existing body already empowered with the legal authority to promote Chicago's economic development, take the lead (City of Chicago, 1986). The task force further recommended that the EDC establish a Southeast Chicago Oversight Committee.

One major EDC function was to encourage the development and use of technologies that assured the competitiveness of the region as center for heavy manufacturers (City of Chicago, 1986). The EDC was also called on to help obtain greater federal support for research into technologies that would make basic industries more competitive in both university and national laboratories (City of Chicago, 1986).

2. The Apparel and Fashion Industry Task Force

The Apparel and Fashion Industry Task Force faced a small and fragmented industry. Getting the key apparel industry actors to sit down together was a major step in the process. In addition, the industry was highly competitive and had many barriers to overcome. In response to the fragmentation, the task force recommended the formation of a permanent Apparel Industry Board (AIB) to implement task force recommendations (City of Chicago, 1987).[29] Task force recommendations included an incubator for designers, new technologies that could be shared cooperatively, increased training and retraining opportunities for apparel production workers, and a "Buy Chicago" program that would encourage the consumption of locally made garments. All these initiatives came to fruition.[30]

[29] The AIB is still in existence.

[30] The AIB, CMC, and the public and private sector currently sponsor all these initiatives.

D. State Initiatives

As discussed in the previous chapter, commercialization centers were funded by DCCA at various universities and federal laboratories throughout the state in the mid-1980s. One of the funded centers was located at the UIC. In addition to operating funds, DCCA made additional project funding available on a competitive basis. The focus of this initiative was small companies, with the goal of adapting university innovations for commercialization to fit the needs of this population (Illinois, 1983). In addition, firms could come to the university with ideas and test them using university facilitates. This initiative remained in operation until 1991, when the program was eliminated in the governor's budget (Illinois, 1990d).

A second initiative, funded by the IBHE in 1989, was a geographically focused initiative designed to develop partnerships and networking among universities (Illinois, 1988). The concept was based on the premise that community colleges, who had existing relationships with SMMEs around training-services delivery, would bring SMME-technology needs to the attention to the universities. Several centers were funded in the Chicago area including UIC, DuPage Community College, Elgin Community College, Lake County Community College, and Citywide Colleges. The partnerships developed under this initiative were part of the proposal submitted to NIST for MEP funding (City of Chicago, 1993). IBHE funding was used as part of the match identified in the application.

E. Technology-Modernization Assessment Efforts in Chicago

In 1991, using funding made available by DCCA and the EDA as part of its dislocated-workers program, the city and the EDC set to work to try to help the thousands of dislocated steel workers primarily located on the south side of Chicago.[31] One major initiative was a joint effort

[31] Alexander, Steve, project manager, City of Chicago. Interview conducted by Natalie Davila. Chicago, Illinois. June 2000.

to conduct SMME-company assessments undertaken by Daley College, the EDC, the city's Department of Economic Development, and the Illinois Institute of Technology (IIT). This effort continued for approximately two years (CMCT, 1993).

The company assessments served a variety of purposes. First, they provided insights into the operations of company management and on actions that might produce improvement. The companies received a debriefing, as well as a written report. In addition, the assessments made recommendations that, in some instances, allowed the city, EDC, and city colleges to take action. In terms of public policy, the assessments provided insights into the operations and problems of SMMEs. This in turn provided information to help develop public policy as it related to SMMEs.

This SMME-assessment tool was tested on sixty city firms using the Local Industrial Retention Initiative (LIRI) groups for outreach to firms (CMTC, 1994). It was this project that initially put together the major players that would go on to develop the proposal for funding CMC. Indeed, the assessment tool developed during this process was adopted by CMC when it opened its doors in 1994.[32]

F. Illinois NIST/MEP Proposals

1. First Proposal

Upon hearing of the MTC pilot in 1988 David Baker, then head of Illinois Coalition, suggested that Illinois apply for MTC funding in the next round of funding applications.[33]

---

[32] McKee, Keith. Interview conducted by Natalie Davila. Chicago, Illinois. Giannisis, Demetria. Interview conducted by Natalie Davila. Chicago, Illinois. Gulley, David. Interview conducted by Natalie Davila. Chicago, Illinois.

[33] Baker, David, head, Illinois Coalition. Interview conducted by Natalie Davila. Chicago, Illinois. April 2000.

When this round of funding opened up in 1990, IIT, in conjunction with the Illinois Coalition, made a proposal for an MTC in the Chicago area.[34] Other partners in this first proposal included Bradley University, Argonne National Laboratory, UIC, Northwestern University, and DCCA. This proposal contained $1 million in matching funds from the state of Illinois and a number of ideas about the need for an overall-company-assessment tool, based on previous experience IIT had in working with manufacturing companies. It also contained an inventory of manufacturing resources around the state, but said very little about what industry needed. Interviews with policy makers suggested that in reality its basic message was that Illinois needed a center because they needed it.[35]

The proposal was rejected. Reasons suggested for the proposal's rejection included insufficient matching funds and lack of demonstration of need.[36] However, while it was not selected, the proposal accomplished the task of starting to collect an inventory of what was occurring throughout the state.

2. Second Proposal

At the time the first proposal was submitted, very few Illinois organizations worked with SMMEs. In fact, interviews with policymakers suggested that until 1991 there was almost no manufacturing training in the city of Chicago.[37] The stage changed by the time the

[34] Baker, David, head, Illinois Coalition. Interview conducted by Natalie Davila. Chicago, Illinois. 17 May 2000.

[35] McAdam, interview. Hume, Nelson [pseud.]. Interview by Natalie Davila. Chicago, Illinois. 10 April 2000.

[36] *Ibid.*

[37] *Ibid.*

second proposal was developed in 1993. During that time, networks began to be developed under IBHE funding (Illinois, 1992).

In late 1992 an RFP for MTC funding was released by NIST (NIST, 1992). In 1993 IIT and the city's EDC went to the IBHE to request funding to help develop a proposal.[38] With STEP finished, Illinois needed to develop a proposal that would outline regional strategies for technology assistance and transfer within the state. DCCA wanted to submit a proposal to NIST for $8 million to fund a MTC that would have statewide coverage.[39] However, they did not have any funding to provide matching funds. At the time, the only pot of money identified as available was housed in the IBHE. In addition, the president of the Illinois Coalition was advised by NIST MEP to focus on putting together a proposal for the Chicago area, an area with over 10,000 SMMEs.[40] Once this MTC received funding, state officials and technology advocates could focus on submitting a proposal for coverage in the rest of the state.

Based on this guidance, the group that originally worked on the STEP grant and the assessment pilot funded by IBHE got back together, and in 1993, under the leadership of the chairman to Chicago's EDC, worked on developing a proposal.[41] The Illinois Coalition, the EDC, and IIT partnered to write a proposal. UIC also became involved at this early stage. For this round of proposals, NIST was not being as insistent that proposals be focused around a university-based system.[42] Between 1988 and 1993 there was an informal change in NIST policy. NIST now preferred MEPs to be outside of the university system.[43] NIST MEP eventually

[38] McAdam, interview. Giannisis, interview.

[39] McAdam interview. Hume, interview. Baker, interview.

[40] Baker, interview.

[41] Baker, interview. Hume, interview. McAdam, interview. Giannisis , interview.

[42] Boyd, interview. Hume, interview. Giannisis, interview.

[43] *Ibid.*

funded a two-year $7 million 1994 proposal (CMTC, 1993). The financial partners identified in the second proposal were: IDHE, EDC, DCCA, UIC, Prairie State 2000, city, TCGP, and IBHE (CMTC, 1993).

An engineer from Basic Industry Research Laboratory (BIRL) was selected as president for the newly founded CMC.[44] He would remain president of CMC for three years. Other staff in place included the contracts administrator and vice president.[45] Over one thousand applications for the CMC engineering-consulting positions were received and the organization gradually became functional.[46]

For the first three years NIST used TRP dollars to fund CMC (NIST, 1994). This was a pot of federal money that NIST used to help support centers throughout the nation (NIST, 1994). In addition, NIST gave DCCA an enabling grant for two years to help organize the rest of the state (Illinois, 1994b). DCCA did not charge against this $3.4 million grant for almost the first year. Finally, after interventions by the new head of the Illinois Coalition and the head of DCCA, the project began to move forward. This proposal, COMPETE, when finished was submitted to NIST and at that time federal funding was extended to cover extension services in the rest of Illinois (Illinois, 1998b).[47]

---

[44] In the application to NIST MEP the center was given the name Chicago Manufacturing Technology Extension Center. However, when it actually opened for operation the name was changed to the Chicago Manufacturing Center. McAdam, interview. Hume, interview. Giannisis, interview.

[45] Blair, Andrew. [pseud.] Interview by Natalie Davila. Chicago, Illinois. 17 May 2000.

[46] *Ibid.*

[47] NIST MEP funding was made available to establish an MEP center that covered the rest of the state of Illinois in 1997.

G. CMC

1. Development

CMC opened its doors for business in mid-1994.[48] CMC's partners included universities, a federal laboratory, a training organization, community colleges, local economic development organizations, an arm of a financial institution, and several private consultants (CMTC, 1993). For the first two years of operation, CMC was in the budget-development process, its goals were unclear. Much time was spent in establishing the organization, hiring staff, formalizing contractual relationships with partners, and developing services. Advertising in major newspapers, the CMC-leadership team was looking for senior technical people, with a master's degree and a background in manufacturing.[49]

CMC's initial approach was to "hit the deck running," cold calling was used as the primary method of contact).[50] However, this was not done in any systematic way; there was no attempt at targeting companies or industries at this early stage.[51] The service-delivery model employed by CMC fell into the core-staff/affiliate model. Core staff (approximately thirty in the first year of operation) provided services to firms, as well as managing projects conducted by more than twenty affiliates and subcontractors (Shapira, 1995). CMC's primary-service offerings were free company-benchmark questionnaires and heavily subsidized company assessments,[52] with little emphasis placed on actual revenue-generating projects.

The central feature of the center's initial market service efforts was a company assessment tool. Originally developed by Chicago Manufacturing Technology Consortium

---

[48] McAdam, interview. Giannisis, interview. Hume, interview.
[49] Blair, interview.
[50] *Ibid.*
[51] *Ibid.*
[52] Assessments are a distinct type of project that involves a company-wide, comprehensive analysis that lays the groundwork for future improvement activities.

(CMTC) from 1989 to 1991, CMC modified the tool slightly.[53] After an initial visit and provided the company agreed to participate, a three-person team spent one to three days conducting a strategic review. This resulted in the compilation of a very detailed assessment report that included: project recommendations, written, and presented to the company. Originally, CMC charged the client $10 per employee for the assessment, thereby passing on a large government subsidy to the client.[54]

In addition to conducting initial visits, assessments, and benchmarks, during the first two years of operation CMC delivered projects in conjunction with its partners. Staff also conducted seminars and workshops for manufacturers. Other activities included sponsorship of industry and group projects in the foundry and electronics sectors.[55]

CMC's original philosophy was to get the clients in the door.[56] In fact, for the first year, CMC paid half the actual project costs. However, after the first year, NIST suggested moving away from this strategy and CMC complied.[57] During this time there was no push for project revenue. This began occurring by mid-1995, and has continued and increased over time. Hourly rates charged by CMC also increased from $65 per hour at inception to $75 per hour in May 1996 to $85 per hour in 1997.[58]

Originally ad hoc in nature, by mid-1996 the assessment process was streamlined to make sure it was conducted in a consistent and timely manner.[59] The assessment format was changed in 1997, from a very detailed report to a less labor-intensive presentation format. This change was instituted to reduce the cost to CMC of generating the report. Even with this change

[53] Hume, interview; McAdam, interview; Giannisis interview.
[54] *Ibid.*
[55] *Ibid.*
[56] *Ibid.*
[57] *Ibid.*
[58] *Ibid.*
[59] Blair, interview.

in format. CMC continued to lose money on assessment reports. Eventually, in the drive for CMC to become financially self-sufficient, assessments were all but discontinued.

Shapira (1995) describes CMC during this period as a flexible-decentralized structure; that had established links with a series of other organizations in the area; and developed systematic-service tools and approaches. He identifies the assessment process as a key component of CMC's approach. Shapira concludes that CMC-service affiliates were mostly well integrated into CMC's flexible-decentralized structure. He claims this federal funding was the glue that held the network together, while acknowledging that CMC had to make some compromises and trade offs due its position in a complex-political environment.

With the impending reduction in NIST funding, by mid-1996 more focus was placed on revenue generating activities. While the goals were not clear, there was much discussion internally about the weight to be given to the public mission within CMC.[90] Initially, CMC gave the public mission a very high priority as witnessed by the focus on the heavily subsidized, labor- and cost-intensive assessments, and by negotiating reduced fees from subcontractors to make sure that CMC was able to provide value-added subcontracting services to clients. However, as funding began to decline, emphasis on public mission began to fade. The emphasis became more focused on revenue-generating projects and less on labor-intensive, money-losing assessments. Staff time began to be tracked on a project.[91] The exception to this more private-sector approach was CMC's work with the apparel industry. In 1996, senior staff felt, that by continuing to fund this initiative, CMC was meeting its public mission.[92]

[90] Hume, interview. McAdam, interview. Giannisis interview.
[91] *Ibid.*
[92] *Ibid.*

By the end of 1996, CMC's main budget goal was to generate 50 percent in retained earnings.[63] Senior management decided the only way to do this was to reduce CMC's historic emphasis on assessment. However, as only bigger companies possessed the internal resources and systems to determine needs, it soon became evident to CMC that there were problems associated with doing a project without an assessment. Senior staff began to realize that "at the end of the day assessments make a difference."[64]

By 1997 a change in client profile was evident. The average size of the CMC client was a larger company. In addition, expectations of staff by management changed - individual goals and budgets were instituted for the first time in fiscal 1997.[65] Referrals were added as an additional individual performance metric. Other changes were the creation of business units. The idea behind these changes was to reward individuals in a holistic way – taking account of the how well people worked as a team, as well as on an individual basis.

Youtie (1997) conducted a case study of CMC in late 1997. Her research acknowledged that several key elements of CMC's operation changed in Year 4. The first key change identified is the reduction of NIST funding to $2.8 million. However, in their budget CMC planned to offset this loss with additional sponsorship, client fees, additional state and federal grants (Youtie, 1997). CMC changed its method of contacting potential customers, assessing their needs, and providing appropriate service. Now a telemarketing firm set up initial visits. The assessment process was streamlined - thinner client reports with information disseminated in presentation style. Review of final assessment reports was conducted by CMC's vice president rather than by assessment team members. CMC had also added twelve employees between Year 2 and Year 4 (Youtie, 1997).

---

[63] Blair, interview. Hume, interview.
[64] *Ibid.*
[65] *Ibid.*

Youtie (1997) also found that CMC's relationships with outside organizations had changed considerably. The majority of the original partnerships were no longer in place. For example, in the first years of operation, CMC entered into partnerships with eight of the city of Chicago's LIRI groups (Youtie, 1997). CMC did not consider this partnership with local economic development organizations to be successful and it was eliminated after one year (Youtie, 1997). LIRI organizations were not successful in referring many companies to CMC. However, several new partnership initiates had taken their place. One of the more significant new partnerships was with community colleges located in the suburbs of Chicago (Youtie, 1997). CMC received $200 thousand in its first year of operation from the state to work with community colleges to provide Human Resources (HR) assistance (Youtie, 1997). This increased to $0.5 million in 1996-97 and 1997-98 (Youtie, 1997). In January 1997 CMC formalized these relationships and designated a point person within CMC to help develop these partnerships (Youtie, 1997).

2. Specific Targeted Initiatives

CMC began to receive significant additional funding from MEP by late 1996 for the development of pilot programs.[96] They included: environmental,[97] international,[98] and access to financing.[99] In addition, in anticipation of receiving additional pilot funding through MEP, CMC developed a supply-chain initiative in 1997.[70] That initiative did not receive MEP funding.

The environmental-integration program was the first example of CMC's strategy of replacing core NIST funding with program-development grants. In partnership with the Illinois Waste Management Research Center (WMRC), CMC won a two-year NIST contract in

[96] Blair, interview; McAdam, interview; Giannisis, interview; Hume, interview.
[97] Blair, interview
[98] McAdam, interview
[99] Giannisis, interview
[70] *Ibid.*

1995 to develop new tools, training, and service delivery in the area of pollution prevention.[71] This pilot program, in adherence with the original MEP mission, had at its core the transfer of pollution-prevention technology to SMMEs. An engineer from WMRC transferred to CMC to manage the environmental-integration program, which caused some interorganizational tensions (Youtie, 1997). The pilot was funded with $0.6 million from MEP and a $0.4 match from other sources.[72] Largely due to a lack of understanding of the mission and goals of the grant program between WMRC and CMC, this pilot took a long time to take off. WMRC thought the purpose of the grant was to train CMC to identify opportunities for WMRC, whereas CMC understood the purpose the development of joint projects to assist manufacturers.[73] Because of delay in embarking on this project, NIST extended the time line for the pilot through 30 September 2000.[74]

In December 1995 CMC received $0.7 million from MEP to contribute to the development of an access to financing program (renamed the Manufacturing Investment Network by CMC).[75] This pilot initiative was designed to improve SMMEs access to financial capital and services. The grant required a $1.9 million match from CMC. CMC was expected to broker mergers and acquisitions between domestic-based companies. This pilot was very slow in getting up and running.[76] Program planning took a year and the program was not staffed until the end of 1997. A perceived lack of success by NIST caused the program to be put on hold in 1998.[77] No actual client projects brokering such relationships were completed under the pilot.

In July 1996 CMC received a one-year STEP grant of $0.4 million from MEP to conduct a planning study for an MEP-wide international program. The grant required $0.5

---

[71] Blair, interview.
[72] Gilbert-Miller, Susan, Project Manager. Interview by Natalie Davila. Chicago, Illinois. 13 November 2000.
[73] *Ibid.*
[74] *Ibid.*
[75] Giannisis, interview.
[76] *Ibid.*
[77] Giannisis, interview. Hume, interview.

million in matching funds from CMC. The goal of this planning grant was to develop a program that would improve the effectiveness of MEP in advancing the global competitiveness of the nation's SMMEs. This was to be achieved primarily through economies of scale by consolidating marketing efforts thereby reducing the marketing costs to individual firms breaking into overseas markets. Significantly, the scope of work issued by NIST MEP in July 1996 requires that: "The Recipient shall assist small and medium sized manufacturers in making technological changes which strengthened their competitiveness" (NIST, 1996, p. 1).

This is a striking example of the difference between MEP's publicly stated goals and the directions it was actually encouraging centers to take. This planning grant was not related to firms making technological changes. Planning activities were completed in June 1997.[78]

In anticipation of pilot NIST MEP funding, CMC began to purse a supply-chain initiative.[79] The supply-chain movement began in the early 1980s. Larger OEMs reduce their number of suppliers; require them to take a more active role in the design process; and requires them, in order to contribute, to have higher levels of technology. (Cohen and Zysman, 1987). The CMC supply-chain initiative, encouraged by MEP, was designed to develop relationships with and provide services to OEMs and their suppliers.[80] CMC used existing staff and added this initiative to the staff's existing responsibilities.[81] The effect was to dilute CMC's overall impact and, as clients were not sure what type of services CMC focused on, often confused clients.[82] CMC's attempt to enter this market placed the organization in competition with the consulting firms that had a lot more resources and expertise in this area.[83] This initiative in particular highlights a movement away from providing services that were not being provided by the private

[78] McAdam, interview.
[79] Giannisis, interview.
[80] *Ibid.*
[81] Giannisis, interview. Blair, interview. Hume, interview.
[82] Blair, interview.
[83] *Ibid.*

market. In 1997 when NIST/MEP failed to get funded for their proposed supply-chain initiative, the initiative was discontinued.[84]

By moving in these new directions, CMC (with encouragement from NIST/MEP) began to move away from delivering the core, technology-based services toward more general-business-assistance services, albeit with limited success.

