Expediting Organizational Transformation in the Small Firm Sector: Lessons from the Metalworking Industry

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ABSTRACT
This dissertation examines the adoption of new work organization practices in the small firm, manufacturing sector through an in-depth examination of the metalworking industry in western Massachusetts. An original survey of 46 firms was conducted as were detailed firm-level case studies. Four key questions were addressed through the research: 1) what does the new work organization look like in the small firm sector? 2) how widely have new forms of work organization diffused? 3) what explains variation in workplace innovation outcomes? 4) what are the most effective mechanisms of diffusion?

Survey and case study results show that new work organization practices have diffused widely in the small firm sector but that adoption levels vary dramatically among similarly situated firms. Detailed review of data indicates that whether and when firms embark on a path of organizational reform must be analyzed in the context of each firm’s market environment and overall strategy. The extent and rate of adoption is determined by two key variables: the nature of market pressure a firm experiences (shaped predominantly by the industry sector the firm supplies to and customers relations); and the strategic orientation of firm leadership. The presence of cooperative customer-supplier relations and/or innovative, investment-oriented firm leaders appears to facilitate adoption of new work practices.

The current policy approach to small firm modernization encourages piece-meal change that fails to address far more fundamental issues of firm strategy. The research suggests that public programs should build from the powerful mechanisms of change indigenous to the small firm economy. A concerted focus on management education, and development and promotion of customer supplier ‘partnerships’ across key industry sectors is a more promising way to encourage long-term adjustment strategies in the small firm sector.

Thesis Supervisor: Richard Locke
Title: Professor of Political Science and Industrial Relations
Acknowledgments

This dissertation was a long time coming. Like many graduate students, I completed my course work without a clue as to what I would write a dissertation on (or what a dissertation really was for that matter). At that point in my life, I was more interested in putting ideas into practice than pursuing a path of research and scholarship. For several years I was able to do this at Jobs for the Future—a Boston area organization specializing in education and labor market policy. It was in the context of an industrial network evaluation project I managed at JFF from 1993-1995 that I began exploring the issues that ultimately became my dissertation.

Detailed knowledge of a subject does not a dissertation make, however, and it would be some time before my understanding of the issues at hand would take on the shape of a genuine research proposal. For this transformation I am indebted to my advisor Paul Osterman. Paul was instrumental throughout the most difficult part of the project—devising the methodology. He read various proposal drafts and provided quick and thoughtful feedback on research strategies. Throughout what was often a tortuous process for me, Paul knew when to be supportive and encouraging but also when to push me to work harder. I am extremely thankful for his help and his patience. Richard Locke, my thesis chair, was also very helpful at critical moments. In particular, he helped me shape the case study data effectively by encouraging me to structure the cases using the ‘controlled comparison’ method. I want to thank both Paul and Ricky for the time they dedicated to my project.

The firm-level research that constitutes the dissertation could not have been carried-out without generous assistance from many people. In particular I want to thank Robert Forrant (former director of the Machine Action Project and now professor at UMass Lowell). My relationship with Bob was critical in terms of establishing my legitimacy with firm owners. Bob was also instrumental in helping me secure a fellowship at the Center for Industrial Competitiveness at UMass Lowell which provided me with the initial time and space to figure out the project. At the National Tooling and Machining Association, John Hoops was key. John was extremely helpful throughout the project—always willing to talk, to provide his perspective, and to help me gain access to firm owners. Of particular help was his assistance in setting up the initial field visits. And of course without the participation of the many firm owners, managers and employees who took time to speak with me about their work, I could never have completed the dissertation. I am thankful to all of the individuals who took time to share their experiences with me. In particular, I’d like to thank Bill Lyons of Brimfield Precision and Jim Stone of IDC. These two firms owners helped me gain a deep understanding of the issues and tirelessly answered my questions for hours upon hours.

On a personal note, I want to thank my parents for their constant love, support and encouragement over the years. My mother and father are the great anchors in my life. Having two babies during the course of my research and writing definitely slowed me down, but my two boys—Eli and Sammy—have brought me incredible joy. Finally, I want to thank my husband, Ben Willman, for his patience, love and support. Without him by my side, I’m quite certain I would never have completed this project.
DEDICATION

Richard Gordon
1946-1996

This dissertation is dedicated to the memory of Richard Gordon, my mentor and friend at the University of California at Santa Cruz. Rick was truly an inspirational professor of political economy. He helped me look at the world in new ways and spurred my budding interest in the social and political issues surrounding work, technology and the organization of production.

Most importantly, he made ‘work’ a lot of fun.
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Introduction

This dissertation stems from current policy debates over how to expedite economic adjustment in the small firm, manufacturing sector. Small manufacturing firms are a relatively new area with which public policy is concerned. Over the past 15 years as international competition has increased and as large manufacturing firms have shed jobs and moved production oversees, communities, states and the federal government have turned increasing attention to small manufacturers which now employ a majority of the nation's 18 million manufacturing workers.

The burgeoning policy focus on small firms can be traced to two interrelated factors. The first factor is an overall shift in manufacturing employment toward smaller firms. Though total manufacturing employment has declined over the past 30 years in the U.S.—particularly since the late 1970's—the relative importance of small firms has increased dramatically. Manufacturing job loss of the past three decades has occurred in large firms: between 1967 and 1992, employment in large manufacturing establishments decreased by approximately 2.0 million; over the same period, employment in smaller manufacturing establishments increased by approximately 1.7 million (Census of Manufacturers, 1992). As a result, smaller manufacturers now employ 65.7 percent of the manufacturing workforce up from 54.5 percent in 1967.²

The shift in employment from large to smaller firms stems from now familiar macro economic forces. The rise of intense international competition in the 1970's led to

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¹ Small and medium-sized firms are generally defined as those manufacturing firms with less than 500 employees. Small firms are defined as those with under 100 employees.

² While the U.S. manufacturing sector has shed more than 2.5 million jobs since its employment high mark in 1979 when 21 million Americans were employed, the 1992 Census of Manufacturers reveals that the sector employed just 300,000 fewer workers in 1992 than it did in 1967.
layoffs and plant closings in traditional mass production industries in the U.S. as markets from textiles to electronics were penetrated by low-cost competitors abroad.

Deindustrialization—as the phenomenon is referred to—resulted in the permanent loss of hundreds of thousands of manufacturing jobs throughout the 1970's and 80's. (Bluestone and Harrison, 1982). In addition, the globalization of manufacturing—enabled by breakthroughs in communication and transportation technologies—led many remaining U.S. manufacturers to seek out lower labor and regulatory costs through off-shore production strategies. Finally, beginning in the mid-1980's many large U.S. firms began to downsize as they pursued 'lean production' strategies and returned to 'core competencies' in an effort to reduce costs and improve productivity (Womack et. al., 1990; Harrison, 1994). As a result of these strategies, larger firms began to 'contract out' aspects of production that were formerly conducted in-house. Today, production activities such as design, tooling and parts production are routinely subcontracted to smaller supplier firms that are typically non-union and have dramatically lower overhead than large firms (Luria, 1996). Together, these three developments—deindustrialization, globalization of production, and strategic downsizing—have contributed to dramatic changes in the nation’s industrial fabric including the redistribution of manufacturing employment toward smaller firms.

The second factor contributing to the greater policy focus on small firms is lagging productivity in the small firm sector. Concerns about U.S. competitiveness and productivity in the late 1980's led to a number of reports that documented weaknesses in the U.S. industrial base (Dertouzos et. al., 1989; U.S. Office of Technology Assessment, 1990). A particularly weak thread in the industrial fabric, these reports posited, was the
supply base composed of thousands of smaller firms. Several studies followed which documented small firms' widespread failure to adequately invest in automated technologies such as computerized machine tools and computer-aided design. (Industrial Technology Institute, 1987; Department of Commerce, 1989; U.S. Office of Technology Assessment, 1990; Kelley and Brooks 1991;). Later research revealed that small firms also suffered from outdated work practices, poor organization and management, and inadequate education and training. (National Research Council, 1993). By the early 1990's, these weaknesses were routinely cited as explanations for the growing productivity gap between large and small firms (Luria 1996). In 1967, smaller manufacturers averaged 80 percent of the productivity of large manufacturers. By 1992, the productivity of smaller manufacturers measured just 66 percent of large manufacturers (Census of Manufacturers, 1992).

The employment shift toward small firms combined with the corresponding decrease in small firm productivity raised the plight of small manufacturers from relative obscurity to the forefront of academic and policy debates about economic adjustment by the early 1990's. In an influential report issued by the National Research Council in 1993, the Manufacturing Studies Board of the NRC concluded that smaller firms' use of "modern manufacturing equipment, methodologies, and management practices is inadequate to ensure that American manufacturing will be globally competitive." (National Research Council, 1993, pg. 1). Small firms, it was recognized, provide critical sources of manufacturing employment and income that are not footloose. Furthermore, as suppliers of tools, parts and assemblies, small firms represent a critical link in the

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3 The Census of Manufacturers defines productivity as output per worker.
industrial chain that directly impacts the ability of upstream manufacturers to compete in an increasingly global marketplace.

Recognition of widespread performance problems in the small firm sector spawned policy innovation at the local, state and federal levels throughout the 1990’s. In an effort to encourage economic adjustment and growth, regional policies designed to assist small firms in the adoption of more flexible and efficient forms of organization proliferated. At the federal level, state and local experimentation with economic adjustment strategies has been facilitated by establishment of the Manufacturing Extension Partnership (MEP)—a federal-state system of manufacturing modernization centers created to assist smaller manufacturers with adoption of productivity enhancing innovations. At the state and local level economic development practitioners have experimented widely with new service delivery mechanisms aimed at small firm modernization. Across the country, industry associations, employer consortia, manufacturing networks, and community and technical-college programs have sprung up to assist smaller manufacturers with the adjustment process.

Small Firms and the New Work Organization

My research focuses on a critical and largely unexplored aspect of small firm adjustment—the adoption of flexible work organization. Over the past two decades, heightened international competition has caused many companies to restructure the way

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4 The globalization of manufacturing has led, ironically, to a renaissance in regional economic development. As a number of theorists have noted (Scott, 1992; Saxenian, 1994; Piore, 1995; Sabel, 1996) the new economic paradigm places pressures and demands on firms that are best solved through regionally coordinated strategies based on 'local knowledge' of industry dynamics. As a result "regionalization has been encouraged by the urgent desire of higher level governments...to escape responsibility for outcomes they regard as beyond their control by delegating decision-making authority to lower jurisdictions." (Sabel 1996, pg. 2).
they organize work. In an effort to simultaneously reduce costs, improve quality and bring products to market more quickly, some manufacturers have made fundamental changes in how they organize both machines and people. The new work organization is typically characterized by the use of agile and highly efficient computer technologies combined with organizational strategies that maximize flexibility through involvement of front-line workers in production-related decision making.\(^5\) A growing body of research suggests that when new work practices such as teams, manufacturing cells and job rotation are implemented in conjunction with complimentary human resource practices such as performance-based compensation and training, improvements in performance and productivity follow.\(^6\)

New work practices have received considerable attention in the academic and policy literature over the past decade. Most of the research, however, has been conducted in large manufacturing firms such as automobile, apparel and steel plants. Few studies have examined if and how new forms of work organization are taking root in the small firm sector. Yet small firms vary from large firms in fundamental ways. The vast majority of small manufacturing firms are family owned and employ fewer than 100 people. As a result, these firms have few management layers, are often owner-run and managed, and have limited financial resources (National Research Council, 1993). In addition, the vast majority of small manufacturers are suppliers. As a result, they are continuously subject to both the performance and price requirements of their customers.

\(^5\) The new work organization discussed throughout this dissertation has taken on a variety of names in the literature including but not limited to: high performance work organization, transformed work organization, innovative work practices and new work systems. As Ichniowski et.al. (1996) note in their review of the research, these terms have no settled meaning but refer generally to nontraditional work practices that have become increasingly common among U.S. businesses in recent years.\(^6\) See Kling, 1995 and Ichniowski et.al, 1996 for reviews of the research and literature on the new work organization.
For these reasons the new work organization is likely to both look, and come about, differently in small firms than in large firms.

My examination of small firms and the new work organization is located at the intersection of two bodies of research and writing: the 'work organization' literature and the small firm 'modernization' literature. Implicit in both is the belief that firms must adjust the organization of production in order to survive in today's economy and that adoption of new work systems is an integral component of improved performance and productivity. Yet neither body of work provides a compelling explanation of how and why small firms reorganize. Without an understanding of why firms adopt new work systems and how firm reorganization occurs, however, it is difficult to design effective public intervention strategies that facilitate more widespread diffusion of the new work organization.

I examine small firms and the new work organization through an in-depth examination of the metalworking sector in western Massachusetts. Rather than focus on the impact of the new work organization on firm performance, this dissertation focuses on adoption: under what circumstances do small firms adopt new work systems and what mechanisms appear to facilitate the process? The dissertation presents detailed data on work organization practices collected from 46 small metalworking firms through an original survey. The survey included both written and phone interview components and was completed by either the president or general manager of the firm. The dissertation also includes controlled comparison case studies of four metalworking firms identified through the survey process. Through presentation of survey data and case studies, the dissertation addresses the following four questions:
1. \textit{What does the new work organization look like in the small firm, manufacturing sector?}

2. \textit{How widely have new forms of work organization diffused in the sector?}

3. \textit{What explains firm variation in workplace innovation outcomes?}

4. \textit{What are the most effective mechanisms of diffusion?}

To provide context for my study, I provide cursory reviews of the 'work organization' and small firm 'modernization' literature below.

\textbf{The Transformation of Work Organization in the United States}

Over the past two decades a great deal of research and writing on new forms of work organization has been generated. At the broadest level this work is motivated by the hypothesis that workplaces that reduce hierarchy, increase flexibility and utilize the problem-solving skills of employees will improve workforce motivation, product quality and/or company efficiency. As Ichniowski, et. al. (1996) note in their review of the research,

theories of new work practices imply that these new arrangements can cause workers to work harder and share more ideas. Further, they can make organizational structures more efficient regardless of any effects these practices may have on worker motivation. In either case, companies with these practices should enjoy higher productivity and quality, leading to lower costs and higher product demand, all else equal (pg. 301)

The principle thrust of research on new work practices has been to prove this theory correct by measuring the effects of the practices on firm performance. A number of studies have measured the impact of a single practice such as skill training (Bartel, 1994) or employee participation (Levine and Tyson, 1990) on productivity. These studies suggest a positive relationship between use of the individual practice and
productivity (Kling, 1995). Other studies have measured effects on productivity when new work practices are bundled. The study of ‘integrated work systems’ stems from the hypothesis that individual practices are likely to have limited impact on employee performance and productivity unless they are supported by other complimentary practices (Milgrom and Roberts, 1990). As many working in the field have noted, employees organized into problem-solving teams are unlikely to make productivity improvements that may cost them their job without guarantees of employment security. Conversely, employees may have little incentive to suggest productivity improvements unless they receive some monetary reward from corresponding cost savings.

Existing research appears to confirm the ‘bundles’ hypothesis. In a review of studies on new work practices and systems implemented in steel (Ichniowski, Shaw and Prennushi, 1995), components manufacturing (Cutcher-Gurshenfeld, 1991) and automobiles (MacDuffie, 1995), Kling (1995) concludes that new work practices are associated with greater productivity improvements when implemented together in systems. Ichniowski et. al. (1996) reach a similar conclusion based on their review of empirical evidence from case studies, samples of plants within specific industries, and broad national samples of firms. Economic performance, they assert, “is highest only when firms adopt whole bundles of work practice, and firms that adopt single practices without other necessary changes will not experience improved performance.” (pg. 326)

If implementation of new work systems can improve employee performance and company productivity, we would expect them to be widely adopted. Yet research demonstrates that most company initiatives are piecemeal rather than systemic. Based on a comprehensive review of the research, Applebaum and Batt assert that changes in work
organization in most companies are marginal because they tend to consist of changes in a single practice (such as training or compensation) that impact a limited number of employees. Only rarely do the practices make up a strategic whole that transforms the workplace (Applebaum and Batt, 1997). Osterman’s (1994) survey of 700 establishments with over 50 employees (including manufacturing and services) found that approximately 35% of establishments had a majority of core employees engaged in two or more new work practices (either teams, job rotation, Total Quality Management, or quality teams). This suggests fairly widespread diffusion of individual practices; however, it does not indicate widespread movement toward implementation of integrated work systems. Within manufacturing, industry studies reach similar conclusions. In steelmaking (Ichniowski and Shaw, 1995), automobiles (MacDuffie 1995) and apparel (Dunlop and Weil, 1995), most facilities have adopted one or more of the practices associated with the new work organization but only a small proportion have implemented a fully integrated system of innovative work practices (Ichniowski, et. al, 1996).

While the use of individual new work practices appears fairly widespread, the fact that most companies don’t implement bundles of complimentary practices to transform work organization suggests that few firms are reaping the performance and productivity gains that new work practices promise. This finding has led researchers to consider what the barriers to more widespread adoption of new work systems might be. Understanding variation in workplace innovation outcomes is a less developed area of research on the new work organization. Impediments to adoption are not well understood: for some companies they may be related to external factors such as product market and customer relations; for others, they may be related to internal factors such as labor relations and
managerial ability. Conversely, beyond the generic motivation of productivity improvement, there is limited understanding of how and why firms that adopt whole systems of work practices do so.

Modernizing America’s Small Firms

A second body of research and writing that bears on my study is the academic and policy literature on small firm modernization. In the wake of corporate downsizing and restructuring in the 1980’s, many state governments turned their attention away from recruitment of large firms (‘smokestack chasing’) toward upgrading the capabilities of remaining small manufacturers. Efforts to modernize small firms—which began in the late 1980’s—followed two related, but distinct paths: the ‘industrial district’ path and the ‘industrial extension’ path. While both sought to upgrade technology, quality, work practices and skill levels in the small firm sector, they represent different models of intervention.

In a decade marked by large-scale layoffs and plant closures, the ‘discovery’ of dense clusters of small, ‘flexibly specialized’ manufacturing firms in northern Italy captured the imagination of economic development theorists and practitioners throughout the United States and Europe (Piore and Sabel, 1984; Best, 1990; Pyke and Sengenberger, 1992). Utilizing advanced computer technologies, theorists argued, these family-owned, craft-oriented firms were capable of responding more quickly and effectively to fluctuating demand in the international marketplace than large, vertically integrated corporations. With assistance from membership service centers and industry
associations to support activities such as technology acquisition, joint marketing, product development, and education and training, these small firm clusters—coined ‘industrial districts’—achieved impressive economies of scale and contributed to a thriving manufacturing economy.

The ‘flexibly specialized’ firms of the Italian industrial district provided a model for regional economic development and growth at a time when traditional industrial regions in the U.S. were hemorrhaging jobs. Several states that experienced severe manufacturing job loss—such as Michigan, Massachusetts and Pennsylvania—sought to invigorate the small firm manufacturing sector through conscious construction of industrial districts in the late 1980’s. Targeting firms in a common region and industrial sector (e.g. metalworking, plastics or apparel), these efforts sought to improve small firm performance through collaborative problem-solving and collective service provision. By 1994, approximately 20 US states had begun experimenting with cooperative approaches to small firm competitiveness (Rosenfeld, 1996).

Industrial extension programs also gained popularity as an approach to small firm modernization in the late 1980’s. Modeled on the U.S. agricultural extension service, industrial extension programs employ ‘field agents’ (usually engineers) who visit individual firms to assess and solve technical and organizational problems. In contrast to the industrial district approach that brings firms with common processes, problems and goals together, state-sponsored industrial extension programs typically work with individual firms on discreet projects. States with a significant concentration of

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7For an excellent and succinct overview of this shift in economic development theory and practice see, Tetiz (1994). Also see Eisinger (1995) for a review of state economic development trends in the 1980’s and 1990’s.
manufacturing activity such as New York, Ohio and Pennsylvania, pioneered statewide industrial extension programs. By 1991, 28 states funded some type of industrial extension activity (Clark and Dobson, 1991).

The federal government provided a tremendous boost to the industrial extension approach to small firm modernization beginning in 1993. Under the Clinton administration a small manufacturing extension program administered by the National Institute of Standards and Technology (the Manufacturing Technology Centers) was dramatically expanded. By the end of 1994, NIST had awarded federal funds (matched at the local level by a combination of state, local, and private sector contributions) to nearly 50 manufacturing extension centers. By 1997 the NIST Manufacturing Extension Program (MEP) system included 400 manufacturing extension field offices in all 50 states and Puerto Rico (NIST MEP, 1997).

The rapid expansion of the NIST Manufacturing Extension Program has fueled debate over the most effective mechanisms for small firm modernization. Critics of the MEP model argue that one-on-one assistance to firms does not promote the institution building and inter-firm learning necessary for successful technology transfer. Modernization approaches that target groups of firms with similar technical problems and/or common customers, it is argued, are more likely to solve underlying problems (Kelley and Arora, 1996). Moreover, there is concern that hasty acceptance of the MEP model eclipsed efforts to produce information critical to effective program design. For

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9 Following the enactment of the Omnibus Trade and Competitiveness Act in 1988, the National Institute of Standards and Technology (NIST) established seven Manufacturing Technology Centers across the country.

10 In 1996, for example, an entire volume of the academic journal Research Policy was dedicated to ‘Evaluation of Industrial Modernization.’
example, studies that document small firm decision making processes and modes of firm learning were neither conducted nor incorporated into the MEP design (Feller, et. al. 1996).

Toward a Theory of Small Firm Reorganization

Through an in-depth examination of metalworking firms in western Massachusetts, my research aims to further our understanding of why small firms adopt new forms of work organization and the mechanisms that facilitate adoption. The study is descriptive, explanatory and policy evaluative. It provides a detailed description of what the new work organization looks like in the small firm sector and measures diffusion of the new work practices. In addition, it examines firm behavior in order to explain why firms adopt new work practices at uneven rates. Based on an understanding of the mechanisms that facilitate adoption, it proceeds to evaluate current policy approaches to small firm modernization.

Research Strategy and Methods

The research strategy was carried out in a single industrial sector in a single region in order to gain deep insight into industry dynamics. Metalworking was selected for two primary reasons. First, metalworking is the industrial sector with the largest concentration of small firms: approximately one-third of all small manufacturing firms in the United States are in the metals industries—primary metals, fabricated metals, or industrial machinery (Mt. Auburn Associates, 1995). Second, metalworking is considered a ‘mature’ or ‘traditional’ industry in need of modernization. As such, it is frequently the target of public manufacturing assistance programs. Western
Massachusetts was selected as the research site for several reasons. The region has a long history of metalworking dating back to the Revolutionary War and provides a rich backdrop for contemporary industry analysis. Since that time, the region has been characterized by a dense cluster of small, specialized metalworking firms that act as suppliers to larger manufacturers. In recent decades, the region has been subject to precisely the competitive dynamics likely to spur adoption of new work practices and systems. Throughout the 1980's the region underwent dramatic industrial restructuring as manufacturers downsized and/or shut down due to fierce international competition. In the 1990's, the region was rocked by defense industry downsizing and restructuring. The final reason for selection of western Massachusetts as the research cite was practical. Through professional participation in public initiatives to revitalize the region's metalworking sector I developed relationships with metalworking firm owners that enabled me to gain firm access—a critical consideration in a field-driven dissertation.

Research for the dissertation was carried out over a three-year period from spring of 1996 through the spring of 1999. The primary research consists of a survey and firm-level case studies. The administered survey consisted of a six page written segment and a phone interview that lasted approximately a half an hour. The written survey collected detailed information on products, markets, customers and training practices while the phone interview collected detailed information on company history and, if applicable, recent experience with work reorganization. While the number of completed surveys is limited (48 written surveys and 40 phone surveys), the quality of the data received was high providing the equivalent of four dozen mini case studies (Appendix 1 provides details on survey methodology and implementation).
Field research was conducted in 12 different firms over the three-year period. Based on themes that emerged from the survey, four firms were selected for in-depth analysis. Throughout the design, data collection and analysis of the case study research I adhered to the ‘controlled comparison’ case study method. Following this method, I constructed two matched-pair case studies to explore key sources of variation regarding work reorganization outcomes (details on the case study methodology are included in the introduction to Chapter four).

In total, I conducted 140 interviews with firm owners, employees and economic development professionals throughout the course of research. Secondary research included review and analysis of state reports and employment and industry data.

The Spread of New Work Practices and Systems

What proportion of small firms are making the transition from the traditional job shop to the high performance small firm? The survey data suggests that a majority of firms have implemented individual practices associated with the new work organization. Over half of surveyed firms have implemented a formal quality program; one-third have reorganized core production jobs to increase productivity and gain internal flexibility; 37 percent have implemented some form of performance based compensation beyond hourly wages; and 75 percent report an increase in the amount of training provided to production employees in the past three years. These numbers indicate that new work practices have penetrated deeply into the small firm manufacturing economy. At the same time, however, there is considerable variation regarding the extent of adoption. Based on a ‘work organization profile’ developed for each surveyed firm, I estimate that 35 percent
of firms have ‘transformed’ their work organization through implementation of integrated work systems; 22.5 percent have made moderate changes in work organization through implementation of individual work practices; and 42.5 percent of firms have made no fundamental changes in work organization. I refer to the three groups, respectively as ‘transformed,’ ‘transitional,’ and ‘traditional’ firms.

**Explaining Variation in Workplace Innovation Outcomes**

What explains why firms in the same industrial sector exhibit such wide-ranging behavior when it comes to the new work organization? Based on the technology diffusion literature and insights from my own field-work, I identified seven explanatory variables that could logically account for variation in workplace innovation outcomes. These variables were incorporated into the survey instrument and enabled me to construct a profile of firm characteristics by innovation level. Detailed analysis of this data indicates that whether and when firms embark on a path of organizational reform must be analyzed in the context of each firm’s market environment and overall strategy.

I argue that adoption of organizational innovations is not an “either/or” phenomenon but an evolving process conditioned by two key variables: 1) the nature of market pressure a firm experiences; and 2) the strategic orientation of firm leadership. Because these variables are subject to change, however, the innovation categories I have proposed—*traditional*, *transitional* and *transformed*—are far from fixed. To the contrary, survey and field data suggest that movement up the work organization spectrum is an extremely fluid process shaped by external (market) factors and internal (firm-based) factors.
The Nature of Market Pressure

Market signals alert firms to the need for organizational reform. The ways in which these signals are transmitted to firms varies considerably, however, depending on the industry sector the firm supplies to and the nature of customer relations. Different industries adhere to different supplier performance standards and the point at which these requirements become the norm varies across industries. In some industries (e.g. aerospace) organizational reforms are explicitly required and have become a precondition of doing business. In other sectors (e.g. industrial machinery), requirements for organizational reform are not widespread nor are they uniformly imposed on suppliers. Accordingly, the level of organizational reform required to be a competitive supplier in some industries is higher than in others.

The context in which market pressure is applied also varies by customer. Some customers impose pressure for organizational reform in the context of production ‘partnerships’ characterized by information sharing and long-term contracts; other customers, in contrast, exert market pressure on suppliers in the context of ‘cost-driven’ relationships. Suppliers engaged in ‘partnership’ with their customers are generally given a timeline for implementing organizational changes that will improve quality, delivery and price. In addition, these customers will often provide assistance to suppliers to help them fulfill the new requirements. In ‘cost-driven’ relationships, by contrast, customers exert pressure on suppliers by threatening to terminate—or actually terminating—contracts when they are unhappy with supplier performance. In this context, customers provide no information or assistance regarding how suppliers can improve performance.
Variation in the nature of market pressure is reflected quite dramatically in the three innovation categories. Unlike ‘traditional’ and ‘transitional’ firms, a majority of ‘transformed’ firms supply to industrial sectors (e.g. aerospace and medical instruments) that require their suppliers to implement organizational reforms. Furthermore, many of these firms are engaged in ‘production partnerships’ with their most important customers.

**Strategic Orientation of Firm Leadership**

The second key determinant in the timing and extent of adoption is the strategic orientation of firm leadership. The survey data suggests that ‘transformed’ firms do not adopt new work systems in isolation. Rather, it appears that *organizational reform is pursued as part and parcel of a broader set of strategic choices that include the manufacturing and marketing strategies of the firm and its key customers.*

The leaders of ‘transformed’ firms are growth and investment oriented. They are typically making changes on many levels inside the firm—not just work organization. In order to expand and improve internal capabilities, sales, and market reach, these firm leaders are forging wholesale change in the organization of production and company culture. Accordingly, the implementation of new work systems is one component of a larger strategic vision shaped by product market and customers. In contrast, leaders of ‘traditional’ firms are typically maintaining the status quo. They are far less likely to have, let alone implement, a strategic vision that requires related changes in production, marketing, customer relations and work organization. These firm leaders tend to be reactive and are apt to pursue organizational change only if the firm’s livelihood is threatened.
Embedding New Work Systems in a Strategy of Distinction

Individual case studies indicate that implementation of new work systems is a critical component of small firm success. Changes in work organization alone, however are not sufficient. The case studies reveal that ‘transformed’ firms implement new work systems in the context of a strategy to develop (or maintain) distinctive products and customized service. I argue that both levels of adjustment—in work organization and in products and services—are necessary to insulate firms from lower cost competition.

The widespread use of programmable technology over the past 15 years has made it easier and easier for new entrants to perform the complex machining and assembly tasks that only highly skilled craftsmen could achieve before. As a result, it is now possible for high-skill, craft-based firms to be beaten out by lower wage firms (both foreign and domestic) that have mastered the new technology as well as organizational strategies that contribute to lower costs. Survey data and field research suggest that the more distinctive (i.e. difficult to produce) and/or customized (specialized knowledge of customers’ technical requirements) a firms’ products and services are, the less likely the firm is to be undercut by price-based competition. Accordingly, to escape the losing battle of price-based competition, small industrial manufacturers must be proficient in the new organizational disciplines that increase quality and lower costs and distinguish themselves from competitors through development of unique, higher-end products and services.

What the case studies reveal quite dramatically is that firms do not automatically know how to make these adjustments. Faced with similar market dynamics, firms exhibit an extremely broad range of behavior—both conceptually and practically. Through the
loss of major contracts, flat or declining sales, or customer requirements for performance improvements, firms become aware of new market dynamics and recognize the need for adjustment. But firm leaders don’t automatically know how to interpret market signals or how to respond effectively to them. Thus, while market signals alert firms to problems and to the need for adjustment strategies, they do not help firms make the changes—in work organization, products, or services—that will solve those problems.

**Mechanisms of Change**

Two mechanisms appear to facilitate successful adjustment along these critical dimensions. The first mechanism—the customer-supplier ‘partnership’—is a coercive mechanism of change; the second mechanism—innovative, investment-oriented management—is a normative mechanism of change.

**Customer-Supplier ‘Partnerships’**

The customer-supplier relationship is a powerful force for change in the small firm environment. Over the past decade an increasing number of OEM’s have entered into production partnerships with a select group of suppliers to reduce procurement costs, enable ‘co-engineering’ and improve quality levels. To qualify as a preferred supplier, firms are typically required to assess internal operations and provide documentation regarding how they will meet stringent technology, quality, cost, delivery and service requirements. Suppliers are provided with performance benchmarks and monitored by customers regarding progress toward meeting them. Thus, in the case of the customer-supplier partnership, the strategic response is shaped, and in some respects scripted, by
explicit customer requirements. The suppliers’ challenge is to work out the strategy through practice.

Most small firms need to make significant investments—in technology, work organization and requisite training to acquire preferred supplier status. Suppliers are willing to make these investments because they are ineligible for contracts with customers unless they do. Suppliers that demonstrate compliance with the new requirements are rewarded with exclusive, long-term (3-5 year) contracts. In this respect, the customer-supplier partnership represents a coercive mechanism of economic adjustment.

**Innovative Management**

Most firms are alerted to the need for change without the benefit of customer input or commitment—typically through the loss of a major contract or customer. Under these circumstances, innovative management—capable of conceptualizing and implementing an adjustment strategy—is critical.

Many small firm leaders are highly skilled (particularly in the technical sense), but few are innovative managers. By innovative I refer not to technical ability (which is a given) but to the ability to assess market dynamics and respond effectively. The ability to ‘read’ the market, anticipate what customers want and need and figure out how to provide it to them in the most cost effective and efficient way possible is paramount in today’s manufacturing economy. This requires an expanded skill set on the part of firm leaders and managers: the ability to think strategically and see the ‘big picture’, the ability to interact constructively with shop-floor employees to implement the necessary changes in the organization of production, and the willingness to make requisite
investments in plant, machinery and human capital. In short, navigating the transition from the ‘mom and pop’ shop to the ‘high performance’ small firm requires a new standard of small firm leadership.

Policy Implications

The mechanisms of change identified through my research, while powerful, are not widespread enough to facilitate economic adjustment in the small firm, manufacturing sector on a broad scale. The customer-supplier partnership is a potent mechanism of diffusion: however, because it has been adopted by a limited number of industries and because it stems from a desire to rationalize (and therefore reduce) OEMs’ supply base, it is unlikely to spur adjustment throughout the small firm economy. And firms led by innovative, investment-oriented managers are still the exception, rather than the rule, in the small firm, manufacturing sector. Accordingly, on their own, a broad swath of the small firm population is unlikely to make the adjustments in work organization that I argue are critical for long-term, small firm survival.

The power of the mechanisms of change I have identified lies in their ability to reorient firm strategy. I argue that the conceptualization of an alternative strategy—one that responds to new market dynamics by simultaneously upgrading work systems and products and services—is the single most important change that can take place in the small firm. Once this change has occurred, firm leaders must work tirelessly to implement the strategy through practice. In the implementation phase, firm leaders may need to draw on outside resources to develop design capabilities, upgrade computer
systems, purchase new technology, reorganize the shop-floor, provide training, meet documentation requirements etc.