3. Project Activity 1994 to 1999

The following statistics describes CMC project activity between April 1994 and September 1999. It is not possible to compare data after September 1999 as CMC converted to a new computer and database system.

During the first five years of CMC's operation, it helped companies in a variety of areas. Most significant are company assessments, HR, market development, quality, process improvement, business systems, and plant layout. Other areas include environmental, CAD Computer Assisted Manufacturing (CAM), product development, Electronic Data Interchange (EDI), control systems, material engineering, and robotics. During this period the average activity profile was with firms employing 122; cost of CMC services to the firm $5,353; took CMC 87 hours to complete the project; with 60 percent of the work conducted by subcontractors.[85] The following section analyzes trends in service delivery over time and relates this to organizational and policy changes occurring both at the local and federal level.

In the first calendar year of operation (1994), CMC conducted 59 projects. The average project was for a firm with 79 employees, took CMC 117 hours to complete, and cost the company $1,499 (or $12.81 per hour). Approximately 79 percent of the project work was

[84] Giannisis, interview.
[85] All cost figures are in 1998 dollars.

conducted by subcontractors. CMC was paying subcontractors on average $65 per hour, indicating the average loss per project was $4,500. Almost 80 percent of projects in 1994 were company assessments. The next largest category was quality - 5 percent of the total. Control systems and product development each accounted for 3 percent of project activity, with the remaining projects occurring in CAD/CAM, EDI, material engineering, plant layout, and business systems.

This first year of data indicates a tendency to focus on assessments and more complex, technology and process-improvement-type projects. Of note is the absence of softer-type projects such as HR and market development.

In the second year, the average project fee increased to $3,478 and took CMC 133 hours to complete. In 1995, the percent of work conducted by subcontractors increased to 84 percent. Average employment within firms working with CMC fell slightly to 61. While assessments still account for a significant percentage (58 percent), this is down from the first year. This is the beginning of a downward trend in assessments. Of the 192 projects conducted in this year, 7.8 percent were in market development. Market development is an area that CMC has devoted increasing resources to throughout the analysis period. This is followed by plant layout and process improvement, with 6 percent each. Next are HR and business systems with 5 percent, followed by quality with 4 percent. This is the first year HR projects show up as a service offered by CMC. Their significance in the CMC portfolio will continue to grow over time. Other types of projects conducted include product development, control systems, environmental, material engineering, and EDI. At this point, excluding assessments, 45 percent of projects delivered by CMC could be classified as technology, and process improvement related.[86] However, when assessments are added to this category the percentage jumps to 77 percent.

[86] In this definition I include process improvement, business systems, product development, control systems, environmental, material engineering, EDI, and CAD/CAM. Project areas excluded are

By 1996, CMC-project activity stood at 133, with 52 percent of project activity in the form of assessments. The size of the average firm was 83 employees, with the average project costing $4,088, and lasting 64 hours. The percent of work conducted by subcontractors fell to 45 percent. Market development projects increase to 17 percent of the total, while business systems account for 9 percent. Quality projects increase to 8.3 percent, while plant layout activity falls to 3.8 percent. Other projects conducted in 1996 include process improvement and HR (4 projects each), environmental and EDI (2 projects each), and product development and CAD/CAM (1 project each). In 1996, 34 percent of project activity can be considered technology and process improvement related: including assessments increases this figure to 68 percent.

In 1997, the average firm assisted by CMC had 74 employees. The average project took 103 hours, and cost $5,653 (or $53.83 per hour). Subcontractors conducted 45 percent of project work. CMC conducted a total of 171 projects, 52 of which were assessments (30 percent of total project activity). For the remaining activity, market development accounted for 21 percent and quality for 18 percent. Process-improvement projects accounted for 8 percent of activity, CAD CAM 5 percent, with plant layout, and HR accounting for 4 percent respectively. Environmental and business systems each accounted for 3 percent of total project activity. The remaining 4 percent was comprised of product development, control systems, material engineering, and EDI projects. In 1997, 32 percent of project activity fell into the category of technology and process improvement; 53 percent including assessments.

CMC staff carried out 226 projects in 1998, with assessments dropping to only 5 percent of total activity. Average firm size jumped to 212, while project cost increased to $7,764. In 1998, the average time taken to complete a project was 74 hours, with subcontractors conducting 69 percent of the work. These statistics yield a cost to the client firm of $104.92. HR

assessments, quality, plant layout, market development, financial, and HR.

projects headed the list with 34 percent, followed by quality (17 percent), and market development (16 percent). This is followed by process improvement (11 percent), business systems (8 percent), and plant layout (4 percent). The remaining 6 percent of projects were comprised of product development (2.2 percent), environmental (2 percent), control systems (1 percent) and CAD, EDI, robotics, and material engineering with one project each. Approximately 26 percent of the projects in this year were classified as technology and process improvement. This statistic increased slightly to 30 percent if the assessment metric was used.

Between January and September 1999, CMC undertook 110 projects, with only 2 assessments taking place. The average project profile was a firm employing 201, took 72 hours to complete, and cost $6,803. Subcontractors conducted 43 percent of the work. Once again, HR projects topped the list accounting for 42 percent, followed by market development at 12 percent, and quality at 10 percent. All other activities account for less than 10 percent - process improvement (8 percent), EDI (6 percent), CAD (6 percent), and business systems (6 percent). Plant layout and environmental projects each accounted for 4 percent, with the remaining 3 percent comprised of financial and material engineering. Twenty nine percent of projects in 1999 are classified as technology and process improvement; including assessments this figure is 31 percent.

H. Economic Impact

As noted in Chapter 4, there have been many economic impact studies conducted of the MEP program. One recently published study (Ehlen, 2001) focuses specifically on Illinois. Ehlen addresses two questions. First, have the two Illinois centers contributed to state economic growth? Second, did the program generate more in state tax revenue that it received in state subsidy?

Using the Illinois Regional Economic Models Incorporated (REMI) model, in conjunction with MEP survey data, Ehlen finds that during a two-year period, the two Illinois centers helped client firms create $22.5 million in sales and create or retain 483 jobs.[37] In addition he finds that through their induced and indirect effects on the state economy, the initial benefits generate an estimated $119 million in new state output and 450 new state jobs during a 4-year period. The answer to the author's first question is affirmative – the program has contributed to economic growth in Illinois.[38]

To answer the second question, Ehlen uses data from the REMI model in conjunction with tax tables published by the Federation of Tax Administrators, and state and local government expenditure data to measure the costs and benefits to the State of the Illinois MEP program. Data indicate that state and local tax revenues increased by $9.5 million in two years, compared with a total two-year cost to the state of $6 million.

This sophisticated analysis supports the claim that the MEP in Illinois is successful when looking at regional economic measures such as job creation, sales, and tax revenue. For purposes of this analysis, what is important is not the magnitude of these impact data but rather how it is derived. All projects, technology-related and nontechnology-related, conducted by the two centers are included in the analysis. Nontechnology services are not part of the MEP mission. In

[37] The REMI model is a widely used and accepted regional input-output model.

[38] Unpublished data obtained from Ehlen by the author indicate that CMC's impact alone was $12.3 million in sales and 201 direct jobs. Induced and indirect jobs totaled 181, while total output was $52.4 million. Total CMC government costs were $7.2 million while total tax revenue benefits were $8.9 million.

the absence of examining whether or not the services provided that led to this impact actually meet the mission of the program, one is left to conclude that the "end justifies the means."

1. Pre-1997 Comparison with Post-1996

The original hypothesis identifies 1997 as a turning point in CMC history. If this is indeed true, project statistics prior to 1997 should be significantly different than post-1996 statistics. The following analysis will test this hypothesis using staff hours per project, third-party hours per project, total hours per project, project fee (1998 dollars), company employment, and type of project.

Results indicate that there are statistically significant differences in all variables with the exception of staff hours per project. Pre-1997 projects take 104 hours to complete, with 76 hours conducted by third-party providers and 28 hours by CMC staff. The average project fee is $3,385 and is conducted for companies employing an average of 71. In this period, 77 percent of the 384 projects are technology and process-improvement related (this figure includes assessments). Compared with the previous period, projects in the post-1996 period are smaller in terms of total hours spent and third-party hours per project, involve larger project fees, are conducted with larger companies, and less likely to be a technology-related project. The average post-1996 project lasts a total of 81 hours, with 45 hours being conducted by third-party providers. Projects cost an average of $6,843 and are conducted for companies with an average of 164 employees. Only 38 percent of the 507 projects conducted during this period were technology related.

The analysis leads to the conclusion that the average project profile changed in many ways. Over time, CMC is working with larger firms who are spending more money per project, while the project is significantly less intense in terms of time spent. The average project fee more

than doubles, while the hours spent decreases by 22 percent. The average project is likely to be in the nontechnology-related areas of HR, marketing, and quality.

J. Synopsis

Consensus among CMC staff is that by 1997 CMC's efforts to service their client base were diluted by trying to do "too much too soon."[89] Many of these initiatives are introduced by CMC in an attempt to mitigate reduced NIST funding. However, this drive to generate additional revenue leads to a shift away from an emphasis on **public service** and toward **revenue generation**. In turn, this causes CMC's move away from providing technology-related services, such as process and productivity improvements; using experts; and charging low costs for such services.

The data presented in this chapter indicated a significant change in CMC's activities from 1994 to 1999. The average firm size increased from 79 employees in 1994 to 201 employees in 1999. Project fees increased from $1,499 to $6,803; while the time taken to complete a project fell from 117 hours to 72 hours.

These findings are consistent with the hypothesis that CMC is servicing larger firms. However, projects are becoming smaller while fees are significantly larger. These statistics indicate that CMC is charging more per project, thereby bringing into question the extent of the cost reduction being passed onto the client. The number of technology-related projects (including assessments) decreased from 91.6 percent to 31 percent, indicating a movement toward the delivery of general-business-assistance services.

The next phase of the research is the development of models that have predictive power in identifying firm characteristics and that have explanatory power in determining whether or not a

[89] Blair, interview; Hume, interview.

firm becomes a CMC client. This model development is strongly influenced by a review of the literature on firm characteristics influencing economic performance.

VII. AN INVESTIGATION OF FIRM CHARACTERISTICS: CLIENTS AND NONCLIENTS

A. Introduction

The first section of this chapter contains a review of the literature on firm characteristics that influence economic performance. This applied-literature review is guided by and complements the theories of economic growth and technology diffusion discussed in previous chapters. The applied-literature review is organized into the following areas: productivity, profitability, location, firm size, capital intensity, general industry factors, organization characteristics, and technology diffusion. It is conducted in order to lay the foundation for model development in the second section of the chapter. In the second half of the chapter, econometric-logit models are developed that capture the characteristics that distinguish the difference between CMC clients and nonclients.

B. Applied-Literature Review

The applied literature review is organized into the following areas: productivity, profitability, location, firm size, capital intensity, general industry factors, organization characteristics, and technology diffusion.

1. Productivity

A 1996 groundbreaking study by Ronald Jarmin measures the impact of the participation in the federal-manufacturing-extension program on productivity and sales growth at manufacturing plants.[99] To do this, Jarmin matches manufacturing-extension-client data with

[99] What makes Jarmin's paper groundbreaking is that it is the first time the LRD has been used in evaluation studies. He demonstrates that it is possible to match a sufficient number of program records to the LRD in order to perform a credible analysis. Further, he does it in a way that does not violate Census Bureau data disclosure rules.

the Census Bureau's Longitudinal Research Database (LRD), which contains data for all manufacturing establishments in the United States and provides a number of measures of plant performance and characteristics measured consistently across plants and time. This allows a valid comparison between both CMC-client and nonclient plants and among clients serviced by MECs.

Jarmin (1997) investigates whether or not measures of plant performance (e.g., productivity and sales growth) are systematically related to participation in manufacturing extension, while controlling for other factors that are known or thought to influence performance. Using a two-stage model, Jarmin measures the mean difference in productivity and sales growth between clients and nonclients.

Variables used in Jarmin's model include age, employment, two-digit Standard Industrial Classification (SIC), whether or not the plant was an MEP client, number of extension projects, total project costs, capital-to-labor ratio, multiplant or not, and whether or not the plant was located in a Standard Metropolitan Statistical Area (SMSA), and whether or not the SMSA had an extension center. When using sales growth as the dependent variable, significant variables are growth in the capital-to-labor ratio, growth in production workers as a percent of firm employment, whether or not the firm was within a SMSA, if it was part of a multi-plant firm, and if the SMSA where the firm was located had an extension center. When using labor productivity as the dependent variable, statistically significant variables include growth in the capital-to-labor ratio, whether or not the firm was an MEP client, and the growth rate of labor.

Dunne, Roberts, and Samuelson (1989) develop an empirical model to examine the patterns of employment growth and plant failure in U.S. manufacturing establishments using census of manufacturing data for 1963, 1967, 1972, 1977, and 1982. This study identifies characteristics that predict employment growth, a crude measure of productivity. The model

examines growth (the difference between current size and initial size), two-digit SIC, year of observation, establishment, and ownership status. Their theoretical model predicts nonlinear effects of size and age on growth as well as interactions between size and age. The model also assumes that there are no adjustment costs so that all information about a plant's history is summarized by its current size. The model is applied separately to the single-unit and multiunit plants. This recognizes the importance of the learning process at the plant level, and thus its effect on plant growth and failure rates, may depend upon whether the firm that owns the plant has experience from operating other plants.

When examining plant-growth rates, using only the information on nonfailing plants, the pattern found is that mean growth rates decline with size. This is true for both single and multiunit plants. In addition, mean growth rates are found to decline with increases in plant age for virtually every size class. The only exception is for the largest plants. Results indicate that age, size, and industry have significant effects on growth patterns. Age/size interactions are also important for multiunit plants. However, initial plant size has no significant effect in the regression.

The authors' results can be summarized as follows - failure rate, mean growth rates of nonfailing plants, and variance of the growth rate of nonfailing plants decline with size and age for both single and multiunit plants (Dunne et al., 1989). The mean growth rate for larger, nonfailing, single-unit plants is negative which contrasts with the positive mean growth rates of nonfailing, multiunit plants across virtually all size and age classes. In addition, the growth rate for all plants tends to decline with size and age.

One could hypothesize either a positive or negative relationship between client status and productivity. On one hand, firms that are more technology aware may also be more willing to seek unbiased, outside assistance to help them make future-investment decisions. On

the other hand, firms that are less productive may be more likely to seek unbiased, outside assistance to help improve their performance.

2. Profitability

Stoneman and Kwon (1996) investigate the relationship between profitability and technology adoption. While controlling for characteristics of the firm, the authors find that for a sample of United Kingdom engineering firms between 1983 and 1986 the nonadopters experience reduced profits as other firms adopt new technologies and that the gross profit gains to adopters of new technology are related to firm and industry characteristics, the number of other users of new technologies, and the cost of acquisition. Industry characteristics include size, sales, firm-concentration ratios, and the real wage rate. The demonstration of such a relationship indicates profitability is likely to differ between clients and nonclients.

3. Location

One feature of industry organization is that similar businesses cluster geographically and become increasingly interdependent. A cluster can be defined as a concentration of firms that are able to produce synergy because of their geographic proximity, even though their scale of employment may not be pronounced or prominent. Concentrations of interdependent businesses that are intrinsically linked through common or complementary inputs, innovations, processes, or products dominate markets in almost every industrialized country (Scott, 1988).

Firms find it advantageous to be close to their suppliers, customers, services, and competitors. Close proximity allows them to transact business more cheaply and easily, resolve their problems more quickly and efficiently, and learn earlier and more directly about new, innovative technologies and practices. The velocity of circulating capital though the cluster is accelerated and this increases the advantages of agglomeration. Industrial clusters also represent

important centers of employment and local labor-market activity. Agglomeration economies are further amplified where there is collective provision of infrastructure services and public goods; where useful social infrastructures, attuned to local needs, emerge such as business associations, information-providing services, educational and research institutions (Rosenfeld, 1997).

The phenomenon of clustering can be viewed as an economic problem rather than an economic advantage. When an economy has high concentrations of a few industries, the economy can become very susceptible to the ebbs and flows of that industry during the business cycle. Economic development agencies can provide incentives designed to diversify local and regional economies through their business attraction strategies.

Kelley and Helper (1997) investigate how regional agglomeration influences the adoption of CNC-machine technology. The authors use data from national surveys conducted in 1987 and 1991. A size-stratified random sample of establishments was selected. The authors find that a firm's propensity to modernize was a function of size and previous experience with new technologies. They also find that there was a higher probability of technology adoption when the establishment was located in region that is rich in agglomeration economies. The argument for this last variable is that regions with dense concentrations of firms engaged in the same production process are likely to be information rich. The more information that is available about a new technology, the more likely a firm is to adopt it. It is interesting to note that the authors find a negative coefficient on the interaction between size and the intensity/diversity of search behavior, suggesting that the smaller the firm the greater the learning advantages from the local management's network of connections to other organizations and institutions. They also find that when small firm's experience an ownership change there tends to be an increase in new technology adoption.

4. **Firm Size**

Four possible measures of industrial concentration exist: employees, sales, income generated, and assets. Adelman (1951) argues that income generated is the best single measure of economic size - a statistic similar to the term *value added*. If one wishes to analyze the social and political aspects of concentration, Adelman recognizes that the number of employees is the most relevant measure. While recognizing that sale is the most readily available measure of size, Adelman rejects it as it disregards the extent of vertical integration. Adelman acknowledges that if current size is considered to be a result of past forces, assets are the best measure. However, the longer the period over which assets have been accumulated, the greater the uncertainly about their valuation on a common basis. This uncertainty is widened further by the variations in accounting and valuation methods among corporations.

There is extensive literature that supports the hypothesis that larger firms are likely to be more profitable than smaller firms (Nabseth, 1973; Ray, 1969). Large firms tend to have more equipment than smaller firms, tend to experience a wider range of operations, have more resources available to them, and are more likely to be able to absorb a loss in the short run. Jovanovic (1982) finds that firm size and concentration seem to be positively related to rates of return. This finding holds true over the long run. In addition, Jovanovic finds a higher concentration associated with higher profits for larger firms, but not for smaller firms.

Dunne, Roberts, and Samuelson (1989) find that plant size, age, and ownership type are determinants of plant growth. Their study finds that if attention is limited to successful plants, the mean growth rate declines with size. However, when the failure probability is integrated into the analysis the relationship between plant growth and size is negative for plants owned by single-plant firms but positive for plants owned by multiplant firms. For single-plant firms the growth rates decline with size. For plants owned by multiplant firms, expected growth increases with size.

5. Capital Intensity

One factor that strongly influences productivity is the extent which capital is substituted for labor in response to changes in relative input prices - increases in the amount of capital per worker will increase labor productivity (Mansfield, 1968).

6. Industry Factors

Some economists believe that higher productivity growth occurs within highly concentrated industries, while others believe just the opposite (Schumpeter, 1942; Solow, 1957). Due to data limitations, most research that attempts to quantify this growth is forced and uses some measure of supplier concentration in the industry. The degree of seller concentration can be measured in many different ways (Scitovsky, 1955; Adelman, 1951). Some of the most common methods are the number of firms in an industry and the variance of the distribution, as measured by employment, of the natural logarithm of firm sizes.

7. Organization Characteristics

Economists have devoted little attention to organizational culture. One way economists view this variable is when individuals can be motivated and directed without financial incentives, a tremendous saving of resources can occur. On the other hand, if a firm's culture and strategy are not aligned it is less likely that any ensuing increase in productivity will be observed (Teese, 1986).

The progressiveness of management is an additional factor affecting how a firm begins along a path of modernization. Measurements of progressiveness are difficult to obtain. As a proxy one might consider the education and age of the relevant management personnel. One hypothesis is that firms with better-educated and younger managers tend to be more open to new ideas than older, less-educated managers. One caveat is that in industries with larger firms these

variables may not be significant as the data available pertains only to the presidents of firms, who may be far removed from the decision to introduce innovations (Rogers, 1962).