The current federal-state system of industrial extension (Manufacturing Extension Partnership) can provide assistance to firms in these areas. However, unless firm leaders have already conceptualized a new approach to their business, services offered by extension centers are unlikely to transform firm organization or behavior. Extension center performance is evaluated by the number of ‘hits’ field agents get and the number of completed ‘engagements’ these hits lead to. This evaluation criteria encourages extension centers to provide the lowest common denominator of service to firms in order to sustain project volume. Recent review of the MEP system in Massachusetts for example, indicates that service delivery has been dominated by very low-price, low-intensity projects. In 1997 web page development was the fastest growing segment of the service portfolio and 56 percent of all technical assistance projects were priced below $2,500.

The current policy approach to small firm modernization encourages piece-meal change that fails to address the far more fundamental issue of firm strategy. My research findings suggest that public programs should pursue a targeted service delivery strategy that builds on the powerful mechanisms of change indigenous to the small firm economy. Through the development of regional supply consortia, public resources should be directed toward agglomerations of firms in key industry sectors. The starting point of these efforts should not be service delivery but deep learning and relationship building—between customers and suppliers and between innovative and traditional small firms. A concerted focus on management education and development and promotion of customer-
supplier 'partnerships' across key industry sectors is a more promising way to encourage viable, long-term adjustment strategies in the small firm sector.

**Organization of the Dissertation**

The dissertation is organized into five chapters. Chapter One provides an overview of the western Massachusetts metalworking sector. The first section of the chapter provides an historical overview of the region's metalworking sector beginning with the establishment of the Springfield Armory in 1794. Section two provides a contemporary overview by documenting the region's 'deindustrialization' and the subsequent redistribution of manufacturing employment to smaller firms. Section three presents survey data to provide an overview of the region's metalworking sector today.

Chapter Two draws on field work and survey data to describe the external factors driving organizational change in small firms and the various ways in which firms are responding to these pressures. In the first section of the chapter I focus on five critical ways firms are responding to the new competition. In the second section, I consider the implications of these changes for firm owners, employees and human resource practices.

Chapter Three presents survey data regarding the spread of new work organization practices among surveyed firms. In the first section I examine the distribution of individual work practices and the distribution of bundled practices. In section two I review the technology diffusion literature in order to develop hypotheses regarding variation in the adoption of new work organization practices. I then present survey findings regarding sources of variation. In section three, I interpret variation and present an argument regarding its key determinants.
In chapter four, I present matched pair, firm-level case studies to demonstrate how the sources of variation identified in Chapter 3 shape the real-world responses of firms to the new manufacturing environment. The first section of the chapter describes the case study methodology. In section two, I present the two controlled comparison case studies. Section three is analysis of the cases and elaboration of the explanatory framework.

I conclude the study in chapter 5 with a summary of my research findings and a discussion of the policy implications that stem from the research.
Chapter One:

Industrial District, Industrial Decline:
An Overview of the Western Massachusetts
Machining Industry

Introduction

For over 150 years, Springfield, Massachusetts was the heart of a prosperous and innovative manufacturing region that ran the length of the Connecticut River from White River Junction, Vermont in the north to Hartford, Connecticut in the South. Throughout the past two centuries, the region’s manufacturing economy has been characterized by a dense cluster of specialized metalworking and machinery shops that provide larger manufacturers with the machines, tools, parts and assemblies required to manufacture a plethora of products from guns to sewing machines to aircraft engines.

Though the public policy focus on small industrial suppliers dates back just a decade, these firms have a rich history in western Massachusetts that dates back to the Revolutionary War. This chapter provides an historical overview of the rise and decline of the greater Springfield area as a manufacturing center with a focus on the region’s small machining firms. Throughout the chapter, particular attention is paid to the interaction between the region’s large manufacturing establishments and the network of small metalworking and machinery firms that act as their suppliers.

The first section of the chapter provides an historical overview of the region’s metalworking sector beginning with the establishment of the Springfield Armory in 1794. This section highlights commercial manufacturing breakthroughs that have occurred in
the region as well as the region’s historic reliance on defense contracts. Section two
documents the region’s ‘deindustrialization’ and subsequent redistribution of
manufacturing employment to smaller firms. Section three presents survey data to
provide an overview of the region’s metalworking sector today.

I. Historical Overview: The Springfield Armory and ‘Interchangeable’
Manufacturing

The roots of the Connecticut River Valley’s metalworking economy date back to
the Revolutionary War. In response to a 1775 arms embargo placed on the colonies by
Britain, Congress urged manufacturers to take steps to produce firearms. Subsequently,
private armories and machine shops specializing in small arms began to form up and
down the Connecticut River Valley in the late 1700’s.1 Following the embargo, Congress
established a cannon factory in Springfield, MA in 1778. According to the American
Machinist, metalworkers began to flock to Springfield at this time in order to supply the
military depot (American Machinist, 1996).

Following the Revolutionary War there was widespread concern in Washington
over potential arms shortages. In 1791, Alexander Hamilton presented a major report to
Congress in which he recommended that national arsenals be established to store arms.
These arsenals, he suggested, should both produce arms and purchase arms from private
contractors in order to insure an adequate supply (American Machinist, 1996). In 1794,

1 According to American Machinist, the first arms production in America is credited to Hugh Orr, a
Scottsman who started an iron works in Bridgewater, MA around 1738. During the Revolution, he
produced arms and supervised a second factory at Bridgewater to produce cannons which were cast solid
and then bored to the proper size. Other small armories developed in Providence, R.I. and Harrisburg, PA.
(American Machinist, 1996).
Springfield was selected as the site of the first federal armory.\(^2\) Within a few years, the Armory employed 68 men and produced 4,000 muskets a year. In 1798, Congress passed an act appropriating $800,000 for the federal armories to purchase arms and ammunitions from private sources. As a result, according to historian Merrit Roe Smith, Springfield became a "magnet for skilled mechanics and inventors and the center of a thriving gun trade in the Connecticut Valley" by the turn of the century. (Smith, 1994)

The Springfield Armory played a pivotal role in the development and dissemination of "interchangeable parts" manufacturing—a technological innovation that provided a critical basis for mass production and "the American system" of manufacturing. Following disastrous gun malfunctions in the War of 1812, the federal Ordnance Department and Department of War sought greater reliability through uniformity in arms production. Working closely with the small private armorer's, tool makers, and machine builders in the region, the Armory—under the federal Ordnance Department's oversight—developed the technology of "interchangeability" in which specialist machines produced identical parts that could fit into any rifle (Best, 1990; Boucher, 1995). Interchangeable arms manufacturing represented a radical departure from the European handwork system in which individual gun parts were custom-made by highly skilled craftsmen. As Michael Best describes in his examination of the Armory, "interchangeability required breaking-down products into their simplest parts, designing a specialist machine capable of producing each piece, and inspecting each part with a custom-designed set of gauges (pg. 32)."

\(^2\) Springfield was chosen as the site of the first federal armory for several reasons. The cannon factory established by Congress in 1778 had already attracted skilled machinists and metal artisans to the region. In addition, Springfield was on the Connecticut River and provided easy access to both New York and
While production of small arms based on the concept of interchangeable parts eliminated the need for skilled handwork, it required new skills in the design and application of machine tools, specialized gauges, and fixtures to the production process. The small metalworking shops of the Connecticut River Valley proved remarkably adept in these new technologies and the Armory's leaders—according to historian Smith—"exelled at ferreting out technical novelties developed elsewhere and incorporating them into the production process at Springfield."

In 1815 Armory officials began scouting private armories and machine shops throughout New England in search of mechanical innovations that would further advance interchangeable manufacturing. In some cases, these field trips yielded tremendous results. In 1816, for example, Armory officials became aware of the first machine for milling metal when they visited the Middletown, CT factory of an armory contractor named Simeon North. They also learned about a young mechanic from Millbury, MA who invented the first woodworking lathe in 1818. The mechanic—Thomas Blanchard—became a contractor to the Armory and designed and perfected 14 different woodworking machines between 1822 and 1827 that mechanized and standardized the process of gunstocking (Smith, 1994).

Stemming from its public stature, the Armory had an 'open-door' policy enabling all interested parties to visit the Armory to study the new technology and see it in action. Arms manufacturers, mechanics, and machinists throughout the Connecticut Valley took full advantage of the policy and a number of firms quickly emerged that specialized in the building of machine tools for interchangeable arms manufacturing. In contrast to the

Boston. Shortly after Springfield, a second national armory was established in Harpers Ferry, VA. (American Machinist, 1996; Smith, 1994).
craft system in which each part had to be hand fitted into an individual gun, the new
machine tools incorporated specified part tolerances into the machine itself. To insure
the machines were meeting stated tolerances, measuring tools were developed to check
the dimensions of the machined parts. Thus, in addition to a proliferation of machine tool
builders, small firms that specialized in gauges and measuring tools emerged throughout
the Valley. Finally, dozens of machine shops emerged that specialized in the production
of various gun components such as stocks, barrels, bayonets, locks and mountings (Best,
1990).

Critical to the region’s vibrant economic development in this period was the
Armory’s contractual requirement that all Armory suppliers share their technological
inventions and improvements with the national armories on a royalty-free basis. Given
the Armory’s ‘open-door’ policy, the requirement meant that private inventions
immediately became part of the public domain. Thus, the Armory unintentionally
became a clearinghouse for leading manufacturing technologies, information, and
technical assistance. As Norman Boucher notes, everyone benefited from this
arrangement: “The armory got its desired technology, the local economy prospered, and
the small-arms manufacturers developed both a reliable customer and the expertise they
needed to tackle new markets (Boucher, 1994).”

Economist Michael Best asserts that the Valley’s network of small firms—with
the Armory at the center—formed an “industrial district” characterized by competition,
cooperation, and institutions of collective learning. Small firm suppliers had to compete
for armory jobs and in order to qualify they had to demonstrate their mastery of the new
production technologies. At the same time, the Armory helped suppliers meet these
rigorous standards through provision of information, advice, tools, machinery and skilled labor (Best, pg. 38). Contractors, in turn, used information gleaned at the Armory to improve their own production processes and these improvements—through the ‘open-door’ policy—became widely available to manufacturers of all kinds. The result of this dynamic environment was that Springfield—by the 1830’s—had become one of the most sophisticated metalworking establishments in the world (Smith 1994, pg. 7).

**Armory Practices Spread to Commercial Markets**

While the Springfield Armory’s status as the world’s most innovative arms manufacturer was relatively short-lived, its influence on American manufacturing was not. By the late 1840’s, technologies developed at the Armory had begun to spread to the larger manufacturing economy. Technological developments were transmitted primarily by skilled workers who had “received their early training at one of the public or private armories and subsequently moved to new positions as master machinists and production supervisors at other manufacturing establishments.” (Smith, 1994 pg, 12) As workers moved from shop to shop accumulating and dispensing knowledge, the new technologies quickly spread across industry lines.

Central to the process of cross-fertilization was the gradual development of machine tools for commercial purposes. Armory contractors—such as the Ames Manufacturing Company of Chicopee, MA, Robbins and Lawrence of Windsor, VT, American Machine Works of Springfield, and Samuel Colt of Hartford—borrowed armory tool and machine designs and began to adapt them to different uses in the 1830’s. By the mid-1800’s, a number of firms emerged whose main purpose was the
development and building of machine tools for commercial purposes (American Machinist, 1996). According to the American Machinist, these commercial firms were distinct from the arms makers that developed the original machine tools for interchangeable manufacturing:

Although capitalizing on the system of interchangeable manufacture created by the arms makers, these new firms did not grow out of arms makers. Rather, they developed out of the unique type of general machine shop that would develop and build any kind of machine that one might wish to order for any purpose. Such shops did not produce standard machines and go out and sell them; they innovated on demand. (American Machinist, 1996)

By 1850, a flourishing trade in machine tools existed in the Connecticut River Valley (Smith, pg. 14). As machinists and mechanics from these small firms changed jobs, they introduced their technological know-how to new sectors of the manufacturing economy. As historian Smith explains,

Through these institutions and their cadres of remarkably mobile mechanics, armory practice....spread to technically-related industries and by the later 1850’s could be found in factories making sewing machines, pocket watches, padlocks, railway equipment, shoes, wagons, and hand tools. From these beginnings it was only a matter of time before the new technology found applications in the production of typewriters, agricultural implements, bicycles, gramophones, cameras, cash registers, business machines, automobiles and a host of products associated with the mass production industries of the twentieth century (Smith, pg. 15).

The specialist metalworking and machine shops that emerged in the Connecticut River Valley were a unique feature of New England in the first half of the nineteenth century. Together, they constituted a "shop culture" which was

an elite group in a day when a machinist was 'one who invents or makes machines.' The shops were usually individual or partnership operations, and they rarely grew very large. To sign on as an apprentice in such a shop in those days

3 The Springfield Armory was rapidly eclipsed by private companies such as Colt, Sharps, Remington, and Winchester. By 1855, for example, Samuel Colt’s Hartford, CT armory used almost 400 machines to produce guns and the machine tools to make them (Boucher, pg. 8)
was the only route to becoming a mechanical engineer (American Machinist, 1996)

The dense concentration of specialty machine shops made the region particularly attractive to entrepreneurs and manufacturers developing new products. (Best, pg. 41) In addition to machine tools and arms production, Springfield and the surrounding towns of Holyoke and Chicopee became centers for the manufacture of paper, sewing machines, textiles and bicycles, while Hartford became a center for the manufacture of motorcycles and automobiles. By the second half of the nineteenth century, New England was the nation’s industrial leader and the Valley’s small firms were producing machines, tools, components, and parts for every conceivable manufacturing sector.

**The Rise of Aircraft and Aerospace Production in the Connecticut River Valley**

The next boon for the region’s small metalworking firms came with the rise of the aircraft industry. The precision production methodologies developed for interchangeable gun parts in the 1800’s proved to be equally important to the manufacture of aircraft engines in the 1900’s. In 1925, engineer George Mead and businessman Frederick B. Rentschler of the Wright Aeronautical Company in Dayton, Ohio approached Hartford’s Pratt & Whitney about the development of a new air-cooled airplane engine. Pratt & Whitney—an armory supplier and leading machine tool producer after the Civil War—agreed to provide start-up money and factory space for the new venture (Pratt & Whitney, 1999).

According to Markusen et. al. (1991), Mead and Rentschler approached Pratt & Whitney because they didn’t believe their engine could be manufactured in the mid-west which was geared to low-cost, mass production of the automobile. Production of airplane
engines would require highly skilled craftsmen accustomed to high precision and quality. Mead and Rentschler were drawn to Pratt & Whitney for its reputation as a mechanical innovator but also because of the network of skilled metalworkers, machinists and mechanics that populated the Connecticut River Valley.

Pratt & Whitney’s first aircraft engine—the \textit{Wasp}—was completed in 1925. Within less than a year from completion, the United States Navy had ordered 200 engines. In 1929 Pratt & Whitney joined forces with the Sikorsky Aviation Corporation, Chance Vought, and the Hamilton Standard Propeller Corporation to form Hartford-based United Aircraft (UT, 1999). Together, these companies revolutionized American aviation through the development of engines, propellers, airplanes and helicopters. Another early player in the development of the aircraft engine was General Electric and in 1941 the U.S. Army picked General Electric’s Lynn, MA plant to build the country’s first jet engine (GE, 1997).

By the time of the Second World War, Connecticut had become a world center of aircraft production. United Aircraft’s wartime production, for example, included 300,000 Pratt & Whitney engines, 500,000 Hamilton Standard propellers, 20,000 Chance Vought airplanes, and 150 Sikorsky helicopters (UT, 1997). In 1947, GE’s Lynn plant developed a new jet engine (the J47) for front-line military aircraft. The engine proved so popular that GE had to build a second production line to accommodate demand. By the end of the 1950’s, 35,000 J47’s had been produced.

\footnote{United Aircraft became United Technologies in 1975. Today UT is the 43rd largest corporation in the United States.}

\footnote{In 1949, GE opened the new line at a Lockland, Ohio plant which had made Wright Aeronautical piston engines during World War II. Later the plant would be known as Evendale and would grow to be much bigger than the Lynn plant. Eventually GE Aircraft Engines would open two additional manufacturing and assembly sites in New England, in Rutland, VT and Hookset, NH. In total, 3 of GEAE’s 10 manufacturing and assembly plants are located in New England.}
The expanding aircraft business provided endless opportunity for the region’s existing small metalworking firms and the impetus for the establishment of many new shops. In order to meet their enormous production goals, each aircraft company developed elaborate webs of specialized machine shops that supplied them with necessary tools, precision parts and components. These shops—which came to be known as ‘precision manufacturers’ due to the high tolerance production work they perform—clustered in and around Hartford, CT and Springfield and Lynn, MA.

The aircraft and aerospace sector provided an abundant source of work for the region’s small metalworking firms throughout the post-war period. From World War II through Vietnam, the region’s small shops relied on lucrative, if cyclical, contracts with the giant aircraft firms. In addition, many metalworking shops secured work in this period with defense contractors responsible for the production of defense-related transportation vehicles including tanks, and eventually, guided missiles and space vehicles.\(^6\)

II. **Contemporay Overview: Deindustrialization, Globalization and Lean Production**

Though New England manufacturing companies mastered the art of mass commodity production in the first quarter of the twentieth century, they were unprepared for the competition unleashed by globalization fifty years later. Beginning in the late 1970’s, New England—like many industrial regions across the country—was wracked by a series of layoffs and plant closing that resulted in the permanent loss of hundreds of thousands of blue-collar production jobs. Many large manufacturers in mature industries

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\(^6\) While the aerospace and defense sectors are notorious for boom and bust cycles, strong demand for consumer goods in the post-war period offset wartime reductions (Pages, 1995).
such as metalworking, apparel, textiles, and paper were forced out of business as their traditional markets were penetrated by low-cost competitors from Taiwan, Hong Kong and Korea.\(^7\)

New England’s machine tool sector experienced a particularly dramatic collapse as a result of international competition. Beginning in the 1960’s, many of New England’s small and medium machine tool companies were bought by large conglomerates which failed to invest in upgrading technical and manufacturing capabilities (Bank of Boston, 1991). At the same time, foreign firms were automating production processes and redesigning products to be made from standard parts, components and modules. Outdated technology and long order backlogs among U.S. firms resulted in foreign companies (particularly Japanese and German) capturing 50 percent of the U.S. machine tool market by the mid-1980’s (McKinsey, 1993).\(^8\) In Springfield, VT—a regional center for machine tool production—industrial machinery employment declined seventy percent between 1980 and 1990 from 3,100 workers to just 900 (Boucher, VT Dept. of Employment and Training).

In Massachusetts over 40,000 jobs were lost in traditional manufacturing sectors between 1980 and 1985. Initially, these losses were obscured by rapid growth in high-tech and defense-intensive manufacturing (see Table I). As employment in industries

\(^7\) Massachusetts’ traditional, non-durable manufacturing industries such as apparel, textile and leather goods were experiencing long-term, secular declines prior to the 1970’s as manufacturers moved south in search of cheaper labor, raw materials, power and transportation. Overall, the Massachusetts manufacturing sector entered a long-term period of decline or slow growth that lasted from the 1920’s to the 1960’s (Commonwealth of Massachusetts, 1993).

\(^8\) Ironically it was the smaller job shops that turned to off-the-shelf machine tool products from Japan, Taiwan, and Korea in the late 1970’s and early 1980’s. During this period machine tool orders in the U.S. were at very high levels. Many industries were retooling to make smaller, more energy efficient products. The auto industry (large customers) got preferential treatment while smaller shops had to endure long lead times. Due to the contract nature of their work, small firms were less able to wait for tools and began purchasing from U.S. competitors (McKinsey, 1993).
such as metalworking, apparel, and paper plummeted, high tech and defense-intensive manufacturing sectors added over 25,000 jobs to the state economy. (DEET 1996) As a result of employment growth in these two areas, overall manufacturing employment at the state level decreased by only 3.5 percent between 1980 and 1985. Between 1985 and 1990, however, the severity of manufacturing job loss became all too clear. Job loss in traditional manufacturing sectors continued unabated during this period. In addition, Massachusetts high-tech manufacturing sectors began to face stiff foreign and domestic competition. In total, between 1984 and 1988, Massachusetts lost 92,000 manufacturing jobs. By early 1989, Massachusetts entered the worst economic recession (measured in job loss) since the Great Depression of the 1930's.  

The state’s metalworking sector (including primary metals, metal fabrication and industrial machinery) lost 17,100 jobs statewide representing a 13 percent employment decrease between 1980 and 1985. Between 1985 and 1990, the sector lost another 22,000 jobs for total statewide job loss of 39,500 between 1980 and 1990. Hardest hit among the various metalworking sectors was industrial machinery (SIC 35) which accounted for over 50 percent of all metalworking job loss. Industrial machinery firms lost over 20,000 jobs between 1980 and 1990—representing a 34 percent decrease in employment.

(Massachusetts Department of Employment and Training, 1996).

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9 According to the 1992 Census of manufacturers, Massachusetts lost 111,000 manufacturing jobs between 1987 and 1992. Only three states — New York, New Jersey and California - all with many more employed in manufacturing, lost as many jobs. As a percent of total manufacturing, Massachusetts lost more jobs than any other industrial state – 18.8 percent of the total manufacturing base.
<table>
<thead>
<tr>
<th>Table I: Statewide Sector Employment and Job Loss in Traditional and High Tech Manufacturing Sectors 1980 - 1995</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total</strong></td>
</tr>
<tr>
<td>All Manufacturing</td>
</tr>
<tr>
<td>Metal Fabrication</td>
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<tr>
<td>Industrial Machinery</td>
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<tr>
<td>Textiles</td>
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<tr>
<td>Apparel</td>
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<tr>
<td>Paper</td>
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<tr>
<td>High Tech Manufacturing</td>
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<tr>
<td>Computer Equipment</td>
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<tr>
<td>Electronic Components</td>
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<tr>
<td>Transport Equipment</td>
</tr>
</tbody>
</table>

Source: Massachusetts Department of Employment and Training

Throughout the 1980's metalworking job loss occurred primarily in large unionized plants (Commonwealth of Massachusetts, 1993; Forrant, 1994). In the industrial machinery sector statewide, for example, employment in establishments with more than 250 employees fell by forty percent between 1981 and 1991 (from 75,154 jobs...
to 44,940 jobs). Over the same period, employment in industrial machinery establishments with less than 250 employees declined by only five percent—from 35,570 jobs to 33,722 jobs. The result was a redistribution of employment from larger to smaller firms: firms with under 250 employees jumped from just under one-third of all sector employment in 1981 to 43 percent of sector employment by 1991. By 1996, firms with fewer than 250 employees provided the majority of sector employment. (See Table II)

**Table II: Statewide Employment by Establishment Size 1981-1996**

**Industrial Machinery Sector (SIC 35)**

<table>
<thead>
<tr>
<th>Year</th>
<th>Sector Employment</th>
<th>Firms 1-249</th>
<th>Percent Total</th>
<th>Firms 249+</th>
<th>Percent Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1981</td>
<td>110,724</td>
<td>35,570</td>
<td>32%</td>
<td>75,154</td>
<td>68%</td>
</tr>
<tr>
<td>1987</td>
<td>104,024</td>
<td>37,728</td>
<td>36%</td>
<td>66,746</td>
<td>64%</td>
</tr>
<tr>
<td>1991</td>
<td>78,662</td>
<td>33,722</td>
<td>43%</td>
<td>44,940</td>
<td>57%</td>
</tr>
<tr>
<td>1996</td>
<td>64,461</td>
<td>35,724</td>
<td>56%</td>
<td>28,737</td>
<td>44%</td>
</tr>
</tbody>
</table>

Source: Massachusetts Department of Employment and Training


**Increasing Defense Dependency**

For the small metalworking suppliers of the Connecticut River Valley, international competition resulted in the loss of key customers. As large New England manufacturers in various sectors went out of business, they no longer ordered the

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10 These figures include computer and office equipment. Establishment changes by size only available at 2-digit SIC level.
machines, tools, and component parts necessary to produce and assemble their products. In addition, remaining mass production firms began to purchase more of their machines, tools and parts from lower-cost suppliers in other parts of the world.

While the structural economic changes brought forth by globalization might have decimated the once-thriving network of small supplier firms, the region’s concentration of aircraft manufacturers and defense contractors provided a steady stream of work to machine shops located in Massachusetts and Connecticut throughout the 1980’s. As orders from traditional manufacturing sectors shrank, demand for machines, tooling, precision parts and mechanical assemblies in the aircraft and aerospace sectors soared due to the Regan-era defense build-up.\(^{11}\)

During the 1980’s, approximately 600,000 new manufacturing jobs were generated across the country in defense-related production while manufacturing as a whole shed one million jobs (Markusen and Yudken, 1992). New England garnered a disproportionate share of defense-related manufacturing jobs during this period.\(^{12}\) While the region accounted for 7.9 percent of total U.S. manufacturing, it accounted for 13.3 percent of all defense industrial employment (Bank of Boston, 1991; Machine Action Project, 1993). Between 1988 and 1991, Connecticut and Massachusetts were among the four most defense dependent states in the country; by 1992, they ranked number one and

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\(^{11}\) As mature industries such as metalworking, apparel and textiles shed thousands of jobs between 1980 and 1985, defense dependent sectors of the Massachusetts manufacturing economy grew. Transportation equipment (which includes aircraft and parts, guided missiles and space vehicles, and tanks and tank components) grew by 10 percent between 1980 and 1985 adding 4,300 jobs to the economy. Communications equipment added 10,900 jobs growing by 33 percent between 1980 and 1985. For both sectors, 1985 represented peak employment.

\(^{12}\) The largest defense-related manufacturing sectors in Massachusetts in the 1980’s were: missiles, aircraft engines and electronics and communications equipment. Prime contractors include: Raytheon, General Electric, Textron Defense Systems and GTE.
two respectively, among all states in terms of private-industry defense dependency (Pages, 1995; Kodrzycki, 1995).13

Aircraft engine and airframe components composed a large share of total defense related purchases in New England throughout the 1980’s. Pratt Whitney and other divisions of United Technologies secured large defense aerospace contracts as did General Electric. For the region’s small metalworking firms, the defense build-up compensated for the loss of traditional manufacturing markets. At the same time, however, it changed the nature of the small firm network. As domestic markets eroded, the network of small interdependent shops became increasingly dependent on a handful of large, multinational corporations.

Defense Downsizing and Reduction of the Supply Base

Declines in federal defense spending resulting from the end of the Cold War led to employment reductions in defense-intensive manufacturing beginning in the late 1980’s. At the national level the reductions were minimal. In New England, however, the reductions were severe and contributed greatly to the region’s economic recession. According to the Federal Reserve Bank of Boston, prime contract awards to Massachusetts companies fell 41.7 percent from $8.7 billion to $5.1 billion between peak year 1989 and 1994 and defense-related private sector employment fell by 41,100. In Connecticut, prime contract awards fell 59 percent from $6 billion to $2.4 billion and employment fell by 35,000. By comparison, the total federal cut in defense spending during this period was 21 percent (Kodrzycki, 1995). As a result of their high levels of

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13 Defense dependence refers to the extent a state’s economy depends on defense-related purchases. All New England states except Vermont were among the top half of states in terms of defense dependency.
defense dependency, Connecticut and Massachusetts suffered increases in unemployment more than 2.5 times higher than other states during this period (Pages, 1995).

The most common response to defense cuts among prime contractors in the early 1990’s was downsizing. In 1993, eleven of the top twelve U.S. defense firms laid off at least 2000 employees (Pages, 1995). New England’s largest aerospace companies laid-off thousands of employees at this time as well. Pratt and Whitney’s workforce fell from a high of 38,000 in 1980 to 20,000 in 1993 and General Electric Aircraft Engines laid off approximately 4,000 workers, 700 of them in Lynn, MA (Machine Action Project, 1993). Prime contractors also began to reduce their vendor bases in response to the cuts. As noted earlier, prime contractors historically relied on large numbers of suppliers to meet production goals. Beginning in the early 1990’s, however, many prime contractors began to shift toward ‘preferred suppliers’—a strategy that involves closer cooperation with a smaller number of high quality subcontractors—in order to streamline procurement and reduce costs.

**Lean Production**

With the collapse of predictable mass markets in the 1980’s, large U.S. firms faced declining market share, rising consumer expectations for greater quality and customization, and intense competition from rival firms in Japan and Europe. Beginning in the mid-1980’s, many large U.S. manufacturers began to reorganize their own production processes in response to these global pressures. In order to develop “lean production” systems, however, large firms discovered they needed suppliers that could supply defect free parts, on a “just-in-time” basis, at the lowest possible cost. As a result,
many large firms began to place demands on their suppliers for performance improvements in the areas of quality, delivery and price.

Customer demands for performance improvements among the supply base have taken different and somewhat opposing forms: a minority of large U.S. corporations have entered into close working relationships with a select group of “core” suppliers to help upgrade their internal capabilities. These relationships are commonly characterized by long-term contracts, continuous communication and information exchange, and two-way, on-site technical assistance. The majority of U.S. manufacturers, however, continue to engage in “arms-length” relationships with their suppliers. Under these conditions, demands for higher quality and more frequent delivery have become additional criteria for supplier selection in a competitive bidding system traditionally driven by price.

Supplier Development Programs

Inspired in part by Japanese supply “keiretsu,” a number of prominent American companies established supplier development programs (SDPs) aimed at improving productivity among the supply base in the late 1980’s and early 1990’s. \(^{14}\) SDP’s—most common in the auto, aerospace and electronics industries—place responsibility on OEM’s to assist their suppliers in achieving performance improvements in cost, quality, scheduling and delivery. In the most developed SDP’s, large firm customers involve suppliers in the design of OEM products and employ advanced technology to enable “co-engineering.” In a review of inter-firm production networks in the United States, Harrison (1995) notes that the big three auto firms—GM, Ford and Chrysler—“have

\(^{14}\) Supply keiretsu refers to a complex system of ‘relational contracting’ between parent companies and their suppliers in Japan in which suppliers invest in technologies and work practices required by the parent company in exchange for long-term contracts, equity investments and technical assistance. See Chapter 7 in Harrison (1994) for a description of keiretsu governance and practices.
shifted in varying degrees toward the Japanese method of supplier selection, awarding three-to-five year contracts to preferred suppliers and putting more emphasis on rewarding quality and innovation.” Comprehensive surveys of auto industry suppliers conducted by Helper (1991) for the MIT International Motor Vehicle Program indicate that the auto industry is moving toward a “voice” relationship characterized by greater commitment and exchange of information. However, in their definitive study of changes taking place in the U.S. automobile industry, Womack et. al. caution that nearly all of these changes reported in Helper’s surveys have been driven by cost pressure and mass production logic rather than by a contract framework that encourages cooperation (Womack et. al, 1990).

More relevant to the case of Massachusetts is the aerospace industry which has undertaken fundamental change in the area of supplier base management in recent years. According to MIT’s Lean Aircraft Initiative, “supplier partnerships, encompassing a variety of evolving cooperative arrangements between customer companies and their major suppliers are emerging as a key strategic means of building lean customer-supplier networks.” Through case studies, site visits and field interviews, LAI researchers identified two types of supplier partnerships in the industry: the first type is a development-focused partnership that focuses on new product, process or technology development; the second type is a production-focused partnership that involves long-term supplier agreements in support of continuous improvements in production operations. (Bozdogan, 1998)

Following the lead of the electronics giant Motorola, both Allied Signal and General Electric—multinational corporations with large aerospace divisions—recently
launched Six Sigma programs to improve performance and product yield by “reducing the number of defects inherent in the processes and material used to produce them.” (GE web site).\textsuperscript{15} Six Sigma refers to the goal of attaining only 3.4 defective parts-per million produced.\textsuperscript{16} Integral to Six Sigma is adoption of a core supplier system in which qualified suppliers work closely with the customer to improve product quality by minimizing defects. Explaining the logic of supplier development, Lawrence Bossidy, CEO of Allied Signal recently told Purchasing Magazine, “if we’re at Six Sigma and our suppliers are at Two Sigma, it’s just not going to work. We need to ensure a top level of quality all along the supply chain.” (Minahan, 1997).

Allied Signal Aerospace (ASA) purchases approximately 200,000 parts and assemblies per month mostly from small job-shops (many of which are located in the Connecticut River Valley). To achieve Six Sigma among its aerospace parts suppliers, Allied Signal’s material management group is weaning out poor performing suppliers, training supplier partners in techniques such as statistical process control and lean manufacturing, awarding long-term contracts to high achieving suppliers, and focusing on early supplier involvement in product conception and manufacturability. Once a supplier is awarded a long-term contract, ASA “commodity teams” are responsible for measuring supplier performance in four major areas including quality, cost, delivery (cycle time) and service and for ensuring that suppliers make annual productivity improvements of seven percent (Purchasing Magazine, 1997).

\textsuperscript{16} GE defines Six Sigma slightly differently as defects per opportunity – i.e. defects don’t just apply to parts but to billing, delivery etc.
GE Aircraft Engines (GEAE) unveiled its preferred supplier strategy at a worldwide vendor convention in Cincinnati in 1995. From its thousands of vendors, GEAE announced that it would select a limited number of suppliers to work with in much closer partnership. In order to qualify for consideration as a preferred supplier, vendors were required to submit a comprehensive plan in which they demonstrated how their company would satisfy GE requirements in five areas including technology, quality, delivery, management and pricing/productivity (personal interview). In addition, suppliers were required to submit, in writing, how they planned to accomplish a variety of internal quality and documentation procedures. According to local suppliers, this represents a radical departure from GEAE’s previous procurement practice in which vendors typically submitted a one-page bid sheet.

Supplier development programs contain great potential for upgrading supplier performance. However, because SDP’s typically stem from a desire to rationalize (and therefore reduce) an OEM’s supplier base, SDP resources are devoted to a very select group of small firms. Pratt & Whitney, for example, cut its supply base by 86 percent between 1991 and 1995 (Pages, 1995) and Allied Signal reduced its vendor base by 80 percent from 10,000 to 2,000 suppliers between 1992 and 1997 (Purchasing magazine). MIT’s Lean Aerospace Initiative estimates that the aerospace supply base has been reduced by 50 percent across all aspects of the industry since 1991 (MIT Lean Aircraft Initiative, 1998).
A literature review of SDPs conducted by Mt. Auburn Associates (1995) for the U.S. Small Business Administration concludes:

Suppliers who are able to comply with OEM needs are more likely to have a longer-term, less adversarial relationship with the buyer, and can enjoy increased technical capacity. At the same time, SDPs often operate in a context of, and in conjunction with, massive decreases in the OEM supplier base. In response to competitive pressures – to reduce transaction costs and increase quality – OEM’s are significantly trimming the number of suppliers they utilize...(t) hose that make the cut have demanded of them greater service and quality, and lower prices.

Arms-length Procurement

In contrast to the partnership model of customer-supplier relations, most manufacturing customers continue to adhere to the “arms-length” model of procurement. In this approach to supplier relations, purchasing agents seek multiple bids in order to secure the lowest possible price. Under this competitive bidding system, potential suppliers must bid on each individual job and are offered no guarantees of future work by the customer. This system insures that the customer can abandon the supplier if it is able to locate another supplier capable of producing the job at a lower cost. Arms-length procurement most often characterizes relatively simple, “build-to-print” jobs in which limited engineering is required. On a “build-to-print” job, the supplier receives detailed blueprints from the customer’s engineering department and builds (or machines) parts to customer specifications; in this type of relationship, customers do not typically involve suppliers in the design of the part nor do they solicit improvements in the manufacturing process.

Traditionally, the principle basis of short-term, arms-length customer-supplier relations has been price. Over the past decade, however, new quality procedures, shorter lead times, and just-in-time delivery requirements have been incorporated into the
competitive equation. In addition to low-price, many customers now require that suppliers deliver in smaller lot sizes and comply with quality and documentation standards such as statistical process control and ISO 9000. Under “arms-length” contracts, however, these new requirements are typically imposed on the supplier without offers of either technical or financial assistance by the customer. Without long-term contracts that guarantee future work, the investment required to master these new disciplines poses considerable risk for the supplier.

The New Manufacturing Environment

The combined impact of deteriorating commercial markets, defense downsizing and supply base reduction placed the small metalworking firms of the Connecticut River Valley in an extremely vulnerable position by the early 1990’s. Many firms operating in commercial sectors were forced to seek out markets beyond New England for the first time. Some of the region’s defense dependent shops were able to secure ‘preferred supplier’ status with their traditional aircraft and aerospace customers; however, other shops were forced to go out of business or lay-off employees as they searched aggressively for new work. By the early-mid 1990’s, most metalworking firms in the region found themselves operating in a new and unfamiliar manufacturing environment characterized by volatile markets, demanding customers, lower unit prices, smaller lot sizes, and greater all around competition. The changes the new manufacturing environment requires of these firms is the subject of Chapter II.
III. The Western Massachusetts Metalworking Sector Today

Like the rest of Massachusetts, Springfield was hard-hit by the dual forces of globalization and defense downsizing. Between 1977 and 1995 manufacturing employment in the greater Springfield area declined 37 percent from over 63,000 employees to just under 40,000 (DET, 1996; Census 1992). By 1995, manufacturing employed just 16 percent of the region’s workforce, down from 25 percent in the early 1980’s.

Despite steady job loss over the past two decades, metalworking continues to dominate greater Springfield’s manufacturing sector. Today, metalworking and machining companies in the region employ approximately 15,000 people with a total payroll exceeding $450 million. While metalworking comprised just over 18 percent of all manufacturing employment statewide in 1995, it comprised thirty percent of all manufacturing employment in the greater Springfield area (DET Annual County Data 1995 and DET 1996). At the establishment level, metalworking is particularly integral to the region’s economy: of the 822 manufacturing establishments in Hampden County in 1992, 41 percent (338 establishments) were engaged in metalworking of some sort (Census of Manufacturers). Within the metalworking sector as a whole, industrial machinery (SIC 35) comprises a majority of firms. Of the 338 metalworking establishments in Hampden County in 1992, 60 percent (203 establishments) were industrial machinery firms.
Western Massachusetts Industrial Machinery Firms in Comparative Perspective

The majority of machinery firms in the greater Springfield area today are small, family-owned job shops that produce custom tools, prototypes, parts, assemblies and machines for customers in the aerospace, machinery, paper, computer, and medical supply industries. Except for a small minority of firms that have proprietary products, this population of firms works on a contract basis for other manufacturing customers.

Given the unique manufacturing history of the Connecticut River Valley, it is not surprising to find that the region’s machining sector has maintained many of its distinctive qualities. There is still a strong “shop culture” throughout the region. Most shop owners I met or spoke with throughout my research had apprenticed in the region—either in their own shop (formerly their father’s shop) or in other area shops. Shop owners tend to know each other and many socialize together through their local industry association (the western Massachusetts Chapter of the National Tooling and Machining Association). Among production workers and managers, job mobility (or “hopping”) between shops is extremely high.

Most machinery firms in western Massachusetts are high-end suppliers that focus on specialty—rather than assembly line—manufacturing. These firms operate in markets where technical expertise and high quality are paramount. This stands in stark contrast to the majority of small industrial firms in the United States today that engage in commodity production. According to the Performance Benchmarking Service (PBS) of the Ann Arbor, Michigan Industrial Technology Institute, 70 percent of all small manufacturing firms in the country function mainly as suppliers to larger manufacturers (i.e. they make
intermediate goods such as parts, components and assemblies). The remaining 30 percent of firms are split evenly between firms that make capital goods for other manufacturers (i.e. machines and tooling) and those that make end-use, consumer products such as suitcases, brooms or furniture. The distribution in my sample of 48 western Massachusetts firms presents a striking contrast to the national distribution. In my sample, 42 percent of firms make capital goods for other manufacturers and 59 percent make intermediate goods. None of the firms in my sample make end-use consumer products.

Based on in-depth analysis of the PBS dataset, Dan Luria and his colleagues at PBS suggest that performance and strategy varies tremendously across the small firm sector. They estimate that 50 percent of small manufacturers are pursuing a ‘low-road’ strategy of “sweated labor and meager investment in capital equipment and workforce development” thereby contributing to low productivity in the small firm sector. At the opposite end of the small firm spectrum are ‘high-road’ firms that invest in workforce skills and advanced technology to provide distinctive products and services to customers. PBS estimates that 20 percent of small manufacturers are “high roaders.” The remaining 30 percent of firms, PBS estimates, are “lean commodity” firms. These firms focus on rooting out waste and minimizing costs by undertaking behaviors—such as work teams, statistical quality assurance and defect tracking—associated with improving cost, quality and delivery performance. According to Luria,

lean commodity shops do many of the things that advocates of “high performance work organization” admire but they do them not to become more modern or distinctive. Indeed, they do them precisely as an alternative to the investment that

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17 The Performance Benchmarking Service of ITI maintains the country’s largest database of small manufacturing firms. The PBS dataset is compiled through annual surveys completed each year since 1992 by 500-1000 smaller establishments. As of April 1996, PBS had analyzed data on 3700 smaller shops.
would be required to become more capital-intensive and capable. Because they are not distinctive but instead simply the best-run firms in the huge set of shops quoting relatively easy-to-make "commodity" jobs, being systematic lowers their costs and wins them orders, but neither wages nor productivity improve much in the process (Luria 1996, pg. 6).

Here again, the industrial machinery firms of western Massachusetts present a contrast to PBS's estimated distribution of firms. According to Luria, capital goods firms, by nature, are high-road firms (Luria, 1996). These firms make one-of-a-kind, engineered to order items that require advanced technology and extremely high levels of technical skill. Intermediate goods producers, by contrast, may be high-road or low-road producers depending on the type of goods produced (e.g. hard-to-make machined parts and assemblies vs. easy to make components). In my survey sample, the majority of intermediate goods producers are engaged in small batch production of extremely high tolerance parts and assemblies for the aircraft and industrial machinery sectors. Like the capital goods producers, these firms employ highly skilled machinists and advanced computer technologies. Accordingly, the majority of intermediate goods producers in they survey also qualify as "high road" firms. Taken together, capital goods producers and small batch production firms constitute 80-percent of the survey sample. Thus, approximately 80% of firms in my sample qualify as "high-road" firms compared to 20 percent of small manufacturers nationally. The remaining twenty percent of firms in my sample are intermediate goods producers engaged in mass production of commodity parts and components—the firms most likely to pursue the "low road" or "lean commodity" paths.
General Firm Characteristics

The typical industrial machinery firm in western Massachusetts today is a private, family-owned establishment that was started in the 1960’s and is now run by the son (occasionally the daughter) of the original founder. Several firms in the sample are currently undergoing a leadership transition from the first generation to the second. Twenty-seven firms in the sample are private, family-owned establishments; 20 are private corporations; one is a publicly traded company; and eight are subsidiaries of larger companies. Like most manufacturers in Massachusetts, these firms are very small. Average employment among surveyed firms in 1996 was 44 employees and average sales were $4.8 million.

<table>
<thead>
<tr>
<th>Firm Size</th>
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<tr>
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</tbody>
</table>

Note: Small = 10-19 employees; medium = 20-49 employees; large = 50+ employees.

Products

Despite a shared industrial code (SIC 35), industrial machinery firms make a wide variety of industrial products, in a variety of batch sizes, for an array of industrial customers. The two most common types of industrial machinery firm in western Massachusetts are tool and die shops and machine shops. Of the 203 industrial machinery firms in Hampden County, 38 are tool and die shops and 102 are machine shops. These
firms are often referred to as ‘metalworking firms’ because they shape, bend and form metal to exacting specifications.

Tool and die shops typically design and build one-of-a-kind, engineered-to-order items such as machine tools, dies, jigs, fixtures, and molds. Tool and die shops are integral to the manufacturing economy because they make the tools that enable products to be manufactured. Luria et. al (1994) note that the significance of tool and die shops to the manufacturing economy is disproportionate to the number of people employed in the industry. While tooling has just 200,000 employees nationwide, “it rates special status because patterns, dies, molds, jigs, and fixtures not only define products, but also determine how cheaply, quickly, and accurately products can be manufactured.”

Twelve of the 48 firms in my sample are tool and dies shops. Of these twelve firms, four are die makers, four are mold makers, and four design or build machine tools that enable the manufacture of miscellaneous metal products. Two of the four die makers in the sample make stamping dies while two make cutting dies. Stamping dies—made from precisely machined metal materials—stamp other metals into exact sizes and shapes. Cutting dies, in contrast, take flat material such as paper, cardboard or plastic, and turn it into a function. Everyday examples of die-cut products include cereal boxes, plastic 6-pack rings, and adhesive labels. Cutting dies are made by hand bending steel cutting rule into patterns on pieces of die board. While stamping dies are highly complex and require weeks or months to build, cutting dies typically take only a few hours to construct.

Industrial molds are the inverse of dies (one survey respondent said “think of the difference between a cookie cutter and a cake pan”). Instead of stamping or cutting out a
product, material is poured into a mold to form a product to exact specifications. Molds are used to create products out of liquid/injection plastic. All the mold-makers in the survey make steel molds for injection plastics. Mass-produced products made out of plastic—such as combs, brushes, compacts, film containers, toys, and patio furniture—are made from steel molds. Molds vary in complexity, size and price depending on the number of ‘cavities’ they contain (e.g. a one-cavity mold makes one action figure at a time while a 64-cavity mold makes 64 at a time).

In contrast to tool and die shops, machine shops typically work from customer blueprints to engineer and machine discrete metal parts that are subsequently integrated into more complex assemblies. Some of the machine shops I surveyed engage in assembly of multiple parts while others ship discrete parts directly to the customer where assembly occurs. Metal parts and assemblies are rarely visible to the consumer because they are integrated into complex products such as aircraft engines or industrial machines. According to a recent survey of suppliers conducted by Purchasing Magazine, metal parts buyers are among the most exacting, “constantly pushing for highest quality parts at the lowest total costs.” (Purchasing Magazine, 1998).

While some western Massachusetts machine shops are engaged in prototype production and mass production, the majority of machine shops in my survey produce complex, high-precision metal parts in small batches (under 200 pieces per purchase order). Of the twenty-two machine shops in my survey sample, eighteen are engaged primarily in small batch production. The machine shops I surveyed are highly specialized: they typically concentrate in a single industry and often provide their customers with unique, ‘hard-to-imitate’ products and services. Of the 22 shops
surveyed, nine make parts and assemblies for the aerospace industry; seven make parts and assemblies for industrial machinery; and two make parts and assemblies for medical instrument companies. Four of the shops provide services to other industrial machinery firms: these include deep hole drilling, thermospray coating, and equipment rebuilding.

The remaining firms in the industrial machinery sector fall into two main categories: specialized machines and equipment and components for general industrial purposes. Specialty machine and equipment builders design and build machinery and equipment on a custom-order basis for other manufacturers. My sample contained six machine and equipment builders. These firms run the gamut from equipment that drains water and pulp out of paper manufacturing to machines that assemble Milton Bradley’s Monopoly Board Game. Component manufacturers, in contrast, mass-produce components used in industrial machinery and equipment such as joints, bearings, and compressors. This category composed seven firms in my sample.

Production Runs

Most firms concentrate in a single type of production (i.e. 50 percent of sales or more are generated by one type of production). Of the 48 firms, 20 specialize in one-of-kind, engineered to order items such as tools, dies and machines; 18 firms specialize in small batch production of parts and assemblies; and 10 firms specialize in mass production of parts and components.
<table>
<thead>
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<td>18</td>
<td>37.5</td>
<td>37.5</td>
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</tr>
<tr>
<td>mass production</td>
<td>10</td>
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<tr>
<td>Total</td>
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</table>

It is also common, however, for firms to engage in multiple types of production. On field visits I encountered firms engaged in two and sometimes three distinct production activities. A firm I visited that makes one-of-a-kind stamping dies, for example, also performs limited production stamping work in the back of the shop to offset lulls between die orders. Another firm, whose primary work is designing tooling to manufacture jet engine blades and vanes, operates a machine shop to repair and maintain dies for its most important customer. And a firm I visited whose principal business is selling and installing specialized tooling (designed by its German parent company) also mass-produces compressors for air conditioners.

**Piece Prices**

The heterogeneity of the industrial machinery sector is reflected in an extremely broad range of piece prices. Piece prices among surveyed firms vary dramatically from a high of $800,000 for customized wastewater distillation equipment to a low of .04 for washer parts. The high end of the price scale is dominated by one-of-a-kind, engineered to order items such as special machinery and equipment and custom stamping dies and molds. These items range from $20,000 to $800,000 a piece. The mid-range piece price is from $100-$500 and includes small batch machine shops and cutting die firms. The
low end is from $.04 to $100 and includes all firms engaged in mass production of parts and components.

**Skill Levels**

Given the highly specialized nature of production industrial machinery firms are engaged in, it is not surprising that overall skill levels among production employees are extremely high. The median firm in my sample reported that 72% of its production workforce was composed of skilled trades-people and technicians. Over one third of surveyed firms reported that 80% or more of their production employees were highly skilled. At the other end of the spectrum, all 10 firms engaged in mass production reported that less than 25% of their production workforce was composed of skilled trades-people and technicians.

**Markets**

Despite the industrial restructuring of the past two decades, industrial machinery and aircraft/aerospace continue to be the top two markets for the region’s small metalworking firms. Twelve firms reported industrial machinery as their primary sales sector while 10 firms reported aerospace. These sectors were followed by the paper industry (6 firms), medical instrumentation (4 firms) and computer, communications and electronics (3 firms). Five firms indicated they had no primary market but served multiple industries and 4 firms failed to specify their primary market (these firms are included as “other” in chart). Defense contractors (non-aerospace), auto, and construction accounted for the remaining 3 firms.
<table>
<thead>
<tr>
<th>primary sales sector</th>
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</tbody>
</table>

For a majority of small metalworking firms, New England continues to be the primary sales market. A substantial number of firms, however, have penetrated markets beyond New England. 29 of the 48 surveyed firms listed New England as the primary sales region while 18 firms listed their primary sales region as “other U.S.” These figures reflect the growing need for firms to expand their geographic reach as regional markets declines.\(^{18}\)

\(^{18}\) A 1991 survey of western Massachusetts metalworking firms conducted by the Machine Action Project states that “less than 20 percent of the region’s customers are found outside the Northeast” (MAP, 1991, pg. 5). In contrast, my survey suggests that well over a third of metalworking firms operate in primary markets outside New England. The change suggests that a significant proportion of firms have been successful in their effort to expand markets.
<table>
<thead>
<tr>
<th>primary sales region</th>
<th>Frequency</th>
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<tr>
<td>other U.S.</td>
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<td>37.5</td>
<td>97.9</td>
</tr>
<tr>
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<td>48</td>
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Reliance on regional markets varies according to the type of production firms are engaged in. Firms that make one-of-a-kind, engineered to order items, for example, are the most dependent on the regional economy: eighty percent of these firms list New England as their primary sales region. This suggests that the majority of these firms continue to make tools, dies and machines for other manufacturers located in New England. Small batch production firms are also quite dependent on regional markets: two-thirds of these firms list New England as their primary sales region. The reliance of small batch producers on the regional economy is related to the high concentration of aerospace engine builders in New England. As noted earlier, many of the machine shops in western Massachusetts have contracts to produce aircraft parts in small batches for companies such as Pratt Whitney, General Electric and Hamilton Standard. In contrast to one-of-a-kind and small batch producers, only ten percent of mass production firms list New England as their primary sales region. In order to achieve necessary sales volumes for their products, most mass production firms need to expand beyond regional markets.

Approximately 30 percent (14 firms) of surveyed firms reported a decrease in the proportion of total sales to defense contractors since 1991.
defense market shift

<table>
<thead>
<tr>
<th></th>
<th>Frequency</th>
<th>Percent</th>
<th>Valid Percent</th>
<th>Cumulative Percent</th>
</tr>
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<tbody>
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<td>48</td>
<td>100.0</td>
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</table>

Most of the aircraft and aerospace suppliers I interviewed said they were able to recover from the loss of defense contracts by picking up a greater share of commercial aircraft work which picked up in 1995. However, several defense dependent firms I spoke with said they responded to the draw-down by aggressively seeking out new commercial markets. A machine shop that made jet engine parts for Pratt Whitney, GE and Northrop, for example, made a strategic shift into the medical instruments market and now makes machined parts for Johnson and Johnson and U.S. Surgical. Another firm that made test equipment for missiles now makes freon recycling equipment for HVAC contractors.

For some firms the defense draw-down was devastating. One machine shop I interviewed went from 75 percent to 4 percent of sales to defense contractors due to dramatic cutbacks in a single missile program between 1992 and 1996. Employment in the shop fell from 40 to 16 employees during this period. Another shop that made mechanical assemblies for defense contractors went from 90 percent defense sales in 1991 to 20 percent by 1996. Between 1991 to 1993, the shop’s employment fell from 110 to 45.

Customer Relations

There is tremendous variation in the intensity of the customer-supplier relationship among surveyed firms. Many firms have close—and in some cases
intensive—working relationships with their most important customer. ¹⁹ Other firms, however, report little regular contact with their most important customer.

Overall, suppliers provide much more assistance to customers than they receive from customers. For example, while the median supplier provides technical assistance to its most important customer once a month, the median supplier receives technical assistance from its most important customer just two times per year. And while 18 firms (37.5%) reported that they received no technical assistance in 1996, only 5 suppliers (10%) reported providing no technical assistance to their most important customer in 1996.

A subset of firms in the sample has very intensive technical assistance relationships with their most important customer. For example, 15 firms (31%) report technical assistance from their most important customer once a month or more while 11 firms (23%) provide technical assistance to their most important customer once a week or more. These numbers reflect the specialized nature of production some suppliers are engaged in with their customers. Many suppliers today work closely with their customers co-engineering the tools, machines and parts that facilitate customer production. And while a majority of suppliers still work to customer specifications, many are also actively engaged in product design with their most important customer.

¹⁹ To gain an understanding of the customer-supplier relationship, I asked firms a series of questions about their most important customer (i.e. the customer that provided the greatest sales volume to the firm). Findings reported here are based on the firms' relationship to their most important customer not the firms' total customer base.
who is responsible for design of product shipped to MIC?

<table>
<thead>
<tr>
<th></th>
<th>Frequency</th>
<th>Percent</th>
<th>Valid Percent</th>
<th>Cumulative Percent</th>
</tr>
</thead>
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<td>56.3</td>
<td>56.3</td>
</tr>
<tr>
<td>your company</td>
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<td>27.1</td>
<td>27.1</td>
<td>83.3</td>
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<tr>
<td>joint</td>
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<td>Total</td>
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</table>

Overall, surveyed firms report a high level of commitment from their most important customer. On a scale from 1 to 5 (with 1 being “none” and 5 being “high”), a majority of firms report that their most important customer has a “high” level of commitment to them.

does company report “high” commitment from MIC?

<table>
<thead>
<tr>
<th></th>
<th>Frequency</th>
<th>Percent</th>
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<th>Cumulative Percent</th>
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<td>37.5</td>
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<tr>
<td>Total</td>
<td>48</td>
<td>100.0</td>
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Note: firms that gave their customers a “4” or “5” on the scale were coded as a “yes” response.

At the same time, however, few firms in the survey sample have long-term contracts with their most important customer and a majority work on a “per job” basis with no contracts at all.
### MIC contract length

<table>
<thead>
<tr>
<th>Valid contract/per job basis</th>
<th>Frequency</th>
<th>Percent</th>
<th>Valid Percent</th>
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</tr>
<tr>
<td>less than 1 year</td>
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<td>Total</td>
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</tbody>
</table>

| Total                       | 48        | 100.0   |               |                    |
Chapter Two:

Becoming Sophisticated: From the ‘Mom and Pop’ Job Shop to the High Performance Small Firm

Introduction

The small industrial firms of western Massachusetts have faced a rapidly changing manufacturing environment over the past two decades. Throughout the 1980’s and early 1990’s, supplier firms lost core customers due to a combination of plant closures and defense downsizing. As a result, small firms in the region have been forced to expand their geographic reach in order to achieve necessary volumes. At the same time that markets have dwindled for these firms, performance requirements have increased dramatically. As large U.S. manufacturers began to reorganize their production processes in response to international competition in the mid-1980’s, they also began to place demands on their suppliers for improvements in the areas of quality, delivery, and price. In order to achieve “lean production,” large manufacturers recognized that they needed suppliers capable of producing defect free tooling and parts, on a “just-in-time” basis, at the lowest possible price.

New customer requirements for continuous improvements in quality, delivery, and price have placed intense pressure on many firms to modernize and systematize their production practices. In addition, the advent of computer-numerical control machine tools, computer-assisted drafting, and personal computers has transformed the production
process. For firms to compete effectively today, both shop-floor and office employees must now be proficient in a variety of new computer skills.

The combined impact of declining markets and heightened performance requirements hit western Massachusetts's industrial suppliers hard in the early 1990's. Many firm owners I interviewed recalled this period as the worst time in their lives. Owners and managers described a fundamental change from the 1980's to the 1990's. Due to an abundance of defense work through the 1980's, many small firms were able to secure lucrative contracts, make money, and expand operations purely on the basis of their technical expertise. By the early 1990's, however, both commercial and defense customers were demanding greater efficiency and accountability from suppliers in a variety of areas in order to reduce overall costs.

The competitive environment ushered in by the 1990's forced many suppliers—particularly defense-dependent firms—to lay-off employees, assess internal operations, and consider how to organize their shops more efficiently. As one Vice President of an aerospace shop put it: "Machine shops made money in the 1980's in spite of themselves because of the market. In the 1990's we've had to become businessmen (sic)." In field and survey interviews conducted between 1996 and 1998, firm owners expressed a range of emotion regarding the new manufacturing environment: some spoke of the exciting challenges and possibilities it contains, some expressed simple resignation, while others expressed cynicism and dismay. In each case, however, firm owners acknowledge that the era of global competition requires a level of professionalism unforeseen just a decade ago. Shedding the image of the "mom-and-pop" shop of yesteryear, many firms are painstakingly transforming themselves into 'high performance' small firms. Recounting
the profound changes undertaken at her own company over the past decade, the vice president and heir apparent of a tool and die company aptly described a process common to many firms in my sample: "We call it 'becoming sophisticated,'" she said. "We use that word a lot here. We want to be sophisticated; this is not a raw shop environment anymore."

In this chapter I describe the external factors driving organizational change in small firms and the various ways in which firms are responding to these pressures. In the first section, I focus on five critical ways firms are responding to the new competition. These include investing in computer technologies that automate design and production functions, implementing new quality assurance and inspection techniques, reducing cycle time through new forms of work organization, documenting work procedures, and developing distinctive products and services. The goal of this section is not to measure the extent of innovation in these five areas but to provide a composite of innovation based on fieldwork and survey data. In the second section of the chapter I consider the implications of the new work organization for owners, employees, and human resource practices. Throughout the chapter I draw on field work and survey interviews to illustrate key points.

I. Responding to the 'New Competition'

Overall, the scope of change taking place in the sample of firms I surveyed and visited is quite dramatic. Firms are undertaking a vast range of technical, organizational, and cultural change in response to the new business environment. The ability to respond to customers is the driving force behind the majority of changes firms are implementing.
Customer demands for price reductions and performance improvements have penetrated deeply into the industrial machinery sector of western Massachusetts providing strong impetus for small firms to implement new forms of work organization.

**Automating Design and Production**

The most fundamental way firms have responded to the new manufacturing environment is through investment in advanced computer technologies that automate key aspects of the production process such as design, cutting, machining, and inspection. Commercial technologies such as computer-aided design (CAD) and computer-numerical control machine tools (CNC) perform complex procedures quickly and accurately increasing the volume, variety and difficulty of work small firms can take on.

Research conducted by the Machine Action Project in the early 1990's indicates that western Massachusetts metalworking and machinery firms were national front-runners (among small firms) in the adoption of these technologies. In a survey MAP conducted in 1990 of 75 small metalworking firms, for example, 76 percent of firms had at least one CNC machine and nearly half used computer-assisted drafting (Cann, et. al., 1991). These adoption rates were much higher than those found in Kelley and Brooks' national study on CNC adoption and in a study of mid-west machine shops conducted by the Industrial Technology Institute.

The probable explanation for high and early rates of technology adoption among western Massachusetts firms is their historical dependence on the defense and aerospace sectors. In a 1991 comparison of the adoption of programmable automation machine tools between defense and non-defense manufacturers, Kelley and Watkins determined that firms in the network of defense manufacturers had significantly higher technology
adoption rates. The differences were particularly pronounced for smaller firms: for firms with fewer than 50 employees, adoption rates were 50 to 150 percent higher for defense-related manufacturers. MAP's survey research also determined that firms that had Department of Defense or aerospace as their top customer were more likely to use advanced technologies such as CNC machines or CAD systems. Kelley and Watkins attribute higher rates of adoption among defense dependent firms to the following factors: participation in Pentagon programs that encourage manufacturing investments; the relationships between prime contractors and their suppliers; and the learning opportunities created by cooperation among defense contractors, suppliers, and customers (Kelley and Watkins, 1992)

My field visits and interviews with aerospace suppliers support these earlier findings. Though most of the contracts received by firms in my sample between 1996 and 1998 were for commercial aircraft, these firms continue to exhibit very high adoption rates of the most sophisticated commercial technologies. A firm I visited that designs tooling for General Electric Aircraft Engines (GEAE), for example, had recently invested $500,000 to purchase eight Unigraphics 'seats.' Unigraphics is a state-of-the-art CAD/CAM system used for complex design and assembly of motor vehicles and aircraft and the parts that produce them. GEAE selected Unigraphics as its CAD/CAM system in 1991 and now requires all of its suppliers to work on Unigraphics to enable "co-engineering."

Investment in advanced technologies is not limited to defense and aerospace firms, however. Interviews and fieldwork indicate that suppliers across industries are investing in advanced technologies in order to increase productivity and offer unique
services and products to customers. A firm I visited that makes printing plates and cutting dies for the corrugated box industry, for example, has made continuous investments in computer technology in order to maintain its reputation as an industry leader. The company specializes in tooling that applies sophisticated graphic images onto boxes for consumer items. Over the past 10 years, the explosion in computer graphics combined with higher customer expectations for vivid imagery has transformed the industry. In order to offer customers the highest quality designs and images, every aspect of the firm’s design and plate-making work has been computerized. In addition, the company has recently invested in a state-of-the-art laser system that burns designs for cutting dies into die board with great accuracy and speed—work that was previously done by hand.

Another firm I visited made major investments in CNC technology after its defense market collapsed. Prior to 1992, the firm made mechanical assemblies for defense contractors in long production runs. When the firm entered commercials markets, by contrast, it had to produce much smaller orders and deliver these on a much more frequent basis to customers. In order to gain speed and flexibility, the firm owners decided to pursue a high technology strategy: the firm went from 50% CNC machines in the late 1980’s to 92% CNC machines by 1997—a changeover which corresponded to a nearly 100% shift from defense to commercial customers.

A critical implication of the large investments in capital equipment that many small firms are making is that they must acquire more work to offset the costs of the investment. As a result, many of the firms in my sample are expanding their market reach, moving into new geographic territory, and growing rapidly.
Some firms I interviewed are partnering with complimentary firms in order to expand their production capabilities and market reach while others are aggressively seeking new customers in other parts of the country. The printing plate and cutting die firm described above recently partnered with a similar company in Ohio to increase its geographic and technological domain. According to the company’s Vice President, this is the only way the company can maintain a competitive edge in the industry:

Our competitors are growing so fast—they are purchasing and merging with other companies. We need to continue growing and our partners in Ohio help us to be bigger. Our customers want it cheaper and faster so we have to keep investing but we also have to cut back on the pricing. You need to grow to get that flexibility—both technologically and financially. It’s almost necessary because of the expense of the technology. A small company like ours can’t afford to invest $100,000 in a piece of equipment that may become obsolete in five years.

Nor can these small companies afford to let expensive equipment sit idle. The tooling design firm that invested half a million dollars in Unigraphics to maintain its GE contracts, for example, had to seek out several new national customers to keep the CAD systems in use when the GE work was in a downturn. Since the company purchased the Unigraphics system in 1995, it has secured contracts with 3 new customers, employment has increased from 7 to 29 employees and sales have tripled from $500,000 to $1.5 million.

**Quality Assurance and Inspection**

Another widespread activity undertaken by firms in response to the new competition is in the area of quality assurance and inspection. In an effort to improve product quality and reduce costs, large manufacturers began to transfer greater responsibility for quality assurance to their suppliers in the late 1980’s. Today, the ultimate goal of many customers is to integrate parts (or tools) into the assembly (or
production) process without having to inspect them first. In order to achieve "lean
inspection," customers need to be extremely confident that suppliers are using the most
sophisticated quality control techniques available. Accordingly, customers are requiring
suppliers to integrate these techniques into their operations.

Traditionally, industrial machine shops have been organized into separate
departments each performing a specific job on a part (e.g. milling, turning, welding,
polishing etc.). Under this system of work organization, shops had quality inspection
departments responsible for insuring the quality of parts shipped to the customer.
Typically, roving quality inspectors would perform first piece and periodic in-process
inspections while final quality inspectors would perform checks on jobs prior to shipping.
Inherent flaws in the traditional inspection system revealed themselves to customers and
small firm owners as heightened competition required both to perform more efficiently.
First, the traditional system resulted in high defect and scrap rates and costly rework
because quality was inspected after jobs were completed. Second, traditional quality
inspection was time consuming because bad parts had to be sent back to
machinists/operators for rework. Third, because quality was assigned to inspectors,
machinists/operators did not take responsibility for the quality of their own work.

Over the past ten years, many small firms have begun the transition from
“inspection” to “prevention” approaches to quality control. As the American Machinist
notes in a recent report, “the trend has been to eliminate inspection by controlling quality
during the manufacturing process. Inspection is like a watchdog. It keeps out
undesirable elements, but it does not, in itself, prevent the fault from occurring.”
(American Machinist, 1996). In the preventative approach to quality control, firms strive
to gain control of the manufacturing process through assessment and monitoring. In theory, each manufacturing process in the manufacturing cycle of a product must be assessed to determine its potential for meeting established quality goals. Once implemented, the process must be monitored on a regular basis to make sure it does in fact meet that potential. In shops striving to control quality during the manufacturing process, a great deal of the ‘monitoring’ function is now performed by production employees who learn quality control skills that enable them to perform their own in-process inspection on parts. Responsibility for quality becomes an integral part of each production employees’ job therefore reducing (and eventually eliminating) the need for a separate quality department.

A number of production shops in my sample have responded to the push for quality assurance by implementing in-process inspection techniques such as statistical process control (SPC). SPC is a method of preventing defects by analyzing deviations in production processes during manufacturing. Production workers trained in SPC take periodic measurements of parts as they are machined. These measurements track the statistical variance of parts against the tolerances stated on the blueprint. If the variance is greater than the accepted deviation, the employee can stop the production process and make necessary adjustments (or call in a programmer/engineer to make adjustments) to the machine.

SPC works well for firms engaged in long production runs but often poses problems for firms producing in small batches. An alternative to SPC is to train machinists and operators how to conduct their own first piece and in-process inspection on parts. Another new approach to quality control I encountered is certified operators.
To minimize defects and insure optimum quality on expensive, complex parts, some customers—particularly aerospace—are now requiring suppliers to certify their machine operators in “mistake-proofing” inspection techniques for individual parts, operations and machines. Under certified operator programs, only individuals who have received certification—either through completion of course work or examinations—are allowed to receive and perform operations on specific parts.