A firm with a strategy of continuous improvement through employee empowerment is considered to be progressive and forward thinking (Howard, 1990). Facilitating such strategies necessitates investment in employee growth and skill development. It addition, successful continuous improvement is facilitated by the creation of work teams, which creates an atmosphere where people share information openly and broadly, and listen to each other's point of view (Howard, 1990).

Teams have the ability to balance short-term performance emphasis with longer-term institution building by translating longer-term purposes into definable-performance goals and then developing the skills needed to meet those goals (Katzenbach and Smith, 1993). The performance challenges that face companies, such as technological change, demand the kind of responsiveness, speed, on-line customization, and quality that is beyond the reach of individual performance, but can be met by teams. If a firm's management is sophisticated (a slight variation on whether or not they are heavy users of technology and whether or not they are progressive) one could hypothesize that the firm will be more likely to adopt new technology. It is, however, difficult to derive a measure for sophistication.

8. Technology Diffusion

Early empirical studies on technology by Griliches (1957) and Mansfield (1968) explore the diffusion of innovations in agriculture and manufacturing. These studies examine the speed at which innovations diffuse through sectors and the characteristics of industries and firms that lead to faster technology adoption. In addition to these works, there have been numerous case studies done on technology diffusion in particular industries and innovations (Kelley and Brook, 1991; Romeo, 1975; Hannan and McDowell, 1984; Levin et al., 1987). These industry-

specific studies focus on the importance of firm characteristics (size, market share, workforce skills) and industry characteristics (market concentration, R&D intensity, and scale economies) as basic determinants of technological adoption and diffusion.

Dunne (1991) uses data from the 1988 Survey of Manufacturing Technology (SMT) to examine technology usage in U.S. manufacturing industries.[91] The survey is administered by the Census Bureau and asks manufacturing plants about the use of seventeen separate technologies that are grouped into five advanced-technologies categories. Dunne models how plant-technology use varies with plant characteristics. The dependent variable equals one if a plant uses a given technology, otherwise it is zero otherwise. The technology-indicator variable is then regressed on a set of plant characteristics and industry controls. Since the data was for only one point in time, the model examines the usage of technology, not the pattern of diffusion. Explanatory variables include: a dummy to control for whether a plant is owned by a single-unit firm or a multiunit firm. A dummy variable is included to capture the effect of defense-related production on technological adoption. Plant size is included in the model to capture differences in relative efficiency across plants. Previous work predicts size and efficiency are positively correlated (Jovanovic, 1982). Hence the author postulates that large firms will be most likely to take advantage of the newest technology (Dunne, 1991).

The age of the plant is also included as an explanatory variable in the analysis (Dunne, 1991). The author offers several hypotheses of why one may observe dissimilar technology-adoption patterns across plants of different ages. One might expect younger plants to

[91] The 1988 SMT is a survey of approximately ten thousand manufacturing establishments employing twenty or more within SIC 34-38 about the use of seventeen individual advanced technologies. These technologies are general innovations primarily used in the design or production of manufactured products. The seventeen technologies can be broadly classified into five technology groups including: design and engineering (CAD/CAM), fabrication machining and assembly (robotics, lasers), automated material handling, automated sensors, and communication and control (computers, networks, programmable controllers). The survey also contains data on plant characteristics such as size, age, industry, and defense production.

have higher-adoption rates because they probably have newer equipment. Countering this argument is the possibility that survival is positively correlated with adoption. If plants that fail to adopt new technologies have higher-exit rates, then the observed distribution of surviving plants from an entry cohort will be skewed toward plants that adopted.

The author finds that adoption rates increase as plant size increases, holding age fixed (Dunne, 1991). The observed strong-size effect is consistent with previous work examining the effect of size on the adoption of technologies.[92] He also finds that the age results varied across technology and are generally weaker than size. These age results are consistent with two basic hypotheses. One is that there is no advantage or disadvantage in adopting technologies associated with plant age. A second is that sample selection may be biasing the age parameters downward for young plants. The sample selection stems from the fact that only successful, old plants are observed (Dunne et al., 1989). The author contends that older firms will be the most efficient plants among their cohorts, while the young-plant cohort contains both efficient and inefficient plants. The age parameters, therefore, pick up both differences in plant age and differences in efficiencies. He claims that, in part, the size parameters, which proxy for relative efficiencies, should control for this problem. He does, however, recognize that it is possible that the age parameters are still biased if size does not sufficiently index relative plant relative-plant efficiency. Examining the remaining variables in the model, the multiunit dummy indicates that plants owned by multiestablishment firms have higher-adoption rates. The effect of defense-related production on technology usage is also generally positive and statistically significant.

Dunne (1991) concludes that larger plants, plants owned by multiunit firms, and plants engaged in defense production have higher-technology-adoption rates. Plant age has

[92] For example, Kelley and Brook, 1991.

mixed effects on the adoption of technology depending upon the technology under study. At a minimum he claims that many older plants employ relatively young technologies and are not trapped into old technologies. He also finds that technology usage is correlated across technologies. Plants that use one advanced technology have a tendency to use other advanced technologies.

Doms, Dunne, and Roberts (1995) investigate the role of technology use in the survival and growth of manufacturing plants. The goal of the research is to extend the empirical literature on plant growth and failure by more fully controlling for the producer heterogeneity that arises from differences in the level and type of capital equipment used in the plant. The research is conducted using data from the 1987 census of manufactures, the 1988 SMT, and the 1991 Standard Statistical Establishment List. The study finds, predictably, that capital-intensive plants and plants employing advanced technology have higher growth rates. In conclusion, the literature claims that companies employing more technologies will have higher growth rates than other firms (Dunne, 1991; Kelley and Helper, 1997).

This review investigated the literature on factors influencing firm growth and behavior. Many of the variables identified in this literature complement those factors identified earlier in this research as either being contributors or barriers to improved performance of SMME-firm performance.

C. Econometric Logit Models

1. Introduction

What follows are the development, testing, and presentation of results from various logit models that investigate characteristics of CMC-client and nonclient firms. In all, four models and four hypotheses are tested. These models examine whether or not there are statistically significant differences between CMC-client and nonclient firms in 1996 and 1997.

Models are also developed to test whether or not there are statistically significant differences in characteristics of CMC clients in 1996 and 1997; and 1996 nonclients compared with 1997 clients.

The hypotheses are developed using the following rationale. Over time MEP gradually reduced their emphasis on firm technology adoption, as it was becoming increasingly clear that firms needed more basic assistance and that the adoption of technology did not necessarily lead to increased productivity. This is evidenced by the MEP funding made available for workforce development, access to financing, and international-program development.

In addition, NIST-reduced funding to CMC proceeded as scheduled. Funding was gradually reduced from 50 percent in 1994 to 40 percent in 1996 to 33.3 percent in 1997. This forced CMC management to become more focused on the organization's "bottom line," leading to a movement away from working with companies that were more technologically sophisticated and towards those that were interested in more general-business services. It is hypothesized that the effect of the previously discussed sunset provision was to force MEP centers facing federal-funding subsidy reduction to focus less on technology adoption and concentrate more on the larger market and possibly a greater-revenue center - general-consulting services.

2. Characteristics of SMME Firms

i. Hypothesis 1 – CMC-Client and Nonclient Firms - 1996

The first model examines firm characteristics, whether or not there is a statistically significant difference between CMC-client and nonclient firms in 1996. The federal MEP, through which CMC receives partial funding, has as its mission to "give hands-on assistance to small and medium sized manufacturers trying to improve their operations through the use of appropriate technologies" (United States, 1996). Therefore, the program's original

focus was on those SMMEs more likely to adopt new processes and technologies. This targeted approach is supported by the fact that one of the four criteria that NIST used to evaluate proposals for center funding was the technology resources and technology-delivery mechanisms (NIST, 1992). Other factors NIST employed in evaluating proposals included regional need, management, and financial plans. The first hypothesis is that there will be a statistically significant difference between firms that became CMC clients in 1996 and those who did not.

ii. Hypothesis 2 - CMC-Client and Nonclient Firms - 1997

The next phase of the analysis compares characteristics of CMC clients with nonclients in 1997. By 1997, NIST provides funding to CMC for the development and delivery of services outside of the original mission - technology diffusion. In addition, by 1997 CMC is beginning to feel the effects of reduced MEP-core funding. For these reasons, the hypothesis is that there will not be statistically significant differences in firm characteristics between clients and nonclients in 1997.

iii. Hypothesis 3 - CMC-Client Firms - 1996 and 1997

The third model tests whether or not there is a difference in firm characteristics between CMC clients in 1996 and 1997. For the reasons outlined above, the hypothesis is that there will be a difference between CMC clients in 1996 and 1997 for the following reasons: reduced core funding and additional pilot program funding for service delivery outside the core mission. In particular, it is hypothesized that CMC clients in 1997 are less likely than 1996 clients to have upgraded machinery and equipment or to have adopted IT-related technologies.

iv. Hypothesis 4 - Nonclient Firms - 1997 and CMC-Client Firms 1996

The final model examines characteristics between nonclients in 1996 and CMC clients in 1997. It is anticipated that CMC-client-firm characteristics changed to be more

representative of the population as a whole. The hypothesis tested is that there is no statistically significant differences between nonclients in 1996 and clients in 1997. Specifically, 1997 clients will not be more likely to have adopted IT-related technologies or invested in machinery and equipment than non-CMC clients.

3. Analysis

i. Data

The analysis is based on Chicago-area-firm data obtained from surveys conducted in 1996 and 1997 by the PBS, a unit of the Industrial Technology Institute located in Ann Arbor, Michigan.[93]

The PBS database is built primarily of responses to a direct-mail solicitation of trade-association members. This obviously raises issues about how representative the dataset is of the population. The dataset may have some nonresponse bias, which could occur if firms who respond to benchmarking questionnaires differ systematically from those that do not. This hypothesis is tested in 1994 by PBS staff.[94]

After a follow-up with nonrespondents - obtaining survey responses and comparing results with original respondent results - the PBS found that firms in the nonrespondents group were not significantly different than those in the respondent group.

---

[93] PBS was launched in 1992, and is a service that allows manufacturers to compare their performance with similar plants. In return for providing data (and as an incentive for accurate reporting) each participating firm receives a confidential, customized, PBS report comparing it with other firms on more than one hundred industry-relevant measures.

[94] Dziczek, Luria, and Wiarda, unpublished. In 1994, PBS conducted a small experiment designed to test for the presence and extent of self-selection bias among benchmarking participants. The experiment consisted of a telephone survey of randomly selected nonrespondents: plants that had been asked to participate but had not done so. The response rate on this survey was 77 percent, sufficiently high to expose systematic differences between the respondent and nonrespondents groups.

Nonrespondents, as a group, were no less interested than respondents in the concept of benchmarking. Indeed, at the conclusion of the interview with the surveyed nonrespondents, when given a brief explanation of the benchmarking service, asked to be included in future benchmarking activities.[95]

The PBS data was then matched with CMC-client information to determine which companies completing the PBS survey went on to become CMC clients (those companies that went on to have a substantive engagement with CMC) in the same year. The total firm distribution by year and client status is displayed in Table II.

Table II
Firm Distribution, by Year and Client Status

	1996	1997
Nonclients	42	40
Clients	39	16

ii. Variables

For the purposes of this analysis, the one hundred plus Performance Benchmarking variables were examined, reduced, and separated into major categories of variables that, based on the literature and information obtained from practitioners in the field,

[95] Respondents and nonrespondents did not differ in size. However, nonrespondents were slightly more likely to belong to a firm with over five hundred employees: roughly 12 percent of the nonrespondents were owned by a firm employing over five hundred, compared with just under 3 percent of respondents. Nonrespondents also showed somewhat slower growth in sales than respondents (29 percent versus 36 percent). However, this difference was only weakly significant at just under the 10 percent level. Nonrespondents differed significantly from respondents in only one area - they reported a higher percentage of shop-floor employees were members of production work-teams. The ramifications of these findings are unclear. In fact, if anything, the opposite might have been expected. It is reasonable to hypothesize that benchmarking participants would have been more attuned to the latest workplace practices. Respondents and nonrespondents did not differ on computer use, quality training, or on-time performance; nor were nonrespondents any more or less likely to report having sought outside assistance since 1991. Thus, it is reasonable to conclude that there is no systematic self-selection bias in investment patterns, whether that investment is in computerized equipment, employee skills, or outside consultants. These results provide reassurance that the PBS database is not an unrepresentative sampling of smaller manufacturers. There is no evidence to support the hypothesis that benchmarking participants might be more "progressive" than the typical firm. If anything, there is weak evidence to the contrary.

coincide with potential barriers to improved performance.[96] The categories of variables are financial, company, technology diffusion, and organization (management).

> Financial variables include measures such as real gross profit to capital replacement, real gross profit per employee, real value added per employee, payroll per employee.
>
> Company variables include measures such as firm location (city versus suburbs), industry, and number of employees.
>
> Technology Diffusion variables include an index compiled using information on whether or not the company uses CAD or CAM, uses Statistical Process Control (SPC), or computers to analyze quality data. Other variables include whether or not the firm purchased or upgraded equipment since 1993, whether the firm purchased or upgraded software in the last three years, the percentage of units scrapped, the percentage of lots rejected, number of keyboards per employee, and the percentage of shop-labor time doing assembly.
>
> Organization variables include percentage of sales from products not made three-years ago, of sales to customers not served three years ago, percentage of sales to customers outside the United States, percentage of sales engineered-to-order, number of shop employees as a percentage of all shop workers in work teams, real dollars per employee spent on training and tuition, percentage of shop-floor workers in unions, ratio of shop workers to total employees, if the firm was International Organization for Standardization (ISO) certified, percentage of workers trained using quality, and whether or not the firm received outside assistance in the last three years.

D. 1996 Data

1. Overview

The initial analysis examines 1996 data to determine whether or not firms that became CMC clients had significantly different characteristics than the firms in the database in

[96] Examples of the PBS survey can be found at www.iti.org/pbs.

general. However, the first presentation is the overall statistics from the database to discuss firm characteristics in general. All figures are in 1998 dollars.

The average company in the sample has 81 employees, with shop employees accounting for 70 percent of the total. Sales average $11.6 million annually, while the average value added per employee is $62,522. However, once wages and opportunity cost of capital were taken into consideration the gross profit per employee is $28,870 while the average payroll per employee is $28,498. The average replacement value of machinery is $2.8 million.

On average, 22 percent of sales come from products not made three years ago, while 21 percent of sales come from customers acquired in the last three years. Almost 10 percent of sales are to customers outside the United States. Some 13 percent is low-volume made-to-order and 57 percent is from repetitive made-to-order.

Approximately fifteen percent of shop workers are members of teams. Average tuition training spent per employee is $275. Seventeen percent of workers are in unions.

Almost 38 percent of employees use a computer. There is an average of one keyboard for every four employees. Only 6 percent of firms are ISO certified. With regard to technology 40 percent use CAD to generate data, 54 percent use CAD to receive data, 46 percent use SPC, 55 percent do business electronically, 56 percent have purchased software in the last two years, and 51 percent analyze quality data using a computer. Some 19 percent of employees are trained in quality methods.

2. Comparison

After providing a general overview of the average company's profile, the next stage is to compare attributes of firms that are CMC clients with those that are not. This is done

using two methods. For continuous variables, t-statistics are calculated while for binary variables chi-squared statistics are used. The null hypothesis is that there is no difference between CMC clients and nonclients. Variables tested include continuous and binary.

i. Continuous Variables

Sales less costs: Sales less purchases (materials, parts, services, utilities, temporary employees) and payroll in 1998 dollars. This variable was chosen to give a measure of the financial health of the firm.

Gross Profit: Sales less materials, parts, services, utilities, payroll, temporary employees, and depreciation (replacement cost of capital times corporate-base rate) in 1998 dollars. This measure also provides a measure of the financial health of the firm. By incorporating a measure of depreciation this figure provides a more accurate picture of the firm's overall health.

Gross profit/replacement cost of capital: This measures, again another measure of the financial health of the firm, provides a proxy for the opportunity cost of capital.

Gross profit per employee: This measure gives an estimate of labor productivity.

Sales per employee: This variable provides an alternative measure of labor productivity.

Value added: Sales less purchases in 1998 dollars. This variable provides an indication of the size of the company.

Percentage of sales from products not made three years before: This variable acts as a proxy for the innovative nature of the firm. More innovative firms will have a larger percentage of sales from new products.

Percentage of sales to customers not serviced three years ago: This variable provides an indication of whether or not the firm is pursing an active growth-strategy. The larger the percentage of sales to customers not served three years ago, the greater the probability that the firm is interested in growth.

Percentage of sales to customers outside the United States: This variable provides an indication of whether the firm sees itself as a

global company and also is an indication of the global competitiveness of the firm and whether or not.

Total employees: This variable provides an additional measure of firm size.

Real tuition per employee: Tuition per employee in 1998 dollars. This variable is used as a proxy for management progressiveness. Those firms spending more on employee training are more likely to be aware of the benefits of a well-trained and educated workforce.

IT index: Additive index including whether the company uses CAD to generate data, receives CAD from customers, use SPC, or use computers to analyze quality data. This variable is a proxy for the technology intensity of the firm.

Keyboards per employee: This variable is also a proxy for the firm's willingness to adopt new technologies.

ii. **Binary Variables**

Use CAD to generate data? This variable is a measure of a firm's willingness to adopt new technologies.

Receive CAD from customers? This variable is a measure of a firm's willingness to adopt new technologies.

Located in the city of Chicago? Whether or not the firm is located in an older-urban area. The large concentrations of firms in the city may lead to greater word of mouth about how CMC can help companies, thereby causing increased participation in the program by firms. In addition, as the city of Chicago is one of CMC's funders, one would hypothesize that city bureaucrats would advertise CMC services to assist Chicago-based firms.

Do business electronically? This variable is a measure of a firm's willingness to adopt new technologies.

ISO certified? This variable indicates whether or not the firm has made a commitment to quality improvements.

Received outside assistance since 1991? Indicates whether or not the firm is open minded about seeking help from outside the organization.

Two-digit SIC code. This variable controls for any differences across industries.

Use of SPC? This variable is a measure of a firm's willingness to adopt new technologies.

Purchased or upgraded their machinery in the last three years? This variable indicates the willingness of firms to invest in modernizing technologies and processes.

When using Levene's test for equality of variances - a test of the null hypothesis that both samples come from populations with the same variance - results indicate that, in almost all cases, the null hypothesis cannot be rejected (Table III).

After accounting for difference in variances, when examining t-tests for equality of means, the only variables for which the null hypothesis must be rejected are real tuition per employee and tuition as a percent of sales. In these two cases, nonclients spend significantly more on tuition per employee and as a percentage of sales than clients.

Table III
Descriptive Statistics for 1996 Continuous Variables

Variable	Description	Client Status*	Mean	Standard Deviation
SLCPE	Sales less costs	1	2,976.42	3,348.55
		0	3,044.82	3,766.18
GP	Gross profits (sales less costs less cost of capital)	1	2,718.91	3,241.90
		0	2,742.64	3,621.81
GPRCC	Gross profit replacement cost of capital	1	1.57	1.99
		0	1.58	1.78
GPE	Gross profit per employee	1	27.86	21.65
		0	29.69	28.15
SPE	Sales per employee	1	31.66	20.17
		0	33.87	27.88
VA	Value added	1	60,844.91	23,818.23
		0	64,110.00	33,064.90
PROD3	% sales from products not made 3 years ago	1	21.99	18.47
		0	22.30	19.53
CUST3	% sales to customers not served 3 years ago	1	17.65	17.13
		0	23.27	19.89
FCUST	% sales to customers outside U.S. last year	1	10.57	15.49
		0	8.54	11.50
EMP	Total employees	1	82.13	70.91
		0	79.67	68.05
TPERE	Tuition per employee deflated †	1	149.40	181.59
		0	391.08	641.08
TPERS	Tuition as percentage of sales‡	1	0.12	0.14
		0	0.43	0.87
TECHIND	Technology index - sum	1	2.03	1.31
		0	1.84	1.30
KEYPE	Keyboards per employee	1	0.22	0.22
		0	0.28	0.35

*1=1996 client; 0=1996 nonclient
†Significant at the 95 percent level
‡Significant at the 95 persent level

When testing to determine if there were any statistically significant differences in the binary variables measuring firm characteristics only the variable measuring whether or not the firm upgraded its machinery is statistically significant (Table IV). In this case, the null hypothesis that client status and upgrading of machinery and equipment are independent must be rejected.