Greater responsibility for quality assurance has also been imposed on producers of one-of-a-kind items such as tools, dies and molds. The manager of a tool and die firm I visited said that customers now require an inspection report with each die and that machinists are required to perform “their own inspection on their own parts.” Another tool and die shop that produces complex molds for injection plastic explained that customers are now pushing final inspection requirements down to suppliers.

Traditionally, customers performed final inspection on the mold; now customers want suppliers to perform the inspection prior to delivery. At the time of our discussion, the firm was sending its molds to a professional third party inspector. Because outside inspection adds a large cost to each job the firm was planning to invest in a coordinated measuring machine that would enable it to perform final inspection.

While many of the new quality inspection techniques generate additional costs for suppliers (e.g. quality training, new measurement equipment etc.), most firm owners believe that the cost of not implementing these techniques is even greater due to expensive scrap and rework and potential loss of customers. Accordingly, a number of firms I spoke with were in the midst of implementing comprehensive “quality initiatives” in their firms. Several firms had recently hired new management level employees to
upgrade existing quality systems and increase awareness of quality issues among employees. Typically these new hires were individuals who had experience managing quality programs at larger companies. Company wide quality efforts often serve as a vehicle for greater employee involvement in the production process. In an effort to continuously assess and adjust manufacturing processes, many firms now track customer returns and internal scrap rates at regular intervals to measure improvement and/or setbacks. In many firms this information is shared with production employees who help analyze root causes and determine appropriate solutions to quality problems.

An important byproduct of the new quality assurance and inspection techniques is that they move jobs through the supplier’s shop more quickly. In-process inspection by the supplier reduces the need for time-consuming rework within the supplier’s shop while final inspection reduces the chance that customers will send defective work back to the supplier. Greater efficiency achieved through these techniques is critical because customers are demanding faster and faster “cycle time” from their suppliers.

Reducing Cycle Time

The drive to reduce cycle time (the period between when an order is placed and received by a customer) stems from heightened global competition in manufacturing and the commensurate pressure to get products to the market more quickly. In interviews, firm owners described a dramatic change in customers’ expectations regarding the time it should take to complete and deliver a job; most traced this change to the early 1990’s. Overall, firm owners said that on-time delivery poses their greatest performance challenge. (In fact, several firm owners I spoke with said the pressure to reduce cycle time is so great they are forced to promise unrealistic delivery dates in order to get jobs.)
Requirements for accelerated delivery are widespread, cutting across product and industry lines. The owner of a firm that designs tooling for the manufacture of jet engines described how delivery requirements have changed at every level of the aerospace supply chain:

Everything is more competitive now and time is being compressed. They—General Electric Aircraft Engine—are now building aircraft engines in a period of weeks, not a period of months. Right now Boeing is behind schedule. They can’t produce fast enough for the orders they are supposed to meet. GE has to produce engines in a given amount of time to get Boeing to buy from them. If GE’s suppliers are equal, they’ll go with the faster delivery. Our lead-time before was 2-3 months for one job. Today, we get a job in from GE’s computer system to our computer system and we send it back in a week. It’s a fantastic reduction.

At another firm specializing in cutting dies for the electronics industry, cycle time has gone from days to hours. The main way the company has responded to this change is through investment in computer technology that expedites key components of the production process. The Vice President of Sales and Marketing for the company described changes since he arrived at the company in 1985:

When I first started we took an order and somebody said ‘what’s your delivery?’ and we said, ‘4 to 7 working days.’ Today they call at nine in the morning and they want the die that day. That’s the change. It’s incredible pressure. You need to respond quickly: to take two days to figure something out is a luxury we can’t afford. You have to be able to figure things out on the spot. This is where computers come in—they enable people to do the same job with quicker turnaround and sometimes even at higher volume.

In many cases the demand for faster delivery is coupled with demands for price reductions. The General Manager of a small firm that makes stamping dies described how her firm is being squeezed by the new performance requirements:

Ten years ago (1986), everything was fat. Things were late and it didn’t matter. Now that would never happen. Things have gotten really tight in the last five years. Customers want to keep their costs down so they go out and get three
quotes when they used to get one. You’re forced to do the job for less money than you originally bid and to deliver it at an earlier date. It’s really tough: employees need more money, the shop needs more machines, and the customers want it faster and cheaper.

At the time of my visit to this firm (2/96), the company had just invested in a computer-aided design system (CAD) and was sending its designer to CAD training at the local community college. Automating the design process (formerly conducted by hand on drafting board) was one in a series of planned steps to increase efficiency in the shop.

For production firms delivery issues are equally complex. These firms are under pressure to produce in smaller lot sizes and to deliver these on a “just-in-time” basis to customers. Large manufacturers that adhere to “just-in-time” (JIT) delivery schedules require their suppliers to deliver smaller batches of parts and assemblies on a more frequent basis in order to reduce their inventories of stockpiled parts. Reduced inventory drives down production costs and provides manufacturers with greater flexibility in responding to market demand. JIT is one of many organizational techniques U.S. manufacturers borrowed from the Japanese in the 1980’s in order to improve manufacturing efficiency. In theory, JIT production minimizes inventory all along the supply chain because each stage of manufacturing is to be completed just in time for the next stage (i.e. materials are purchased and delivered just in time to be transformed into fabricated parts which are delivered just in time to go into subassemblies and so on). However, because many suppliers don’t yet operate on a JIT basis—either in their own shop or with their suppliers—small firms often end up carrying costly inventory for their customers. (Womack et. al., pg. 160).

The schedule and delivery challenges resulting from smaller batch production and JIT were unfamiliar to most firms in my sample just ten years ago. Today, however, JIT
delivery is a prerequisite to business with many customers. As one production manager put it, "just-in-time delivery is everything today because nobody wants to stalk inventory." Prior to 1991, many of the industrial machinery firms in western Massachusetts produced precision parts and assemblies in long production runs for defense contractors and defense aerospace companies. The defense downsizing of the late 1980's and early 1990's led many firms to move into commercial markets, including commercial aerospace. As a result of these shifts, many suppliers faced new delivery requirements for first time in the early 1990's.

The co-owner of a large machine shop that made an almost complete shift out of defense into commercial markets described the change this way:

The defense department would allow us to make as much of the stuff as we wanted and they would just pay us for it. If we made it six months in advance, they'd say, "great – just bill us for it." Instead of doing multiple parts in the thousands or the hundreds, the commercial work came to us in lots of 10, 20, or 30 pieces. The commercial companies typically have production control schedules: they say, "when you deliver this stuff, we'll pay you but you can't deliver it all right away - you can only ship what we tell you to ship." We hadn't experienced any of this before. Internally, this was our most significant change – to have to really plan and know what we were going to do.

The trend toward small batch production and JIT has far-reaching organizational implications for small industrial firms. At the managerial level, it requires firms to develop much more sophisticated planning and scheduling capabilities. Firms now need to be able to carefully track the progress of jobs in order to insure they are moving through the shop at a speed that will guarantee on-time-delivery. This is particularly important for firms engaged in complex assembly work in which multiple processes are performed on multiple parts. To facilitate the scheduling and planning process, many firms are investing in scheduling software and Materials Requirement Planning – a
computerized inventory management system that continuously updates the firm on availability of parts and materials needed to meet production schedules. These systems focus attention on bottlenecks by “raising flags” when processes or parts are not completed by the date required to meet the schedule.

At the level of the shop floor, the move toward small batch production and JIT has multiple organizational implications. A clear change among firms is the greater emphasis they are placing on reducing machine set-up time. Because firms are now producing a greater variety of parts in smaller lots, change over of tooling occurs much more frequently. Under JIT, reducing the amount of time it takes to break down a machine and re-tool it for the next job becomes critical. In addition, because set-up time is extremely costly for firms (since machines aren’t making parts), reducing set-up time also lowers overall production costs. A number of firms I spoke with and visited are training (or have trained) machinists to perform their own set-up and breakdown of machines. This saves time because it is no longer necessary to coordinate each job with an engineer or programmer who sets up the machine for each job.

Another way firms are working to reduce overall lead times is through reorganization of the shop floor. Several firms in my sample had participated in Kaizen training in order to maximize efficiency on the shop floor. Kaizen is an incremental approach to shop floor improvement in which teams of employees break down and analyze production steps in an effort to eliminate non value-added activities. A typical Kaizen exercise might reveal that parts are traveling back and forth across the shop unnecessarily due to poor lay out of machines. The result of this Kaizen would be a new configuration of machines and people that eliminates the unnecessary travel. A number
of firms have also reorganized the shop floor into manufacturing cells (which can be organized by product or process). The distinguishing feature of manufacturing cells is that employees within the cell are given increasing levels of responsibility for meeting production, quality and scheduling goals. Firms that have organized into manufacturing cells often implement team production and job rotation as well in order to maximize employee flexibility within the cell.

Certification and Documentation

Closely related to the new quality, inspection and delivery requirements are new certification and documentation requirements. Customers frequently want a written record of how jobs are performed and how quality is maintained throughout the supplier's shop. The proliferation of certification and documentation requirements in the manufacturing sector over the last decade reflects a fundamental change in orientation toward process. Customers not only want guarantees of high quality from suppliers; they want proof that suppliers are adhering to sanctioned procedures in a consistent manner.

The objective of certification and documentation requirements is to make the manufacturing process both more transparent and more accountable. Traditionally, small industrial firms have relied on employees' tacit knowledge to produce jobs and get them out the door. Many firm owners I spoke with explained that the firms' work processes reside primarily "inside people's heads." By requiring firms to get this knowledge down on paper, documentation both routinizes supplier operations and insures that employee turnover won't bring production to a standstill. It also insures that when there is a problem with a part or tool, the source of the problem can be tracked down and analyzed. As one firm owner put it, "documentation is an effort to turn black magic into science."
Some industries, such as aerospace, have adopted formal supplier rating, certification and selection systems. According to MIT’s Lean Aircraft Initiative, the most important characteristics quantified in aerospace certification systems include supplier defect rates, on-time delivery rates, implementation of statistical process control, and commitment to on-going process improvement (Bozdogan, 1998). In order to secure long-term contracts with aerospace customers, many suppliers must now be able to demonstrate and document their track record in these areas. An aerospace firm I visited in the spring of 1998 had just submitted a comprehensive self-assessment of its “core processes and capabilities” to Allied Signal’s Aerospace Supplier Development Team in an effort to become a ‘Premier Supplier’. Upon review of the self-assessment (and supporting documentation) representatives from Allied Signal were scheduled to perform an on-site review of the supplier’s facilities.

Suppliers to the medical instruments sector are also subject to extensive documentation requirements. According to firm owners I spoke with, medical customers are now emphasizing “good manufacturing process” over inspection. Increasingly, medical customers such as Johnson and Johnson and U.S. Surgical are requiring suppliers to demonstrate and document adherence to Japanese production techniques including work cells, employee involvement and Kaizen continuous improvement. “Medical customers want a Kaizen approach where improvements are made all along, not just checking at the end,” said a machine shop owner that produces parts for non-invasive surgery. “These parts are used by doctors and he (sic) wants to know that you used the right materials. They need to know the correct procedures have been used. You enter
into a very elaborate planning and documentation process from the beginning with the medical customers."

In addition to the comprehensive documentation requirements described above, suppliers to the aerospace and medical industries may also be required to maintain and submit job folders that create a record of each individual job. A comprehensive job folder documents every procedure related to the job including blueprints, inspection reports, explanations of errors if they occur, corrective actions taken, costs and cost overruns if incurred, and hours dedicated to the job. For straightforward production jobs, customers may require only blueprints and inspection reports; for complex jobs with exacting tolerances, however, they may require more thorough documentation.

Customers in myriad industries are also requiring their suppliers to work toward certification in quality assurance standards such as ISO 9000. Published by the Geneva-based International Standards Organization in 1987, ISO 9000 is a set of quality processes that focuses on the systems and practices a company has in place to assure that its goods and services meet or exceed customer expectations.

Many large U.S. companies undertook ISO 9000 certification in the late 1980's to insure access to European markets. By the early 1990's, many of these companies were pushing ISO onto their suppliers. Companies striving to achieve ISO 9000 certification must document policies and procedures in 20 different areas ranging from inspection, statistical techniques and corrective action to design and training. The certification process begins with a 100-page, five-part guidebook that directs companies in documenting how employees perform every function that affects quality and in

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1 Certain industries such as aerospace and auto have their own versions of ISO 9000. AS 9000, for example, is the aerospace version which is more demanding than ISO.
establishing mechanisms that insure that employees follow through on the stated routine. Internal teams verify that procedures are being followed in all 20 areas. Once a company feels ready, it can hire an independent, third party registrar to perform an audit to determine if the company meets certification (Business Week, 1994).

While only a handful of firms in my sample were actually certified in ISO 9000, several said they were compliant with the standard, many others reported working toward certification, and several indicated they would need to become certified in the next few years. In some industries, ISO 9000 has become a baseline for new business. An aerospace firm I visited has been required to meet elaborate quality assurance standards beyond ISO 9000 for two of its key customers—GE and Hamilton Standard (UT). In order to secure business with new customers, however, the firm owner said he must also be certified in ISO 9000. “It’s a marketing tool. Anybody we call or talk to that’s the first question they ask us, ‘are you certified in ISO 9000?’ We have to send them copies of our ISO manual to show them we are in the process.” Even firms that haven’t pursued certification recognize how pervasive the standard is and what it symbolizes to prospective customers. The manager of a small company that specializes in multi-cavity molds for pharmaceutical companies told me that his company has not undertaken certification because they have a strong track record in quality with their customers. However, he said that if the company was starting today and going after new customers, it would have to have ISO in place to instill confidence in customers.

**Distinctive Products and Services**

As examples from the preceding sections have illustrated, the widespread availability of both new computer technology and organizational strategies is enabling
firms to produce tools, parts and assemblies more quickly and accurately than ever before. As a result, competition at the low-end of the marketplace (i.e. commodity production) has become fiercely competitive. In order to escape strict price-based competition, many firms in my sample have developed unique products or services that distinguish them from the competition.

A number of machine shops I visited distinguish themselves by providing their customers with extensive engineering assistance on complex jobs. A machine shop I visited that specializes in medical instrumentation, for example, has developed expertise in the design and engineering of extremely high tolerance medical implants. The company works with its customers through all phases of production from product development to manufacturing. This expertise has enabled the company to secure lucrative, long-term contracts with medical customers such as Johnson and Johnson and U.S. Surgical. Another machine shop I visited has recently developed expertise in machining hydraulic controls called ‘lap fits.’ Lap fits—which control the rudder and flaps of airplane wings—are small, highly detailed assemblies that must be machined within a millionth of an inch. Due to the complexity of the production process and the large capital investment required to enter this market, the firm faces only two competitors nationally.

Tooling firms are also figuring out how to provide distinctive services to their customers. The printing plate and cutting die firm described earlier, for example, has stayed ahead of its competition by developing expertise in ‘color management’—a technique that enables customers to view the precise color of the final product before it goes to press. Using advanced computer imaging technology, the firm can simulate the
properties of a boxmaker's press and demonstrate to the final customer how the press will interact with particular dies. This process helps the customer select an appropriate die and avert costly mistakes (e.g. reordering hundreds of thousands of 'Huggies' boxes because the baby came out the wrong color.) Another way toolmakers are distinguishing themselves is by providing their customers with "one-stop-shopping." An aerospace tooling design firm I visited, for example, recently invested in several CNC machine tools and established a machine shop to build and repair dies for its most important customer—General Electric Aircraft Engines. With the addition of a machine shop, the firm can now provide customers with 'design and build' services which helps customers reduce overall lead times.

What sets all of these firms apart is that they have figured out ways to become indispensable to their customers. Through the development of unique products and services these firms frequently act as both supplier and 'technical consultant' to their customers.

II. Implications of the 'New Competition' for Owners, Employees and Human Resource Practices

As described in the previous section, the 'new competition' has myriad implications for how work is performed and organized in small industrial firms. In order to achieve 'total customer satisfaction', each individual in the firm—from owner down to shipping clerk—must work together with others in the firm in order to improve quality, reduce costs, reduce cycle time and meet delivery dates. Achieving these goals requires unprecedented levels of strategic planning, coordination, and cooperation within the firm.
policies within the firm? In the following section I describe how employees at different organizational levels are affected by, and responding to, the new manufacturing environment. This is followed by a short summary of changes firms are making in their human resource policies.

**Implications for Firm Owners**

The new manufacturing environment poses significant challenges to the small firm owner. Traditionally, owners of small industrial firms have not been trained in business disciplines. Rather, they have apprenticed in the machine trades and possess impressive—and sometimes unique—technical expertise. Two career trajectories emerged among firm owners in my sample. In the first, the owner attended vocational school, entered into the family business at a young age, apprenticed with his father, and took over the family business when the father passed away. In the second, the owner attended vocational school, apprenticed and learned the trade at an established firm (or firms) in the region and subsequently started his own company because he wanted more autonomy and money and believed he could do a better job than his former boss.²

The model of firm owner as technical expert fit well with the old manufacturing environment in which work was abundant, technology didn’t change rapidly, and customer requirements were far less stringent. Under these stable conditions, many small firm owners were able to handle multiple aspects of the business including day-to-day management of the shop floor, customer relations, sales and marketing, and technology acquisition. Over the past decade, however, performance requirements have increased so dramatically that fewer and fewer firm owners can handle these same responsibilities.
alone. Today, small firm owners must negotiate with banks to finance new technology and expansion, extend their marketing vista and solicit new customers as local and regional markets diminish, determine how to provide unique products and services to customers, educate themselves in the new business disciplines such as TQM, JIT, and Kaizen, organize their shops to meet customers’ quality, delivery and price requirements and motivate employees to work in new ways. While technical expertise is still essential, it is no longer sufficient to run a successful small company.

To grow and prosper today, a greater share of the firms’ resources must be dedicated to strategic planning activities—or as one firm owner put it, to “thinking about the big picture.” A key way that firm owners have expanded their strategic planning capacity is by hiring ‘Vice Presidents’ who take on responsibility for critical aspects of the business such as financing, marketing, and work organization. Typically, these individuals have broader manufacturing experience than the owner and have worked in larger companies.³ The owner of a small company that makes air-cil separators, for example, hired a Vice President two years ago to “get everyone on the same page and enhance the quality program” which the owner viewed as the key to company growth. The V.P had previously run the quality initiative at a 200-person shop in the region and before that had worked at Digital. In a similar fashion, the owner of a small firm that makes aerospace parts recently hired a V. P. to “niche” the company’s market and expand sales. The V.P. was formally Director of Marketing at one of the largest and most respected aerospace shops in the region. In his previous job, he had spent four years

² Interviews reveal that small firm owners are increasingly college educated. Firms owners in their 30’s and 40’s have often followed the same path described here but also attend four-year college or university and receive a technical degree, typically in engineering.

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working closely with different divisions of General Electric Aircraft Engines through their supplier consortia-training program. As a result, the V.P. brought tremendous contacts, industry specific knowledge, and business savvy to his new position.

Another way firm owners are expanding strategic planning capacity is through targeted use of business consultants. Several firms I interviewed had hired consultants for limited periods to launch company-wide quality initiatives or to implement new forms of work organization on the shop floor such as teams or work cells. Other firms had hired consultants to conduct strategic analyses in order to determine how the firm should restructure internally to improve its competitive position. Typically, firm owners located consultants through third-party organizations such as their local industry association or technical college.

In contrast to large firms where management layers have been reduced in response to greater competition, the growing complexity of the small firm environment is causing management layers to multiply. In addition to the creation of new senior level positions which expand strategic planning capabilities, firm owners are delegating greater responsibility for day-to-day operations to lower-level managers. The Vice President of a tool and die company that has grown from 60 to 110 employees over the past decade described the changes in management structure at her company:

We used to be so small that word of mouth was enough. You worked so closely with people that everybody understood what was needed from department to department. Now with more employees and increasing complexity, we need more control of systems and processes. Management used to be my father. He was the general manager and we had a production manager and that was it. Now we have my father (the President), me (the Vice President), a general manager, a customer service manager, a quality assurance manager, production managers, supervisors and “lead” people.

3 In several instances these individuals were offered partial ownership of the company in exchange for a lower salary than they were making with their previous employer.
At other companies, positions have been created specifically to implement and manage new “systems” such as ISO 9000, MRP, and scheduling. A medical implants company created a new ‘Developmental Systems Coordinator’ position to handle customer relations, customer audits, ISO 9000 and employee training. A small aerospace design shop—run exclusively by the owner for 20 years—recently hired a general manager to track jobs on a daily basis, manage documentation (including ISO 9000 and other customer specific quality programs) and provide customers with the required paperwork. Another aerospace company I visited was in the process of designating a manager to implement and maintain a new MRP system. The firm’s production manager described how the growing complexity of the shop’s work requires a more coordinated effort to get jobs shipped on time:

The plant manager used to have every part number in his head and the pace was a lot slower then. Now it’s just too much for one person. Our typical parts have 35 to 40 operations and then there is assembly. We get 26 weeks of lead-time and then in the last 4 weeks we are scrambling to put it all together. Delivery is everything so we need to get over this hump and get our systems in place. We’re going to designate a single person to be responsible for the MRP. Once we get over that hurdle we’ll be more organized and we’ll be able to run all this stuff through the shop a lot more efficiently.

Reactions to Change

Firm owners’ embrace of the new work organization varies considerably. One end of the spectrum is occupied by conservative firm owners who resist change. These owners—typically in their 50’s and 60’s—are uncomfortable with the challenges brought forth by the new manufacturing environment. After running their shops the same way for many years, they resist organizational innovation. They tend to view customer requirements as an expensive burden rather than as a mechanism for improving shop
operations. These firm owners are often reluctant to take the risks necessary to grow their businesses: they don’t want to acquire debt nor do they want to delegate responsibility to managers. Accordingly, their firms are often stagnant in terms of sales and employment growth.

At the other end of the spectrum are firm owners who zealously embrace organizational change and innovation. These firm owners tend to be younger—in their 30’s and 40’s—and are more likely to have college degrees. These firm owners are dynamic and aggressive. They are driven by the challenges of the new manufacturing environment and are not afraid to take risks. They spend a lot of their time on strategic planning, marketing, and customer relations. It is important to these firm owners to be viewed as modern and sophisticated. They are well versed in the management and organizational change literature, they embrace participatory management and employee involvement, and are intolerant of crude shop behavior. Their firms are often in a rapid growth mode.

In the middle are a majority of firm owners who are making incremental changes to modernize their companies. For the most part these firm owners recognize and accept the contours of the new manufacturing environment. However, they may not have the confidence, skills or resources to implement changes effectively.

**Implications for Shop-Floor Employees**

As noted earlier in chapter one, the level of skill among shop-floor employees in the firms surveyed is extremely high. The majority of shop-floor employees in these firms are skilled machinists, tool and die makers and technicians. Many attended
vocational high school in the region and apprenticed in local shops. Under the old form of work organization, most shop-floor employees specialized in a single machine or process and worked on one order at a time until it was completed. The old work organization required high level technical skills, attention to detail, and the ability to work alone. As a result, a shop-floor culture evolved which valued individualism and autonomy. In contrast, the new work organization requires unprecedented levels of interaction, communication and flexibility among shop-floor employees.

In the effort to improve quality, reduce cycle times, lower costs and satisfy customers, today’s shop-floor employees may be required to work in a team or work cell; work with other employees to coordinate scheduling; and/or work in groups to analyze and solve production problems. These new practices within the firm place a premium on communication skills. Shop floor employees need to be able to interact with one another and reach consensus on how to organize and perform work tasks. In addition, to insure quick response, many firms now want employees cross-trained on several different machines. With smaller lot sizes and shorter cycle times, employees often need to be moved around from one job to another to meet delivery dates. This change requires a level of flexibility and adaptability among employees that was unnecessary when employees specialized in a single machine.

Another big change for shop-floor employees stems from documentation requirements. As noted earlier in this chapter, many customers now want a written record of how jobs are performed and how quality is maintained throughout a shop. These changes require the ability to move comfortably between machines and paperwork. Shop-floor employees may be required to fill out SPC charts, document and log specific
changes made to jobs, and/or complete and submit inspection reports with jobs. For companies undertaking ISO 9000, employees may also be required to articulate and document their own job process.

Interviewed firm owners who have made shop-floor changes described how the new work organization has altered the nature of production jobs. Reflecting on the process of implementing self-directed work teams in his firm, the owner of a company that makes tools for non-invasive surgery described the difficult process of change:

Their mentality (machinists') is 'give me my job, give me my stuff, tell me what to do and how to do it and I'll see you tomorrow.' Now we are saying, 'See this schedule? We want you to figure out how to meet it and that's not going to be your decision, that's going to be all the people on the team.' Now they have to figure out priorities and how to make it work. I'm trying to say to these guys, 'you're going to do this part of the job and it has got to work with everyone else's part and you've got to work together to get it done.' They see it as a waste of time. For this reason, I've had to let some really, really good machinists go.

Another firm owner in the aerospace sector who is audited regularly by his top customers described how the new work organization has impacted machinists in his shop:

You have to do the paperwork. If you can't adapt, we can't afford it. The machinists say, 'but I'm a machinist, I'm not going to do paperwork.' I tell them, 'fine, then you're not going to work at B&E Tool.' That's the bottom line. You need that cross-functional ability between the machine and the paperwork. But you also need guys who can work on different machines. Everything is reaction, reaction. If a customer calls up and says, 'I need that part now,' I need that guy to jump off that machine and do that customer's part. All of this requires greater flexibility.

At a company that makes cutting tools, the Director of Organizational Development described employee resistance to the concept of cross training:

Louie is a 55 year old machinist who makes hack saw blades. He's a smart guy and he works 12 hours a day. We told Louie, 'Louie, we need you over here today on a different job so we're going to cross train you.' Louie said, 'I was hired to do hacksaw blades and that's what I want to do.' We said, 'Louie, the customer doesn't need hacksaw blades today so the choice is this: you can come to work when we need hacksaw blades but on the days we don't need them, you'll
stay home and you won’t get paid. Or you can get cross-trained and meet the customers’ needs in the best way possible that day, that hour, that minute, that second.’ And believe me, Louie is coming around.

Taken together, the changes embodied by the new work organization constitute a wholesale change in work culture for shop-floor employees. Overall, the new work organization is a much more social model of work organization than its predecessor. Employees accustomed to working alone, secure in the knowledge of their individual technical expertise are now expected to be communicative, responsive, flexible and open. While some employees embrace these changes, many employees—particularly older ones—have a hard time adjusting. According to firm owners, resistance to the new work organization is particularly strong among shop-floor managers. Accustomed to the traditional command and control management style, many shop-floor managers have been unable to adjust to a more participatory work environment. Several owners I interviewed said they had fired shop-floor managers who could not adapt to the changes.

**Implications for Human Resource Practices**

The new manufacturing environment has several implications for human resource practices within the firm. Through interviews and fieldwork I discerned four areas in which firms are making changes: 1) employee screening and hiring; 2) increased training for incumbent workers; 3) cultivation of the next generation of skilled metalworkers through coop and apprenticeship; 4) implementation of performance-based compensation.
Employee Screening and Hiring

In an effort to create a new work culture within the firm, many shops are now looking for different skills among new hires. While technical skills are still critical, good attitude, communication skills, the ability to learn and flexibility have become much more important. Screening prospective employees for these attributes helps firms avert employee resistance to change described in the previous section. For firms committed to organizational change and improvement, these new, 'social' attributes have become paramount. As one firm owner of a shop that produces extremely high tolerance parts and assemblies for aerospace customers put it: "If the person comes in and embraces the new way of doing business and the structure of the business, then you've got a good employee. I'd rather have a team player with a B average than a negative person with an A average."

At some firms heightened screening procedures have been formalized to insure a good fit between new employees and company philosophy and practice. At a firm that has moved to cellular manufacturing and team production, for example, team members hold interviews with prospective employees and make hiring recommendations to managers. At a mass production firm that is implementing a company-wide quality assurance program, all new employees are tested in math and reading to insure their ability to read charts, compute data, and perform SPC.

Increased Training for Incumbent Workers

While screening and hiring procedures help insure that new employees will be able to function effectively in the new work environment, firm owners also recognize
they must provide existing employees and managers with additional skills. I observed three general categories of training taking place in firms:

- **Technical Training** in machine set-up and operations, advanced math, interpreting blueprints, CNC, and CAD/CAM;

- **Quality Training** including gauging, inspection, documentation, testing and statistical methods; and

- **Communications Training** in team-building and problem solving to facilitate cellular/team production, scheduling, planning and continuous improvement efforts.

Overall, firm owners described a marked increase in the amount of training provided to managers and shop-floor workers in the last several years. The increase is attributed to rapidly changing technology, increased demands for quality, and heightened customer expectations for excellent service.

Firms draw on a variety of outside resources for training including the local technical college (Springfield Technical Community College), the local chapter of the National Tooling and Machining Association, the Massachusetts Employer Association, the American Management Association, customers, private training organizations, private consultants and vendors.

Some of the larger firms in the survey have managers who coordinate the training function within the firm. Responsibility for training is often one component in management level jobs being created by new ‘systems requirements’ described earlier in the chapter. A number of firms also have employees on staff who play the role of ‘in-house trainer.’ Several firms that have launched comprehensive quality initiatives, for example, have ‘quality coordinators’ who maintain the quality system and train shop-
floor employees in appropriate in-process inspection techniques. Another common
practice is for a select group of individuals within the firm to attend outside training
sessions on new organizational practices such as Kaizen or ISO 9000 and to teach what
they learned to small groups of employees inside the firm.

**Cultivating the Next Generation through Apprenticeship and Coop**

One of the biggest problem firms face today is recruitment of skilled employees.
During the recession of the early 1990’s, hundreds of skilled metalworkers and
machinists left western Massachusetts to seek work in other parts of the country. In
addition, due to a decade of restructuring and lay-offs, fewer and fewer young people in
the region entered the machine trades. When the economy began to pick up in the mid-
1990’s, skilled metalworkers were in extremely short supply.

Today, many firm owners are concerned about where the next generation of
skilled metalworkers and machinists will come from. The average tool and die maker in
western Massachusetts’ machine shops today is in his 50’s and will retire within the next
ten years. In response to current and projected labor shortages, a number of firms have
become active in education and training programs to cultivate the next generation of
skilled metalworkers and machinists. In field interviews, employers described a number
of different ways in which they are working in collaboration with local education
providers to encourage young people to enter the field. The most formal programs
include MechTech—an apprenticeship and pre-apprenticeship program developed by the
local chapter of the National Tooling and Machining Association—and a Machine Tool
and Mold Making Technology program based out of Leominster’s Center for Technical
Education. In addition to these formal programs, many companies are working with their area vocational schools to place part-time coop students in their shops.

**Performance-based Compensation**

To encourage shop floor employees to work toward achieving company-wide goals for quality, productivity improvements, on-time delivery, and total customer satisfaction, some firms have moved toward performance-based compensation systems. Some firms tie compensation to overall company performance. One firm I visited had recently implemented a ‘profit-sharing’ plan in which employees receive a predetermined share of profits at the end of each quarter. Under this plan, employees receive 10 percent less than market rate for hourly pay in exchange for quarterly profit sharing. The first eight percent of company profits go to stockholders. After this is paid out, remaining profits are split 70/30 between employees and stockholders. The payout is equal across all employees and is not based on position or pay scale within the firm.

Other firms have implemented compensation programs based on individual performance. To encourage machinists to work more quickly, the owner of a machine shop that makes custom parts on a repeat basis, hired a consultant to evaluate shop processes and devise standard production times for different parts. Based on the consultant’s evaluation, a performance incentive system was implemented in which machinists’ wages and jobs are directly tied to their productivity. The new system works as follows: if the machinist makes the part in standard time he gets regular pay; if he
makes the part in less than standard time, he receives a bonus; if he makes the part in
over standard time for three months in a row, he is subject to review and termination. 4

A number of firms have also implemented formal ‘employee suggestion’
programs to encourage production workers to contribute ideas for productivity
improvements. Under this type of program, individuals receive a bonus when their idea
is implemented. The bonus may be a fixed amount (e.g. $100 per implemented
suggestion) or it may depend on the level of the contribution. For example, at one firm I
visited, managers attempt to estimate the annual savings generated by a specific
performance improvement and provide a bonus in accordance with savings (e.g. if the
improvement saves the company $10,000 annually, a 5 percent bonus would yield $500
for the employee).

4 According to the general manager of this shop, employees hated the new system and resisted it. Two
people left the firm voluntarily as a result and two more were fired for poor performance. Despite these
initial problems, the manager reported that the system is now working and is contributing to record profits.
Chapter 3:
Understanding Variation in Work Organization Outcomes: Results from a Survey of 40 Metalworking Firms

Introduction

In the previous chapter, I described the vast array of technical, organizational and cultural changes firms are undertaking in response to the new manufacturing environment. This chapter narrows the focus by examining the spread of new work organization and human resource practices among firms in the survey sample.

While movement toward new, more flexible forms of work organization is taking place among the industrial machinery firms of western Massachusetts, the extent of change varies tremendously from firm to firm. Some small machinery firms in the region have made little or no movement in the direction of the new work organization while others have embarked on comprehensive reorganization paths aimed at transforming production processes and company culture. To gain insight into this variation, I conducted phone interviews with 40 firm owners in which I asked a series of questions regarding the firm’s current practice in the areas of quality assurance, organization of production jobs, and compensation. This information was coupled with data on firms’ training practices gathered through the written survey to form a work organization “profile” for each firm.