Table IV
Descriptive Statistics for 1996 Binary Variables

Variable	Description	Client Status*	Mean	Standard Deviation
CADIN	Use CAD data to generate	0	0.41	0.5
		1	0.38	0.49
CADOUT	Receive CAD	0	0.57	0.5
		1	0.5	0.51
CHICAGO	City of Chicago	0	0.12	0.33
		1	0.26	0.44
ECOMMERCE	Do business electronically	0	0.62	0.49
		1	0.47	0.51
ISO	ISO certified	0	7.14E-02	0.26
		1	5.13E-02	0.22
OUTASSIST	Outside assistance	0	0.57	0.5
		1	0.57	0.5
SIC20	VSIC20	0	7.14E-02	0.26
		1	2.56E-02	0.16
SIC30	VSIC30	0	9.52E-02	0.3
		1	0.15	0.37
SIC34_35	VSIC34 35	0	0.45	0.5
		1	0.51	0.51
SPC	Use SPC	0	0.41	0.5
		1	0.51	0.51
UPGRDEM	Upgrade machinery†	0	0.48	0.51
		1	0.68	0.47

*1=1996 client; 0=1996 nonclient
†Significant at the 95 percent level

This first phase of the analysis indicates that there is an apparent statistically significant difference, between firms that became CMC clients and firms that did not, in two characteristics. One has to do with spending on training and tuition. Nonclients appear to spend more per worker than clients. Second, clients appear to have been more likely to have invested in machinery and equipment than nonclients. In these cases, the null hypothesis (no difference) cannot be accepted. All other variables show up as not statistically significant.

The next phase of the research is to develop a logit model that will help to predict the odds of a firm being a CMC client. Summarized results are displayed and their significance discussed.

3. The Logit Model

i. CMC Clients and Nonclients - 1996

Logit models were constructed using variables to represent each of the four major categories (financial, company, technology diffusion, and organization). The field was narrowed to make sure the model did not use up a large amount of degrees of freedom. Selected variables were: tuition per employee, investment in machinery and equipment, located in Chicago, the gross profit to replacement cost of capital ratio, percentage of customers not served three years before, percentage of sales abroad, employment, technology index (an index of adoption of various IT techniques), and whether or not the firm-received outside assistance.

First, a model was constructed using only two of the variables that previously showed up as significantly different from zero - investments in machinery and equipment and real tuition per employee. Results from this model can be found in Table V. In this logit model, both variables appear to be significantly different from zero.

Table V
1996 Client and Nonclient*

Variable	Description	Model 1	Model 2
TPERS	Tuition as a percentage of sales	-0.002 -0.041 †	-0.005 -0.111
UPGRDEM	Upgrade machinery	1.370 -0.017 ‡	2.066 -0.044 §
CHICAGO	City of Chicago		0.401 -0.711
GPRCC	Gross profit replacement cost of capital		-0.185 -0.488
CUST3	% sales to customers not served 3 years ago		-0.185 -0.519
FCUST	% sales to customers outside U.S. last year		-0.020 -0.481
EMP	Total employees		-0.001 -0.802
TECHIND	Technology index - sum		-0.013 -0.968
OUTASSIST	Outside assistance		-0.023 -0.981

*1=1996 client; 0=1996 nonclient
†Significant at the 95 percent level
‡Significant at the 95 percent level
§Significant at the 95 percent level

A second full model was then constructed. Conclusions obtained from running this model were slightly different than the results obtained from the t-statistics and chi-squared-statistics (see Table V). Investment in machinery and equipment remained significant at the 95 percent level, while real tuition per employee became statistically significant only at the 85 percent level. The remaining independent variables were not statistically different than zero. The only really strong statistically significant relationship I find when modeling 1996 data is that investment was more likely to have occurred in firms that were CMC clients.

The finding - CMC clients were more likely to have made recent investments in machinery and equipment than nonclients - is interpreted as a measure of client firms above average willingness to invest in technology and process improvements.

iii. CMC Clients and Nonclients – 1997

As stated previously the hypothesis is that there will be no statistically significant difference between CMC clients and nonclients in 1997. Examining t-statistics (Table VI) and chi-squared statistics (Table VII), I find that the technology index - whether or not a company received CAD data, whether or not the firm updated its machinery and equipment, and whether or not the firm was located in the city of Chicago - are statistically different from zero. CMC clients are less likely to use the combination of ITs that make up the index, less likely to receive CAD, less likely to upgrade machinery and equipment, and more likely to be located in the city of Chicago. These results are surprising in that these 1997 statistics are the opposite of the 1996 findings in the area of technology. Nineteen ninety-seven clients appear to be less likely than the population to have a propensity to adopt new technologies.

Table VI
Descriptive Statistics for 1997 Continuous Variables

Variable	Descriptions	Client Status*	Mean	Standard Deviation
SLCPE	Sales less costs	1	2,258.04	3,924.67
		0	4,418.16	5,956.07
GP	Gross Profits (sales less costs less cost of capital)	1	2,122.51	3,887.65
		0	3,495.83	4,889.34
GPRCC	Gross profit replacement cost of capital	1	4.65	13.33
		0	1.48	3.12
GPE	Gross profit per employee	1	31.72	41.71
		0	30.31	22.96
SPE	Sales per employee	1	33.14	41.40
		0	35.19	23.86
VA	Value added	1	67,672.08	50,308.38
		0	66,760.17	29,988.85
PROD3	% sales from products not made 3 years ago	1	29.23	33.50
		0	22.56	18.79
CUST3	% sales to customers not served 3 years ago	1	22.88	25.91
		0	23.73	18.82
FCUST	% sales to customers outside U.S. last year	1	2.55	4.77
		0	4.45	6.01
EMP	Total employees	1	67.31	70.43
		0	107.51	112.28
TPERE	Tuition per employee deflated	1	346.95	495.55
		0	325.58	445.49
TPERS	Tuition as percentage of sales	1	0.32	0.53
		0	0.29	0.46
TECHIND	Technology index - sum*	1	1.42	1.08
		0	2.31	1.53
KEYPE	Keyboards per employee	1	0.17	0.24
		0	0.29	0.39
LTDA	% shop-labor time doing assembly	1	14.31	23.43
		0	24.70	30.13

*1 = 1996 client, 0 = 1996 nonclient
*Significant at the 95 percent level

Table VII
Descriptive Statistics for 1997 Binary Variables

Variable	Description	Client Status*	Mean	Standard Deviation
CADIN	Use CAD data to generate	0	0.50	0.51
		1	0.29	0.47
CADOUT	Receive CAD*	0	0.64	0.49
		1	0.31	0.48
CHICAGO	City of Chicago‡	0	0.08	0.27
		1	0.38	0.50
ECOMMERCE	Do business electronically	0	0.43	0.50
		1	0.44	0.51
ISO	ISO certified	0	0.10	0.30
		1	0.00	0.00
OUTASSIST	Outside assistance	0	0.60	0.50
		1	0.62	0.51
SIC20	VSIC20	0	0.10	0.30
		1	0.06	0.25
SIC30	VSIC30	0	0.13	0.33
		1	0.13	0.34
SIC34_35	VSIC34_35	0	0.43	0.50
		1	0.38	0.50
SPC	Use SPC	0	0.53	0.51
		1	0.44	0.51
UPGRDEM	Upgrade machinery§	0	0.67	0.48
		1	0.25	0.45

*1 = 1996 client, 0 = 1996 nonclient
*Significant at the 95 percent level
‡Significant at the 95 percent level
§Significant at the 95 percent level

I then construct several logit models to examine the independent variables in more detail (Table VIII). The first model contains two independent variables - tuition per employee and whether or not the firm upgraded its machinery. In this model, upgrading machinery is significant at the 90 percent level. The sign on the coefficient is consistent with the primary chi-squared analysis. CMC clients are less likely than nonclients to upgrade machinery. As noted earlier, this is opposite of the findings obtained when examining 1996 data. When adding other variables to the model, location is the only variable that is significant at the 95 percent level. CMC clients were more likely to be located in the city of Chicago than nonclients. At the 90 percent significance level employment is significant. CMC clients appear to somewhat larger than nonclients. Further bivariate analysis of the employment variable and the location variable find only the location variable to be statistically significant. Results from these bivariate analyses are in Table VIII - Model 3 and Model 4.

Table VIII
1997 Client and Nonclient*

Variable	Description	Models			
		=1	=2	=3	=4
TPERE	Tuition per employee deflated	0.0008 -0.3630	0.0020 -0.3610		
UPGRDEM	Upgrade machinery	-1.4670 -0.0730	-1.0000 -0.7670		
CHICAGO	City of Chicago		11.2410 ‡ -0.0410		2.00 -0.012
GPRCC	Gross profit replacement cost of capital		-2.6390 -0.1925		
CUST3	% sales to customers not served 3 years ago		0.0170 -0.7430		
FCUST	% sales to customers outside U.S. last year		0.2120 -0.5170		
EMP	Total employees		0.0420 -0.0760	-0.0050 -0.2010	
TECHIND	Technology index - sum		-3.4940 -0.1000		
OUTASSIST	Outside assistance		0.2720 -0.9070		

*1=1997 client; 0=1997 nonclient
†Significant at the 90 percent level
‡Significant at the 95 percent level
§Significant at the 95 percent level

In conclusion, with the exception of location, CMC clients and nonclients appear to have similar characteristics in 1997. CMC clients are more likely to be located in the city of Chicago. There is some evidence at around the 90 percent level of significance that CMC clients are less likely to have invested in machinery and equipment and less likely to have adopted the ITs that make up the technology index.

iii. CMC Clients - 1996 and 1997

A similar series of analyses and modeling was then conducted for CMC clients over the two time periods. In this case the dependent variable was "1" for 1996 and "0" for 1997. Similar variables were tested as in the previous models.

Table IX
Descriptive Statistics for 1996 and 1997 Client Continuous Variables

Variable	Description	Client Status*	Mean	Standard Deviation
SLCPE	Sales less costs	1	2,976.42	3,348.55
		0	2,258.04	3,924.67
GP	Gross profits (sales less costs less cost of capital)	1	2,718.91	3,241.90
		0	2,122.51	3,887.65
GPRCC	Gross profit replacement cost of capital	1	1.57	1.99
		0	4.65	13.33
GPE	Gross profit per employee	1	27.86	21.65
		0	31.72	41.71
SPE	Sales per employee	1	31.66	20.17
		0	33.14	41.40
VA	Value added	1	60,844.91	23,818.23
		0	57,672.08	50,308.38
PROD3	% sales from products not made 3 years ago	1	21.99	18.47
		0	29.23	33.50
CUST3	% sales to customers not served 3 years ago	1	17.65	17.13
		0	22.88	25.91
FCUST	% sales to customers outside U.S. last year+	1	10.57	15.49
		0	2.55	4.77
EMP	Total employees	1	82.13	70.91
		0	67.31	70.43
TPERE	Tuition per employee deflated	1	149.40	181.59
		0	346.95	495.55
TPERS	Tuition as percentage of sales	1	0.12	0.14
		0	0.32	0.53
TECHIND	Technology index	1	2.03	1.31
		0	1.42	1.08
KEYPE	Keyboards per employee	1	0.22	0.22
		0	0.17	0.24

*1=1996 client; 0=1997 client
+Significant at the 99 percent level

Table IX and Table X indicate that the t-statistic for percentage of sales to customers outside the United States was significant at the 99 percent level while whether or not firms upgraded machinery was significant at the 95 percent level. CMC clients in 1996 were more likely to have invested in machinery and equipment and had a higher percentage of sales outside the United States than their 1997 counterparts.

Table X
Descriptive Statistics for 1996 and 1997 Client Binary Variables

Variable	Description	Client Status*	Mean	Standard Deviation
CADIN	Use CAD data to generate	0	0.2900	0.4700
		1	0.3800	0.4900
CADOUT	Receive CAD	0	0.3100	0.4800
		1	0.5000	0.5100
CHICAGO	City of Chicago = 1	0	0.3800	0.5000
		1	0.2600	0.4400
ECOMMERCE	Do business electronically	0	0.4400	0.5100
		1	0.4700	0.5100
ISO	ISO certified	0	0.0000	0.0000
		1	5.13E-02	0.2200
OUTASSIST	Outside assistance	0	0.6200	0.5100
		1	0.5700	0.5000
SIC20	VSIC20	0	6.25E-02	0.2500
		1	2.56E-02	0.1600
SIC30	VSIC30	0	0.1300	0.3400
		1	0.1500	0.3700
SIC34 35	SIC34 35	0	0.3750	0.5000
		1	0.5128	0.5064
SPC	Use SPC	0	0.4400	0.5100
		1	0.5100	0.5100
UPGRDEM	Upgrade machinery+	0	0.2500	0.4500
		1	0.6800	0.4700

*1=1996 client; 0=1997 client
+Significant at the 99 percent level

Results from the logit analysis are presented in Table XI. In the reduced model (Table X, Model 1) whether or not a firm invested in machinery and equipment is significant at the 95 percent level while expenditure on training and tuition is significant at the 90 percent level. CMC clients in 1996 are more likely to have invested in machinery and equipment while 1997 clients are more likely to have spent more on training and tuition than 1996 clients.

Table XI
1996 and 1997 Client*

		Model 1	2	3
TPERS	Tuition as percentage of sales	-0.003	-0.003	-0.003 †
		-0.071	-0.393	-0.073
UPGRDEM	Upgrade machinery	1.714 ‡	-2.091	2.025 §
		-0.049	-0.467	-0.07
CHICAGO	City of Chicago = 1		-3.436	-0.880
			-0.077	-0.302
FCUST	% sales to customers outside U.S. last year		0.538	
			-0.108	
EMP	Total employees		-0.244	-0.005
			-0.096	-0.484
TECHIND	Technology index		2.296	
			-0.104	

*1=1996 client; 0=1997 client
†Significant at the 90 percent level
‡Significant at the 95 percent level
§Significant at the 90 percent level

In the full model (Table XI, Model 2), employment and location are significant at the 90 percent level. 1996 clients are more likely to be located in Chicago than 1997 clients. In addition, CMC clients in 1996 are likely to be smaller than clients in 1997. In this model, upgrading machinery is no longer statistically different than zero.

In order to investigate these findings further, additional models were constructed. A bivariate model was constructed with employment as the only independent variable. Results from this model indicated that the null hypothesis in this case cannot be rejected. There was no difference in 1997 between clients and nonclients in terms of employment. Similar bivariate models were constructed and similar results obtained for percentage of sales abroad, location, and technology-index variables. However, when models were constructed for tuition per employee and upgrading machinery and equipment a significant difference was obtained. Nineteen ninety-six CMC clients were likely to have spent less on training per employee and more likely to have upgraded machinery than clients were in 1997. A final model was constructed using upgrade in machinery and equipment, training per employee,

employment, and location. The technology index was excluded as it was highly correlated with employment (-0.8). This was also the case with percent of sales abroad (-0.8). Results from this model, displayed in Table XI as Model 3 indicated that investment in machinery and equipment, and training per employee are significant at the 10 percent level.

In sum, the results point in the direction that CMC clients in 1996 were more likely to have invested in machinery and equipment than those clients doing business with CMC for the first time in 1997. In addition, CMC clients in 1996 spent less on real tuition per employee than clients in 1997. The result of significance obtained for the investment variable is as hypothesized. It demonstrates a shift in client profile away from companies that were more likely to have invested in machinery and equipment and toward companies that were more likely to be representative of the population as a whole.

iv. **Nonclients 1996 and CMC Clients 1997**

This combination of program participation was constructed to test the hypothesis that 1997 CMC clients were representative of the population not only in 1997, but also in 1996. Examination of the-t-statistics and chi-squared statistics (Table XII and Table XIII) indicated that this was true with the exception of percentage of sales to customers outside the United States and located in the city of Chicago. CMC clients in 1997 were less likely than 1996 nonclients to have sales abroad.

Table XII
Descriptive Statistics for 1996 Nonclient and 1997 Client Continuous Variables

Variable	Description	Client Status	Mean	Standard Deviation
SLCPE	Sales less costs	1	3,044.82	3,766.18
		0	2,258.04	3,924.67
GP	Gross profits (sales less costs less cost of capital)	1	2,742.64	3,621.81
		0	2,122.51	3,887.65
GPRCC	Gross profit replacement cost of capital	1	1.58	1.78
		0	4.65	13.33
GPE	Gross profit per employee	1	29.69	28.15
		0	31.72	41.71
SPE	Sales per employee	1	33.87	27.88
		0	33.14	41.40
VA	Value added	1	64,110.00	33,064.90
		0	67,672.08	50,308.38
PROD3	% sales from products not made 3 years ago	1	22.43	19.27
		0	29.23	33.50
CUST3	% sales to customers not served 3 years ago	1	22.91	19.79
		0	22.88	25.91
FCUST	% sales to customers outside U.S. last year	1	8.33	11.44
		0	2.55	4.77
EMP	Total employees	1	78.40	67.75
		0	67.31	70.43
TPERE	Tuition per employee	1	379.90	635.03
		0	346.95	495.55
TPERS	Tuition as percent of sales	1	0.42	0.86
		0	0.32	0.53
TECHIND	Technology index	1	1.87	1.30
		0	1.42	1.08
KEYPE	Keyboards per employee	1	0.27	0.35
		0	0.17	0.24

*1=1996 nonclient; 0=1997 client

[a]Significant at the 99 percent level

A logit model was then constructed to measure any significant differences in characteristics between nonclients in 1996 and clients in 1997 (Table XIV). It should be noted that location appeared as significant at the 10 percent level. Nineteen ninety-six nonclients were less likely than 1997 clients to be located in Chicago. However, no variable was significant at the 95 percent level allowing for the general acceptance of hypothesis that there is no significant difference between the two groups – clients in 1997 were representative of the population of nonclient firms in 1996.

Table XIII
Descriptive Statistics for 1996 Nonclient and 1997 Client Binary Variables

Variable	Description	Client Status*	Mean	Standard Deviation
CADIN	Use CAD data to generate	0	0.41	0.50
		1	0.27	0.46
CADOUT	Receive CAD	0	0.57	0.50
		1	0.36	0.50
CHICAGO	City of Chicago†	0	0.12	0.33
		1	0.35	0.49
ECOMMERCE	Do business electronically	0	0.62	0.49
		1	0.41	0.51
ISO	ISO certified	0	7.14E-02	0.26
		1	0.00	0.00
OUTASSIST	Outside assistance	0	0.57	0.50
		1	0.57	0.51
SIC20	SIC 20	0	7.14E-02	0.26
		1	5.88E-02	0.24
SIC30	SIC 30	0	9.52E-02	0.30
		1	0.12	0.33
SIC34_35	SIC 34 or 35	0	0.4524	0.5038
		1	0.4118	0.5073
SPC	Use SPC	0	0.41	0.50
		1	0.47	0.51
UPGRDEM	Upgrade machinery	0	0.48	0.51
		1	0.29	0.47

*1=1996 nonclient; 0=1997 client
†Significant at the 99 percent level

Table XIV
1996 Nonclient and 1997 Client*

		Model 1	Model 2
TPERE	Tuition per employee	0.001	-0.001
		-0.962	-0.497
UPGRDEM	Upgrade machinery	0.261	-0.424
		-0.728	-0.707
CHICAGO	City of Chicago		-2.300
			-0.067
FCUST	% sales to customers outside U.S. last year		0.155
			-0.308
EMP	Total employees		-0.009
			-0.245
TECHIND	Technology index		0.705
			-0.146

*1=1996 nonclients; 0=1997 clients

E. Synopsis

The data supports the original hypothesis that 1996 CMC clients are significantly different in terms of technology investment than 1996 nonclients, using the upgrading of a machinery and equipment as one measure of propensity to adopt new technologies. CMC clients in 1996 are more likely to have made recent investments in machinery and equipment than nonclients. While this seems to be consistent with the original mission of the MEP program - to assist firms in adopting new technologies and/or in modernizing - one would have anticipated that other variables, such as adoption of electronic commerce and the technology index would be statistically significant. This is not the case.

When one reaches 1997, the results indicate that the profile of CMC clients changes, with regard to propensity to adopt technology, to be more like the general population. The only major statistically significant difference between these two groups is that the 1997 CMC clients are more likely to be located in the city of Chicago than nonclients. With the exception of some

tentative results with regard to their location, additional modeling results indicate that CMC clients in 1997 are not statistically different than non-CMC clients in either 1996 or 1997.

In sum, the MEP program, as carried out by CMC, moved away from a propensity to have clients that are more likely to be technology innovative to firms that, if anything, have a less than average propensity to invest in technology. In the following chapter the logit analysis was supplemented by examining in more detail the CMC-client base using several case studies. These case studies are used to illuminate the conclusion reached in this chapter - there is a difference between clients in 1996 and 1997 in their technical sophistication and willingness to modernize through technology.

VIII. CMC-CLIENT CASE STUDIES

A. Introduction

Case studies of six CMC-client firms are presented in this chapter: the first three case studies are of firms that became clients prior to 1997; the second three case studies are of firms that became clients after 1996.[37] These case studies provide a qualitative analysis that illuminates the quantitative analysis provided in the previous chapter. The evidence from these case studies supports findings of the previously discussed statistical hypotheses – firms that became CMC clients prior to 1997 tend to have different characteristics compared with those that became clients in 1997 or later. They also demonstrate that all six interventions are considered successful using NIST MEP evaluation criteria, although only three involved increased technology adoption by the firm.

B. Pre-1997 Case Study 1 - Company A

1. Company Profile

Company A operated in the metal-fabricating industry (SIC 34) producing metal products. Established in 1908, this third-generation, family-owned, Chicago-based company has had its current leadership since 1984. Annual sales were around $10 million, having increased by 500 percent since 1992. In tandem, the company's workforce increased steadily since 1985 reaching forty-five employees in 1992. This increased to sixty-five in 1999. The firm is nonunion.

[37] Case studies were selected randomly from those CMC clients who had comprehensive client files within CMC at the time of this study.

2. CMC Involvement

A company assessment was made in 1992 by the CMTC. Company A, using CMC, the successor of CMTC, as a resource, undertook most of the recommendations made by the assessment team. Company A was one of CMC's first customers, and became a client in 1994.

3. Technology and Process Improvement

The assessment team found the plant to be fairly well laid out, providing a circular workflow for principal products. At the time of the assessment, the bulk of the company's production equipment dated from 1930 to 1950. The company maintained and built its own tooling and some product equipment. However, the maintenance group was poorly equipped with very old, inadequate machine tools. The assessment team recommended either upgrading or replacing most of the company's existing machinery and equipment.

After receipt of the assessment report, the company's president embarked upon an investment strategy to upgrade and modernize most of his firm's equipment. By 1996 the president added production capacity, purchased a new CNC-bending machine and purchased new machinery to increase product line. He also implemented a computerized-job-tracking system; purchased new computer programs; upgraded two machines; added computers to the shop floor; introduced a purchasing system, new phone system, and a United Parcel Services (UPS) shipping system; and purchased a new crane.

4. Human Resources

The assessment team found high-employee morale at Company A. The employees interviewed by the team were interested in providing good service to the

customers and accepted responsibility for the company's performance. In other words, they considered themselves to be members of a team. On the whole, the team considered the company to have an exceptionally good system for HR. One outcome of the assessment was the identification of training opportunities. These recommendations included basic-manufacturing-skills training, English as a Second Language (ESL), quality-systems (QS) training, and HR-systems training.

From 1992 to 1996 the company spent considerable resources on workforce development and training. The long-term objectives included increased communication between management and employees, between coworkers, improved worker ability to cope with and resolve work-related problems, and implementation of self-directed work teams. Other HR initiatives included the facilitation of company changes in technology and organization, development of a learning organization that promoted a worksheet-learning culture, and clear communication to employees about the company's new emphasis on learning. Implementation of these development and training initiatives involved hiring CMC to conduct back-to-learning workshops, one-to-one advising with employees, on-site ESL classes for Polish- and Spanish-speaking employees, and development of individual-learning plans. The president also established an in-house training facility to demonstrate his strong support for these efforts.

5. **Quality**

The assessment team concluded that, without having formal QS, the company produced a quality product that satisfied customers. The assessment team report noted that the company's customers were likely to insist on a formal system in the future and recommended that before customers began demanding it, the company

implement a formal QS. CMC worked with the company to achieve this. At the time of writing, company had not applied for ISO/QS certification.

6. New Products

The company had and continued to have the ability to quote and deliver special orders rapidly, leading new customers to become regular customers. The assessment team concluded that, "while the actual market size for the company's products was unclear, the company could compete cost effectively with firms that produced similar products in-house for use in its final product...this large, hidden market could be served by JIT delivery to companies in the Midwest." This is what the company decided to do. Now it sells CNC products in new markets, not only in the Midwest, but also throughout the country.

7. Impact of CMC Involvement

Company A was an exemplary CMC case study, demonstrating the success of a holistic approach when working with a company that has a far-sighted owner. The company's president was receptive to ideas that would help grow his company through technology, workforce development, and new product lines. The president claimed that working with CMC led him to increase sales by $8 million, as well as growing his employment by 45 percent.

8. Analysis of CMC Activities

Company A is a high performing organization, with management that is open to new ideas and sensitive to workers' needs. Based on CMC's recommendations, management allocated funding for upgrading and replacement of the company's machinery and equipment. Management also followed up on CMC's recommendation of

expanding their product line. Increased productivity occurred as a result of their investment in technology. This company can be considered a successful intervention not only using NIST MEP evaluation criteria but also in relation to the original MEP mission of increasing technology adoption in SMMEs.

C. Pre-1997 Case Study 2 - Company P

1. Company Profile

Established in 1951, Company P produces metal stamping and builds subassemblies that use the stamping (SIC 34). With over $35 million in annual sales and 250 employees, this union shop, Chicago operation is land locked thereby prohibiting expansion at this location. The company has two other facilities, one in the greater-Chicago area and one in the southwestern United States. Company P is one of over one hundred metal-stamping companies within the Chicago region and is growing at an annual rate of 15 percent over the last five years. The company's customers are OEMs in the automotive and consumer-electronics sector located throughout the United States and in Mexico.

The company is currently under the management of the second generation. The hands-on management is involved in every aspect of the business. It is a technology-based company with growth dependent upon being able to design the tooling, control the processes, and manage the complex, progressive-die-manufacturing processes.

The company operates in a highly competitive industry. Most customers are large, sophisticated companies that make purchases based on quality, delivery, and price. Metal stamping is an industry where tooling costs can be high ($50 thousand to $300 thousand) for a single part. Customers typically pay for and own the tooling, with

the metal-stamping companies maintaining, repairing and, if necessary, replacing the tooling for the life of the contract. Order quantities are typically high (hundreds of thousands or millions) and the same part may be produced over a several year period. As the tooling belongs to the customer, the penalty for poor quality, delivery, or price is the removal of the tooling by the customer and the order given to a competitor.

Starting in the early 1990s, Company P's customers have become more demanding and began requiring either ISO or QS certification. One spin-off of these customer demands is that currently almost all communications with the customers are electronic including engineering, sales, and shipping data. Following national trends, the company's customers want to rationalize its supply chain by using fewer vendors and, as a result, have higher expectations of Company P. These include subassembly, packaging for the OEM internal convenience, and shipping precise qualities for delivery at precise times.

2. CMC Involvement

Company P interacted with CMC in a variety of ways over the last six years. The company commissioned an assessment in 1996. Areas identified by the assessment included better control of inventory and materials flow; documentation of QS; Management Information System (MIS); marketing; hazardous waste minimization and disposal; and manufacturing technology and process improvement. In the years following the assessment a variety of improvements were, and continue to be, made.

3. Technology and Process Improvement

CMC's review of the Company P's MIS suggests directions that the company should take. Based on these recommendations, Company P is currently

operating an almost totally paperless operation. Most communication with customers is done using the Internet, while all internal systems are computerized.

CMC helped facilitate the adoption of sensor technologies used in the company's progressive die operations. Such sensors can avoid press crashes, which often lead to extensive die and press damage. Company P installed many of these types of sensors, leading to improved productivity and quality. In addition to direct cost savings as a result of fewer crashes, savings resulted from the reduction in production down time that occurs while a die is being repaired.

4. Human Resources

At the time of the assessment, the team's consensus was that the company had very good training in general skills (ESL and shop math), as well as SPC. The company used many sources for its training including: the TMA program for tool and die makers and for machinists, in-house training for setup men and operators on die sensing, and external courses on a variety of manufacturing-related subject. In addition, the company used a cross-departmental team approach to problem solving. CMC did not make any recommendations in the area of HR, other than to encourage the president to "keep up the good work."

5. Quality

Shortly after the assessment, CMC helped Company P to evaluate its original QS and develop an approach to become ISO and QS certified. Company P is now ISO and QS certified and successfully completed its first recertification. These certifications allow Company P to retain existing customers and to more effectively compete for new national and international customers.

6. City Services

At the time of the assessment, the president expressed some dissatisfaction with the plant's Chicago location. The company had considered moving this headquarters facility to a suburban location. Working with the city of Chicago, CMC was able to help the company solve some local problems including having abandoned cars near the plant towed and making much needed street repairs. In part because of the city's actions, the company remained in Chicago.

7. Impact of CMC Involvement

Since working with CMC, Company P added approximately one hundred employees and almost doubled its sales. Clearly, primary credit went to able, aggressive management working with inputs and suggestions from CMC, along with other external resources. The company, which was technologically based, used more advanced technology to further improve its competitive position.

8. Analysis of CMC Activities

Company P operates in a highly competitive industry. With CMC's assistance, the company rises to this challenge through upgrading their communications technology, internally and externally. They also invest in CMC-recommended sensor technologies that save time and money. Management invests in technology and its workers – the result is a technology-sophisticated company with technology-sophisticated workers. The company is a success story both in terms of meeting NIST MEP evaluation criteria and in terms of meeting the initial mission of MEP.

D. Pre-1997 Case Study 3 - Company T

1. Company Profile

Company T (SIC 33) was founded in 1984, with very limited funding, based on an idea for a plastic communication product. This company, operated out of a five thousand square feet suburban facility and had grown to a $5 million business with approximately one hundred employees. The company's president was the founder and the person with the original concept.

The principal (and original) product is a high-volume, competitively priced electronic component with small parts including some that are gold plated. The company's approach is to purchase parts, both domestically and internationally, for assembly. The company also operates an assembly facility in China, thereby allowing it to avoid paying royalties for final products sold outside of the United States. Although the dominant player in the market, the company does have one competitor. However, its product, though slightly more expensive, is superior in terms of quality

2. CMC Involvement

The president contacted CMC for assistance in 1996. The president was seeking independent advice and recommendations to help him aggressively grow the business. A CMC team conducted an assessment of the company's operations in mid-1996. Recommendations made by the team included broadening the product line, manufacturing improvements, and organizational improvements. Largely because of overwhelming organizational change caused by the company's rapid growth, recommendations regarding organizational improvements have not been implemented.

3. Technology and Process Improvement

The team found that the manufacturing operation was inefficient, and comprised of nonvalue-added activities such as external materials handling and in-process storage. The team estimated that approximately 30 percent of all efforts devoted to manufacturing would be required in an optimum plant. The major discovery by the team was that the company was assembling the product, then checking for quality. While there was 100 percent quality going out the door, around 35 percent of the product was found to be defective during testing and had to be sent back to be reworked.

To address these problems the team had three recommendations. First, so there would be limited rework, it recommended 100 percent quality control be built into the assembly process. Second, so that handling and storage along with supervision were reduced, it suggested the introduction of cellular manufacturing.[38] As a means of minimizing manual labor while improving quality, the team also recommended automation be introduced to replace many of the simple assembly activities.

The company worked with CMC to develop the most cost-effective, cellular-manufacturing system based on planned volumes. CMC also helped develop an overall-automation plan including investment, savings, and return-on-investment estimates. Production within the facilities doubled and further improvement was possible. The company added another twenty-five hundred square feet for a printing operation

[38] Cellular manufacturing is when all parts of the operation are conducted within a "cell" to reduce inefficiencies.

4. Human Resources

The assessment revealed that workforce training would be required if the company was to move toward improved quality and automation. In order to understand product requirements and equipment, the team suggested that workers be cross-trained. Communication with management also needed improvement. CMC identified a variety of related barriers and challenges within the company. First, factory workers were managed in an autocratic way, the president was not what the team considered a progressive manager. In addition, the challenges of multiple languages spoken by employees were made more complex by a lack of clear communication the organization. Based on cross training and new hires, the management and administrative staff (one-third of total employees) evolved into a reasonably effective management team.

Shop workers are relatively unskilled, receive no training, and are paid hourly wages with no benefits worker. They suffer from low morale, primarily because of the indifference shown by the employer. CMC recommends that the company develop an HR plan to help facilitate company growth. One component of the plan is to address the issue of low shop-worker moral. However, the recommendation is not implemented. -

5. Quality

The company's primary product, sold to the communications industry, is a moving product that must have high reliability and service life. As the product is 100 percent inspected, the company claimed that it is very quality conscious. Any product that did not pass the quality test was rejected. The company had a Quality Control (QC) manager who controlled systems and testing. Customers insisted on good products, but did not require ISO certification.

In spite of the fact that Company T produced a high-quality product, the CMC team recommended quality improvements as a top priority. As QC was done manually, the quality approach used by the company was very costly. The team estimated this labor-intensive, quality effort, conducted at the end of the assembly process, and was responsible for 25 percent of total manufacturing costs. The company acted upon this recommendation and automated part - up front in the assembly stage - of the quality process. This automation significantly reduced the cost of detecting flawed products.

6. Marketing and Product Diversification

The president is very aggressive and interested in growth through product differentiation and the addition of new product lines. The original product continues to represent over 50 percent of total sales. Based on CMC recommendations the company continues to develop that market with variations on the same theme.

The team suggested that the company should consider product diversification as a strategy for growth. The president, acting upon this recommendation, introduced new complementary products and began acting as a distributor for companies making noncompetitive products. CMC also conducted a market research study and identified a possible a new addition to the company's product line. This recommendation was adopted and is very successful.

7. Impact of CMC Involvement

Based on CMC's advice and marketing research, the company increased growth primarily by adding new product lines and introducing manufacturing-process

improvements and technoiogies. Since 1996, sales grew by 300 percent. No action was taken by the president to address the HR issues.

8. Analysis of CMC Activities

CMC made a number of technology and HR recommendations to Company T. Company management was very receptive to the technology-related recommendations – investing in automation technology that allowed production to double. In terms of manufacturing process, company owners responded positively to CMC's recommendations for cellular manufacturing and increased QC processes. With increased production capacity arising from these changes, management was able to act on yet another of CMC's recommendations – product diversification. However, company owners were not receptive to CMC ideas for improving worker morale. No HR issues were addressed by the company as a result of the assessment.

Company T is successful when measured against MEP evaluation criteria and MEP's mission. While not part of the MEP mission it should be pointed out that, in contrast to the previous two case studies, this company has not introduced any initiatives that improve shop worker training or morale.

E. Post-1996 Case Study 4 - Company B

1. Company Profile

Company B (SIC 35) is a privately held company founded during World War II in Chicago. The present owners assumed control of the company in 1979 and moved to its present, well-maintained, sixty thousand square feet building in a suburban location in 1984. The company move was due to a need for more space to accommodate an expansion and also a desire to purchase property rather than continue leasing.

The company has approximately fifty employees, thirty of whom are union. It produces a special machine tool and has 16 percent of the U.S. market. The company has very sophisticated marketing material and participates in trade shows. Its equipment, while workable, is old

Employment has remained relatively unchanged over the past five years, with sales increasing by 5 percent annually over inflation to approximately $5 million. Company B is the largest of the independent producers of this tooling and sets the quality and price standards. The overall market is growing little, if any, so significant growth can come only from beating out competitors or offering new products.

Company B, although consistently profitable, invests little since moving to its current facility. The equipment in the plant is old and predates CNC and other technological innovations. For this reason the operators are crucial and can only specialize on one machine. However, the equipment is comparable with that used by Company B's competitors. There is no equipment commercially available to replace the present equipment, but CMC engineers believe that alternate, more efficient, approaches could be developed. As a way to give Company B a competitive advantage, the new president is interested in trying to develop alternative equipment. The owner is currently unwilling to allocate funds for development of this computerized-metalworking-process machinery.

This type of technological application would lead to equipment taking up less floor space and reductions in processing time. It would also lead the company to lay off workers if it did not grow its market.

Because of health problems, the owner hired an external person as president in 1997. Since then investment has increased slightly. Because of concerns about the company's computer's ability to successfully handle the change from the year 1999 to 2000, approximately $0.25 million was invested in a new computer and MIS system. -

Because it takes several years to become proficient at operating the manufacturing equipment, workers in the plant are highly skilled and most have been with the company for many years. The company pays for the training and tuition costs for workers to attend schools and short courses.

Prior to 1997, management style was very traditional, leading to ill will between management and factory workers. Workers reportedly felt that they were doing what they were told to and nothing more. Their opinions were neither solicited nor listened to by management.

2. CMC Involvement

CMC conducted an assessment of Company B in 1994. However, the company owners did not pay attention to the recommendations until 1997. Shortly after the death of a partner in 1997, the owner contacted CMC to help him select and hire a new president. On an ongoing basis, the new president used the assessment tool to help plan future company activities. Areas identified in the assessment included improved MIS, improved communications with employees, formalized QS, and upgraded technology and equipment. Since assuming his position, the new president engaged CMC to assist in several areas.

3. Technology and Process Improvement

CMC's assessment identified opportunities for technology adoption and equipment modernization in the area of computerized-process machinery. None of these suggestions was implemented. While there were ongoing discussions between the new president and CMC about providing assistance in evaluating alternate-manufacturing technologies, the owner did not give his approval for the recommended investments.

4. Human Resources

The CMC assessment identified tension between workers and the owners as an area that needed to be addressed. The source of the tension was rooted in a strike that occurred in 1992. It was mainly because of the individual's personality and management style that CMC selected and recommended the candidate for the presidency of the company to its owner.

The new president tries to reduce the tension by having more meetings and encouraging open and honest communication at all levels throughout the plan. He also involves workers in the overall planning and operations of the company.

5. Quality

Although its customers do not require quality certification, the company's reputation was based on producing quality products. Prior to CMC's intervention, it did not have formal QS. Beginning in 1997, CMC worked with Company B to help it become ISO certified in the hope of increasing the company's growth opportunities, especially overseas. The company recently received this certification.

6. Marketing

The new president wanted to determine the potential market for the firm's product. In 1997 he hired CMC to conduct a marketing study and to develop a report card to let him know where the company stood in the market. The study involved developing techniques for contacting past customers as a way to increase sales, developing a mailing strategy, methods of scheduling visits to potential customers, and prioritizing where to geographically target sales efforts. Based on perceived strengths from current customer feedback, CMC staff developed a marketing strategy to appeal to new customers and encourage more repeat business. The customer feedback helped the company to determine that it needed to drastically reduce cycle time on quotes. This was, in part, what caused it to invest in improving the MIS.

7. Impact of CMC Involvement

Company B operates in a relatively low-tech industry, where most of its competitors use the same, old technology. This makes it difficult for the firm to maintain its market share.

Actions taken over the last few years led to retaining and slightly increasing market share. New software enabled Company B to more rapidly prepare quotations and this, combined with improved deliveries, gave the company a slight, competitive edge. ISO certification is expected to give the company a marketing edge.