In this chapter I present findings regarding the spread of new work organization practices among surveyed firms. The first section of the chapter describes the dependent variables in greater detail and examines the frequency of innovation at the level of individual practices and when practices are bundled. In section two, I review the technology diffusion literature in order to develop hypotheses regarding variation in the
adoption of new work organization practices. I then present survey findings regarding sources of variation. In section three I interpret variation and present an argument regarding its key determinants.

I. The Distribution of Individual and Bundled Work Organization Practices

Defining the Variables

To narrow the focus of my investigation into firm-level change, I limited the dependent variables of the survey to the following four areas: quality assurance, reorganization of core production jobs, compensation, and training. These variables were selected based on review of the literature on “high performance work organization” and extensive fieldwork summarized in the previous chapter. The first two variables (quality assurance and reorganization of production jobs) measure organizational change within firms while the second two variables (compensation and training) measure change in human resource practices that support new forms of work organization. Clearly, these four variables do not capture the plethora of changes small firms are undertaking in response to the new manufacturing environment. They do, however, capture a particular dimension of change and therefore help develop a rough gage of the extent to which small industrial firms are reorganizing work and workers in response to heightened competition. The four variables and their measurement are described in turn:

Quality Assurance

As described in the previous chapter, suppliers are increasingly under pressure to implement preventative quality assurance procedures in order to reduce scrap and rework
and the need for customer inspection. I asked firm owners whether they had undertaken a formal, company-wide quality program in the past three years aimed at reducing error, scrap and rework. If the firm owner replied “yes”, I probed further to determine whether the company had moved away from an inspection approach toward an in-process approach to quality assurance. I also asked whether the company routinely tracked scrap and customer rejects as part of its quality program. If the firm owner replied “yes” to both of these, the firm qualified as having a preventative quality assurance program. As a subset of the quality question, I asked firm owners whether the firm was pursuing, compliant or certified in ISO 9000.

Reorganization of Core Production Jobs

In order to reduce cycle times, improve productivity and increase internal flexibility, some firms are reorganizing how machines are laid out and how production jobs are performed. Some firms have moved away from a process-oriented layout (i.e. milling department, grinding department, assembly department, quality department) to a cellular layout in which multiple processes are performed within a single cell. Employees operating in manufacturing cells are often responsible for a product (rather than a process) and are often given greater responsibility for meeting production goals such as quality, schedule, and delivery. In order to facilitate the flow of work within cells, employees are often cross-trained in different jobs. Other firms have organized groups of employees into “self-directed work teams.” Teams may or may not be organized into manufacturing cells but are typically assigned increased responsibility for production goals and quality. In a tool and die firm, for example, a ‘team’ may be assigned a specific job and given responsibility for all aspects of production from
engineering to final inspection. It is the team's responsibility to figure out how the work will get done, who will perform what work tasks, and how to meet the delivery date.

While the reorganization of people and machines into more efficient and flexible configurations is a key component of the new work organization, it is difficult to capture quantitatively for several reasons. Because many of the firms in the survey sample are very small (nearly one-third have between 10 and 20 employees) organizational innovations such as cells and teams may not apply. A typical response to questions regarding work reorganization among the smallest firms was, "our whole shop functions like a team." Another response I heard several times was, "teams form on an as needed basis in response to specific jobs." Another measurement problem stems from the fact that firms tend to 'phase-in' organizational innovations over time. For example one firm was in the process of putting together a work cell designed to build a 'family of products' while the rest of the firm remained organized by process. Another firm had recently implemented cellular manufacturing and was "moving toward team production and cross-training." In response to these measurement problems, I decided that only those firms that had undertaken company-wide reorganization of core production jobs qualified.

I asked firm owners whether they had reorganized core production jobs in their shop in order to improve efficiency, productivity and/or flexibility. If the firm owner responded "yes", I asked him or her how extensive the reorganization was. I then asked him or her to describe the nature of the new work organization to determine whether a traditional form of work organization had been given a new name (e.g. as when a department is renamed a "team") or whether, in fact, real changes had occurred that gave production workers greater responsibility for meeting production goals. I determined
that any firm that had reorganized the shop-floor into cells or teams in which cross-training and job rotation took place qualified as reorganizing production.

**Performance-based Compensation**

To encourage production workers to work in ways that are consistent with the new manufacturing environment, some firms are moving away from strict hourly pay and implementing compensation systems in which bonuses are tied to company performance, team performance, individual performance and/or employee suggestions for productivity improvements. I asked firm owners whether they had implemented any type of performance-based compensation for production workers. If the firm owner responded “yes”, I asked him or her to explain how compensation beyond hourly wages was tied to performance.

**Training**

The training effort of firms is difficult to measure for a variety of reasons. As Osterman describes, “firms do not keep good or standardized data on their training expenditures...to complicate the measurement problem further, a great deal of employee development or “training” occurs informally on the job. Supervisors, co-workers, mentors etc. all are important “trainers” for employees as they improve their proficiency” (Osterman, 1995). These problems are intensified in the small firm environment in which few, if any, resources are dedicated to formal training and the majority of training is “on-the-job.”

I asked firms to calculate the dollar amount spent on formal training for production workers in 1996 to compare training efforts across firms. This was
impossible, however, because many firms were unable to calculate an amount. Nineteen out of 46 firms were either unable to calculate their training expenditure or reported spending nothing on training in 1996. Eleven firms reported they were unable to calculate their training expenditure because it was unknown or because all training was on-the-job. In addition, another 8 firms reported they spent nothing on training in 1996 either because they provided no training or because all training was on-the-job. Twenty-nine firms did report their training expenditure for 1996. However, a number of these firms incorporated on-the-job training expenditures into their calculation (this was discovered through phone interviews), making it nearly impossible to compare training efforts across establishments.

Anticipating these sorts of measurement problems, I asked some more basic questions that could provide a general gage of firms’ training effort over the past three years. Specifically, I asked if firms had increased the amount of training provided to production workers over the past three years. In addition, I asked about the proportion of managers and shop-floor employees that received quality training in the past three years and about the distribution of training for shop-floor employees over the past three years. Regarding the distribution of training for shop-floor employees, I asked firms to indicate the percentage of total training that each of the following categories represented:

- basic skills (reading, writing, and math);
- communication skills (teamwork, problem-solving, and interpersonal skills);
- quality control skills (gauging, inspection, documentation, testing and statistical methods);

1 Training data based on 46 observations because it was incorporated as part of the written survey. Other work organization variables based on 40 observations. When bundled, I eliminate the six training observations that didn’t provide additional information on the other three work organization variables.
• technical skills (machine set-up and operations, advanced math, interpreting blueprints, CNC; CAD/CAM).

The idea here was to determine the extent to which firms are providing training that is consistent with the new work organization. For example, I would expect firms that have reorganized production into teams to provide more training in communication and problem-solving skills than firms that have not reorganized production in this way. Similarly, I would expect firms that are striving to improve quality and become more systematic in order to reduce scrap and rework to provide more training in quality control and documentation than firms that are not yet moving in this direction.

**Distribution of Individual New Work Practices**

At the level of individual practices, a significant proportion of firms exhibit behavior consistent with the new work organization. Just over half of all firms (21/40) report implementing a formal quality assurance program. Of the 21 firms that have implemented a program, 15 report they are pursuing or compliant with ISO 9000 and 4 report they are ISO 9000 registered. Approximately one-third of firms (13/40) report reorganizing core production jobs to increase productivity and gain internal flexibility. Thirty-seven percent of firms (15/40) have implemented some form of performance-based compensation beyond hourly wages. And over three-quarters of firms (31/40) report an increase in the amount of training provided to production employees in the past three years.

The prevalence of quality assurance programs and reorganization of core jobs suggests steady movement toward new forms of work organization in which production employees are given greater responsibility for meeting production goals. In terms of
human resource policies to support these changes, however, the evidence is less clear. Many firms have implemented compensation tied to some aspect of company performance. However, few firms have explicitly linked their compensation programs to the new work organization in any meaningful way. Most firms, for example, provide a one-time, year-end bonus tied to overall company financial performance. With regard to training, the vast majority of firms report an increase in the amount of training provided to production workers over the past three years. Most of the provided training, however, is technical training. Far fewer firms have provided significant training in quality control skills and communication skills.

Table I: Distribution of Individual Practices

<table>
<thead>
<tr>
<th></th>
<th>Firms Reporting</th>
<th>Percent of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality Assurance Program</td>
<td>21</td>
<td>52.5%</td>
</tr>
<tr>
<td>Reorganization of Core Production Jobs</td>
<td>13</td>
<td>32.5%</td>
</tr>
<tr>
<td>Performance–based Compensation</td>
<td>15</td>
<td>37.5%</td>
</tr>
<tr>
<td>Increase in Shop Floor Training</td>
<td>31</td>
<td>77.5%</td>
</tr>
</tbody>
</table>

Note: N = 40

Quality Assurance

The trend toward eliminating inspection by controlling quality during the manufacturing process has made considerable headway among western Massachusetts machining firms. Just over half of all surveyed firms (21/40) have implemented (or are in
the process of implementing) company-wide quality assurance programs in which shop-floor employees take on greater responsibility for quality. Measurement and assessment (or "benchmarking") are now integral components of quality assurance in these firms. These firms track scrap, customer returns and on-time-delivery on a routine basis in order to measure performance and improvement. Most companies issue weekly or monthly reports on these statistics. These serve as the basis for "cause and corrective action" meetings in which quality and delivery problems are identified and analyzed by groups of shop-floor employees.

While many of these innovations have been undertaken in direct response to customer requirements, there is a strong sense among these firms that sophisticated companies today must demonstrate that they are in control of their processes. A comprehensive quality initiative that enables the firm to track, measure and demonstrate quality improvement is now part and parcel of being sophisticated. Involving employees in the process—and getting their "buy-in"—is viewed as an essential step to performance improvements. Despite these widespread convictions, however, few of the firm owners I spoke with were able to quantify improvements stemming from their quality assurance programs. Many survey respondents said they had seen "measurable improvements" as a result of their quality assurance programs yet only four provided me with numbers.²

² Part of this was due to the fact that this information was collected over the phone and interviewees didn't tend to have this information at their fingertips. A few firms I interviewed said they were just beginning their measurement process and were establishing "baselines" to measure improvement against in the future. Most firms claimed to have experienced "measurable improvement" in customer returns and on-time-delivery as a result of their tracking and measurement programs. However, when asked for specific numbers, only four firms provided me with any data. One firm claimed to have increased on-time-delivery from 80 to 96 percent of shipments; another firm said that is defect rate was now "0007 documented with our customers"; another firm claimed the cost of manufacturing had decreased 29%; finally, one firm boasted a "20-25% improvement in on-time-delivery, a reduction in customer rejects from 8 to 2 percent of all shipments, and a 60-70 percent reduction in scrap."
Table II: Quality Assurance Programs

<table>
<thead>
<tr>
<th></th>
<th>Firms Reporting</th>
<th>Percent of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality Assurance Program</td>
<td>21</td>
<td>52.5%</td>
</tr>
<tr>
<td>ISO 9000 Compliant</td>
<td>15</td>
<td>37.5%</td>
</tr>
<tr>
<td>ISO 9000 Registered</td>
<td>4</td>
<td>10.0%</td>
</tr>
</tbody>
</table>

Note: N = 40

A striking finding is the widespread influence of the ISO 9000 quality assurance standards on firms’ quality initiatives. Most firm owners spoke of their quality initiative and ISO 9000 as one in the same. This makes sense given that 15 of the 21 firms that have implemented a quality assurance program said their quality program was compliant with or closely adhered to ISO and 4 of the 21 firms reported they were certified in ISO 9000. Eight of the 21 firms said they undertook their quality assurance program in direct response to customer pressure to comply with the ISO standards. The remaining 13 firms said they had not experienced direct pressure from customers to implement ISO 9000. However, several of these firm owners said they were pursuing quality assurance because “this is the direction industry is moving in.” These firm owners believe a documented quality assurance program provides them with a “leg-up” on the competition and that it is an important marketing tool. Other firm owners discussed their quality assurance programs as an essential component in their overall competitive strategy.
Reorganization of Core Production Jobs

Approximately one-third of surveyed firms (13/40) have reorganized core production jobs in order to improve efficiency and gain internal flexibility. Among the 13 firms that have undertaken reorganization of core production jobs, the two most common types of reorganization are cellular manufacturing (7 firms) and job rotation (7 firms), followed by team production (4 firms). In addition, seven firms have undertaken ‘Kaizen’ in order to improve plant lay out and reduce machine set-up times.

For all firms undertaking these changes, reorganization of machines and core production jobs is a key component in an overall strategy to reduce costs, improve quality and gain flexibility. By improving plant lay out and giving production employees greater responsibility for meeting production goals, firms strive to generate process improvements, cost savings, and fewer defects. For many firms, reorganization is the outcome of a strategic planning process in which internal operations are assessed against company goals. A number of firms in this group, for example, have recently made strategic shifts into new markets. One firm went from making jet engine parts to making medical instruments and another firm went from mass-producing screw machine products to making high tolerance aerospace parts. In both cases, the shift into new markets caused an assessment of internal operations that led to the reorganization of machines and jobs. Other firms in this group have embarked on aggressive growth trajectories in recent years. In order to function efficiently with more employees and at higher volumes, these firms determined that they needed to reorganize the lay out of machines in the shop and upgrade the quality of production jobs. Finally, reorganization may be undertaken in response to specific customer requirements. Several firms in this group, for example,
said they had been required to undertake the costly and time-consuming ‘Kaizen’ process by their customers.

**Performance-based Compensation**

Thirty-five percent of surveyed firms have implemented some form of performance-based compensation (15 of 40 firms). However, few firms have linked their compensation systems to the new work organization in any systematic way. The most common form of compensation provided beyond hourly wages is a bonus based on company financial performance. Of the nine firms that reported bonuses based on company financial performance, six provide one-time, year-end cash bonuses based on profits, two put a share of profits into employees’ 401K plans, and one provides quarterly cash bonuses to employees through a formal profit-sharing plan.

The second most common form of performance-based compensation is based on individual performance. Among the seven firms that reward individual performance, there is little uniformity. Some firms have extremely informal reward systems. For example, the firm owner of a prototype machine shop said she gives bonuses to individuals for “quality and on-time delivery” on specific jobs at her discretion. Other firms, by contrast, have implemented formal incentive systems to encourage specific behavioral changes among employees (e.g. the firm described in Chapter Two that implemented an incentive system based on standard part times).

Four firms have implemented formal employee suggestion programs in which employees earn bonuses if their suggestions for productivity improvements are implemented. Bonuses ranged from $50 to $500 among the four firms that have
implemented this type of system. Two of the four firms provide an additional bonus at the end of the year to the employee who made the most significant contribution to productivity improvements over the course of the year. Only one firm in the survey has tied compensation to team performance. At this firm, individual team members receive a $100 bonus each month the team meets its monthly productivity goals. Finally, in an effort to encourage employees to seek training and skills, one firm is in the process of implementing a 'pay-for-knowledge' system in which employees' base pay increases as they demonstrate mastery of new skills on the job.

Training

Overall, firms report a general increase in training provided to shop-floor employees in recent years. Over three-quarters (77.5%) report an increase in training provided to production workers in the past three years. Technical training composed the greatest share of training provided to shop-floor employees over the past three years, followed by training in quality skills, communication skills, and basic skills.

Firms dedicate the lion’s share of their total training effort to technical training. Half of all firms spent 50 percent or more of their training effort on technical training and ten firms dedicated 80 percent or more of their training effort to technical skills.

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3 Many firms have employee suggestion programs in which employees are encouraged to submit recommendations for productivity improvements. In most firms, however, this is simply considered part of the job and is not rewarded monetarily.
Table III: Technical Training

<table>
<thead>
<tr>
<th>Share of total training effort (past 3 years)</th>
<th>Number of firms reporting</th>
<th>Percent of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>less than 15%</td>
<td>10</td>
<td>22.0%</td>
</tr>
<tr>
<td>from 20-40%</td>
<td>13</td>
<td>28.0%</td>
</tr>
<tr>
<td>from 50-75%</td>
<td>13</td>
<td>28.0%</td>
</tr>
<tr>
<td>more than 80%</td>
<td>10</td>
<td>22.0%</td>
</tr>
<tr>
<td>Total</td>
<td>46</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

Quality control skills were the next most important form of training. Nearly 60-percent of firms (27/46) allocated 20 percent or more of their total training effort to quality and 6 firms dedicated 50 percent or more of their training effort to quality.⁴

Table IV: Quality Training

<table>
<thead>
<tr>
<th>Share of total training effort (past 3 years)</th>
<th>Number of firms reporting</th>
<th>Percent of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>less than 10%</td>
<td>19</td>
<td>41.0%</td>
</tr>
<tr>
<td>from 20-40%</td>
<td>21</td>
<td>46.0%</td>
</tr>
<tr>
<td>more than 50%</td>
<td>6</td>
<td>13.0%</td>
</tr>
<tr>
<td>Total</td>
<td>46</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

In addition, firms report that a significant share of employees have received quality training in the past three years. Nearly half of all firms have provided quality training to all of their managers and 38-percent of firms have provided quality training to all of their production workers. These numbers support the findings regarding quality assurance programs and suggest that widespread training is necessary to implement an
effective quality assurance program. At the same time, however, a significant number of firms have provided no quality training whatsoever to either managers or production workers.

Table V: Quality Training for Managers

<table>
<thead>
<tr>
<th>Share of managers receiving training (past 3 years)</th>
<th>Number of firms reporting</th>
<th>Percent of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>zero</td>
<td>13</td>
<td>28.0%</td>
</tr>
<tr>
<td>from 10-50%</td>
<td>11</td>
<td>23.0%</td>
</tr>
<tr>
<td>100%</td>
<td>23</td>
<td>49.0%</td>
</tr>
<tr>
<td>Total</td>
<td>47</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

Table VI: Quality Training for Production Employees

<table>
<thead>
<tr>
<th>Share of production employees receiving training (past 3 years)</th>
<th>Number of firms reporting</th>
<th>Percent of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>zero</td>
<td>15</td>
<td>32.0%</td>
</tr>
<tr>
<td>from 10-50%</td>
<td>8</td>
<td>17.0%</td>
</tr>
<tr>
<td>from 60-90%</td>
<td>6</td>
<td>13.0%</td>
</tr>
<tr>
<td>100%</td>
<td>23</td>
<td>38.0%</td>
</tr>
<tr>
<td>Total</td>
<td>47</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

Few firms dedicate a significant share of their training effort to communications skills: 91 percent (41/46) allocated 20 percent of their total training effort or less to communications skills and 18 of these dedicated zero. However, 6 firms did dedicate 30 percent or more of their training effort to communication skills.

\[4\] Several of the firms that devoted greater than 50% of their training effort to quality training over the three year period had recently undertaken ISO 9000 certification.
Table VII: Interpersonal Skills/Communications Training

<table>
<thead>
<tr>
<th>Share of total training effort (past 3 years)</th>
<th>Number of firms reporting</th>
<th>Percent of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>less than 5%</td>
<td>19</td>
<td>41.0%</td>
</tr>
<tr>
<td>from 10-20%</td>
<td>21</td>
<td>46.0%</td>
</tr>
<tr>
<td>more than 30%</td>
<td>6</td>
<td>13.0%</td>
</tr>
<tr>
<td>Total</td>
<td>46</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

By far the least common type of training provided by firms was basic skills training: 85 percent of firms (39/46) provided no training in this area whatsoever.

Table VIII: Basic Skills Training

<table>
<thead>
<tr>
<th>Share of total training effort (past 3 years)</th>
<th>Number of firms reporting</th>
<th>Percent of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>zero</td>
<td>39</td>
<td>85.0%</td>
</tr>
<tr>
<td>from 2-30%</td>
<td>7</td>
<td>15.0%</td>
</tr>
<tr>
<td>Total</td>
<td>6</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

While technical training clearly dominates firms’ overall training efforts, the numbers do suggest some general movement toward forms of training supportive of new forms of work organization. Furthermore, within individual training categories, a small subset of firms is dedicating a significant share of the firm’s total training effort to quality control skills and communications skills. The widespread lack of basic skills training is most likely attributable to the generally high skill nature of work performed in most shops included in the survey. In interviews, a majority of firm owners reported that their biggest problem in terms of skills and training was not incumbent workers but new hires.
Many firm owners commented that 'nobody walks in the door with the skills I need.' As a result, firms provide a good deal of technical training to new hires on the job. This may account, in part, for why technical training composes such a large share of total training effort in many firms.

Distribution of Bundled New Work Practices

While it is useful to know the spread of individual practices associated with the new work organization, their distribution alone does not help us develop a profile of innovating firms among the survey sample. In order to develop a 'work organization profile' for each firm, I assigned firms to one of three groups—traditional, transitional, or transformed—depending on the number and type of innovations undertaken.

As noted earlier, the four innovations under examination are of different types. Quality assurance and reorganization of core jobs are organizational change variables while training and performance-based compensation are human resource variables. Because firms may increase training and implement performance-based compensation in the absence of organizational change, I decided that firms that undertook one or both of these practices did not quality as innovative. Accordingly, 'traditional firms' are those that have undertaken no innovations, training alone, performance-based compensation alone, or training and compensation in combination. To qualify as a 'transitional', firms had to engage in one organizational practice plus one additional practice. For example, quality assurance plus training or cellular manufacturing plus training. To qualify as 'transformed,' firms had to engage in one organizational practice plus two (or three) of
the additional practices. For example, quality assurance plus cellular manufacturing plus training. The threshold to qualify as a ‘transformed’ in this measurement scheme is admittedly arbitrary. However, it does provide a useful way to distinguish between firms and to discern salient explanatory variables for variation in adoption of practices.

Based on this measurement scheme, traditional firms compose 42.5 percent (17 firms) of the survey sample; transitional firms compose 22.5 percent (9 firms); and transformed firms compose 35 percent (14 firms). Within each group, some clear patterns emerge regarding practices. Among traditional firms, the most common practice is an increase in training for shop-floor employees. Ten of the 17 firms in this group have increased training and 6 have implemented some type of performance-based compensation (2 firms have done both). Among transitional firms, the anchor organizational practice is quality assurance. Seven of the nine firms in this group have undertaken a quality assurance program while 2 of the nine have reorganized core production jobs. The anchor human resource practice is training. In seven of nine firms, the organizational practice is combined with an increase in training; in two firms it is combined with performance-based compensation. Among transformed firms, the most common combination of innovations is quality assurance, reorganization of core jobs, and training. Eleven of the 14 firms in this group have undertaken this combination. Seven of the 14 firms in this group have implemented performance-based compensation. Four of the 14 firms have undertaken all four innovations.

5 For example, a firm may invest heavily in technical training and provide bonuses at the end of the year based on company profit, without moving toward new forms of work organization in which production workers take on greater responsibility for scheduling, quality, productivity improvements etc.
Table IX:
Distribution of Bundled Practices

<table>
<thead>
<tr>
<th></th>
<th>Traditional</th>
<th>Transitional</th>
<th>Transformed</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of Firms</td>
<td>17</td>
<td>9</td>
<td>14</td>
</tr>
<tr>
<td>Percent of Total</td>
<td>42.5%</td>
<td>22.5%</td>
<td>35.0%</td>
</tr>
<tr>
<td>Breakdown of</td>
<td>T=8</td>
<td>Q+T=6</td>
<td>Q+R+T=7</td>
</tr>
<tr>
<td>Innovations</td>
<td>C=4</td>
<td>Q+C=1</td>
<td>Q+R+T+C=4</td>
</tr>
<tr>
<td></td>
<td>Ø=3</td>
<td>R+T=1</td>
<td>Q+T+C=3</td>
</tr>
<tr>
<td></td>
<td>T+C=2</td>
<td>R+C=1</td>
<td></td>
</tr>
</tbody>
</table>

Note: N = 40
Key: Ø=no innovations; Q=quality assurance; T=training; R=reorganization of core production jobs; C=performance-based compensation.

Overall, the survey data suggests considerable movement toward new forms of work organization among the western Massachusetts supplier base. At the same time, however, it suggests considerable variation in adoption levels. Approximately 58 percent of firms in the survey sample have undertaken new production practices in order to improve internal quality and flexibility and 3/5 of these have achieved significant levels of reorganization. But 42 percent of all surveyed firms have undertaken little or no reorganization. What explains why firms in the same industrial sector exhibit such wide-ranging behavior when it comes to the new work organization? To help answer this question, I turn to the literature on diffusion of innovations and small firms.

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6 These findings are consistent with research conducted by Richard Florida in the Midwest between 1992 and 1995 (Florida, 1996). Large manufacturers surveyed reported that between one-half and two-thirds of the regional supplier base was engaged in the transition to new forms or production organization. They estimated that 10 to 25 percent of the supplier base was not engaged in the shift and preferred to remain organized along traditional lines.
II. Understanding Variation in the Adoption of New Work Organization Practices

In their review of the economic research on technology diffusion, Kelley and Brooks note that “a widely accepted tenet of contemporary analyses of the diffusion of innovations is that certain types of organizations are better positioned than others to generate and to adopt innovations”. (Kelley and Brooks, 1991) In the early 1990’s, concern about the slow rate of adoption of advanced technologies and new organizational practices among small U.S. manufacturing firms resulted in a series of studies and reports that examined why small firms were poorly positioned to adopt productivity enhancing innovations vis-à-vis large firms. (Kelley and Brooks, 1991; NIST, 1992; National Research Council 1993; Shapira, 1990). This body of work provides a consistent description of the obstacles small firms face as they grapple with the costs and benefits of implementing new technologies and organizational strategies. These obstacles can be grouped into three broad categories: incentives, resource constraints, and limited learning opportunities.

Incentives

The economic research on technology diffusion asserts that firms have very different “incentive structures” that help explain why some firms are quick to adopt innovations and others are not (Kelly and Brooks, 1991). In the context of small firm suppliers, the most critical incentive structure a firm faces is its customers. According to some observers of small firm behavior, a large barrier to small firm investment in advanced technologies and workforce strategies stems from the short-term, price-based

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7 Kelley and Brooks 1991 article concerns the diffusion of programmable automation only. The other three reports examine adoption of advanced technologies and organizational practices more broadly.
orientation of large firm customers. Instead of encouraging small firm suppliers to invest in capital equipment, develop unique capabilities and enhance workforce skills, many large firms are driving small firms to pursue “low-road” tactics such as minimizing capital investment and freezing or lowering wages. (Harrison, 1994; Luria, 1996) Under these circumstances, small firms face poor incentives to adopt costly, new technologies.

The irony of course, is that advanced computer and organizational technologies—when implemented correctly—help firms achieve price reductions and productivity improvements. Despite demonstrable gains, however, many firms may fail to invest in productivity enhancing technologies because of perceived “switching costs.” Kelley and Brooks describe the risks inherent in switching costs in their study of programmable automation among large and small firms:

New process technologies always involve a change in the ways in which products are made—a change in the allocation of tasks, a change in machinery, a change in work methods that may imply retraining, or a change in organization. For the firm, there is always some uncertainty about how much new knowledge will be necessary and how drastic a change the new configuration of equipment and people will entail. If these changes require substantially new skills and expertise, then a displacement of the learning curve results, that is, a discontinuity arises between the organizational learning accumulated under the previous production regime and that which is needed for the new technology. This could even result in a short-term decline in productivity until a certain portion of the new learning curve has been traversed as the organization develops the additional expertise needed to more fully exploit the potential advantages inherent in the new technological trajectory (pg. ).

If a supplier is engaged with a large customer that continually demands price cuts and demonstrates no commitment to the supplier, switching costs may be perceived as prohibitively high. Under these conditions, suppliers are likely to forgo investment in technological and organizational change and “squeeze” as much work as they can out of existing machines and people. If, however, a supplier is engaged in “partnership” with its
customers, it may face different incentives to switch. As described in Chapter I, some large customers have moved away from adversarial relations with their suppliers toward a cooperative model in which customers help a select group of "core" suppliers upgrade internal operations and improve performance. For these suppliers, switching costs may be perceived as the price that must be paid to maintain core supplier status with the customer.

Another key factor that shapes incentives regarding innovation is firm strategy.

In the report *Learning to Change*, the Manufacturing Studies Board of the National Research Council differentiates between two types of small firms—investment companies and life-style companies:

Investment companies tend to be young, more interested in aggressive growth and expansion, and willing to assume more risk to achieve that growth. They exhibit a greater willingness to adopt change and increase investment in people and training as well as new machinery and equipment. Life-style companies view expenditures for new product and process technology as risking personal wealth rather than investing in growth and expansion of capabilities and markets. They are more likely to feel that upgrading worker skills is wasted because the employee is likely to accept a job with another company. Their decisions tend to be personal: "should I buy my daughter a new automobile or should I invest in an NC milling machine?" (pg. 21).

In pursuit of growth and expansion, investment companies are likely to view the costs of switching to new technologies and organizational strategies as critical components of their overall competitive strategy. While the costs of switching may be high, the incentive for these companies to switch is equally high because they believe the investments will pay-off in the long run in terms of customers, sales, and profits. Because life-style companies are typically not striving for aggressive growth and expansion, the costs of switching to new technologies and organizational strategies may be viewed as high and of uncertain value. Some lifestyle companies may not
contemplate adopting new technology or organizational strategies unless prodded by customers or declining sales and profit.

*Resource Constraints*

Small firms commonly lack the financial resources required to invest in new technologies as well as the staff resources to effectively manage the internal adjustment process. Furthermore, capital and investment funds for modernization are often difficult for small manufacturing firms to obtain.

In a survey of factors affecting adoption of advanced technology, the Census Bureau found that lack of money is a primary obstacle to adoption (Census Bureau, 1993). This may be particularly true when customers impose price reduction requirements on suppliers. Firms may also experience difficulty acquiring capital should they decide to incur bank loans for new hard or soft technology. The Manufacturing Studies Board, for example, found that small firms are “unlikely to have the capabilities needed to put together proposals for funds in the format familiar to lending officers. In addition, the Board’s report states that

Tightened banking regulations have made banks skittish about investing in small companies, particularly for technologically advanced production machinery and equipment. Even when financing is available for capital equipment, funds to develop the skills and competencies required to apply and operate such equipment are very difficult to obtain. (pg. 47)

Another resource constraint stems from the limited management capacity of most small firms. Typically, multiple management functions are combined in just a few individuals (Mt. Auburn Associates 1995). Few small firms have the internal resources to dedicate an employee’s time to the information gathering, decision making, and implementation tasks associated with the adoption of new hard or soft technologies.
Though outside consultants are eager to fill this role, many small firms regard them as prohibitively expensive.

**Limited Learning Opportunities**

Common to all the studies and reports published in the early 1990’s on the plight of small firms is the belief that they are isolated and therefore cut off from important opportunities to learn about the advantages of advanced technological and organizational strategies. Isolation, according to these accounts, stems from two main factors. First, most small firms have limited opportunity to interact with other similarly situated firms due to the lack of associative institutions and local business infrastructure in the United States (Best 1990; Shapira, 1993; Harrison, 1994). Second, few small firms benefit from structured interaction with their customers—a learning resource that can provide “enormous opportunities for small firms to improve their performance.” (National Research Council, 1993) Isolation in turn, contributes to “lack of awareness” about how concepts of world-class manufacturing apply to the small firm environment.

**Overcoming Obstacles to Diffusion**

The small firm literature of the early 1990’s developed a compelling explanation for why small manufacturing firms are poorly positioned vis-a-vis large manufacturing firms to adopt advanced technological and organizational innovations. Less attention has been paid, however, to variation within the small firm sector itself. Clearly, small firms that have adopted technological and organizational innovations have overcome the

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*In these and other accounts, it is common to contrast the isolated situation of American SME’s to their counterparts in Italy (industrial districts) and Japan (keiretsu) who benefit from continuous interaction and learning with peers, customers and intermediary organizations.*
obstacles to diffusion described above. But how and why some small firms adopt innovations is not well understood.⁹

Based on the literature on diffusion and my own field work, I identified seven explanatory (independent) variables that could logically account for variation among the survey sample. The variables were measured through the survey instrument in order to characterize the ways in which 'transformed firms' vary from 'transitional' and 'traditional' firms. The seven variables are organized into two categories described below: firm environment and firm characteristics.

**Firm Environment**

A growing body of theory and research suggests that the external environment a firm operates in effect its propensity to adopt workplace innovations. This insight was first developed in the organizational sociology literature on isomorphism (Dimaggio and Powell, 1983; Dimaggio and Powell, 1991; Meyer and Scott, 1983). According to this school of thought workplace innovations diffuse across the economy not because they are necessarily more efficient but because they provide firms with a level of legitimacy required to survive in their respective field or sector.

Comparative political economists also stress the importance of firm environment. In an effort to understand variation in performance and productivity among small firms in advanced industrial societies, a rich body of literature developed in the early 1990's describing how the different social and institutional contexts small firms operate in

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⁹ The Performance Benchmarking Service of ITI provides the best data on variation of technological and organizational strategies among firms with under 500 employees. Luria et. al. have identified three distinct patterns of innovation which they label systematic; modern; and distinctive. Systematic firms have implemented innovations such as quality assurance and manufacturing teams to increase quality and reduce costs; modern firms have automated key aspects of the production process from scheduling to machining; and distinctive firms provide unique services and invest heavily in workforce training. So far, however, PBS has not attempted an explanation of why firms pursue the strategies they do. See Luria et. al., 1996.
impact firm behavior (Best, 1990; Pyke and Sengenberger, 1992; Harrison, 1994.)

Particular attention has been paid in this literature to the social and institutional features of the Italian ‘industrial district’ and Japanese supply ‘keiretsu.’

Despite shared technology, geography and workforce, the small industrial firms of western Massachusetts operate in markedly different social and institutional environments. Some firms work in close partnership with their customers to achieve performance and productivity improvements while others work in isolation. Some firms operate in national markets with many customers while others are dependent on two or three regional customers. Some firm owners are active participants in trade associations and industry groups while other firm owners rarely have contact with their peers. I hypothesize that this environmental variation shapes the incentives firms face regarding the adoption of new organizational strategies. Through my field work I identified several variables related to firm environment that potentially increase a firm’s incentive to adopt organizational innovations. These include industry sector; sales region; contract length; and access to learning opportunities.

- **Industry Sector**

The industry sector that a supplier’s customer operates in is bound to shape the customer-supplier relationship. Two dimensions of industry sector seem relevant. The first dimension involves defense vs. commercial customers. In chapter two, I described how several defense suppliers changed their work organization in order to meet the quality and delivery requirements of new commercial customers. Accordingly, I expect firms that made the transition from defense to commercial markets as a result of defense
downsizing to adopt innovations associated with the new work organization in order to establish credibility with their new commercial customers.

The second dimension of industry sector involves the trend toward supplier development and certification programs. As noted in Chapters I and II, there has been considerable movement in certain industry sectors in the past decade toward supplier development and certification programs. At the national level, these approaches are increasingly common in the auto, aerospace and electronic industries. In supplier development programs, customers work with a select group of “core” suppliers in order the help upgrade supplier performance in key areas including quality and delivery. These programs are often characterized by contract guarantees, continuous communication and information exchange, and on-site technical assistance. In supplier certification programs, customers rate supplier performance across multiple areas in order to determine their eligibility for preferred supplier status (which often results in long-term contracts and/or participation in supplier development programs).

I expect suppliers engaged in supplier development and certification programs to adopt organizational innovations associated with the new work organization at higher rates for several reasons. First, adoption of organizational innovations such as quality assurance and cellular manufacturing may be a requirement of “core” supplier status. If so, suppliers must comply with customers’ innovation requests or risk losing the benefits of “core” supplier status. Second, customers that have moved in this direction may provide their suppliers with information and assistance about organizational innovations which substantially lowers the costs associated with switching to a new organizational
structure. Third, the prospect of long-term contracts should create a strong incentive for suppliers to adopt the innovations measured through supplier certification systems.

- **Contract length**

In contrast to the partnership model of customer-supplier relations, most manufacturing customers continue to adhere to the “arms-length” model of procurement. In this approach to supplier relations, purchasing agents seek multiple bids on jobs in order to secure the lowest price. Under the competitive bidding system, potential suppliers must bid on each individual job. Firms that operate on a “per job” basis with no guarantees of future work may regard the costs of switching to a new technology as prohibitively high.

For firms that have long-term contracts, however, the risks inherent in switching to a new technology are significantly lower. In her study of U.S. automotive suppliers, Susan Helper found that the use of CNC machine tools, CAD/CAM and manufacturing cells increased markedly with longer contracts. According to Helper,

> The rationale for the connection between technology use and contract length is that firms want to have some assurance that they will have enough work to cover their additional fixed costs before they make large investments. (Helper, 1991, pg. 22)

Because long-term contracts reduce the risks associated with adopting new technologies, I expect adoption rates of organizational technologies to increase with contract length among the survey sample.

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10 In the sociological literature this is referred to as “coercive isomorphism.” Dimaggio and Powell claim that coercive isomorphism occurs when requirements regarding organizational models are placed on a dependent organization through an authority relationship (Dimaggio and Powell, 1983).
• *Sales Market*

The scope of a firms’ sales market may also impact its propensity to adopt innovations. Firms that have historically served a handful of small regional customers are less likely to be exposed to new performance requirements than firms that serve a large, national customer base. Furthermore, firms seeking new business opportunities on a national basis may want to demonstrate to customers that they have adopted workplace innovations associated with higher quality, lower costs and greater productivity in order to secure new contracts (i.e. innovations are part of a marketing strategy).

• *Opportunities for Learning*

Learning about the advantages of technological and organizational innovations is believed to be a key to their adoption. Yet small firms frequently lack opportunities for learning due to arms-length customer-supplier relations and a weak business infrastructure. In their study of programmable automation, Kelley and Brooks found that a small firm’s propensity to adopt a process innovation was enhanced by the nature of its linkages to external resources for learning about technological developments. They concluded that small firms with close connections to customers were more likely to adopt programmable automation as were those actively involved in trade and professional associations. (Kelley and Brooks, 1991).

The idea that small firms can overcome their isolation through “active/social” links to learning resources has provided the justification for a number of different policy interventions over the past decade. State-supported industrial ‘network’ and ‘extension’ programs—described in the Introduction—are two examples of policies that seek to
increase opportunities for small firms to learn about the benefits of advanced
technological and organizational strategies.

I asked firms in the survey sample about three types of links to external learning
opportunities:

1) does the firm have an intensive technical assistance relationship with its most
important customer in which information and technical assistance are exchanged on a
continuous basis?

2) is the firm an active member of an industry association (i.e. do representatives from
the firm regularly attend meetings and participate in social and learning activities with
representatives from other firms?)

3) has the firm engaged with its local manufacturing extension organization in an effort
to increase access to knowledge and resources regarding technological and
organization change?

Theoretically, links to these three learning resources should help reduce the information
costs associated with learning about new technologies. Therefore I expect firms that
report these linkages to exhibit higher rates of organizational change than firms that don't
report these linkages.

Firm Characteristics

Common to analyses of diffusion is the recognition that manufacturers are a
heterogeneous population operating in different markets with different resources and
strategies (Ichniowski et. al., 1996). My study controls for some of this variation by
limiting analysis to non-union firms with fewer than 250 employees in a single industrial
sector (SIC 35) and geographic region. Despite these controls, however, I discovered
that small firms in the same industrial sector vary on several key dimensions that may
affect their propensity to adopt new forms of work organization. Three salient variables
emerged through field-work that may help explain variation in adoption of new forms of work organization. These include product type, firm strategy, and firm size.

- **Product Type**

  Industrial machinery firms make a range of different products in a variety of lot sizes. My survey sample, for example, contained 20 capital equipment firms that make tools, fixtures and special machines; 18 firms that make parts and assemblies in small batches and 10 firms that mass-produce parts and components. As described in Chapter One, firms in each production group vary in terms of production methods, piece prices, contracts, the intensity of the customer relationship, and design capabilities.

  I expect new forms of work organization such as quality assurance, cells, and work teams to be less prevalent in capital equipment shops than in production shops for several reasons. Capital equipment firms make the tools and machines that make the parts that are assembled into final products. Because these machines and tools are made “one-at-a-time”, capital equipment firms are unlikely to be subject to in-process inspection requirements such as SPC (increasingly, however, capital equipment firms are subject to more stringent final quality inspection checks and to comprehensive quality documentation programs such as ISO 9000). In addition, while production workers in capital equipment firms are frequently “cross-trained” and capable of working on different machines, they appear rarely to be organized into formal teams or cells. As one Vice President of a small mold making company told me, “our shop is full of mold makers that run all kinds of machines and perform multiple processes. When a job requires several people, one mold-maker will act as a team leader. Once the job is completed, the team dissolves.”
In contrast to capital equipment firms, production firms make parts, assemblies and components that customers seek to integrate into the production process without having to inspect them first. As noted in Chapter 2, this is driving many production firms to implement comprehensive quality assurance programs. Further, firms that produce parts and assemblies in small batches on a just-in-time basis are apt to pursue new organizational strategies such as cellular manufacturing in order to gain the internal flexibility required to excel at this type of production (Piore and Sabel, 1984). Mass production firms—particularly those engaged in commodity production—are apt to pursue new organizational strategies in an effort to reduce waste and lower costs (Luria, 1996).

• **Strategy**

Small firms have different goals and strategies. As noted in the previous section on obstacles to adoption, small firms can be categorized as *investment* companies or *lifestyle* companies. In my sample of 40 firms I found tremendous variation with respect to this variable. For reasons outlined in the previous section, I expect *investment* companies to adopt new organizational strategies at a greater rate than *lifestyle* companies. In order to determine where firms lie on the *lifestyle-investment* spectrum, I asked firm owners a series of questions regarding company goals and strategy in phone interviews. These included questions regarding the amount of time owners and managers spend in strategic planning meetings, plans for company growth and expansion, current and future plans for new products and/or services, the firm owner’s time horizon (e.g. does he/she plan to retire in near future) and succession plans. Based on responses
to these questions, I coded each firm as either a lifestyle company, an investment company or a transitional company.\footnote{11}

- \textit{Firm Size}

A number of studies have concluded that firm size is an important predictor of the rate at which firms adopt advanced technological and organizational strategies (U.S. Department of Commerce, 1989; Industrial Technology Institute, 1990; U.S. General Accounting Office 1991). In general, small firms are believed to face greater obstacles to adoption than large firms. The relationship between firm size and adoption is twofold. The first dimension involves resources. Small firms have fewer resources (money and people) to devote to the development and implementation of new organizational strategies. The second dimension involves scale. Scale requirements may make it infeasible and/or unprofitable for some firms to undertake new organizational technologies.

There is little consensus, however, on what constitutes a “small” firm. Some definitions include firms of up to 500 employees while others define a small firm as 100 employees or less. In addition, studies of adoption tend to lump all “small” firms together. Yet there are tremendous resource and scale differences between a 20-person firm and a 100-person firm. Within the small firm sector, I expect to see greater rates of adoption among the largest “small” firms.

\footnote{11} I created the third category “transitional company” because several firms were experiencing leadership or management changes in response to flat or declining sales and had just begun to implement new strategies to achieve higher level sales and profitability.
Survey Results

Through cross-tabulation of the independent variables with the three innovation categories (dependent variable), several patterns emerge which differentiate surveyed firms. Findings regarding the independent variables are presented in the same sequence (i.e. firm environment and firm characteristics) as in the previous section.

Firm Environment

The external environment a firm operates in appears related to the adoption of organizational innovations. Among the variables associated with firm environment, *industry sector*, *contract length* and *sales market* emerged as salient. *Opportunities for learning*, however, appear unrelated to firms’ adoption of new work organizational practices.

- *Industry Sector*

The vast majority of firms that experienced a *shift in defense markets* have undertaken new forms of work organization. Twelve of 40 surveyed firms experienced a shift out of defense markets between 1992 and 1996. Of these 12 firms, 10 implemented changes in work organization and 2 did not. Of the ten firms that made changes, 8 are significant innovators and 2 are moderate innovators (4 entered new commercial markets while six shifted from defense to commercial aerospace). Of the two firms that did not implement changes in work organization, one is in decline and anticipates going out of business; the other is a new firm that increased its share of defense work from zero to 15-percent between 1992 and 1996.
Firms engaged in supplier development programs are more likely than other firms to have innovative work practices in place. While only 6 out of 40 surveyed firms report active participation in supplier development or certification programs, all six are significant innovators (four supply to large aerospace customers and two supply to large medical instruments companies).

**Contract Length**

Innovative work practices are more common among firms with long-term contracts. Eighty-five percent of significant innovators have at minimum a one-year contract with their most important customer and 35 percent have long-term contracts (3-5 years) with their most important customer. In contrast, the vast majority of non-innovating firms operate on a “per job” basis with their most important customer.
Contract Length with Most Important Customer

<table>
<thead>
<tr>
<th>MIC contract length</th>
<th>reorganization code</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>no contract/per job basis</td>
<td>non</td>
<td>16</td>
<td>4</td>
<td>1</td>
<td>21</td>
</tr>
<tr>
<td>less than 1 year</td>
<td>moderate</td>
<td>2</td>
<td>1</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>1-3 years</td>
<td>significant</td>
<td>1</td>
<td>2</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>3-5 years</td>
<td></td>
<td>1</td>
<td>5</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>17</td>
<td>9</td>
<td>14</td>
<td>40</td>
</tr>
</tbody>
</table>

- **Sales Market**

Innovative work practices are more widespread among firms operating in national as opposed to regional markets. While 50 percent of all firms operating in national markets are significant innovators, less than a third of firms operating in regional markets are significant innovators.

Sales Region

<table>
<thead>
<tr>
<th>primary sales region</th>
<th>reorganization code</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>New England</td>
<td>non</td>
<td>13</td>
<td>5</td>
<td>7</td>
<td>25</td>
</tr>
<tr>
<td>other U.S.</td>
<td>moderate</td>
<td>3</td>
<td>4</td>
<td>7</td>
<td>14</td>
</tr>
<tr>
<td>international</td>
<td>significant</td>
<td>1</td>
<td></td>
<td>7</td>
<td>14</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>17</td>
<td>9</td>
<td>14</td>
<td>40</td>
</tr>
</tbody>
</table>
• Learning Opportunities

Over half of surveyed firms report *opportunities for learning* (i.e. intensive customer assistance defined as once a month or more, active participation in a trade association, or engagement with state industrial extension programs). However, engagement in learning opportunities appears unrelated to sampled firms’ adoption of innovative work practices. In total, 22 firms report opportunities for learning. Of these 22, half are non-innovative firms.

<table>
<thead>
<tr>
<th>Learning Opportunities</th>
<th>reorganization code</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>non</td>
</tr>
<tr>
<td>learning opportunities</td>
<td>yes</td>
</tr>
<tr>
<td></td>
<td>no</td>
</tr>
<tr>
<td>Total</td>
<td>17</td>
</tr>
</tbody>
</table>

Non-innovative firms are just as likely as significant innovators to participate actively in a trade association, they are more likely to engage with industrial extension programs and are twice as likely to have intensive customer assistance relationships. Contradicting my hypothesis, the data suggests that non-innovative firms are not isolated or cut-off from learning opportunities. The learning they are engaged in, however, does not appear to result in the implementation of new forms of work organization.

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12 Of the 22 firms that reported engagement in learning opportunities, 13 reported intensive customer assistance, 11 reported active participation in a trade association, and 5 reported engaging with the Massachusetts Manufacturing Partnership (the state industrial extension system). Most firms (17) reported just one linkage. Four firms, however reported 2 linkages, and one firm reported all three.
Firm Characteristics

Among the variables associated with firm characteristics—product type, strategy, and firm size—all three appear related to a firm’s propensity to undertake new forms of work organization.

- Product Type

The type of production firms are engaged in appears related to adoption of innovative work practices. Significant innovators are dominated by small batch and mass production firms while non-innovators are dominated by capital equipment firms.

<table>
<thead>
<tr>
<th>Product Type</th>
<th>Reorganization Code</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>non</td>
</tr>
<tr>
<td>Capital equipment</td>
<td>11</td>
</tr>
<tr>
<td>Small batch production</td>
<td>6</td>
</tr>
<tr>
<td>Mass production</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>17</td>
</tr>
</tbody>
</table>

Firms engaged in one-of-a-kind production are far less likely than small batch or mass production firms to undertake formal quality programs or reorganization of core production jobs. Only 1 out of 15 capital equipment firms has reorganized core production jobs and just over one-quarter have implemented formal quality programs. This stands in marked contrast to mass production and small batch production firms. Nearly all mass production firms have implemented a formal quality program and over half have reorganized core production jobs. Among small batch producers, nearly 60
percent have implemented a formal quality program and just over 40 percent have reorganized core production jobs.\textsuperscript{13}

### Quality Program by Product Type

<table>
<thead>
<tr>
<th></th>
<th>capital equipment</th>
<th>small batch production</th>
<th>mass production</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does company report</td>
<td>yes</td>
<td>4</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td>formal quality program?</td>
<td>no</td>
<td>11</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>15</td>
<td>17</td>
<td>8</td>
</tr>
</tbody>
</table>

### Reorganization of Core Production Jobs by Product Type

<table>
<thead>
<tr>
<th></th>
<th>capital equipment</th>
<th>small batch production</th>
<th>mass production</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>has the company</td>
<td>yes</td>
<td>1</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>reorganized production jobs?</td>
<td>no</td>
<td>14</td>
<td>10</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>15</td>
<td>17</td>
<td>8</td>
</tr>
</tbody>
</table>

**Firm Strategy**

Firms pursuing an *investment* strategy are more likely to implement innovative work practices than firms pursuing a *lifestyle* strategy. Based on the coding scheme described in the previous section, 20 firms qualified as investment companies, 14 as lifestyle, and 6 as 'in transition'. Significant innovators are dominated by investment companies: nearly 80-percent of significant innovators are pursuing an investment strategy. In contrast, a majority of non-innovative firms are lifestyle companies.

\textsuperscript{13} The discrepancy between capital equipment firms and production firms with respect to organizational innovations is supported by the data collected on firm training practices. Production firms are far more
### Firm Strategy

<table>
<thead>
<tr>
<th>Firm strategy</th>
<th>reorganization code</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>non</td>
</tr>
<tr>
<td>lifestyle</td>
<td>10</td>
</tr>
<tr>
<td>transitional</td>
<td>2</td>
</tr>
<tr>
<td>investment</td>
<td>5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>17</strong></td>
</tr>
</tbody>
</table>

- **Firm Size**

Implementation of innovative work practices appears to increase with *firm size*. Non-innovative firms are predominantly small and medium size: 15 of 17 non-innovators employ fewer than 50 people. In contrast, half of all significant innovators are large firms: 7 of 14 significant innovators employ over 50 people.

### Firm Size

<table>
<thead>
<tr>
<th>Firm Size</th>
<th>reorganization code</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>non</td>
</tr>
<tr>
<td>small</td>
<td>9</td>
</tr>
<tr>
<td>medium</td>
<td>6</td>
</tr>
<tr>
<td>large</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>17</strong></td>
</tr>
</tbody>
</table>

Note: Small = 10-19 employees; medium = 20-49 employees; large = 50+ employees

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likely to provide quality and interpersonal/communications training to managers and shop-floor employees than capital equipment firms.
III. Interpreting Variation in New Work Organization Outcomes

Based on the survey findings described above and survey phone interviews, it becomes possible to draw and interpret distinctions between firms regarding the adoption of practices associated with the new work organization. Table X below provides a graphic presentation of firm characteristics according to innovation levels.

<table>
<thead>
<tr>
<th></th>
<th>Traditional Firms</th>
<th>Transitional Firms</th>
<th>Transformed Firms</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Size</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(by employees)</td>
<td>small</td>
<td>medium/large</td>
<td>large</td>
</tr>
<tr>
<td><strong>Sales Market</strong></td>
<td>regional</td>
<td>regional/national</td>
<td>regional/national</td>
</tr>
<tr>
<td><strong>Production</strong></td>
<td>tooling, prototype &amp; small batch</td>
<td>mixed production</td>
<td>small batch &amp; mass production</td>
</tr>
<tr>
<td><strong>Contracts</strong></td>
<td>‘per job’ basis</td>
<td>mixed length</td>
<td>1-5 year contracts/ preferred suppliers</td>
</tr>
<tr>
<td><strong>Strategy</strong></td>
<td>‘lifestyle’</td>
<td>mixed</td>
<td>‘investment’</td>
</tr>
</tbody>
</table>

Table X: Work Organization Spectrum
Table X reveals that ‘traditional’ firms and ‘transformed’ firms vary dramatically in terms of size, markets, production, contracts and strategy. Thus far my analysis has suggested that certain external factors (such as contract length, supplier development programs and sales market) spur firms to adopt innovative work practices. Table X suggests another interpretation, however. It may be that firms that adopt new work practices (and thereby improve performance) can more easily secure work with national customers and become eligible for long-term contracts and/or preferred supplier status because they are better able to demonstrate their work processes and track record (in quality and delivery) to prospective customers. In this interpretation, a national sales market, longer contracts and preferred supplier status are outcomes of adoption rather than drivers of adoption. While my hypotheses pursued the first line of reasoning, the characteristics of ‘transitional’ firms revealed in Table X suggest the second. Transitional firms appear to be those firms in transition from traditional to new forms of work organization. As these firms achieve the improvement gains sought by the new work practices (i.e. become more efficient, cost-effective, reliable and transparent) they become more attractive to large, national customers and more eligible for long-term contracts and preferred supplier status. These customer relationships, in turn, reinforce the value of the new work practices as suppliers are rewarded for continuous improvements in work organization. In this respect there is likely a more dynamic interplay of cause and effect among the variables than I originally hypothesized.

Another important implication of the table is the following: adoption of new work practices is likely not the defining variation among traditional and transformed firms. Rather, the table suggests that adoption of new work practices is an integral component
of a broader pattern of industrial upgrading that also involves market expansion, investment in plant, equipment, and human capital, longer contracts and closer relationships with customers. Based on review of the survey data, I provide a general profile of each of the three groups of firms below. These profiles support the notion that new work practices are part and parcel of a larger strategy of innovation and growth.

Traditional Firms

In general, traditional firms are the small tool, die and prototype production firms that have populated the Connecticut River Valley for generations. Many of these firms have been run and organized the same way for decades. Typically, they are lifestyle-oriented companies that specialize in expensive, one-of-a-kind machines and tools and prototype production (a minority of traditional firms specialize in small batch production). These firms usually work for a limited number of regional customers on a “per job” basis. They are not engaged in supplier development programs nor do they have long-term contract agreements. Many of these firms have close working relationships with their customers but the interactions tend to be focused on engineering and technical issues rather than on productivity improvements achieved through shop-floor reorganization. Traditional firms often have strong (sometimes unique) technical expertise but many lack managerial sophistication and strategic planning capacity.

A majority of traditional firms are lifestyle-oriented companies that are not pursuing a strategy of investment and growth. These companies tend to be headed by older firm owners (many close to retirement and without a designated successor) who have established close working relationships with their customers. Because these firms are not actively seeking new customers, they are less likely than investment-oriented
companies to be subject to new organizational requirements. And because traditional firm owners are often lifestyle-oriented, they are unlikely to invest in costly organizational changes without market pressure. While these companies may be able to maintain business due to established reputations for quality in the short term, they run the risk of losing business to more aggressive firms that have mastered the technological and organizational strategies that enable equally high quality at lower prices.

A minority of traditional firms are investment-oriented and are pursuing conscious growth strategies. Firm owners and managers in these companies are aware of heightened performance requirements; however, they have not yet embarked on a path of comprehensive organizational change. This is the case for two reasons. First, some firms (particularly those that make capital equipment) do not perceive customer pressure to change and are unwilling to invest in change unless it is “dictated by the market,” as one firm owner put it. Once that pressure is perceived, however, these investment-oriented firms are likely to change. Second, a number of traditional but investment-oriented firms are pursuing a strategy based primarily on high technology. These firms invest in sophisticated computer technology in order to produce tools and parts more quickly and accurately; however, they haven’t yet linked these technologies to more flexible or efficient forms of work organization. If and when the high technology strategy proves too costly, these firms are likely to assess internal operations and reorganize production to streamline costs.

**Transitional Firms**

Transitional firms are often making changes at two levels: from the ‘old’ work organization to the ‘new’ and from lifestyle to investment oriented strategies. Firms in
this category include capital equipment, small batch and mass production firms. Many are in the process of expanding beyond their traditional regional customers and are identifying and/or developing niche markets that will support growth. These firms are typically implementing organizational change in response to market feedback (e.g. customer demands for accelerated delivery and price reductions).

Most transitional firms are in the beginning stages of their reorganization effort. In several cases new management has been hired to help the firm develop a business strategy and modernize production. Some of these firms are ‘phasing-in’ organizational innovations and will likely become ‘transformed’ firms in the near future. Other firms believe that the level of reorganization they have pursued thus far is currently sufficient to compete effectively in their market sector.

**Transformed Firms**

In general, transformed firms are larger, investment-oriented companies that specialize in small-batch and mass production of parts, assemblies and components. Many of these firms were former defense contractors that shifted to commercial markets in the early 1990’s and consequently became subject to new performance requirements such as smaller lot sizes and just-in-time delivery. As defense and regional markets declined throughout the 1980’s and 1990’s, many of these firms expanded into national markets to increase sales volume.

‘Transformed’ firms typically work on a contract basis with their customers and a number of them are engaged in supplier development programs that emphasize productivity improvement through quality assurance, documentation, and shop-floor
reorganization. Several of these firms are first-tier suppliers to large, multinational corporations that have reduced their supply base in recent years to streamline costs. While many ‘transformed’ firms have implemented organizational change as a condition of core supplier status, others have implemented it as part of an overall strategy aimed at increasing efficiency, and lowering costs.

Transformed firms are often run by young, aggressive owners and managers (many second generation) who are striving to change company culture as they expand market reach. These firm leaders regard organizational innovations such as quality assurance, employee involvement, work teams, job rotation and manufacturing cells as business tools that provide competitive advantage. While some of the innovations—particularly ISO 9000—are viewed as costly and excessive among firm owners and managers, the leaders of these firms generally embrace the new business paradigm and the changes it requires of firms. These firm owners and managers are committed to ongoing organizational improvement and are continuously thinking about how to improve operations and serve customers more effectively.

A minority of transformed firms are lifestyle-oriented. Unlike the majority of transformed firms, these companies are not pursuing aggressive growth. They have, however, implemented a number of organizational changes associated with the new work

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14 Capital equipment firms engaged in production “partnerships” with their customers may adopt new forms of work organization just as readily as production firms. For example, the two capital equipment firms that were ‘transformed’ were both in preferred supplier relationships with their most important customer – one with General Electric Aircraft Engine and the other with Gillette. Overall, however, production partnerships are much less common in the capital equipment segment of the industry than in the production segment.
organization. In these cases, changes were implemented in direct response to customer requirements, not as part of an overall strategy of investment and growth.\textsuperscript{15}

The Importance of Markets and Strategy

The categories proposed in Table X above (constructed to consider sources of variation) are far from fixed. To the contrary, movement up the work organization spectrum—from the traditional to the transformed firm—is extremely fluid. Analysis of the survey data suggests that adoption of organizational innovations is not an “either/or” phenomenon but an evolving process conditioned by external (market) and internal (firm-based) factors. Specifically, the survey data reveals that \textit{whether and when a firm embarks on a path of organizational reform must be analyzed in the context of each firms’ market environment and overall strategy}. Two survey variables emerge as particularly salient in understanding the timing and extent of adoption. These are 1) the nature of market pressure a firm experiences; and 2) the strategic orientation of firm leadership. Whether and when a firm pursues organizational reform is largely determined by the interplay of these two factors. (As the next chapter will demonstrate, however, embarking on a path of organizational reform does not automatically guarantee effective implementation of the innovations. Management skill, the case studies reveal, is also a critical factor.)

\textsuperscript{15} This is what institutional sociologists call “coercive isomorphism” – when workplace innovations are imposed on a dependent organization by an organization in a position of authority.
Nature of Market Pressure

Market pressure is the first key determinant in predicting the timing and extent of organizational innovations among small firms. There are two interrelated dimensions to this pressure that must be considered: 1) the industry sector the firm supplies; 2) the nature of customer relations.

Different industries adhere to different supplier performance standards and the point at which these requirements become the norm varies across industries. The aerospace industry, for example, began to streamline its supplier base and require productivity improvements among remaining suppliers in the early 1990’s as it sought to achieve ‘lean manufacturing.’ It is now the norm for aerospace parts suppliers to adhere to JIT, in-process inspection, cellular manufacturing and ISO 9000. These production and organizational innovations have become a precondition of conducting business with many aerospace prime contractors. In other industrial sectors, however (e.g., industrial machinery), new performance requirements are not as widespread nor are they uniformly imposed on suppliers as a precondition of conducting business. As a result, suppliers’ approach to the new work organization has been more lackadaisical in the industrial machinery sector than in the aerospace sector. Thus, the level of both production and organizational innovation required to be a competitive supplier appears to vary by industry sector.

The context in which market pressure is applied also varies by customer. Some customers impose pressure for organizational innovation in the context of production partnerships’ characterized by information sharing and long-term contracts; other customers, in contrast, exert market pressure on suppliers in the context of ‘cost-driven’
relationships. Suppliers engaged in ‘partnership’ with their customers are generally given a timeline for implementing organizational change and/or achieving price reductions. In addition, customers will often provide assistance to suppliers to help them meet new performance requirements. In ‘cost-driven’ relationships, by contrast, customers exert pressure on suppliers by threatening to terminate—or actually terminating—contracts when they are unhappy with supplier performance.

The different contexts in which customers exert pressure for performance improvements on suppliers are reflected in Hirschman’s “exit-voice alternative.” In a ‘voice’ relationship, the customer works and communicates with the supplier to improve performance and resolve problems; in an ‘exit’ relationship, if the customer has a problem with supplier performance, it simply yanks the contract and finds a new supplier. As Hirschman notes, voice relationships carry more information than exit (1986, pg. 85). In ‘voice’ relationships (i.e. production partnerships) suppliers are provided with information from their customers about specific changes required to maintain business contracts. The exit alternative, by contrast,

is a powerful but indirect and somewhat blunt way of alerting management to its failings. Most of the time, those customers who exit have no interest in improving (management) by their withdrawal and exit does not provide management with much information on what is or has gone wrong. (pg. 78).

While the exit option can result in a “search for causes and remedies…and a plan of action designed to restore performance,” this is in no way guaranteed. In the face of customer ‘exit’ some firms may enter a period of stagnation or decline while others may be forced to go out of business. Thus we would expect suppliers engaged in ‘partnership’ or ‘voice’ relationships with their customers to implement organizational innovations that
improve performance more readily than those firms engaged in ‘cost-driven’ or ‘exit’ relationships.

**Strategic Orientation of Firm Leadership**

The second key determinant in the timing and extent of adoption is the strategic orientation of firm leadership. The survey data suggests that transformed firms do not adopt workplace innovations in isolation. Rather, it appears that *organizational reform is pursued as part and parcel of a broader set of strategic choices that include the manufacturing and marketing strategies of the firm and its key customers.*

To invoke the strategic categories employed earlier, ‘investment’ oriented leaders are typically making changes on many levels inside the firm – not just work organization. In order to expand and improve internal capabilities, sales, and market reach, investment oriented leaders are often forging wholesale changes in the organization of production and company culture. In these cases, the implementation of new forms of work organization is one component of a larger strategic vision shaped by product market and customers. In contrast, traditional (or ‘lifestyle’ oriented) leaders are far less likely than ‘investment’ oriented leaders to have, let alone implement, a strategic vision that requires related changes in production, marketing, customer relations and work organization. Generally striving to maintain the status quo, these firms tend to pursue production and organizational change if and when their livelihood is threatened. Furthermore, these firms may enter a period of decline (or go out of business altogether) rather than make wholesale changes in a firm that has been organized along traditional lines for many years.
It is important to recognize, however, that the strategic orientation of firm leadership is not fixed. In response to market signals, lifestyle oriented firm owners are capable of becoming investment and growth oriented. As the field research in Chapter 2 described, some traditional firm owners are making the transition to an investment and growth philosophy in response to changing market dynamics and customer performance requirements. Many achieve this change in strategic orientation by hiring younger managers with greater experience in strategic planning, marketing and workplace change. In the absence of direct market pressure from customers, the strategic orientation of firm leadership may change when leadership of the firm is passed on from one generation to the next. When the sons and daughters of traditional firm owners take over the reigns of the family business, they often do so with the clear intent of ‘growing’ the firm and taking it in a more expansive and sophisticated direction.
Chapter Four:

Understanding Variation in Work Organization Outcomes: Evidence from Four Metalworking Firms

Introduction

The previous chapter presented rates of incidence and explored sources of variation in the timing and extent of adoption of new organizational practices among small industrial suppliers. In this chapter, I present matched pair, firm-level case studies to demonstrate how the sources of variation identified in Chapter 3 shape the real-world responses of firms to the new manufacturing environment.

To investigate firm-level variation in the timing and extent of adoption, I conducted in-depth, on-site research at four firms identified through the survey implementation process. The case studies were conducted to explore how variation in market pressure and firm strategy shape the timing and extent of work reorganization. While both independent variables are simultaneously at play in each firm, the matched pair case studies are structured to highlight a specific source of variation in order to demonstrate how different combinations of the independent variables lead to different outcomes of the dependent variable. To this end, the first matched pair focuses on variation in market pressure. The second matched pair, in contrast, focuses on variation in strategy.

The first section of the chapter describes the case study methodology. In section two, I present the two controlled comparison case studies. Section three is analysis of the cases and elaboration of the explanatory framework.
I. Methodology

Throughout the design, data collection and analysis phases of the case study research, I adhered to research principles presented in Alexander George’s article, *Case Study and Theory Development: The Method of Structured, Focused Comparison* (George, 1979). Drawing on George’s ‘controlled comparison’ case study method, I constructed two ‘matched pair’ case studies (four firms in total). As George notes, “the investigator will have to gain considerable familiarity with the phenomenon in question and undertake a preliminary examination of a variety of cases before selecting those for controlled comparison.” (George, pg. 57). In ‘controlled comparison’ case studies, cases are not selected randomly. Rather, cases are carefully selected (and controlled) to illustrate an argument. Over the three-year period in which this project was carried out, I conducted field-work at 12 different companies identified through the survey implementation process. The 12 firms selected for in-depth field work reflected the innovation categories developed through analysis of the survey data. Accordingly, four firms were ‘traditional’, four were ‘transitional’ and four were ‘transformed.’ The four case studies presented in this chapter reflect patterns identified across all twelve firms. These four were selected from among the twelve for presentation for two primary reasons: first, they composed, in my judgement, the best and most interesting ‘matches’; second, they clearly illustrate the arguments made in chapter 3 regarding the determinants of organizational change.

In controlled comparison case studies, variety guides case selection. The goal is to select cases that belong to the same class but vary in significant ways. In the context of my study of industrial suppliers, the case studies could be constructed in one of two
ways. I could select cases in which the dependent variable (work organization) is held constant in order to determine which independent variables are associated with particular outcomes of the dependent variable.¹ Or I could select cases where the dependent variable differs in order to determine which conditions and variables account for variation in outcome. I chose the latter strategy because my study is primarily concerned with understanding variation in levels of work reorganization undertaken by small industrial firms. Building on the survey findings presented in Chapter 3, I want to further explore why firms in the same class appear to pursue different strategies with respect to work reform. Accordingly, the two controlled comparisons presented in this chapter seek to explain variation in the dependent variable (i.e., timing and extent of adoption) by examining the interplay of the key independent variables identified in chapter 3.