New technology applications would significantly improve productivity and reduce costs. This could double Company B's market share. CMC engineers believe that new applications of existing technology are feasible. The president is in discussions with CMC about technology-based work in the future.

8. Analysis of CMC Activities

CMC made several recommendations to the management of Company B, including investment in new technology. While the new president supported the technology-based recommendations, the owner was unwilling to allocate funds for these investments. The president instituted some changes based on the recommendations, including developing a marketing strategy and making MIS improvements.

However, as the president is not the owner, there is a limit to how much he can do without additional support and resources. The owner appears to be content with the company's current position in the market and is exhibiting satisficing rather than profit-maximizing behavior. This company intervention is successful using MEP evaluation criteria, but only marginally (MIS system) reflects increased firm performance through technology adoption.

F. Post-1996 Case Study 5 - Company W

1. Company Profile

Company W (SIC 29) is an aggressive Chicago-based family-owned business started over fifty years ago. The company remains in the family and has a second-generation family member as its president. The plant provides a specialty-cleaning product for a niche market. The company is the largest of its kind in the United States, is the leader in its niche market, and continues to be profitable. Customers range

from large OEMs (primarily automotive) to hardware stores. The company has approximately twenty-five full-time employees, hires up to six temporary workers to handle seasonal peaks, and has annual sales of almost $6 million.

The company is located in two buildings in an older, light-industrial neighborhood in Chicago. Overall, the facility has good access for trucking, provides adequate space for present operations, and can handle roughly twice the present volume. The primary building, that the company owns, has two floors. This is an advantage for the production methods used, but does require moving considerable material between floors. As the second building, a leased facility used as a warehouse and for shipping, is remotely located it entails additional material handling, making it relatively inefficient. The buildings are old and require ongoing maintenance.

The overall quality of the workforce is good. The company provides paid vacation time, insurance, and bonuses. Workers seem to enjoy working for the company and appear to make every effort to produce a good product that satisfies customers.

The production processes used by Company W are relatively simplistic. The most sophisticated equipment owned by the firm is its packaging equipment, the installation of which led to a significant reduction in production costs.

2. CMC Involvement

CMC's first discussions with this company were about potential growth via acquisition. This led to a company assessment conducted in 1997. Areas identified in the assessment were the need to more fully automate individually packed items, improve

quality, and enhance sales and marketing functions. Along with the suggested equipment improvements, the team also recommended a general upgrading of the plant. Since the assessment, CMC provided services to the company in a variety of areas.

3. Technology and Process Improvement

CMC staff conducted an industrial-engineering review of MIS and plant layout. Suggestions were made and followed that allowed the company to improve both. Some of the suggestions related to improving the layout for new, packaging machinery that would reduce the number of temporary workers required for peak loads. The team estimated that the investment in such machinery would be recouped in a few months, as it would allow for a reduction in workforce while at the same time doubling output. The company delayed in implementing these recommendations. It eventually acquired and installed the new systems which improved shipping deadlines by twenty-four hours and led to the reduction in the need for temporary workers by 50 percent.

CMC also assisted the company with improving the chemical mix of its product, reducing the need for a particular toxic adhesive, which in turn reduced its wastewater stream from four hundred gallons per month to two hundred fifty gallons per month. This saved the company $6 thousand per year in dumping fees.

4. Human Resource

The company is customer oriented and employees assign a high priority to serving customers. Management and supervisor attend appropriate, external courses. The company provides in-house training for workers for ESL and other basic subjects. The relatively few students available for classes limits this in-house approach.

5. Quality

Quality was a major challenge for Company W with considerable rework (approaching 18 percent of production) and with 8 percent of total production scrapped. CMC worked with Company W to improve understanding of the processes and how they could and should be controlled. This led to establishing QS resulting in a 50 percent reduction in rework and to certification in ISO and QS 9000 standards. A simplified chemical-mixing process also helped reduce rework.

6. Marketing

Traditionally, the company had a low-key approach to sales and did little to recruit distributors. CMC helped Company W develop a marketing plan identifying new markets worldwide, improve promotional literature, and to upgrade the representative helping the company. As a result, to focus on its automotive OEM customers, the company added a salesperson in Detroit. It also began exhibiting at trade shows in North America and made plans to exhibit at three major automotive shows in Europe.

CMC carried out a detailed examination of the competitors, domestic and foreign, and found that the company's products were significantly inferior in quality. CMC persuaded the company to change its price-oriented-sales tactics to one of quality and customer service, and to raise prices 10 percent. This was the first price increase in eight years, and resulted in a sales volume increase 8 percent.

The distribution system available to Company W works well for its niche product. Its distributors are however focused on a particular niche, e.g. automotive markets, and have little interest in expanding sales into unfamiliar territory, e.g.

housewares. Therefore, to expand sales the company has to spend a significant amount of time identifying and signing up specialty distributors in other target sectors.

The technical sophistication of Company W makes it unlikely that it can or will develop a new product in house. It is capable of tweaking the product to adapt it to the demands of other sectors. The company is now seeking to expand the usage of its product in new markets, e.g. electronics and housewares, as well as penetrate European and Canadian markets.

7. Impact of CMC Involvement

Company W had sales of slightly over $4 million in 1996 with a full time workforce of twenty-five. By 1999 sales rose to $5.7 million, an increase of 42 percent (net profit increased 25 percent) and sales growth was projected to increase 12-15 percent per year for the next three years. This occurred with the overall workforce remaining the same size. CMC provided Company W with an ongoing resource for management, marketing, and technical assistance. The company was contemplating moving to a new 50 thousand square feet, single-story, building located in the city of Chicago.

8. Analysis of CMC Activities

CMC became involved with Company W because they were initially interested in growth through acquisition. CMC's ability to respond to this request was a direct result of their receiving NIST/MEP funding through the pilot program. Access to Financing. Company W operates in an industry that does not require technological sophistication. This is why the company was looking toward growth via acquisition – their lack of technological sophistication makes it unlikely that they could develop new

products in house. Company W is a company that is interested in change and growth, but not through technology adoption. Therefore using NIST/MEP evaluation measures, this company is considered successful. However, it has achieved increased sales and productivity through means other than technology diffusion.

G. Post-1996 Case Study 6 - Company Q

1. Company Profile

Company Q (SIC 20) makes a specialty-food ingredient that is sold to large and small bakeries. To most of its customers the product is sold through distributors. The larger customers are handled as house accounts. The current president starts the company in 1982. In early 1997, a small, foreign, multinational company purchases Company Q. The company is adequately profitable under the original ownership, but the new owners have a strong interest in making it more profitable and immediately begin pressing management to improve productivity, without allocating funding for capital investment.

Company Q's product is relatively simple and made with old equipment, manual methods, and with experienced supervisors scheduling and controlling the operations. These systems are adequate when the company starts but are already badly stretched by 1997 when the company has grown to one hundred people and $15 million in annual sales.

Attempts by the company to introduce rapid improvement resulted in a variety of changes in the management and supervisory ranks - staff that previously held key positions were moved into positions in which they had no expertise. These changes,

made because of pressure from the company's new owners, resulted in confusion and conflict rather than improvements.

2. CMC Involvement

The company, to help deal with the pressure it was under from the new owners, approached CMC. Employees in the facility felt a real threat - if they did not increase profitability headquarters would move the machinery to other plants. A CMC assessment, conducted in 1997, identified several improvement areas.

3. Technology and Process Improvement

Since the company had limited equipment, changes were suggested to provide some short-term relief and to better schedule the equipment. In the longer term the only solution was to invest in new and better equipment.

Recommendations for short-term action included implementing centralized scheduling rather than having it done by the individual department. This would not only be a more effective use of resources but also minimize conflicts between departments. At the time of the assessment, scheduling was occurring without first determining if all the necessary inputs were available. This problem would be eliminated with centralized scheduling. A second recommendation was increasing data integrity throughout the organization. This would require more accurate reporting throughout the processing, as well as for material and shipment. It would also require systems to assure that the physical count and computerized information were regularly correlated. The company implemented both these recommendations.

The assessment team recommended some longer-term equipment and technology-related improvements. These included investing in additional automation to reduce the cumulative strain of employees manually lifting, transporting, and delivering items. A second recommendation was to review the economics of investing in bulk-handling systems for large-quantity-raw materials. This pneumatic-bulk-handling equipment, while involving significant up-front expenditures would result in even greater savings in the long run. Unfortunately, due to the continued squeeze on costs by the new owners, the plant was not given sufficient resources to invest in new equipment and technology.

4. Human Resources

First and foremost, the assessment team noted that due to the pressure from headquarters, the company was operating in chaos. Supervisors did not know how to handle the pressure they were under from headquarters, resulting in a chaotic environment. The team found excessive layers of management, while at the same time, minimal supervision of line employees. As line employees were not getting adequate OTJ training, this was causing problems with employee retention and long-term performance. In addition, there was little coordination between shift managers and no team building among employees.

As part of an overall-training plan, the team recommended more formal training on sales and equipment operation. Also suggested was a comprehensive audit and evaluation of all aspects of HR. The audit would determine the extent of gaps between best practices and the current practices of the company. The analysis would also

prescribe additional measures needed to improve approaches and methods.

Unfortunately, none of these HR recommendations were adopted. They are not viewed as cost-reduction strategies by management, who continued to operate in a crisis mode.

5. Quality

A more formal QS, that is less dependent upon the workers, was recommended. It appeared to the CMC team that the existing-informal system costs more in the long run than implementation of a more formal system. No changes were made to the plant's QS.

6. Impact of CMC Involvement

Because of the pressure from the new owners, Company Q's management was unwilling, or unable, to take any actions that would not produce immediate results. Management was convinced that unless immediate productivity improvements were achieved, Company Q's operations would be split up among other plants belonging to the new owners. Company Q immediately implemented some of the short-term suggestions and started working on others. In the short term, the results were adequate enough to satisfy the remote owners. Unfortunately, once these immediate improvements were made, the remote owners asked for even more immediate results. The CMC staff involved felt that Company Q was not being given the time or resources to make substantive improvements, but rather was being driven from one quick fix to the next. The resulting improvements were sufficient to provide the increased-profit levels demanded by the owners in the short run. In the long run, in the absence of capital investment, Company Q seemed destined to remain marginal until a competitor with more advanced technology and systems puts it out of business.

7. Analysis of CMC Activities

Company Q finds itself in the position of needing to upgrade its machinery and equipment to stay competitive in the long run. However, it has been recently purchased by overseas investors who are so far reluctant to make such a financial commitment. CMC made numerous recommendations for improved performance - technological, HR, and quality. The management has only been able to adopt those recommendations that are low cost and result in increased short-run profits. Through the eyes of NIST MEP evaluation criteria, this company is a success story. However, improved performance is not only short-term, but also not a result of technology diffusion.

H. Synopsis

These case studies support the hypothesis that the average CMC-client profile changed from the pre-1997 period compared to the post-1996 period. Client firms tend to be more sophisticated and more interested and willing to adopt new technologies in the first period compared with the second period.

In all cases, the CMC intervention would be considered successful using NIST MEP evaluation criteria of increased sales; reduced labor costs; reduced inventory costs; and jobs retained or created. However, these case studies illustrate that this success can be obtained through a variety of mechanisms, not necessarily technology adoption. Companies that were assisted by CMC prior to 1997 tended to adopt recommendations made by CMC that were technology related. This becomes diluted in the post-1996 clients, who tend to adopt quick-fix solutions that are not technology-based.

The analyses presented in these last three chapters support the hypothesis that, since the inception of the program, encouraged by NIST/MEP, the profile of CMC-client firms and the composition of service provision changed. During the period 1994 to 1996 CMC-client firms tended to be more likely to be adopters of technologies compared with nonclient firms. In this time frame, services delivered tended to be heavily concentrated in technology-related areas. After 1996 a change in firm characteristics and service delivery was observed. CMC clients became indistinguishable from nonclients, while services provided and delivered moved away from being technology focused and became more oriented toward general-business assistance.

IX. CONCLUSION

A. Introduction

The goal of this research is to examine the evolution of the MEP program and to evaluate its effectiveness in meeting the original federal-program mission of facilitating technology diffusion to SMMEs. The research traces the evolution of the program between 1988-1998. It focuses on the theoretical basis of federal and subnational technology-diffusion policy; the program's development to meet the policy goals; the delivery of services to SMMEs by MECs; and evaluations of whether the provided services met the original goals. This involved:

1. Examination of the economic conditions that led to the development of the MEP program.

2. Were the goals of the program consistent with the theories?

3. Using CMC as a case study, did the program meet its original goals and mission? If not, in what direction did the program move and why?

The MEP program was instituted in 1988 for the purpose of increasing the global competitiveness of SMMEs through promotion of technology adoption. Originally funded at an annual level of $2 million, the program was expanded during the Clinton administration. As of 1998 the program developed into a nationwide network of extension centers with total federal funding of $111.04 million. The original legislative mission remained unchanged during the period, while the type of service expanded considerably.

This research begins with a discussion of technology-diffusion and economic development theories. Federal MEP-policy development is based primarily on the neoclassical theory of technology diffusion and is designed to address the identified weaknesses of market imperfections in the area of access to technology-related information. However, the program

evolves over time. Policy entrepreneurs within the MEP system identify a nontechnology-services market and begin to deliver those services to SMMEs. The anticipated elimination of the federal subsidy is the factor that probably precipitates this evolution for the following reason. The initial legislation was flawed because of the sunset provision. While it is laudable to get the government out of providing services that are provided by the private sector, could this ever have been done for the technology-diffusion MEP program? Analysis indicates that there is a need for a public subsidy for this type of program. For the very reasons of market imperfection in information delivery and the satisficing nature of many SMMEs, it is not possible to operate a technology-diffusion program for SMMEs without the public subsidy. This is later recognized at the national level when the sunset provision is eliminated. However, by this time, MEP centers evolved, changing their behavior to supply services that SMMEs are more willing to pay for. In the case of CMC, areas of concentration in service delivery HR, quality, and market development; at the national level the areas are quality, business systems, process improvement, and market development.

Program officials at the federal, state, and local level operated under an evolutionary paradigm. They changed the service mix offered to respond to market demand, while trying to obtain additional funding to subsidize these activities. However, the criteria on which the program is evaluated remains firmly rooted in neoclassical tradition. Metrics used in evaluating program success include reduced labor costs, reduced inventory cost, job creation, and increased sales. Program success, using impact as a measure of success, does not depend on types of services offered or whether these services are being offered as a result of market failures. Metrics that are not as easily observable, such as adaptive learning of both firms and policy makers, are not considered in the evaluation criteria.

Discussion in the earlier chapters of this research illustrates how there may be a dichotomy between federal- and state-government goals and expectations. Theory applied to the national level indicates that productivity improvements, in and of themselves, may be sufficient criteria to judge program success. This can frequently occur with job loss being experienced simultaneously (hence, the labor cost metric used by MEP evaluators). However, at the state and local level, indicators such as job creation, job retention, and increased tax revenue are priorities. Without a meeting of the minds between federal and subnational policy makers on mutually agreeable and noncontradictory-evaluation metrics, MECs are often pulled in opposite directions.

B. Summary and Discussion of Results

Statistical analyses presented in this research consists of several components:

1. Trends in CMC-project activity between 1994-1999,
2. Logit analyses of clients and nonclients, and
3. Case studies of clients.

Examination of the trends in project activity at CMC between 1994-1996 shows that CMC-service delivery is heavily concentrated in the area of technology. Seventy-seven percent of the projects are technology related. A shift in service delivery is observed after 1996. During this period the percentage of technology related projects falls to 38 percent. Figures for the system as a whole are 52 percent and 50 percent respectively. Other CMC project characteristics that change between these two periods are: average cost of a project increases from $3,385 to $6,843 and the average time for a project decreases from 104 hours to 81 hours. The conclusion, based on these statistics, is that in the Chicago-area SMMEs are paying more for less-intensive, nontechnology-related projects. At the national level, only half of the services being provided can be considered technology-related projects.

This analysis is supplemented with logit modeling that examines CMC-client and nonclient characteristics. The findings from the logit analyses are that the characteristics of CMC-client firms in each period are significantly different. The profiles of pre-1997 CMC-client firms are more likely to have invested in machinery and equipment than nonclients. After 1996 the most statistically significant difference between CMC clients and nonclients is their location: CMC clients are more likely to be located in the city of Chicago. These results indicate that while before 1997 CMC clients are those that were more likely to have invested in technology, after 1996 their characteristics are not significantly different than the general population of SMMEs. Any de facto targeting of firms that occurred before 1997 is not occurring after 1996. The logit-modeling analysis is supported by the findings from the case study-analyses of six CMC-client firms. Three of the firms examined become CMC clients before 1997; three of the firms become clients after 1996. Examination of these firms shows that the first three firms tended to have modernizing characteristics. This is demonstrated by their willingness to upgrade and modernize their equipment and make improvements to their production processes. Firms that became clients later in CMC's history are not interested or able to implement similar modernization-through-technology changes.

C. Public Policy and Program Evolution

The analysis in Chapter 7 demonstrates that post-1996 CMC clients are not statistically different than the SMME population. These firms require and purchase nontechnology-diffusion-based services. The inference from this analysis is that CMC's service delivery evolved to deliver more general-business assistance largely because of the demand from the general-SMME market.

This is important for many reasons and needs to be addressed by policymakers. First, although this evolution occurred there has been little demonstration of a need to continue public-sector intervention. In the early program years there is demonstration, although not

comprehensive, that the problem of a lack of technology diffusion in the SMME market is real. MEP continues to be legislatively perceived as a technology-diffusion program. MEP evaluation continues to be based on firm-productivity criteria, regardless of how it occurs. Currently, there is weak evidence that the problem with SMMEs is a lack of technology adoption. Even if the need for technology diffusion is true, after 1996 this is not the primary area of service delivery in Chicago. It is only 50 percent of the service delivery at the national level. Given this, by objective criteria the program as implemented is set up for failure using process-evaluation criteria.

D. Policy Recommendations

1. State and Local

CMC behaved in a manner fully consistent with evolutionary theory. It adapted to a changing environment by delivering an evolving portfolio of service-delivery areas. Given the threat of the sunset clause, CMC management sought to provide services that would generate revenue for the organization and allow them to continue to operate as a going concern. Chapter 6 contains evidence that staff felt that CMC spread itself too thin during this evolutionary process and was diluting the organization's overall impact. Clients were also sometimes confused by the wide variety of services CMC offered. Evolutionary theory tells us that in order to be successful firms should chose to deliver services that conform to its structure and core capabilities. These factors need to be consistent with articulated strategies and management. Applying this theory to the situation CMC was placed in and how the organization responded to the challenge, it can be concluded that the organization moved very far from its original strategies and core capabilities. As an organization, CMC should regroup and embark on a strategic-planning process that brings the organization back to its core capabilities. This will allow the organization leadership to clearly articulate what CMC is and what niche it is best suited to service.

Once a strategic-planning process is completed, CMC management will be in a position to identify partners who can complement their service delivery. At this point in time, evidence suggests that partners identified in the original MEP proposal have fallen by the wayside (Youtie, 1997). Identifying, approaching, and obtaining buy-in from potential partners that complement CMC's core capabilities may be difficult and needs to be approached as a long-term process. However, development of good partners will be a strong asset for CMC both in terms of their political credibility and their financial success.

Having said this, the reality is that the sunset provision is eliminated. CMC, as well as its sister centers, continues to receive federal and subnational financial assistance. In the case of CMC, this figure is $4.9 million for the year 2000. State and local governments need to evaluate the funding they provide CMC given its service-delivery mix, and determine if CMC is the appropriate organization to receive business-assistance dollars. One option the state and local funding agencies could consider would be to specify the types of services that taxpayers dollars can be used for. They could also consider making it a contractual requirement/evaluation metric that CMC establish real partnerships with complementary-service providers. These service providers would also have to be contractually required to establish real partnerships with CMC. City and state officials could take a more direct approach by contractually insisting that CMC accept client referrals from them at a reduced-rate negotiated up front between CMC and government officials; this may even be free to the client depending on type of service and what officials consider priorities. Another way of saying this is that policymakers need to give serious thought to adopting and applying "but for" conditions to the Illinois manufacturing-extension program. It makes sense to have a sliding scale based on ability to pay and need. The fee could also vary depending on the type of service provided, the potential public benefit associated with the service, and the provision of the service by the private market.