The first task of controlled comparison case studies is to specify the variables that will enter into analysis of the cases. As noted above, the dependent variable to be explained through the case studies is variation in the timing and extent of organizational innovation among industrial suppliers. In Chapter 3, I identified the two key independent variables I believe explain this variation. To reiterate, the two variables are: market pressure and firm strategy. Each of the independent variables, in turn, contain variation: market pressure varies by industry and customer; and firms can pursue a ‘lifestyle’ or ‘investment’ strategy.

The next task is to select appropriate cases for controlled comparison in light of the variables that will enter into the analysis. Because my goal is to explain variation in the dependent variable, the cases selected for investigation need to represent different

¹ For example, I could compare two ‘transformed’ firms and/or two ‘traditional’ firms to determine more precisely the different variables that lead to these outcome of the dependent variable.
outcomes. To achieve this goal, I match ‘transformed’ firms (i.e. firms that have undertaken significant levels of organizational reform) with ‘traditional’ and ‘transitional’ firms (i.e. firms that have undertaken less organizational reform). In addition to variation in the dependent variable, the key independent variables must be present in each case to further elaborate how their various configurations lead to different outcomes of the dependent variable. Thus, each case study contains variation in both the specified dependent and independent variables.

In order to focus my analysis on the relationship between the specified independent and dependent variables, I need to hold other variables constant. By nature of the study itself, I have controlled for industry sector (industrial machinery) region (western Massachusetts) and unionization (all non-union shops). In terms of the case studies, I have constructed comparisons that control for the following variables: type of production, level of crisis, employees, and sales.

The first way case study firms are matched is by type of production. As the survey data revealed, mass production and small batch production firms are more likely to adopt the types of work organization measured by the survey than capital equipment firms. In-process quality inspection, cellular manufacturing and team production are more readily applicable to the production environment due to the repetitive nature of the work and larger firm size. In the small capital equipment firms where production occurs ‘one-at-a-time’, some of the innovations measured by the survey are less applicable. In order to compare outcomes, it is critical to select cases that belong to the same class. Accordingly, I have paired two production firms in controlled comparison one and two capital equipment firms in controlled comparison two.
The second way firms are matched is by level of crisis. By this I mean the extent to which each firm was affected by the rampant industrial restructuring of the late 1980's and early 1990's. Each of the four firms profiled experienced trouble in the early 1990's and lost contracts either to performance problems, lower-cost competition, or customer downsizing. As a result of this downturn in business, each firm was in a position to assess operations and rethink strategy and each firm was a potential adopter of organizational innovations that promise to improve quality and productivity.

The final way firms are matched is by size—including employees and sales. Clearly it does not make sense to compare a firm with 30 employees and 2 million in sales to a firm with 100 employees and 12 million in sales. Accordingly I have selected firms that are roughly equivalent in terms of employment and annual sales figures.

The first controlled comparison matches two, small capital equipment firms—Interstate Design and Stan-Allen. The second controlled comparison, in contrast, matches two, large production firms—Brimfield Precision and Dienes Corporation. As noted earlier, though both of the independent variables are at play in each case study, each controlled comparison highlights the dominant source of variation between the two firms in order to focus the presentation and analysis.

II. Case Study Overview

In the case studies that follow two critical dimensions of organizational adjustment are revealed. The first adjustment (described in detail in Chapters 2 and 3) requires the adoption of new forms of work organization that are both more flexible and more systematic. Greater flexibility is required throughout the work process in order to
respond effectively to shorter lead times and the proliferation of customer requirements. Becoming more systematic, in turn, is necessary for getting a handle on internal costs and for meeting customer documentation requirements. The second necessary adjustment in the small firm environment is toward greater customization and specialization of products and services. As computerized production technology becomes widespread across the globe, high precision and quality are easier to achieve. Enabled by new communication technologies that reduce the need for physical proximity, customers increasingly seek out less expensive overseas producers. Accordingly, mass production of precision parts is a less and less viable strategy for domestic suppliers.² Even in highly skilled ‘craft’ firms such as tool and die, new technologies are eroding the distinctive nature of the work.

To skirt price-based competition, both production and capital equipment firms need to develop strategies that distinguish them from lower cost competitors. This move toward customization requires a more sophisticated understanding of customers, competitors and markets and consequently, a more sophisticated strategic planning and management function.

The diagram on the following page provides a graphic illustration of the two critical adjustments necessary for small firm survival. I argue that to compete effectively in today’s markets, small suppliers need to move in the direction of the upper left

² Internet auctions enable suppliers worldwide to bid for jobs simultaneously. According to a recent New York Times article on business to business (B2B) commerce, the company that runs these auctions - ‘FreeMarkets’ – dedicates half of its workforce to searching for suppliers overseas and recruiting them to the auctions (New York Times, January 7, 2000).
Dimensions of Change in the Small Firm Environment

Work Organization

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Traditional</th>
<th>Transformed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Products and Services</td>
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<td>n/a</td>
</tr>
<tr>
<td>Brimfield Precision</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Interstate Design</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Stan-Allen</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Dienes</td>
<td>n/a</td>
<td>n/a</td>
</tr>
</tbody>
</table>
quadrant of the diagram. In short, firms need to increase flexibility, bring internal costs down through new forms of work organization (which generally require greater employee participation in the production process), and gain control of work processes. At the same time, firms must develop distinctive products and services that differentiate them from the competition. Thus, the innovations associated with the new work organization (e.g. quality programs and documentation, teams, cellular manufacturing, cross-training etc.) need to be embedded in a broader strategy that is likely to include complimentary changes in technology, products, customer relations, and marketing.

What the four case studies demonstrate quite dramatically, I believe, is that firms do not automatically know how to make these adjustments. Faced with similar market dynamics, the four firms exhibit an extremely broad range of behavior—both conceptually and practically. Each firm experienced a dramatic change in its market environment in the first half of the 1990’s. For each firm, the early 1990’s represented a break with the past—a departure from tradition and the beginning of a new, if uncertain, chapter. In this period, all four firms were alerted to the need for change by unambiguous market signals. Through the loss of major contracts, flat or declining sales, or customer requirements for performance improvements, each firm became aware of new market dynamics and recognized the need for adjustment. As the case studies demonstrate, however, firm leaders do not automatically know how to interpret market signals or how to respond effectively to new market dynamics. Thus, while market signals alert firms to problems and to the need to reorganize, they do not necessarily help firms make the changes—in work organization, products, or services—that will solve those problems.
Included in the case studies are two firms (Interstate Design Company and Brimfield Precision) that have made adjustments on both dimensions and moved into the upper left quadrant of the diagram and two firms (Stan-Allen and Dienes Corporation) that have not. Based on the survey findings, I argued in Chapter Three that the timing and extent of organizational innovation undertaken by a firm must be analyzed in the context of its strategy and market environment. While the case studies confirm this finding, they also reveal that management skill is a critical variable. The ability to both conceptualize and implement alternative organizational strategies is not a given. And as the case studies demonstrate, managers' failure in these two areas can have severe consequences.

Another important finding that stems from the case studies regards the timing of innovation. Adoption of new work practices may occur in the context of market pressure and broader strategic goals but these two variables, as the cases illustrate, are subject to change. Thus, while the diagram on the preceding page is useful for mapping the four firms relative to the dimensions of change, it is important to recognize that the positions the firms hold in the diagram are not fixed. The case studies capture firms at a moment in time and the snapshot taken at the data collection point is not necessarily indicative of the firm's future. Firms respond to change, fail, learn, and respond again. As the Stan-Allen case demonstrates, a firm's initial response to new market dynamics does not necessarily determine its future response. In the case of Stan-Allen, an insufficient response to new competition was followed, several years later, by what promises to be an effective response (incorporating dramatic changes in the organization of production). At the same time, the case of Dienes Corporation indicates that there may be a window of
opportunity for change that closes. This firms’ failure to anticipate changes in markets and its seeming inability to reorganize production to meet customer requirements led to such dramatic decline that the opportunity for change was effectively lost. Whether the firm will learn from this failure and ‘transform’ itself in the future remains to be seen, but the possibility certainly shouldn’t be ruled out. Thus, it is important to reiterate that adoption of new work practices is not an ‘either/or’ phenomenon—but more likely an evolving process full of stops and starts. The case studies reflect this evolution rather than any final conclusion about the four firms.

A final implication of the case studies is that there is no blueprint for firm reorganization. Though I have argued that firms need to embark on two paths of change simultaneously (work organization and product/customer specialization) the way in which these changes play out will vary enormously from firm to firm depending on firm history and culture, leadership, employees, products, markets, and customers. As the case studies illustrate, the process of reorganization—even among the ‘successful’ cases—is extremely difficult, wrought with challenges and never complete. Rather than follow any generic recipe, firms need to make reorganization their own through a rigorous process of experimentation and learning.

**Organization of the Case Studies**

The controlled comparisons that follow highlight different dimensions of the adjustment process and different explanatory variables. Controlled comparison One, which pairs two capital equipment firms, highlights how different forms of market pressure and customer relations lead to different outcomes in work reorganization. Additionally, this comparison focuses on how the organization of work in the traditional
craft environment is being transformed by computer technologies and how and why the smallest firms are being forced to grow. Controlled Comparison Two, which pairs two production firms, highlights how firm strategy and managerial skill leads to different outcomes in work reorganization and focuses on the reorganization of production through new forms of employee involvement such as team production and cellular manufacturing.
Controlled Comparison One: Interstate Design Co. Inc. and Stan-Allen

Interstate Design and Stan Allen are both small, highly specialized tool and die firms run by skilled craftsmen. Interstate Design designs and builds tooling that manufactures blades and vanes for military and commercial aircraft; Stan-Allen makes small, complex cutting dies for the electronics industry. Throughout the 1970’s and 1980’s both firms served a handful of steady regional customers. Beginning in the early 1990’s, however, competitive dynamics in their respective markets intensified dramatically leading their largest customers to pursue markedly different strategies.

Like many aerospace contractors, IDC’s largest customer reduced its supply base and entered into preferred supplier partnerships with a limited number of suppliers including IDC. Preferred supplier status required IDC to purchase new technology, reorganize production and adhere to stringent price, quality control and documentation standards. Stan-Allen’s largest customer, by contrast, intensified the traditional competitive bidding system among its suppliers and abandoned Stan-Allen in favor of a lower-cost competitor. This market signal alerted Stan-Allen to a ‘price problem’ but did not help the company figure out how to solve it.

In some respects the fates of IDC and Stan-Allen have been reversed as a result of the new competition. For many years, IDC was required to bid for each individual job regardless of its track record with aerospace customers. Under the competitive bidding system, IDC competed primarily on price and delivery and the company dealt with a large degree of uncertainty regarding workload. Since the firm became a preferred supplier, it has been sheltered from price-based competition and has enjoyed stable, long-term contracts with a rapidly growing customer bases. Stan-Allen, in contrast, was the
**Interstate Design Company, Inc.**

<table>
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<tr>
<td>Innovation Level</td>
<td>‘Transformed’</td>
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<tr>
<td>Type of Production</td>
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<td>Market</td>
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<tr>
<td>Employees 1998</td>
<td>30</td>
</tr>
<tr>
<td>Sales 1998</td>
<td>$2.5 million</td>
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**Stan-Allen Company, Inc.**

<table>
<thead>
<tr>
<th>Year Established</th>
<th>1953</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Ludlow, MA</td>
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<tr>
<td>Innovation Level</td>
<td>‘Traditional’</td>
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<tr>
<td>Type of Production</td>
<td>CapitalEquipment ‘Tool and Die’</td>
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<td>Sales 1998</td>
<td>$2.0 million</td>
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exclusive supplier of cutting dies to many New England electronics suppliers and charged
dremium prices throughout the 1980's due to the lack of competition. As lower cost
competitors entered Stan-Allen's small market niche in the early 1990's however, Stan-
Allen was exposed to price-based competition for the first time in decades and found
itself loosing key accounts and customers.

IDC and Stan-Allen are both run by 'traditional' firm owners with craft, as
opposed to business, backgrounds. Prior to the 1990's, neither firm owner was striving
for growth or change and each was content with the family business he had built. In this
sense each firm owner was pursuing a 'lifestyle' as opposed to an 'investment' strategy.
I argue that variation in market pressure and customer relations explains why IDC rapidly
transformed its work organization and became an 'investment' company while Stan-
Allen failed (initially) to make effective changes. As the case study describes, IDC
reorganized production and management functions in direct response to customer
requirements. IDC represents a classic case of 'coercive isomorphism' in which
suppliers (dependent organizations) adhere to prescribed organizational forms imposed
on them by customers (authority organizations) in order to maintain legitimacy. Stan-
Allen, in contrast, was alerted to the need for change by customer 'exit'. As noted in
Chapter 3, "exit does not provide management with much information on what is or has
gone wrong" (Hirschman, pg. 78). Lacking management and marketing skills, Stan-
Allen's president was unable to diagnose the problem and therefore was unable to launch
an effective response to the new competitive dynamics. While IDC was told exactly how
it needed to change to survive in the marketplace, Stan-Allen was left guessing. Only
when Stan-Allen brought in new, more sophisticated leadership was it able to begin a
process of effective change in which new forms of work organization were implemented in the context of a marketing and product customization strategy.
Interstate Design Company

Introduction/Overview

Many small companies recall the early 1990's as a nightmarish period. Defense downsizing and increased worldwide competition in manufacturing led to the restructuring of the supplier base putting many western Massachusetts manufacturers out of business. For some small companies, however, the industry restructuring of the early 1990's marked a dramatic turning point due to their customer's adoption of preferred supplier programs. One such company is Interstate Design Co., Inc. (IDC).

IDC was founded by James Stone in 1973 in Agawam, Massachusetts. From 1973 to 1990 IDC was a five man drafting shop that designed highly specialized, one-of-a-kind tools to manufacture blades and vanes for military and commercial aircraft. For nearly 20 years IDC draftsmen designed fixtures, gages, machines, forging dies, and tools for major aircraft engine builders including General Electric and United Technologies.

In 1991, both the way the company performed its work and its relationship to its main customer suddenly changed. That year General Electric Aerospace Engines (GEAE) informed IDC that in order to continue as a supplier it would be required to perform all design work using Computer Aided Design software that was compatible with GE systems. Through use of common CAD technology, GEAE sought to establish 'concurrent engineering' with its suppliers. For a company as small as IDC, the cost of the new systems was tremendous ($25,000 per work station plus the costs incurred as employees learned how to perform design work on a computer). Even worse, the request was coming at a low point in IDC's workload due to widespread defense downsizing. Faced with the prospect of going out of business, Jim Stone made the initial investment in computer hardware and software required to secure work with General Electric. Unbeknownst to Stone at the time, this investment was the first of many steps IDC would take over the next few years in order to become a preferred supplier to GE—a status that would fundamentally transform the company.

In 1995, IDC became a "preferred supplier" to General Electric Aircraft Engines (GEAE) and secured a five-year contract to provide tooling designs to five North American GEAE plants. Prior to achieving preferred supplier status, IDC was required to bid for each individual job with GE regardless of its track record. Under the competitive
bidding system, IDC competed primarily on price and delivery. Under the preferred supplier system, by contrast, IDC was required to assemble and submit an exhaustive package of materials demonstrating its ability to meet GE's stringent documentation, quality, technology, engineering, pricing, and delivery standards. These requirements have driven changes in the way IDC organizes and performs its work.

Expansion of both technological and organizational capabilities—achieved initially through the GE contract—has enabled IDC to secure long-term contracts with several new customers over the past few years. In addition to GE, IDC now has long-term contracts with Hamilton Standard (UT), Sikorsky (UT), Bell Helicopter, and Kaman Helicopter. In response to customer demand for "one-stop-shopping," IDC opened a machining facility in 1996. The addition of the machine shop has enabled IDC to market itself as a company that provides both "design and build" services. This has distinguished IDC from competitors because the company can now offer customers accelerated delivery of tooling.

IDC has grown rapidly as a result of aerospace industry restructuring. Since 1992, company employment has increased from 5 to 30 employees and sales have increased from $500,000 to $2.5 million. To accommodate the design and production demands of its growing customer base, IDC recently built a new, 10,000 square foot building several miles from its existing Agawam location. But despite long-term contracts and rapid growth, IDC isn't profitable. In exchange for long-term contracts, IDC must guarantee customers fixed prices for the duration of the contract. At the same time, the company must comply with customers' continuous requests for updated hardware, software and quality documentation. These ongoing costs have eaten into IDC's hourly wage and prevented the company from turning a profit as a "preferred supplier" thus far.

**Company Background**

Like many small Western Massachusetts firms, IDC began in a garage. After high school and military service, Jim Stone worked as a draftsman at a local company for 12 years. Restless with his job and tired of working for someone else, Stone quit and ventured out on his own. His search for freelance work led him to Easco Hand Tool, a
large manufacture of Craftsman Tools. At the time, Easco had no drafters and no formal tool designs or patterns—all this information resided in toolmakers' heads. Anticipating the retirement of many die setters, Easco management asked Stone to go out on the shop floor, collect information and make drawings of the dies. Over time, Stone secured contracts with several regional aerospace customers for tool design and opened his own shop. IDC worked extensively for General Electric Aircraft Engines (Rutland, VT) over the years and consequently developed expertise in the design of special tools to manufacture blades and vanes for military and commercial aircraft. From its founding in 1973 through the early 1990's, IDC remained very small, never growing beyond 5 employees nor $500,000 in sales.

The small, steady business Jim Stone cultivated over the years took a sudden turn in 1991. Between 1991 and 1994, GE Aircraft Engines—IDC's largest customer—adopted successive generations of computer aided design hardware and software and required suppliers to do the same. Prior to 1991, all design work at IDC was conducted by hand on drafting boards. While Jim Stone had no experience with computers and little interest in them, his son Keith was anxious to learn the new design technology and agreed to come work at IDC and direct the change over to CAD. Between 1991 and 1992, Keith Stone purchased several CAD stations and trained all IDC employees in the new technology.

Soon after IDC had completed the transition to 2D computer-drafting systems, GE informed the company that it needed to adopt a more powerful 3D computer drafting system called Unigraphics. GEAE adopted Unigraphics as its official CAD system in 1992 and began requiring use of Unigraphics by suppliers shortly thereafter. Through use of common CAD technology, GEAE sought to create a collaborative engineering environment in which language problems, information errors, and quality problems with

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3 Unigraphics is a high-end CAD/CAM system used for complex design and assembly of motor vehicles and aircraft and the parts that produce them. It is the industry leader in jet engine design. Both GE Aircraft Engines and Pratt&Whitney utilize Unigraphics. GE Aircraft Engines selected Unigraphics as its CAD/CAM system in 1991.
suppliers would be reduced and eventually eliminated. Equally important, concurrent engineering with suppliers would enable GEAE to radically reduce cycle time.  

The transition to CAD technology was difficult and costly for IDC. The company had to incur substantial debt to purchase the new systems but employees weren’t proficient on the new systems for nearly a year. At the same time, work was slow during this period due to cutbacks in military aerospace contracts. According to Jim Stone, IDC took a “big hit” between 1991 and 1993 “and went right down to almost closing the doors and packing it up.” By 1994, however, the company’s investment in the new technology began to pay off. As employees developed expertise in Unigraphics, IDC secured additional work with GE as well as several contracts with new customers seeking the added accuracy and speed provided by CAD.

The next big turning point for IDC came in 1994 when GE held a worldwide tooling and parts supplier convention in Cincinatti. At the convention, GE presented its preferred supplier strategy to all its vendors. “What they told everyone at the vendor meeting,” recounted IDC President Jim Stone, “was that they were going to choose companies to work with in much closer partnership than before. They said that in order to continue doing business with GE, we (vendors) had to completely changeover to Unigraphics computer systems. They told everyone at the vendor meeting the same thing and everyone got the same information.”

A critical part of that information was a new and extensive set of specifications set forth in the GEAE Request for Quotation Booklets. Prior to 1994, tooling and parts suppliers bid for individual jobs based largely on price and delivery and GE maintained quality performance records on individual vendors based on past performance. The specifications set forth in the 1995 RFQ’s established an entirely new process in which suppliers had to demonstrate, up front, how their company would satisfy GE requirements in five areas including technology, quality, delivery, management, and pricing/productivity.

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4 GEAE’s adoption of Unigraphics and it’s quest for uniformity among suppliers was a precursor to Six Sigma, the company’s highly disciplined and quantitative approach to quality improvement adopted in 1996. Launched in 1995, Six Sigma refers to GE’s corporate wide goal of reducing defects to 3.4 per million opportunities by 2000. GE Aircraft Engines launched its Six Sigma quality initiative in 1996 and by 1997 had trained 1000 employees to lead projects and spread Six Sigma tools to co-workers and suppliers.
Prior to the new RFQ, vendors would typically submit a one-page bid sheet; now vendors quoting work were required to submit binders with tabbed sections addressing each area of the required evaluation criteria. The RFQ issued by GEAE’s Tooling Consolidation Procurement Team, for example, required suppliers to address each of the five areas noted above in “sufficient detail to show capability, understanding and willingness to provide a tooling contract that is cost effective, streamlined and compliant to all policies and procedures.” In addition, suppliers were required to describe in writing how they planned to perform a variety of quality and documentation procedures including document tracking, in-house quality checks of materials produced, corrective action of product/process problems, and record retention (i.e. maintenance of all technical documents, quality control records, cost accounting/finance records etc. for each job).

The Path to Preferred Supplier

IDC’s decision to pursue preferred supplier status with GE was based on three key factors. First, IDC had a good working relationship with GE. IDC had been supplying tooling to GE facilities for nearly 20 years and had established a strong track record in quality. Second, through a variety of customer contacts, it was increasingly clear to IDC that aerospace contractors were consolidating the supply base and that suppliers that did not move in this direction would soon be out of business. Third, Stone and his son Keith concluded that achieving preferred supplier status was their best and only bet for a viable succession strategy.

For approximately three months, IDC prepared materials to qualify for GE’s preferred supplier program. The company assembled trial work packages for three separate GE facilities: Lynn, MA; Rutland, VT; and Albequerque, NM. Each facility sent IDC a package of work. IDC quoted the entire package and produced designs and tools for components of the package to demonstrate technological capability. All of the packages were quoted based on use of Unigraphics. In addition, IDC produced the required binders of material addressing GEAE’s technology, delivery, quality, documentation, management, and pricing/productivity criteria.

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5 This description is drawn directly from the a GEAE In-house Tooling Specification RFQ provided to Industrial Design Co. in March, 1995 by the GEAE Tooling Consolidation Procurement Team.
6 When Keith Stone returned to IDC in 1991 it was under the terms that he would take over the family business upon his father’s retirement.
"The whole (preferred supplier) thing was a shock to us," said Stone. "We never had to deal with anything like this before. It was a highly competitive process. We knew our work and we knew our capabilities. The only thing we didn’t know about was our competitors. What were their capabilities compared to our capabilities?" As it turned out, IDC’s capabilities surpassed the competition. IDC was the only company in the competition capable of performing the total package of programming and design at a competitive price. In the summer of 1994, IDC was awarded a five-year contract (1995-2000) with GEAE to supply tooling designs to five different GE plants.

While preferred supplier status with GE eliminated competitive bidding and guaranteed IDC a certain amount of work, it did not change the unpredictable cycles characteristic of the aerospace industry. When the GE contract kicked in, an immediate and heavy workload hit IDC. To meet the demand, IDC took out half a million-dollar loan to enable the purchase of eight Unigraphics work stations. The company also hired 10 new designers, many of whom were former GE and Pratt Whitney employees laid off through restructuring. IDC mushroomed—both technologically and personnel-wise—to meet GE’s immediate tooling needs. After 15 months of furious work, however, the GE workload slowed down and IDC operated at a loss for three quarters in a row. When GE was slow, IDC needed other work to cover the costs of the new machinery and personnel added for the GE contract. Anticipating the inevitable slow down of GE work, IDC began an aggressive search for new work in the midst of the GE expansion.

IDC’s GE contract and its Unigraphics capability proved to be excellent marketing tools. Stone traveled to Texas to demonstrate IDC’s capabilities to Bell Helicopter, a manufacturer of commercial helicopters. IDC did a trial package of work for Bell and was awarded an exclusive, five-year contract to design and build tooling. Currently IDC designs and builds approximately 17-18 tools per month for Bell.

Over the past two years IDC has also established long-term contracts with Kaman Helicopter and Hamilton Standard. Kaman—which makes search and rescue helicopters—has secured IDC’s services to design and build fiberglass parts for the nose

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8 According to Stone, their main competitor was unsuccessful in the programming components of the trial. IDC’s knowledge of Unigraphics provided an important advantage in the competition.

9 These include: GEAE Rutland, VT; GEAE Bromont, Canada; GEAE Lynn, MA; GEAE Hookset, NH; and GE Power Generation Greenville, SC.
of the helicopter. And Hamilton Standard, which has radically reduced its vendor base, selected IDC as one of three exclusive suppliers of tooling.

Today IDC has 30 employees and is approaching $3 million in sales. The addition of a separate manufacturing facility in 1996 has enabled the company to market itself as a “design and build” shop which dramatically drives down delivery times. This has been a big selling point for IDC and it’s three newest contracts (Bell Helicopter, Kaman, Hamilton Standard) are all for design and build. To accommodate it’s growing customer base and to better coordinate the design and build aspects of production, IDC recently built and moved into a brand new 10,000 square foot building.

The New Work Organization

The organization of work at IDC has been dramatically transformed as a result of concurrent engineering. Prior to the new CAD systems, IDC customers would provide IDC with complete drawings of parts. IDC would then proceed to design tools to make the parts based on the design prototype provided by the customer. Once IDC completed the tooling design it was sent back to the customer. At that point the customer would either build the tool in-house or contract out the design to a ‘build-to-print’ shop. This job cycle generally took 2 to 3 months. In contrast, the new CAD technology enables simultaneous engineering of parts and tooling. Customers now provide IDC designers with the most preliminary part designs on CAD and request them to begin tooling design immediately. Changes in the part design are ongoing and IDC designers must respond to these changes by continuously reworking their tool designs. In this model of production, the design of parts and tooling literally take place at the same time (this is the definition of concurrent engineering). As a result, cycle times have been radically reduced. Average turnaround time for a job at IDC today is one week.

The new organization of production is enabled by the powerful Unigraphics technology in which customers’ computer systems “speak” to IDC’s computer systems with little delay. But it is the drive for “just-in-time” tooling that drives the new production system. According to IDC General Manager Ed Samson, IDC’s customers are promising faster and faster delivery dates to their customers (i.e. GEAE is quoting faster and faster lead times to Boeing for aircraft engines). As a result, IDC customers
need tooling to make parts on an instantaneous basis. "Everyone is promising unrealistic due dates and this gets pushed down to the supplier," said Samson. "They (the customer) don't have all the information when they start a job so we have to get it from them. Before they gave you a completed package with all the dimensions and it was more of a production process. Getting the product to market faster is driving all these changes."

The new model of production has resulted in a number of changes in work organization at IDC. Overall, IDC employees must be more flexible and responsive than before. Designers now juggle 2 or 3 jobs at a given time and must determine which jobs are highest priority. IDC works much more closely with each of its customers as a result of concurrent engineering and the level of communication between IDC and customers has increased dramatically. IDC designers speak to customers about specific jobs on a daily (sometimes hourly) basis. And, because of the continuous changes being made to tooling design, documentation has become paramount: each change to a design must be documented and accounted for to insure that mistakes aren't made and misunderstandings don't occur.

*Increased Flexibility and Communication*

Under the old production regime, IDC designers worked on one job at a time from start to finish. Today with the increase in the number of jobs and the con-current nature of production, IDC employees juggle multiple jobs simultaneously. In a typical week, an IDC designer may work on 20 different tool designs for five different customers.

Achieving this degree of flexibility requires all IDC designers to be cross-trained in each drafting system the company uses. Thus, in addition to Unigraphics, IDC designers must be proficient in Catia as well as in the remaining 2D systems.\(^\text{10}\) Beyond the drafting systems themselves, IDC receives new software from customers every six months on average. As a result, there is a continuous process of skill upgrading and learning that takes place among IDC employees. The vast majority of this learning takes place informally on site. One employee will dedicate him or herself to learning the new software system and then proceed to train others in it.

\(^{10}\) Catia CADAM was developed by Paris-based Dassault Systemes and is marketed and supported worldwide by IBM. Like Unigraphics, Catia is a 3D computer drafting system widely used in the aerospace and automotive industries. The Boeing Company, for example, has 8000 seats of Catia.
Another significant change in the organization of work is direct communication between IDC employees and customers. Prior to concurrent engineering, the company president interacted with customers exclusively. He received blueprints of prototype parts from customers and assigned jobs to designers. Today, designers work directly with the customer on tool designs and are in constant contact with customers regarding changes and modifications. Accordingly, IDC employees must be comfortable and confident in their interactions with customers. They must be able to negotiate conflicts and misunderstandings and placate customers when jobs are delayed. This requires a level of maturity among employees that was unnecessary under the former production organization.

**Documentation**

Documentation is the mechanism for accountability in a production environment that is fluid and constantly changing. Concurrent engineering, by nature, is a process of continuous change and modification. To minimize the mistakes and misunderstandings inherent in this type of production, customers require thorough and continuous tracking and documentation of each individual job. Every job IDC works on is now accompanied by a folder containing detailed information on the job (e.g. tool request sheet, copy of prints, documentation of errors or problems and how they were corrected, cost changes incurred, hours applied to the job etc.). In addition, each individual working on a given job is required to maintain a log that documents changes, errors, customer contacts, and time on the job.

While the paperwork feels excessive and is generally perceived as a burden by IDC employees, the looming possibility of customer audits provides ample incentive to produce it. Unannounced audits are a precondition of preferred supplier status and customers can send audit teams to IDC at any given time to review job folders. On the positive side, the documentation provides a transparent record of each job. This can work to IDC’s advantage when problems with a job stem from misguided customer directives. Another benefit of documentation is that it eliminates guesswork when diagnosing poor tool performance. If a tool is performing poorly on GE’s shop-floor, for example, IDC can go back to the paperwork and figure out what went wrong. In addition, the paper trail enables IDC to compare similar jobs and pinpoint variation. For example, if a job
goes over budget, IDC may discover upon review of the documentation that it was a result of the customer making changes on five separate occasions, not due to the fact that IDC quoted the job incorrectly.

Quality Assurance

In addition to documentation at the level of the individual jobs, each customer IDC deals with requires quality assurance documentation at the level of the firm. In each case, adhering to the requirements of the program is a pre-condition of preferred supplier status. Sikorsky Aircraft, for example, has a program called T-2000. As a condition of preferred supplier status, IDC is required to comply with every requirement in the T-2000 manual by the year 2000. Every six months, IDC must submit a progress report to Sikorsky describing progress toward T-2000 goals. As noted earlier in the case study, a precondition of preferred supplier status with GE was the up-front demonstration of supplier capabilities in the areas of technology, quality, delivery, management and pricing/productivity. This requirement is part and parcel of GE’s Six Sigma initiative. Bell Helicopter requires IDC to adhere to its ‘Spirit’ requirements. Bell rates IDC quarterly in a number of different areas and requires written response and explanation from IDC if it does not conform precisely to Bell’s standards.

In addition to satisfying each customers’ individualized quality assurance program, IDC has also been pursuing ISO 9000 certification. Although most large aerospace companies have adopted quality documentation programs that exceed ISO 9000, General Manager Ed Samson said IDC can’t get its foot in the door with a new customer unless it can demonstrate its commitment to ISO. “ISO is a baseline for new business,” said Samson. “Anybody we call, that’s the first question they ask us and we have to send them copies of our ISO manual to show them that we are in the process.” Samson estimates it will cost $20,000 to become ISO 9000 certified. ISO 9000, which requires companies to document work processes throughout the firm, has been problematic for IDC. Samson is struggling with how to apply ISO standards in a production environment in which each job is one-of-a-kind. “The procedure for designing a tool is different every single time. Technically, you’d have to write a new procedure for each tool. We never do exactly the same job twice, so it’s unclear how much time we should spend documenting the process. We are moving in the direction of
documenting daily operations as opposed to specific jobs.” IDC recently hired a consulting firm to help it think through the ISO implementation process.

**Closer Partnership with customers**

In the drive to eliminate errors and deliver parts ‘just-in-time,’ several of IDC’s customers have required IDC to work more closely with them on the shop-floor. Since IDC became a preferred supplier to GE, for example, it is in almost constant contact with the Rutland, VT plant which it works most closely with. In 1996, IDC opened an office in Rutland in order to provide timely, hands-on technical assistance. On the shop-floor of the Rutland plant, GE engineers work daily developing new tooling processes to produce blades and vanes using tools designed by IDC. Through this process, they discover possible changes and improvements that are relayed continuously to IDC designers. In turn, IDC employees work closely with GE engineers to help them improve the quality of GE-designed tools and dies. In addition to GE, IDC also has a tool designer that works on site at Hamilton Standard to insure that any problems with tooling can be addressed within a matter of hours as opposed to days.

**Impact on the Workforce**

Over the past five years, the pace of work at IDC has accelerated dramatically. The necessity of juggling and prioritizing multiple jobs, interacting with customers, and adhering to documentation requirements has created a more stressful work environment for IDC employees. As one senior designer put it: “With how quick things are moving its sometimes staggering to keep up with the changes. We have such a large vendor base now and everyone wants everything yesterday. There is just so much to know—you’ve got to know company standards for 15 to 20 vendors—it’s overwhelming and you go home at the end of the day mentally exhausted.” At the same time, however, employees note that the new work organization has made their jobs more interesting. Employees are constantly learning new software and are seldom bored because they work on so many different jobs. Furthermore, most employees enjoy the added responsibility that comes with increased customer contact and follow through.