An SMME-needs analysis, Illinois Modernization Survey, was conducted by CMC and the IMEC in 1998. At a minimum, CMC, state, and local officials should use this data to help determine SMME priorities from the firm's perspective. This would help CMC, state, and local officials determine what their priorities should be in terms of meeting the needs of SMMEs.

In sum, recommendations made at the state and local level are:

- CMC should embark on a strategic planning process to help move the organization back to providing services that are consistent with its core capabilities.
- CMC and state and local government officials should analyze the Illinois Modernization Survey results to provide guidance on organization, policy and program design and direction.
- Once core competencies have been identified, CMC management must decide if they want to remain a nonprofit, government-subsidized program.
- If CMC decides to remain a government assisted program CMC staff and management, with the assistance of state and local government program staff, should identify, approach and establish effective partners that would complement their own service delivery.
- Following from this, state and local government officials should reexamine the measurements of success used to evaluate CMC. The goals and mission of the program from the government perspective need to be clearly articulated. Things to consider in designing metrics include how to share credit with partners, how to account for adaptive learning on the part of firms, and varying metrics by type of service.

2. National

As the data in Chapter 6 indicate, compared with CMC, the national system has not experienced as dramatic of a swing in terms of service-delivery mix. However, these national averages mask what is happening on a center-by-center basis, particularly since centers received funding at different times and therefore would have responded to the implications of the sunset provision at different times. What the data does indicate is that 50 percent of services delivered are nontechnology related. In my opinion, this leaves the national system open to scrutiny and potential criticism.

It is essential that the need for a technology-diffusion program be reexamined at the national level. In the short run this would involve asking SMMEs to identify and prioritize their problems by conducting a nationwide-needs analysis. In the long run, other options should be considered, such as using trade associations or the U.S. Bureau of the Census to collect this and other firm-specific information that would be invaluable to public policymakers, practitioners, and academics doing research on microeconomic issues.

Once the needs of SMMEs are identified, analyzed, and prioritized, the next step would be to determine the appropriate role of the national and subnational governments. This would involve an analysis of market conditions structured around the problem areas previously identified through the needs analysis: the creation of an inventory of the services currently provided by the private sector and their accessibility by SMMEs; and identification of the services that are being under supplied by the private sector. This analysis would need to be conducted at a subnational level, as market conditions will vary by geography.

The following issue should be addressed after conducting a needs analysis of SMMEs and research on market conditions that identify the market imperfections. Once there is determination of the need for a government program that targets SMMEs, the issue of service

delivery must be addressed - should service delivery focus on technology services, nontechnology-related services, or some combination of the two. At this time, appropriate metrics need to be developed - based on goals - to evaluate the success of program. The types of services to be delivered should guide the development of such metrics.

Noticeable absent from the current evaluation criteria are metrics measuring benefits to workers or overall public benefit. Existing metrics are focused on measures of productivity of private firms. However, as this is a government-funded program, metrics should not just focus solely on indicators of improved productivity. One consideration that needs to be addressed is who benefits from this transfer of public-sector dollars to private-business owners. This would include consideration of impact on the well being of workers. An example of this type of a metric would be a connection between the amount of public assistance a business receives and the types of improved training a business provides for workers that enhance the workers' economic mobility and marketability. This type of addition to the evaluation criteria would be a start in trying to capture the adaptive learning that goes on within a firm. The service-delivery evolution that occurs through the learning experiences of policymakers and program staff should also be added to the evaluation criteria. Public-good metrics could include community benefits and other spill-over impacts arising because of the program.

The MEP should not be exempt from the "but for" condition required by almost every economic development program. Some type of "but for" criteria need to be adopted. This could involve demonstration that the firm would not undertake productivity-enhancing projects in the absence of the MEP program. The criteria could also include benefits arising from the project that generate public benefit and community spill overs consistent with other stated public policies. However, addressing the "but for" concern does not address the question of the need for the types of services provided, nor the appropriateness of government's role in the delivery of those services.

If the research and analysis leads to the conclusion that MEP centers should provide all types of business services (one-stop center) for manufacturing firms, then MECs can be expected and encouraged to expand their services in areas such as providing capital through loan pools or providing soft services such as HR management or business-technical services. One question that arises from such a finding would be – given limited funding, should the program be refined to target or concentrate resources and fund those interventions that produce the greatest return. One criticism of the current approach is that it spreads limited resources, originally used for technology-service provision, too thin. This research found this to be the case in Chicago. Luria (1997) suggests that such soft services can be built by fostering partnerships with the existing infrastructure and programs of state and local governments.

Finally, any future MEP-program review and redesign needs to address how to make the partnership between different levels of government work more successfully. This research finds that for this to be a realistic option, partnerships need to be more than just an identification of organizations on paper. Incentives need to be designed into the program evaluation to make it realistic that MECs will work with other service-delivery organizations. Particularly in the area of industrial modernization, the goals of national government are not necessarily consistent with those at the state level. While national government concerns itself with overall-national competitiveness, state governments are concerned with local issues - primarily job retention and creation. Since MEP is generally housed within economic development agencies at the state level, the program is competing with other, more traditional, economic development programs for funding. Federal and subnational policymakers must work more closely together to make manufacturing-extension design meet their needs, while meeting the needs of the client base. This will be no easy task. It is imperative if the program is to sustain itself in the long run, particularly if the economy moves into recession and governments

are looking for programs to cut or eliminate. Based on the above discussion, recommendations for the federal MEP program are summarized as follows.

- Conduct a nationwide-needs analysis of SMMEs.
- Analyze regional market conditions by creating an inventory of serviced currently provided by the private sector and those that are under supplied by the private sector.
- Determine the governmental role in delivery of services - what services should be provided?
- Construct new evaluation metrics that are more comprehensive and capture feedback on adaptive learning, public cost/benefit, spillover effects and worker benefits.
- Develop some concepts that would provide program mangers with techniques to make a consistent "but for" determination of potential clients.

E. Importance for Public Policy

Due to the perception that SMMEs in the United States are lagging in their adoption of technology compared to their international counterparts, SMMEs are identified as a target for public policy in 1988 under the OTCA. This research questions the continued validity of that assumption in the current economy.

Many suggest that SMMEs in the United States continue to face several unique problems (Luria, 1997; Shapira, 1998; NCAM, 2000). These authors suggest that SMMEs continue to have difficulty accessing and applying new technologies and have very limited R&D capabilities. Second, driven by information technologies and strategic decisions by large firms to outsource more of their manufacturing operations, the role of SMMEs in manufacturing is undergoing radical transformations that requires them to be increasingly more technologically proficient and more responsive to changes in technology (Luria, 1997). Third, many SMMEs remain reluctant

to adopt new technologies and processes because they are unaware of, or are unconvinced about, the positive impact the introduction of those technologies many have on their business (NCAM, 2000).

The compiled findings of these researchers suggest that SMMEs will need to develop their capacity to produce value-added products and pursue strategies that yield distinct, competitive advantages in the market based on new capabilities, higher-product quality and/or improved-customer services (Luria, 1997; Shapira, 1998; NCAM, 2000). Productivity gains can be made by increasing value-added products as well as by reducing required resources. Luria claims that this is often ignored in the rush to cut costs to the bone.

It is claimed that the MEP partnership between the federal government, the states, and other public- and private-service providers significantly improved the coordination and flexibility of manufacturing-extension services, integrated a wider range of service expertise, reduced inefficient overlaps, and helped new centers expand quickly by leveraging existing resources (Shapira, 1998). In addition, there is sufficient evidence that MEP helped improve the performance of SMMEs in the United States, albeit by a variety of means not just technology related. The preponderance of their evidence suggests that MEP should continue to receive public funding (Shapira 1998; Luria 1998; NCAM, 2000).

Since this research focuses on program development between 1988 to 1998, it does not provide evidence that either supports or disputes these findings. It does, however, present sufficient evidence to suggest that the MEP program needs to be reexamined and potentially redefined. Once a needs analysis of SMMEs is conducted, and should it complement the research findings of the three authors identified above, the appropriate role of government needs to be clearly articulated. This would require a greater connection between theory, program

design, and evaluation. Chapter 2 suggests the appropriate economic theories in which this program should be placed are evolutionary in nature rather than neoclassical.

If MEP is to be legitimized as a comprehensive-service-delivery model that targets its resources, a critical first step would be to recognize that one of the main outcomes would be to increase the economic worth of SMMEs though raising firm productivity, in addition to increasing the skills and incomes of their workers, as well as their owners. One way this might be defensible is by employing the argument that unlike services that mainly move commodity work from one shop to another, projects that improve SMME value added, productivity, and capability do not decrease the productivity and capability of others (Luria, 1998). However, such an acknowledgment would face considerable political obstacles. For example, a targeted strategy is much more difficult to sell politically than across-the-board business entitlements as it becomes labeled industrial policy or picking winners. Given the current political structure, this seems unrealistic outcome in the short run.

In spite of the questioned validity of the assumption that SMMEs in the United States are currently lagging in their adoption of technology, recent manufacturing-related economic statistics indicate that the manufacturing sector has moved into a recession. One potential cause of this is lagging productivity. One reason suggested for this is reduced investment in technology (Economist, 2001). This diagnosis should sound very familiar. If the trend in manufacturing performance continues to move downward, this interpretation will receive increased attention. This could lead to intensive scrutiny of the MEP at the federal and subnational level. From an optimizing and adaptive-learning standpoint it would behoove MEP program design and policymakers to conduct an overall evaluation of the program based on the ideas outlined in this research and suggest recommendations for program development that would hold up to such scrutiny. A new administration at the federal level, combined with both a state governmental structure that has proved itself capable of eliminating almost all economic

development programs and a recession does not bode well for the sustainability of manufacturing extension in Illinois. Local practitioners and policymakers are advised to conduct a serious reexamination and redesign of the manufacturing-extension program in Illinois and Chicago, returning the focus to MEC-core competencies.

CITED LITERATURE

Adelman, M.: The measurement of industrial concentration. Review of Economics and Statistics XXXIII:269-295, 1951.

Alexander, S., Giloth, R., and Lerner, J.: Chicago's industry task forces: joint problem solving for local economic development. Economic Development Quarterly 1: 352-357, 1987.

Antonelli, C., Petit, P., and Tahar, G.: The Economics of Industrial Modernization. London, Academic Press, 1992.

Atkinson, R.D.: Some states take the lead: explaining the formation of state technology policies. Economic Development Quarterly, 5:33-45, 1991.

Bartik, T.: The market failure approach to regional economic development policy. Economic Development Quarterly, 4:361-370, 1990.

Bartik, T.: Who Benefits from State and Local Economic Development Policies? Kalamazoo, Michigan: W.E. UpJohn Institute for Employment Research, 1991.

Blair, J.: Local Economic Development: Analysis and Practice. Newbury Park, Sage, 1995.

Blair, J.P. and Premus, R.: Major factors in industrial location: a review. Economic Development Quarterly 1:72-85,1993.

Bozeman, B.: Technology transfer and public policy: a review of research and theory. Research Policy 29:627-655, 2000.

Bradley University: Illinois manufacturing extension center proposal. Submitted to NIST/MEP, Peoria, Illinois, July 1996.

Carlisle, R.: The influence of evaluation on technology policy-making and program justification: a state level perspective. In: Manufacturing Modernization: Learning from Evaluation Practices and Results, eds P. Shapira and J. Youtie, pp.119-126. Atlanta, Workshop on the Evaluation of Industrial Modernization, School of Public Policy, Georgia Institute of Technology and Georgia Tech Economic Development Institute, 1997.

Carlisle, R.: Linking industrial modernization evaluation with state policy making. The Journal of Technology Transfer, 23:49-54, 1998.

City of Chicago: Cooperation for Survival and Growth: New Designs for Apparel Manufacturing in Chicago. Chicago, City of Chicago, 1987.

City of Chicago: Building on the Basics: The Final Report of the Mayor's Task Force on Steel and Southeast Chicago. Chicago, City of Chicago, 1986.

CMTC: Chicago manufacturing technology extension center proposal. Submitted to NIST/MEP. Chicago, 1993.

CMTC: Intervention Opportunities for Manufacturing Companies. Chicago, Manufacturing Productivity Center, 1994.

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

Dasgupta, P.: The welfare economics of knowledge production. Oxford Review of Economic Policy 4:1-12, 1988.

David, P.A.: Technical Choice, Innovation and Economic Growth. Cambridge: Cambridge University Press, 1975

Dertouzos, L. and Solow, R.M.: Made In America: Regaining the Productive Edge. Boston, MIT Press, 1989.

Doms, M.E., Dunne, T., and Roberts, M.J.: The role of technology use in the survival and growth of manufacturing plants. International Journal of Industrial Organization 13:523-542, 1995.

Dunne, T.: Technology usage in U.S. manufacturing industries: new evidence from the survey of manufacturing technology. Center for Economic Studies 91-7, October 1991.

Dunne, T., Roberts, M. J., and Samuelson, L.: The growth and failure of U.S. manufacturing plants. Quarterly Journal of Economics 419:671-698, 1989.

Economic Focus: Investment boom to bust. The Economist, 3 March 2001, 72

Edgar, J.: Governor's State of the State Address. Governor of Illinois, Springfield, 1994.

Ehlen, M.: The economic impact of manufacturing extension centers. Economic Development Quarterly, 15:36-44, 2001.

Eisinger, P.: The Rise of the Entrepreneurial State: State and Local Economic Development Policy in the United States. Madison, University of Wisconsin Press, 1988.

Eisinger, P.: State economic development in the 1990s: politics and policy learning. Economic Development Quarterly, 9: 2, 146-158, 1995.

Feller, I.: Issues in the evaluation of technology modernization programs. In: Evaluating Industrial Modernization Programs: Issues, Practices, and Strategies, eds. Shapira, Roessner, and Youtie, pp. 18-25. Atlanta, Workshop on the Evaluation of Industrial Modernization, School of Public Policy and Economic Development Institute, 1994.

Freeman, C.: The Economics of Industrial Innovation. London, Pinter, 1984.

Georghiou, L.: Overview of assessment and evaluation of practice. In: Evaluation of R&D: A Policy Makers Perspective, eds. L. Georghiou and E. Davis. London, HMSO, 1989.

Giloth, R.P.: Industrial Development Bonds in Chicago: Subsidies for What? Ph.D. dissertation, Cornell University, Ithaca, 1989.

Goldstein and Lugar: In: Theories of Local Economic Development: Perspecrtives from Across the Disciplines, eds. R. Bingham and R. Mier, pp. 147-174. Thousand Oaks, Sage, 1993.

Griliches, Z.: Hybrid corn: an exploration in the economics of technological change. Econometrica 25:501-522, 1957.

Griliches, Z.: Research costs and social returns: hybrid corn and related innovations. Journal of Political Economy 66:419-31, 1958.

Hannan, T. and McDowell, J.M.: The determinants of technology adoption: the case of the banking firm. Rand Journal of Economics 15:328-335, 1984.

Hayek, F: Individualism and Economic Order Chicago, University of Chicago Press, 1948.

Howard, R.: The Learning Imperative: Managing People for Continuous Improvement. Boston: Harvard Business School Press, 1990.

Illinois: A Five Year Plan 1989. Springfield, Department of Commerce and Community Affairs, 1989[a].

Illinois: Building Illinois: A Five Year Plan. Springfield, Department of Commerce and Community Affairs, 1986[a].

Illinois: Building Illinois - A Five Year Plan. Springfield, Department of Commerce and Community Affairs, 1987[b].

Illinois: Bureau of Program Administration: Mission Statements and Goals. Springfield, Department of Commerce and Community Affairs, November 1990[c].

Illinois: DCCA Annual Report Fiscal Year 1990. Springfield, Department of Commerce and Community Affairs, 1990[a].

Illinois: DCCA Annual Report Fiscal Year 1993. Springfield, Department of Commerce and Community Affairs, 1993[a].

Illinois: DCCA Annual Report Fiscal Year 1994. Springfield, Department of Commerce and Community Affairs, 1994[a].

Illinois: DCCA Annual Report Fiscal Year 1995. Springfield, Department of Commerce and Community Affairs, 1995[a].

Illinois: DCCA Annual Report Fiscal Year 1996. Springfield, Department of Commerce and Community Affairs, 1996[a].

Illinois: DCCA Annual Report Fiscal Year 1998. Springfield, Department of Commerce and Community Affairs, 1998[a].

Illinois: DCCA Annual Report Fiscal Year 1999. Springfield, Department of Commerce and Community Affairs, 1999.

Illinois: DCCA 1984 Annual Report. Springfield, Department of Commerce and Community Affairs, 1986[c].

Illinois: DCCA 1987 Annual Report. Springfield, Department of Commerce and Community Affairs, 1987[a].

Illinois: DCCA Statistics: Fiscal Year 1986. Springfield, Department of Commerce and Community Affairs, 1986[b].

Illinois. Executive Order, no. 79-3, 1979.

Illinois: Manufacturing extension center proposal [Bradley University]. Submitted by the Department of Commerce and Community Affairs to NIST MEP. Springfield, Illinois, 1993b.

Illinois: Five Year Plan 1990-1995. Springfield, Department of Commerce and Community Affairs, 1990[b].

Illinois: Management and Program Audit of the Department of Commerce and Community Affairs Economic Development Programs. Springfield, Office of the Auditor General, 1989[b].

Illinois: State of Illinois Budget, Fiscal Year 1981. Springfield, Secretary of State, 1981.

Illinois: State of Illinois Budget, Fiscal Year 1982. Springfield, Secretary of State, 1982.

Illinois: State of Illinois Budget, Fiscal Year 1983. Springfield, Secretary of State, 1983.

Illinois: State of Illinois Budget. Fiscal Year 1984. Springfield, Secretary of State, 1984[b].

Illinois: State of Illinois Budget. Fiscal Year 1985. Springfield, Secretary of State, 1985.

Illinois: State of Illinois Budget. Fiscal Year 1986. Springfield, Secretary of State, 1986[d].

Illinois: State of Illinois Budget. Fiscal Year 1987. Springfield, Secretary of State, 1987[c].

Illinois: State of Illinois Budget. Fiscal Year 1988. Springfield, Secretary of State, 1988.

Illinois: State of Illinois Budget. Fiscal Year 1989. Springfield, Secretary of State, 1989[c].

Illinois: State of Illinois Budget. Fiscal Year 1990. Springfield, Secretary of State, 1990[d].

Illinois: State of Illinois Budget. Fiscal Year 1991. Springfield, Secretary of State, 1991.

Illinois: State of Illinois Budget. Fiscal Year 1992. Springfield, Secretary of State, 1992.

Illinois: State of Illinois Budget. Fiscal Year 1993. Springfield, Secretary of State, 1993[c].

Illinois: State of Illinois Budget. Fiscal Year 1994. Springfield, Secretary of State, 1994[b].

Illinois: State of Illinois Budget. Fiscal Year 1995. Springfield, Secretary of State, 1995[b].

Illinois: State of Illinois Budget. Fiscal Year 1996. Springfield, Secretary of State, 1996[b].

Illinois: State of Illinois Budget. Fiscal Year 1997. Springfield, Secretary of State, 1997.

Illinois: State of Illinois Budget. Fiscal Year 1998. Springfield, Secretary of State, 1998[b].

Illinois: State of Illinois Five-Year Economic Development Strategy. Springfield, Department of Commerce and Community Affairs, July 1984[a].

Illinois Chamber: A Report to Governor Jim Edgar on the Needs and Priorities of Illinois Economic Development Programs and Services. Springfield, Economic Development Policy Tax Force, January 1991.

Illinois Public Act: no. 86-870, 1989.

Jarmin, R.: Measuring the impact of manufacturing extension. In: Manufacturing Modernization: Learning from Evaluation Practices and Results, eds. P. Shapira and J. Youtie, pp. 129-154. Atlanta, Workshop on the Evaluation of Industrial Modernization, School of Public Policy, Georgia Institute of Technology and Georgia Tech Economic Development Institute, 1997.

Journal of Technology Transfer 23, Spring 1998

Jovanovic, B.: Selection and the evolution of industry. Econometrica 50:649-670, 1982.

Kane, M., Luria, D., Russell, J., and Heye, C.: The value of manufacturing extension programs in America. In: Manufacturing Modernization: Learning from Evaluation Practices and Results, eds. P. Shapira and J. Youtie, pp.99-114. Atlanta, Workshop on the Evaluation of Industrial Modernization, School of Public Policy, Georgia Institute of Technology and Georgia Tech Economic Development Institute, 1997.

Katzenbach and Smith: The Wisdom of Teams: Creating the High-Performance Organization. Boston: Harvard Business School Press, 1993.

Kelley , M.R. and Brook, H.: External learning opportunities and the diffusion of process innovations to small firms: the chase of programmable automation. Technological Forecasting and Social Change 39:104-125, 1991.

Kelley, M.R. and Helper, S.: Firm size and capabilities, regional agglomeration and the adoption of new technology. H. John Heinz III School of Public Policy and Management, Carnegie Mellon University. Pittsburg, February 1997.

Levin, S., Levin, S., and Meisel, J.: A dynamic analysis of the adoption of a new technology: the case of optical scanners. The Review of Economics and Statistics 69:12-17, 1987.

Luria, D.: Why markets tolerate mediocre manufacturing. Challenge 39:4 11-16, 1996.

Luria, D.: Toward lean or rich? What performance benchmarking tells us about SME performance, and some implications for extension center services and mission. In: Manufacturing Modernization: Learning from Evaluation Practices and Results, eds. P. Shapira and J.Youtie, pp. 99-114. Atlanta, Workshop on the Evaluation of Industrial Modernization, School of Public Policy, Georgia Institute of Technology and Georgia Tech Economic Development Institute, 1997.

Mansfield, E.: The Economics of Technological Change. New York: W.W. Norton, 1968.

Mansfield, E.: Research and Innovation in the Modern Cooperation. New York, Norton, 1971.

Mansfield, E.: The contribution of R&D to economic growth in the U.S. Science 175:477-486, 1972.

Mendelowitz, A.: Overview of GAO's study of companies' perspective on manufacturing extension program services. In: Evaluating Industrial Modernization: Methods and Results in the Evaluation of Industrial Modernization Programs, eds. P. Shapira and J. Youtie, pp. 156-158. Atlanta, Workshop on the Evaluation of Industrial Modernization. School of Public Policy, Georgia Institute of Technology and Georgia Tech Economic Development Institute, 1995.

Metcalfe, S.: The economic foundations of technology policy: equilibrium and evolutionary perspectives. In: Handbook of the Economics of Innovation and Technological Change, ed. P. Stoneman, pp. 409-512. Oxford: Blackwell Publishers, 1995.

Michigan: The Paths to Prosperity. Lansing, Governor of Michigan's Office, Task Force for a Long-Term Economic Strategy for Michigan, 1984.

Mininger, L.: General Accounting Office perspectives in evaluating federal technology-related programs. In: Evaluating Industrial Modernization Programs: Issues, Practices, and Strategies, eds. P. Shapira and J. Youtie, pp. 77-87. Atlanta, Workshop on the Evaluation of Industrial Modernization. School of Public Policy, Georgia Institute of Technology and Georgia Tech Economic Development Institute, January 1994.

Mowery, D.: The practice of technology policy. In Handbook of the Economics of Innovation and Technological Change, ed. P. Stoneman, pp. 513-557. Oxford: Blackwell Publishers, 1995.

Mowery, D. and Rosenberg, N.: The influence of market demand upon innovation: a critical revue of some recent empirical studies. Research Policy 8:103-53, 1979.

Nabseth, L.: The diffusion of innovations in Swedish industry. In: Science and Technology in Economic Growth, ed. B. R. Williams. St. Anton, Austria, Proceedings of a Conference Held by the International Economic Association, 1973.

National Coalition for Advanced Manufacturing (NCAM): Smart Prosperity: Keys to Sustaining Productivity Growth: Policy Analysis and Recommendations. Washington, D.C., NCAM, March 2000.

National Research Council: Learning to Change: Opportunities to Improve the Performance of Smaller Manufacturers. Washington, D.C., National Academy Press, 1993.

Nelson, R.: The Sources of Economic Growth. Boston, Harvard University Press, 1996.

Nelson R. and Soete, L.: Policy conclusions. In: Technical Change and Economic Theory, eds. G. Dosi, C. Freeman, R. Nelson, G. Silverberg, and L. Soete. London, Pinter, 1988.

Nelson, R. and Winter, S.: An Evolutionary Theory of Economic Change. Boston, Harvard University Press, 1982.

Nelson, R. and Winter, S.: Factor price changes and factor substitution in an evolutionary model. Bell Journal of Economics 6:466-486, 1975.

Nelson, R. and Winter, S.: Neoclassical vs. evolutionary theories of economic growth: critique and prospectus. Economic Journal 84:886-905, 1974.

NIST: Manufacturing Technology Centers Third Year Review Panel. Gaithersburg, NIST, 1992.

NIST: Manufacturing Technology Centers: Broad Programmatic Issues. Washington, D.C., Government Printing Office, 1994.

NIST : International scope of work for CMC. NIST: Gaithersburg, 1996

Norgaard, R.: Coevolutionary development potential. Land Economics 60:159-76, 1984.

Oldsman, E. and Heye, C.: Waste not, want not - a look at the impact of manufacturing extension centers. The Journal of Technology Transfer, 23:37-42, Spring 1998.

Organization for Economic Co-Operation and Development: Technology, Productivity and Job Creation, Vol. 1. Paris, OECD, 1996.

Osborne, D.: Laboratories of Democracy: A New Breed of Governor Creates Models for National Growth. Boston, Harvard Business School Press, 1990.

Pennsylvania: Choices of Pennsylvanians. Harrisburg, Governor's Office of Policy Development, 1985.

Pilcher, D.: The third wave of economic development. State Legislatures 17: 34-37, November 1991.

President: Economic Report of the President. Washington, D.C., Government Printing Office, 1988.

President: Economic Report of the President. Washington, D.C., Government Printing Office, 1989.

President: Economic Report of the President. Washington, D.C., Government Printing Office, 1990.

President: Economic Report of the President. Washington, D.C., Government Printing Office, 1991.

President: Economic Report of the President. Washington, D.C., Government Printing Office, 1993.

President: Economic Report of the President. Washington, D.C., Government Printing Office, 1994.

President: Economic Report of the President. Washington, D.C., Government Printing Office, 1995.

Public Law, no. 100-418, 23 August 1988.

Public Law, no. 102-245, 14 February 1992.

Ray, G. F.: The diffusion of technology. National Institute Economic Review, 40-83, 1969.

Ray, G.F.: The Diffusion of Mature Technologies. Cambridge, Cambridge University Press, 1984.

Reamer, A.D.: Institutional assessment of technology programs. In: Evaluating Industrial Modernization: Methods and Results in the Evaluation of Industrial Modernization Programs, eds. P. Shapira and J. Youtie, pp. 122-127. Atlanta, Workshop on the Evaluation of Industrial Modernization, School of Public Policy, Georgia Institute of Technology and Georgia Tech Economic Development Institute, 1995.

Reardon, K.M.: Local Economic Development in Chicago, 1983-1987: The Reform Efforts of Mayor Harold Washington. Ph.D. dissertation, Cornell University, Ithaca, 1990.

Rhoades, S.: The importance of manufacturing extension – a state perspective. The Journal of Technology Transfer, 23:13-16, Spring 1998.

Rhodes, D.: The Manufacturing Extension Partnership Program in America: How Effective? A Review of the Evidence. Masters Thesis, University of Illinois at Chicago, 1999.

Rogers, E.: Diffusion of Innovations. New York, Free Press, 1962.

Romeo, A.A.: Interindustry and interfirm differences in the rate of diffusion of an innovation. The Review of Economics and Statistics, 57:311-319, August 1975.

Rosenfeld, S.: Bringing business clusters into the mainstream of economic development. European Planning Studies, 5:3-23, 1997.

Ross D. and Friedman R.: The emerging third wave. The Entrepreneurial Economy, 9:3-10, autumn, 1990.

Schumpeter, J.: Capitalism, Socialism and Democracy. New York, Harper Brothers, 1942.

Scitovsky, T.: Economic Theory and the Measurement of Concentration, Business Concentration and Price Policy. Princeton, National Bureau of Economic Research, 1955.

Scott, A.J.: New Industrial Space. London, Pion, 1988.

Sears, D.W. and Blackerby, P.: The MEP evaluation approach: past, present, and future. In: Manufacturing Modernization: Implications of Evaluation Results for Program Improvement and Policy Development, eds. P. Shapira and J. Youtie, pp. 161-170. Atlanta, Workshop on the Evaluation of Industrial Modernization, School of Public Policy, Georgia Institute of Technology and Georgia Tech Economic Development Institute, 1998.

Shapira, P.: The Impact of NIST's TRP Programs on Industrial Modernization Service Provision in the United States. Case Study: Chicago Manufacturing Center. Atlanta, Georgia Tech Policy Project on Industrial Modernization, Georgia Institute of Technology, September 1995.

Shapira, P.: Modern times: learning from state initiatives in industrial extension and technology transfer. Economic Development Quarterly, 4:186-202, August 1990.

Shapira, P.: Extending manufacturing extension. Issues in Science and Technology, 14.3:45-50, Spring 1998.

Shapira, P., Roessner, D., and Youtie, J.: Current practices in the evaluation of industrial modernization programs. In: Evaluating Industrial Modernization Programs: Issues, Practices, and Strategies, Atlanta, pp. 1-17., Workshop on the Evaluation of Industrial Modernization, School of Public Policy and Economic Development Institute, January 1994a.

Shapira, P., Roessner, D., and Youtie, J.: Evaluating industrial modernization programs: issues, practices, and strategies. Atlanta, Workshop on the Evaluation of Industrial Modernization, School of Public Policy and Economic Development Institute, January 1994b.

Shapira, P. and Youtie, J.: Evaluating Industrial Modernization: Methods and Results in the Evaluation of Industrial Modernization Programs. Atlanta, Workshop on the Evaluation of Industrial Modernization, School of Public Policy, Georgia Institute of Technology and Georgia Tech Economic Development Institute, 1995.

Shapira, P. and Youtie, J.: Manufacturing Modernization: Learning from Evaluation Practices and Results. Atlanta, Workshop on the Evaluation of Industrial Modernization, School of Public Policy, Georgia Institute of Technology and Georgia Tech Economic Development Institute, 1997.

Shapira, P. and Youtie, J.: Manufacturing Modernization: Implications of Evaluation Results for Program Improvement and Policy Development. Atlanta, Workshop on the Evaluation of

Industrial Modernization, School of Public Policy, Georgia Institute of Technology and Georgia Tech Economic Development Institute, 1998.

Simon, H.A.: Models of Bounded Rationality, Volume 2: Behavioral Economics and Business Organization. Boston, MIT Press, 1982.

Simon, H.A.: Theories of decision making in economics. American Economic Review 49:253-283, 1959.

Solow, R.M.: A contribution to the theory of economic growth. Quarterly Journal of Economics, 70:65-94, February 1956.

Solow, R M.: Technical change and the aggregate production function. Review of Economic Statistics 39:312-320, 1957.

Stoneman, P. and Kwon, M.J.: Technology adoption and firm profitability. Economic Journal, 106:952-962, July 1996.

Stoneman, P. and Vickers, J.: The assessment: the economics of technology policy. Oxford Review of Economic Policy, 4:i-xvi, 1988.

Tassey, G.: The role of government in supporting measurement standards for high technology industries. Research Policy 11:311-320, 1982.

Teese, D.J.: Profiting from technological innovation: implications for integration, collaboration, licensing and public policy. Research Policy 15:285-305, 1986.

Thompson, J.: Proposal for the Super Conducting Collider. Governor of Illinois, 1 September 1997, Springfield.

Thompson, W.: A Preface to Urban Economics. Baltimore, Johns Hopkins Press, 1965.

Tiebout, C.: The Community Income Economic Base Study, Supplementary Paper No. 16. New York, Committee for Economic Development, December 1962.

Tushman and Anderson: Technological discontinuities and organization environments. In: The Management of Strategic Change, ed. A. Pettigrew. Oxford: Blackwell, 1987.

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

United States: Manufacturing Extension Programs: Manufacturers' Views about Delivery and Impact of Services. General Accounting Office. Washington D.C., 1996.

United States: Paying the Bill: Manufacturing and America's Trade Deficit, OTA-ITE-390. Congress, Office of Technological Assessment: Government Printing Office. Washington, D.C., 1988.

United States: Technology Transfer: Federal Efforts to Enhance the Competitiveness of Small Manufacturers. General Accounting Office. Washington D.C., 1991.

University of Illinois at Chicago Center for Urban Economic Development (UICUED): Facilitating Federal Technology Transfer to Small and Medium Sized Business and State and Local Government. Chicago, UICUED, 1984

Vincenti, W.G.: What Engineers Know and How they Know It. Baltimore, Johns Hopkins Press, 1990.

Wilkins, T.: Evaluating MECs: benchmarking with ourselves. In: Manufacturing Modernization: Implications of Evaluation Results for Program Improvement and Policy Development, eds. P. Shapira and J.Youtie, pp. 83-90. Atlanta, Workshop on the Evaluation of Industrial Modernization, School of Public Policy, Georgia Institute of Technology and Georgia Tech Economic Development Institute, 1998.

Yin, R. and Oldsman, E.: Logic Model for Evaluating Changes in Manufacturing Firms. Bethesda, National Institute of Standards and Technology, 1995.

Youtie, J.: The Impact of NIST's TRP Programs on Industrial Modernization Service Provision in the United States, Case Study: Chicago Manufacturing Center. Atlanta, Georgia Tech Policy Project on Industrial Modernization, Georgia Institute of Technology, September 1997.

VITA

NATALIE A. DAVILA

e-mail: ndavila@roosevelt.edu

EDUCATION

University of Illinois - Chicago, Illinois. Ph.D. in Public Policy Analysis. May 2001.
Specialization in Economic Development and Fiscal Policy. Dissertation titled "The Effectiveness of Manufacturing Extension: Economic Development Versus Technology-Diffusion Policy?"

University of Michigan - Ann Arbor, Michigan.
M.A. in Applied Economics. August 1995.
Specialization in Econometrics and Industrial Organization.

Queen's University - Belfast, Northern Ireland.
B.S. in Economics, with honors. June 1984.
Specialization in International and Regional Economics. Minor in Accounting.

TEACHING EXPERIENCE

Roosevelt University, School of Policy Studies
Assistant Professor in Economics, Fall 2000 to Present
Courses: Microeconomics, Statistics, Urban Economic Development.

University of Illinois at Chicago, Department of Urban Planning
Economic Development Analysis II, Winter 2000

University of Wisconsin at Milwaukee, Department of Urban Planning
Planning Analysis, Winter 2000

ACADEMIC AWARDS

Illinois Consortium for Higher Education Scholarship, 1990-1993

University of Michigan Exchange Scholarship, 1984-1985

PROFESSIONAL EXPERIENCE

ND Consulting
President, 1999 to 2000
President of consulting firm specializing in public policy evaluation, economic impact analysis and industry research. Projects included:

- Developed an evaluation plan for the Chicago Economic Development Partnership.
- Researched trends in higher education distance learning for Lake Forest Graduate School of Management.
- Economic impact analysis on the capital improvement spending by the Chicago Board of Education.
- Econometric analysis of factors influencing productivity in small and medium-sized manufacturing firms for the Joyce Foundation.
- Survey and analysis of modernization needs of small and medium-sized manufacturing firms in Illinois for the Chicago Manufacturing Center.

Chicago Manufacturing Center
Director of Economic Evaluation and Market Research, 1995 to 1999

- Directed evaluation and research for a federally funded consulting firm. The mission of the organization was to increase the global competitiveness of small medium-sized firms through the provision of subsidized consulting services.
- Directed professional staff conducting primary and secondary, domestic and international, market research for small and medium-sized manufacturing firms.
- Member of national team of experts selected by the Federal government to develop an evaluation methodology for the U.S. manufacturing extension program.
- Conducted industry and country analyses to direct program resources.
- Established consultant selection process, evaluated proposals, directed projects, and managed consultant relationships.

City of Chicago, Department of Planning and Development
Director of Economic Research, 1992 to 1995

- Directed professional staff analyzing and evaluating regional and urban policy issues in the areas of economic development, industry studies, fiscal policy, international trade, and program evaluation.
- Developed and analyzed federal, state, and local fiscal policy proposals impacting industrial and economic development.
- Prepared and oversaw development of technical reports and made recommendations on industrial and economic development policy issues. Key projects included the effectiveness of Chicago's industrial development incentives, the impact of local tax policy on the theater industry, and the impact of the City's employee tax on business development.
- Conducted economic impact and cost-benefit analysis of proposed industrial development, commercial development, and/or fiscal policies.

City of Chicago, Office of Budget and Management
Chief Revenue Analyst, 1988 to 1992

- Directed staff conducting fiscal policy analysis.
- Prepared official annual forecast of City revenue.
- Advised the Budget Director on federal, state, and local fiscal policy issues.
- Prepared written revenue impact analyses of proposed state and local tax legislation for the Budget Director.
- Prepared analyses of alternative revenue sources for the City.
- Conducted cost studies of the building, fire, and zoning departments.
- Designed, implemented, and evaluated department revenue reporting procedures.
- Developed econometric models to forecast the City's economically sensitive revenue sources.

- Prepared five-year expenditure and revenue projections for fiscal planning purpose.
- Designed and prepared monthly revenue report for the Budget Director.

Federal Reserve Bank of Chicago
Economic Research Consultant, 1987 to 1988

- Co-authored paper on the impact of unemployment insurance programs on various industrial sectors.
- Collected and analyzed economic and financial data for the following projects: The Cost of Doing Business in Chicago; Capital Formation in the United States; and Electric Power Generation in the Midwest.

Northern Ireland Economic Council
Assistant Economist, 1985 to 1987

- Analyzed and reported on industrial and labor trends in Northern Ireland.
- Held focus groups and interviewed business and labor leaders on industrial development issues.
- Made economic development and job training policy recommendations to the British Government.
- Prepared published reports on local industrial policy issues.

PUBLICATIONS

How the Chicago Manufacturing Center Uses Evaluation in Decision Making. In: Manufacturing Modernization: Learning from Evaluation Practices and Results, eds. P. Shapira and J. Youtie, pp. 141-148. Atlanta, Workshop on the Evaluation of Industrial Modernization, School of Public Policy, Georgia Institute of Technology and Georgia Tech Economic Development Institute, 1998.

Case Study Analysis of the Impact of Chicago Manufacturing Center Services on Dynacircuits Corporation. In: MEP Successes: A Case Study Approach, Washington, D.C.:National Institute of Standards and Technology, Department of Commerce, 1997.

Case Study Analysis of the Impact of Chicago Manufacturing Center Services on Glendale Technologies Corporation. In: MEP Successes: A Case Study Approach, Washington, D.C.:National Institute of Standards and Technology, Department of Commerce, 1997, pp. 85-92.

Business Taxes: A Comparison of Seven Cities. Chicago:Civic Federation of Chicago, April 1995.

With William Testa. Unemployment Insurance Taxes. In: Commentary, Summer 1990.

An Economic Strategy for the Northern Ireland Clothing Industry, Northern Ireland Economic Council. Belfast: NIEC, 1988.

An Economic Strategy for the Non-Metallic Mineral Sector in Northern Ireland, Northern Ireland Economic Council. Belfast: NIEC, 1988.

Quarterly Economic Assessment of the Northern Ireland Economy, Northern Ireland Economic Council. Belfast: NIEC, 1987.