**Impact on Performance**

Since IDC began its work reorganization in the early 1990’s, both its customer base and sales have expanded rapidly. Between 1994 and 1999, IDC acquired eight new
customers—four of which provide IDC with exclusive, long-term contracts for tooling; sales increased from approximately $800,000 to $2.5 million; and employment jumped from 11 to 30. According to Jim Stone, the growth of the past five years has largely been forced by market dynamics. In order to maintain business with its largest customer, IDC had little choice but to invest in Unigraphics technology in 1995. But to cover the costs of the technology, IDC had to expand its customer base beyond GE. New customers, in turn, meant additional work and employees which led to further investments in technology. In the near term, IDC anticipates moderate employment growth as it expands its tool building capacity.

While the new CAD technology—and the work organization it engenders—enables IDC to produce a higher volume of work in a shorter period of time, its adoption has not led to profits. This is primarily due to the fact that IDC must guarantee customers a fixed hourly rate in exchange for long-term contracts. In the case of GE, for example, IDC quoted an hourly rate for work in 1995 that lasts through 2000. Meanwhile, GE has required several upgrades of software during this period. In addition, IDC has discovered that the life span of the hardware that runs CAD software is about three years. Continuous investment in new technology reduces IDC’s hourly wage making it impossible, thus far to profit from the preferred supplier arrangement. Despite these problems, Stone believes the preferred supplier system and the stability it provides the company in terms of workload is a significant improvement over the old bidding system. As IDC gets a better handle on its own costs and pricing, Stone is confident the company will become profitable.
Stan-Allen

Overview/Summary

Stan-Allen is a manufacturer of steel-rule cutting dies based in Ludlow, Massachusetts. The family-owned company got its start in 1953 as a supplier of cutting dies to the folding box industry. Stan-Allen supplied dies to customers in this highly competitive industry for approximately 20 years. In the early 1970’s, the company moved out of the box industry into plastics. At that time, plastics were just beginning to be developed in sheet form as a substitute for metal. While plastic had many advantages over metal, manufacturers found it was a difficult material to cut and that it failed to hold close tolerances. Few, if any, New England die makers had expertise in cutting plastics at the time. Stan-Allen filled this void by developing dies that could accurately cut a variety of plastic and polyester-based materials. Today, the company specializes in the production of small, complex cutting dies for the electronics industry. Each die Stan-Allen makes is one-of-a-kind, engineered to order for a particular customer. With 30 employees and close to $2 million in annual sales, it is one of the largest and most technically sophisticated die-making shops in the country.

For many years, Stan-Allen was the industry leader in its small market niche: the company faced few competitors and commanded high prices for its technical expertise and exacting dies. In the early 1990’s, however, the company’s secure position in the marketplace was undermined. The widespread availability of computer-driven technology enabled new entrants to the die cutting industry to approximate Stan-Allen’s high precision and quality while offering customers lower prices. As a result, Stan-Allen found itself losing long-term customers to lower cost competition.

Allen Gurka, the owner and president of Stan-Allen, is an international authority on cutting plastics. Through active participation in the International Association of Die Cutters and Die Makers, Gurka has forged working relationships with die makers throughout the U.S., Europe and Japan. These relationships have provided Gurka with ongoing opportunities to travel, consult and learn about technological developments in the industry. Yet despite his technical expertise, Gurka was confounded when his company could no longer command premium prices for its product. In response to the
new competition, Gurka dramatically reduced the average billing price and expanded Stan-Allen's sales effort to increase volume. To process greater volume with the same number of employees, Gurka invested in state-of-the-art production technology. While these efforts kept the company afloat in the mid-1990's, they were not enough to overcome flat sales or the continued loss of key accounts.

Discouraged by his inability to compete effectively in the new market environment, Allen Gurka began to think about retirement and sought a buyer for his company. In 1996, Richard Sweeting—a graduate of Yale's school of Organization and Management with no previous experience in die cutting—joined Gurka as an equal partner in the business with plans to buy Gurka out within five years. In his capacity as Executive Vice President and General Manager, Sweeting has spearheaded the firm's transition from a traditional, craft-oriented firm to a modern company capable of competing under changed market dynamics.

Like many small firms, Stan-Allen has discovered the hard way that a commitment to craft and quality are no longer sufficient to maintain a leadership position in the marketplace. Advanced computer technology has made it easier for many firms to perform the complex jobs that only high skilled craftsmen could achieve before. As a result, it is now possible for high skill, craft-based firms to be beaten out by lower wage firms that have mastered the new technology as well as organizational strategies that contribute to reduced costs. Stan-Allen's once loyal customers are now placing greater emphasis on price and delivery—competitive advantages not achieved through craft but through more sophisticated sales, marketing and throughput tactics. As the Stan-Allen case reveals, these changes in the market require new management strategies and often, new leadership.

**Company Background**

Stan-Allen was started in Stanley Gurka's Ludlow basement in 1953. For 20 years Stan-Allen provided block dies to the folding carton industry. Beginning in the late 1960's, the company began to venture into dies for plastics. Few die makers had expertise in cutting plastics at the time and Stan-Allen filled a void by developing dies that could accurately cut a variety of plastic and polyester materials. Initially, this
expertise was gained through a close working relationship Stan-Allen formed with FlexCon—a large plastics distributor based in Spencer, MA. Working with FlexCon and its many customers, Stan-Allen researched and developed techniques for cutting exotic new materials such as polyesters, polycarbonate and kapton.

Stan-Allen quickly became a leading authority on cutting plastics and found a niche with New England customers willing to pay premium prices for high precision, high quality cutting dies. Through plastic, Stan-Allen escaped the cut-throat, cost-based competition that characterized the folding carton industry. The company’s specialized knowledge was extremely timely, dovetailing the electronics industry’s take-off in Massachusetts. The dynamic growth of the electronics industry fueled company expansion throughout the 1970’s and 80’s. Corporate heavyweights such as GE and Polaroid consulted with Stan Allen to develop improved tooling, while dozens of electronics industry suppliers ordered their cutting dies from Stan-Allen exclusively.

Since 1980, Stan-Allen has been headed by the founder’s son, Allen Gurka. The 60-year old company president has spent his entire life in the business. Gurka worked in his father’s shop through high school and college. Upon graduation from UMass Amherst in 1962, he joined the company full-time. Unlike his father who prided himself on craftsmanship, Allen Gurka was more interested in new technologies and industry networking. The younger Gurka spearheaded the company’s move into plastics and quickly became a leading international authority on “cutting the tough stuff.” Through active participation in the International Association of Die Cutters and Die Makers, Gurka kept abreast of technological breakthroughs in the industry. On a European tour in 1983, for example, Gurka was exposed to a computerized laser beam that cut die board more quickly and accurately than traditional manual approaches. Stan-Allen was the first die cutter in the United States to utilize this technology and sales and volume increased substantially as a result. In addition to the laser beam, Stan-Allen was also an early adopter of CAD technology (which enables customers to download their computer files

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11 While the average die shop today employs 12 people, Stan-Allen grew to 25 employees by the mid 1980’s.
12 Allen Gurka served as President of the International Association of Die Cutters and Die Makers from 1989-1993. IADD is composed of approximately 365 die cutting and die making firms.
directly to Stan-Allen’s designers) and of CMM (coordinated measuring machine which enables Stan-Allen to perform final inspection in-house).

Production Process

Cutting die technology has undergone several transformations since Stan-Allen opened its doors in 1953. When the company began, it produced “block dies” by cutting small blocks of wood out of maple die board, piecing them together, and inserting steel rules between the wood chips. Customers locked the dies into a giant press; materials were then fed through the press and die cut into folding boxes for a variety of consumer items. This technology was flawed, however, because the wood blocks that held the steel rule in place frequently fell apart under the pressure of the press, causing damage to the machinery. Subsequent to block dies, Stan-Allen began using jig-saws to cut pattern lines into solid pieces of wood. The excess wood was removed and steel rule was inserted into the cut. This method provided greater accuracy and durability. The industry’s biggest technological change, however, came in the late 1970’s with the advent of the computerized laser beam. In this case, the die pattern is programmed into a computer that instructs the laser beam to cut (burn) the line into the wood. This method has the double advantage of precision and speed.

Despite these changes in technology, cutting die production maintains a large craft element. Today, “knifers” manually bend and insert steel rule into the cut just as they did 50 years ago. Stan-Allen specializes in small, high precision dies, some requiring tolerances of up to +/- five thousandths of an inch. Knifers bend the steel rule to these exacting tolerances using manual bending machines operated by hand. According to Stan-Allen’s production manager, the bending process is becoming more computer-driven with the introduction of the automatic bender. However, most bending jobs at Stan-Allen continue to be performed by a single knifer who sees the job through from beginning to end. Knifers at Stan-Allen take considerable pride in their “hand work” and are regarded throughout the company as craftsmen.

The New Competition

With its sophisticated technology and expertise in cutting plastics, Stan-Allen enjoyed its leadership role in a small market niche for many years. The company faced
few competitors and commanded high prices for its technical expertise and exacting dies throughout the 1970’s and 80’s. Beginning in the early 1990’s, however, the company’s position in the marketplace began to change. As competition in manufacturing accelerated in the early 1990’s, Stan-Allen’s customers began requiring faster and faster turnaround times. In the mid-1980’s, average turnaround on a job at Stan-Allen was 5-7 days. By 1998, average turnaround time was 1-3 days. Faster turnaround has been facilitated by the widespread availability of computer technologies such as CAD and the computerized laser beam. As computer-driven technologies became more available in the marketplace, however, other die firms began to approximate the high precision and quality that had historically distinguished Stan-Allen from the competition. According to Michael Ghareeb, Stan-Allen’s Vice President of Sales and Marketing, “the computer has made the craft aspects of this work less important. Now if you buy the equipment you can start a company. The computer is driving the laser, the automatic bending and the quality control inspection. If you have the equipment, you can work toward making dies to about the best tolerance available. This is a very different model of how you start in this kind of business. It used to be that the only way you came into this business was through a family trade.”

Stan-Allen was alerted to the severity of the new competition when its largest customer, Spring Print, abandoned it in favor of a lower cost competitor in 1992. Spring Print, a major manufacturer of computer overlay panels, had been ordering its cutting dies exclusively from Stan-Allen for many years. When the company was acquired by Whirlpool Corporation, however, new purchasing procedures were instituted and Spring Print was required to secure a minimum of three bids for each job. A relatively new die cutting firm based in Wisconsin significantly underbid Stan-Allen and took the Spring Print work away. In addition, the Wisconsin firm—named Apple—promised turnaround times that Stan Allen couldn’t match. Over the next 24 months, Apple managed to take work away from several of Stan Allen’s best accounts.

Allen Gurka’s response to heightened competition was threefold: between 1992 and 1995, the company lowered its prices; expanded its sales effort; and invested in new technology. Based on its reputation for high quality, high precision cutting dies, Stan-Allen had been able to charge premium prices for its product for two decades. When the
new competitor undercut Stan-Allen on price and promised comparable levels of accuracy, however, long-term customers began to feel they were being overcharged by Stan-Allen. To maintain business with existing customers and secure business with new customers, Stan-Allen was forced to drop its prices. To compensate for lower prices, the company needed to process more orders. Thus, the company’s sales effort expanded beyond New England for the first time. Gurka and Ghareeb (the V.P. of sales and marketing) began to spend more time on the road and to pursue customers in North and South Carolina, Florida, Michigan, Ohio and Pennsylvania. In order to process and produce more cutting dies with the same number of employees, Gurka invested in new production technologies including a state-of-the-art custom-designed PRC laser and an automatic bending machine which bends the steel rule to exact tolerances.

Despite expansion of the customer base and a marked increase in volume, sales at Stan-Allen have been flat since 1992 due to price reductions. According to Gurka, the new competition has resulted in a dramatic drop in the average billing rate. “We are bidding lower and making up for it in volume,” said Gurka. People are working overtime but they aren’t getting paid because I’m fixed in the price. Everyone is working harder for the same amount of money. It’s very difficult and a real worry. I don’t like this side of the business and I don’t enjoy it.”

Ownership Transition

Discouraged and stressed by his inability to compete effectively in a changed market environment, Gurka sought a buyer for his company in 1995.13 His goal was to retire from the company by age 62 but continue to travel and work as a consultant in the industry. In 1996, Richard Sweeting came on board as an equal partner in the business with plans to buy Gurka out within 5 years. Shortly after his arrival at the company, Sweeting took over responsibility for internal operations; Gurka, in turn, directed his full-time attention to sales.

As an Ivy League graduate, former fighter pilot, and successful partner in a Boston-based start-up company, Sweeting had no experience in the die cutting industry

13 Though Allen Gurka has four children who have all worked at Stan-Allen at one point or another, none of them were interested in taking over the family business. Gurka hired a consulting firm to locate a buyer for the company.
when he came to Stan-Allen. Sweeting invested in Stan-Allen because he viewed it as a company uniquely positioned to take advantage of industry consolidations. Historically, the die cutting industry has been characterized by hundreds of tiny shops. Craftsmen with ‘knifing’ skills faced limited barriers to entry due to the manual nature of the work. As a result, the vast majority of die cutting shops in the country are very small—often just two or three people ‘jigging’ out dies the old fashioned way in a garage. As the industry has become more technologically sophisticated and as customer expectations regarding delivery time have changed, however, the barriers to entry have grown. Fewer and fewer of the tiny ‘mom and pop’ shops are able to compete with larger shops that have invested in computer technologies that accelerate production.

Based on his analysis of the die cutting industry, Sweeting concluded that Stan-Allen was a good manufacturing opportunity for several reasons. “The company is ‘large, has a great reputation and has made a large investment in technology,” said Sweeting. It’s in a good position to be an industry leader—to be a buyer rather than a seller, an acquirer rather than an acquiree.” Sweeting’s strategy when he came to Stan-Allen was to use the company as a springboard to acquire additional die cutting shops around the country thereby raising barriers to entry and achieving economies of scale. His plans for expansion have been delayed, however, due to Stan-Allen’s weak financial position.

Changes in Work Organization

In order to improve company performance and strengthen Stan-Allen financially, Sweeting has dedicated his time at the company thus far to two main areas: addressing the ‘price problem’ and modernizing work systems.

The Price Problem

Like Gurka, Sweeting was perplexed by Stan-Allen’s price predicament. How, he wondered, had a relatively new entrant to the industry managed to undercut Stan-Allen’s prices so dramatically? And why were some loyal, long-term customers willing to forego Stan-Allen’s quality and experience for price cuts while others were willing to tolerate premium prices? After two-and-a-half years at Stan-Allen, Sweeting believes the problem resides in the company’s failure to differentiate prices across markets. Stan-
Allen supplies cutting dies to electronics industry suppliers, but among suppliers there are multiple product markets. Some of these product markets (e.g. aerospace control panels) require the high quality Stan-Allen guarantees; other product markets, however (e.g. plastic overlays for beepers and cell phones) don’t require such high precision and these customers, according to Sweeting, are happy to forgo some quality for lower prices.

Stan Allen has always priced its cutting dies universally across markets based on costs and all dies adhere to the same high standard of quality. As a result, customers in lower-end product markets were paying for quality they didn’t really need. According to Sweeting, the competition ‘differentiated the market’ better than Stan-Allen and priced its dies according to customer price tolerances rather than cost. Through this strategy they were able to ‘steal’ numerous accounts from Stan-Allen. “This variation in markets is a very hard thing to see,” said Sweeting. “One of the main problems small family run businesses suffer from is that it is rare for them to have someone who is a real marketing person.”

Sweeting’s strategy is to develop a sophisticated understanding of customers and markets and to price dies accordingly. An important first step in implementing this strategy has been to increase knifers’ awareness of different customers’ quality requirements. Work tickets now include the projected selling price and the die’s function. A $150 die that is going to cut gaskets should not take the same amount of a knifer’s time as a $500 die that is cutting an exotic material. Knifers have responded positively to the new system and understand the need to be more efficient on lower-end jobs. At the same time, however, they have difficulty accepting the fact that high-skill and quality are not always valued by customers. “Die makers look at the business from a technical/mechanical standpoint: they have a skill orientation,” said Sweeting. “Unlike us, our competitors are not died in the wool, decades old die makers—they have law and accounting backgrounds. The lack of a craft tradition may be an advantage for them. Knowing how to run a business rather than knowing the craft can go a long way.”

Modernizing Work Systems

Because the diemaking process itself is manual, most of the efficiency gains Sweeting seeks must come from improvements in other parts of the company. The majority of changes Sweeting has implemented have been on the ‘office-side’ of the
company which, according to Customer Service Manager Lynn Guertin, was ‘living in the dark ages’ when it came to clerical functions, inventory control and job tracking. When Sweetching arrived at Stan-Allen in 1996, for example, the office was using a DOS software system that had been programmed in 1991. The individual who developed the program was no longer at the company and no one knew how to change or upgrade the system. As a result, computers were primarily used for printing labels.

Like many small firms, Stan-Allen had relied on the tacit knowledge of its employees for many years and had few ‘systems’ in place. This was especially true of the front office where a decade ago one individual was responsible for all job estimating, billing, customer complaints and changes to customer blueprints. According to employees, the individual was very capable and did it all ‘off the top of his head.’ Today however, with faster turnaround and increased volume (the company processes an average of 25 orders a day or 125 dies per week) this individualistic approach is no longer viable. Over the past two years, Sweetching has spent a great deal of time ‘getting control of how things are flowing through the company and developing a more systematic approach to the work process.’

Sweetching has worked with front-office employees to automate and streamline job entry and job tracking systems which were extremely inefficient. Historically, all job instructions—regardless of how many times a die was ordered before—were hand written and each job had a paper ticket. When customers made changes to jobs, customer service rep’s had to track down the job and re-type job instructions. Now information on each customer and each job—including specs—is on file on a computer. When an order comes in, the customer service manager pulls up the file on the computer, edits the instructions for that particular job and puts a new part number on it. This process of job entry is so much more efficient than the old method that the customer service department has gone from four employees to a single customer service manager.

Another big improvement has come in the area of job tracking. Under the old system, jobs made their way around the shop but no one knew where a job was in the production process at any given time. Customers calling in about the status of a job would get different answers from different people and deliveries were routinely late. Today every job is filed on a computer database and is tracked from order entry to
shipment. “The idea behind the new system,” said Customer Service Manager Lynn Guertin, “is that everybody in the shop can know where a job is at any time. The computer shows the date the job is entered, the planned shipping date and the due date to the customer.” The new system builds in greater accountability because each department knows when it must complete its part in order to meet delivery dates.

The company has also begun to track errors under Sweeting’s leadership. Weekly quality control meetings have been implemented in which customer complaints are reviewed and errors are traced to their source. Representatives from each department (customer service, CAD, sales, and production) attend the meetings. Through error tracking, patterns and problems are exposed that can then be addressed in a systematic way. According to Production Manager Earl Quinn, the meetings are a big improvement. “We didn’t know what problems we had before, we just knew we had problems. We didn’t track a thing. Now we keep track of where the errors occur.”

**Impact on the Workforce**

In Sweeting’s opinion, the rate of change at Stan-Allen is exceedingly slow. “Some people just won’t change,” he said. “A lot of them really hate this stuff. We’ve cut out an enormous amount of manual and redundant task but we still have miles to go.” Employees concede that the learning process is painful. “When we first started with the new systems, we struggled,” said Production Manager Earl Quinn. “People get comfortable with their work flow and when they are asked to change they take offense.” According to Michael Ghareeb, the V.P. of Sales and Marketing, some long-time employees simply could not make the transition to the ‘computer generated levels of communication’ that Sweeting required. “People who want to do their own thing can’t function here very well anymore. It’s more of a team effort now which increases the need for communication. People that are more individualistic are not going to want to be here anymore.”

Several employees have left since Sweeting came on board (including Gurka’s daughter) and several have been fired due to ongoing performance problems. Most employees, however, are coming around to the changes and regard them positively. “We are more professional now,” said Customer Service Manager Guertin. “Allen (Gurka) kept a lot to himself. We really didn’t know what was going on. People have more
information now and a much better understanding of how things get done. It used to be what Allen said and that was that. Rich has an open door policy. He says, ‘no idea is a bad idea unless it’s not going to work.’ He encourages us to come up with better ideas and to let him know.”

**Impact on Performance**

The emergence of aggressive competition woke Stan-Allen from a false sense of security. Commitment to craft and quality, the company discovered, is no longer sufficient to differentiate it from competitors. Today companies without Stan-Allen’s strong craft tradition are able to approximate the same levels of quality and precision due to the availability of advanced computer technologies. As a result customers are now placing greater emphasis on price and delivery—competitive advantages not achieved through craft but through more sophisticated sales, marketing and throughput.

Though Stan-Allen employees deplore the predatory pricing practiced by their main competitor, they concede that the competition has made them smarter. Under new leadership the company has begun to bring down internal costs enabling it to eek out a profit despite lower prices. In 1998, the company broke 2 million in sales and was profitable for the first time in six years. As employees become more proficient in the new, computerized work systems and as the company fine tunes and implements its pricing strategy, Stan-Allen should become more competitive.

Allen Gurka and Rich Sweeting acknowledge that their partnership is behind schedule. The company is not strong enough financially for Sweeting to buy Gurka out and Sweeting is far from his goal of acquiring other tool and die companies around the country. Despite these challenges, Stan-Allen employees feel they have weathered the worst of the storm and are committed to gaining back their coveted leadership position in the industry.
Controlled Comparison Two: Brimfield Precision and Dienes Corporation

Brimfield Precision and Dienes Corporation are both large machine shops located in western Massachusetts. Throughout the 1970's and 1980's, each company typified a mainstay of the region's manufacturing economy—high volume, build-to-print production of precision parts for large New England manufacturers. Brimfield made stapling instruments for manufacturers of medical supplies during this period while Dienes made compressor parts for air conditioning manufacturers. Both companies experienced stable regional markets and customer relations for many years. By the early 1990's, however, both companies' dependable markets began to erode. In response, both companies ventured into new product markets and both began to make organizational changes in order to compete more effectively.

Prior to the early 1990's, both Brimfield and Dienes adhered to traditional forms of work organization in which machining tasks were broken down by operation and organized into separate departments. In addition, both companies also maintained traditional quality departments that inspected parts post-production. Beginning in 1991, both companies launched internal efforts to reorganize their quality programs. In the case of Brimfield Precision, this was the first step toward a comprehensive transformation of firm organization in which shop-floor employees took on increasing levels of responsibility for all aspects of production. Along with higher-end design and engineering services, Brimfield made employee-centered work organization a centerpiece of its competitive strategy between 1992 and 1997. During this period company sales grew quickly as did the customer base. For Dienes, in contrast, the reorganization of the quality department was a promising beginning in a series of failed attempts at employee-centered work organization. Dienes failed to link work reorganization to product strategy.
### Brimfield Precision

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### Dienes Corporation

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between 1992 and 1997. Subsequently, the company’s manufacturing division entered a period of steep decline and it shifted its focus to the sale and distribution of specialized machine tools.

I argue that the variation in outcome between Brimfield and Dienes stems primarily from differences in firm strategy/managerial thinking. In the context of a strategy to offer customers specialized knowledge and skill in the design and engineering of medical implants, Brimfield Precision aggressively pursued new forms of work organization to improve quality and reduce costs. By 1995 when large manufacturers of medical supplies were beginning to require innovations such as Kaizen, team production and ISO 9000 from suppliers, Brimfield Precision was at a large advantage over competitors having already shifted to streamlined forms of employee-centered production. In contrast to Brimfield, Dienes continued to mass produce precision parts. The company failed to upgrade its product and develop a more specialized market niche thereby leaving itself vulnerable to low-cost competition. Unable to gain a handle on work processes and internal costs through new forms of work organization, Dienes was unable to meet customer requirements for quality documentation and/or offer customers price cuts. As a result Dienes’ manufacturing division entered a permanent state of decline.

Management skill is another critical factor accounting for variation in outcome. In response to market signals, the presidents of each company sought to streamline production through new forms of work organization. As the case studies demonstrate, however, this process is not automatic: both strategy and skill are required to successfully implement shop-floor changes. The president of Brimfield Precision educated himself
and trained employees in the tenets of the new work organization. He also utilized consultants and other outside resources to implement his vision. In addition, Brimfield implemented employee screening and hiring mechanisms to insure that new employees supported the new company culture. Dienes' President, in contrast, launched into work reorganization with little experience or knowledge and utilized no outside assistance. Employees were not provided with adequate training or support and shop-floor managers who were antithetical to the new work organization remained in place.

Despite differences in outcome, both Brimfield and Dienes demonstrate the difficulty inherent in organizational change. While Brimfield Precision has transformed its work organization to a remarkable degree, the process has been wrought with challenges. The company has grappled with employee resistance, high turnover, lay-offs and shop-floor resentment at unfulfilled promises throughout the course of its transformation. And Dienes' foray into work reorganization caused many more problems than it solved. The failed effort demoralized and de-motivated shop-floor workers and resulted in strained relations with company management.
Brimfield Precision

Introduction/Overview

Brimfield Precision is a western Massachusetts manufacturer of medical implants and instruments. In 1991, the company began a transition away from traditional, hierarchical management and work organization toward an organizational structure characterized by genuine employee involvement in the production process. Brimfield Precision's pursuit of the new work organization was a strategic response by the company president to changing market conditions. While the company enjoyed stable customer relations in its first 15 years, it suffered repeated customer losses throughout the 1980's. The company lost key customers and/or contracts in 1983, in 1987 and again in 1991. At each of these critical points, the company's leadership was forced to think about how to diversify the customer base in order to stay in business.

To escape the price-based competition characteristic of build-to-print production, Brimfield Precision began to develop expertise in the design and engineering of medical implants in the mid-1980's. While this expertise enabled the company to break into higher end markets, it did not insulate the company from increasing market instability. In 1991, Brimfield Precision was struck with a near fatal blow when it lost its three largest customers simultaneously. While the loss might easily have led to industrial decline, the CEO turned adversity into opportunity by using the customer collapse to assess internal production processes and rethink the company's core activities. The assessment led to a new system of work organization in the firm focused on cost cutting, quality improvement, and customer service.

Over a five year period (1992-1997), Brimfield Precision successfully transformed its work organization. Today the company is broken into four product-focused business units in which members of employee production teams are responsible for designing and scheduling their own work. Management now exists in the form of "support teams" whose role is to facilitate and coordinate the work of the production teams within the business units. The company adheres to a continuous improvement philosophy and has implemented a variety of innovations associated with the new work organization including total quality management, statistical process control, cellular
manufacturing, production teams, employee involvement, cross-training, performance-based compensation and ISO 9000.

The implementation of employee-centered work reorganization has enabled Brimfield—over a period of years—to lower costs, improve quality and make continuous improvements in the manufacturing process. Sales have nearly tripled since the company reorganized, the customer base has grown from 3 to 12 orthopedic customers and the costs of goods sold has decreased by 30 percent. Despite impressive performance improvements, the process of implementation has not been easy or smooth. In the early 1990’s, management fired a number of employees who were unable to work effectively in the new system. In addition, the company experienced dramatic employee turnover when 45 percent of the workforce left the firm in a single year due to the demands of the new work system. More recently, employees have become disgruntled by management’s failure to follow through on promises regarding performance-based compensation.

Brimfield’s thorough implementation of employee-centered work organization is largely attributable to the vision and leadership provided by the company’s President, William Lyons. In an effort to achieve his goals of innovation and growth, Lyons sought to transform his father’s traditional build-to-print machine shop into a precision manufacturer with distinctive capabilities and products. To accomplish this transformation, Lyons upgraded the firms’ design and engineering capabilities and educated himself in the principles of total quality management and lean manufacturing. He also utilized consultants and technical assistance provided through membership in a local industry association—the western Massachusetts chapter of the National Tooling and Machining Association. Together, these activities provided Lyons with both the theoretical and practical tools he needed to enter new markets and implement an entirely new form of work organization in the firm.

**Company Background**

BPI was established by William Lyons in Brimfield, Massachusetts in 1967. From 1967 to 1983, the company made re-useable, metal stapling instruments for U.S. Surgical on a build-to-print basis. In 1983, BPI’s reliable and ample supply of contract work from U.S. Surgical began to diminish. That year, US Surgical went through a major
management shake-up and introduced disposable stapling instruments made out of plastic. The changes at U.S. Surgical prompted William Lyons to begin thinking, for the first time, about how to expand the company's customer base.

Overlapping the decline in business from U.S. Surgical was the return of William Lyons eldest son—William Lyons III—to BPI. Unlike Lyons Sr. whose business philosophy was cautious and conservative, Lyons Jr. was a risk-taker determined to take the company in new directions. Based on his exposure to modern machine shops in Southern California, the younger Lyons was convinced that BPI needed to move beyond contract machining into higher end design and engineering services in order to distinguish itself from the competition.

Beginning in 1983, Brimfield Precision gradually developed expertise in the design and engineering of medical implants by partnering with small medical start-up companies that lacked manufacturing capability. BPI became an exclusive manufacturer of steel staples, hip systems and other orthopedic products for a start-up company called Joint Medical Products. It also entered into partnership with a company called Exactech to manufacture a new hip implant system that was 15 percent cheaper than existing systems on the market. These were followed by a large contract with Bard-Davol, a Rhode Island based company developing a vascular access device for chemotherapy injections. Between 1983 and 1987, BPI successfully diversified its customer base and entered a fast growing market: the design and manufacturing of medical implants.

1987 marked a second turning point in BPI's development. In July, William Lyons died unexpectedly and prematurely leaving Bill Lyons—at age 30—at the helm of the company. In addition, Brimfield lost its manufacturing exclusivity with Joint Medical Products. The loss of exclusivity with JMP was a real jolt and was caused by the fact that far too often Brimfield had been unable to meet JMP's orders on time. Suddenly, another

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14 Bill Lyons was well groomed for a leadership position at BPI. He ran machines on the shop floor during high-school, entered a machinist apprenticeship program at age 16 and received a journeymen’s certificate five years later. Following graduation from University of Connecticut, Lyons Jr. moved to California where he worked in a variety of machine shops and studied for a masters degree in biomedical engineering. He returned to the family business at age twenty six.

15 Brimfield/Lyons partners in JMP.

16 Bard-Davol had never made a metal product before and asked Brimfield to help them in the development phase of the product. The contract began with 3,000 parts and expanded over a one year period to 30,000 parts requiring BPI to construct a new, 10,000 square foot building.
steady stream of business (20 percent of sales) became competitive and Bill Lyons found himself thinking about how to expand the customer base.

With specialty design and engineering skills to offer, Lyons began to seek work with large medical instrument suppliers such as Johnson and Johnson and Zimmer. After several failed attempts, Brimfield finally broke into Johnson and Johnsons’ supplier network in 1989. J&J wanted to build a hip implant system to compete with the low-cost system Brimfield had helped developed for Exactech. J&J’s first contract with Brimfield was a two-year, two million dollar contract for 6,000 hip stems.

By 1990, Brimfield Precision was back on its feet. The company now had several high margin contracts in place that generated considerable profit. The company had successfully weaned itself off U.S. Surgical and recovered from the loss of exclusivity with JMP. In addition, BPI was establishing itself as a high-end machine shop capable of assisting large and small customers through all phases of manufacturing from product development to production.


Despite Bill Lyon’s aggressive focus on product innovation and customer expansion, the organization of work in the plant remained remarkably constant under his leadership. For years, BPI had adhered to a very traditional form of work organization: the shop-floor was organized into physically separate departments for various machining operations, including CNC milling, CNC turning, manual polish, assembly, quality assurance, welding and engineering; all machined parts made there way from department to department, traveling up and down the shop floor; and each department had a department head, foreman, and leadman. In addition there was a quality control staff responsible for checking work-in-process throughout the plant and a central tool crib where workers came to draw out any tools they required for their machines. The company also adhered to very traditional labor management relations: managers and engineers determined how work was to be conducted; shop-floor workers engaged in an "us against them" attitude; management regarded shop-floor workers as relatively interchangeable; and employee turnover at the plant was high.
Two ostensible developments—both related to customer relations—precipitated the radical organizational change that Brimfield Precision embarked on in 1991. The first development was a severe and entirely unanticipated downturn in business. Within an eight-day period in 1991, Brimfield lost three of its largest and most profitable contracts. Two of the three contracts were lost due to high costs. The loss of three high margin jobs simultaneously hit the company hard and left it in a position of having to turn a profit on jobs with much lower margins. According to Lyons, the loss of these contracts served as a catalyst to some company soul searching. What quickly became clear to Lyons was that the "gravy train jobs," as he referred to them, covered up organizational problems. When these jobs were lost, internal quality problems that were contributing to high costs were exposed. In order to make money off the remaining jobs, Lyons realized that costs needed to come down which meant internal processes had to be improved.

Together, Lyons and the department heads agreed that a company self-assessment was in order. The goal of the self-assessment was to identify factors that were contributing to high costs. The first two innovations the company implemented to assess cost and quality were statistical process control and total quality management. SPC and TQM revealed that internal scrap and rework rates were extremely high. Thus, while the company's external quality record was exemplary, internal problems were causing high prices and lost profit. The company began to track quality closely and was able to see specific improvements from the implementation of SPC almost immediately. To encourage and support employees to begin working in new ways, Lyons implemented monthly "Deming" meetings to familiarize everyone in the company with TQM. In meetings, employees were encouraged to talk about successes that resulted from SPC and TQM. According to Lyons, the implementation of SPC, TQM and Deming meetings was an important first step in raising awareness about the need to put new systems and new work practices in place.

Prior to the sudden downturn in business, Lyons had been casually familiarizing himself with the business philosophy of Edward Deming. Lyons had purchased a series of Deming's tapes through MIT's Sloan School of Management and had begun teaching himself the principles of Total Quality Management. Lyons' exploration of Deming and TQM intensified, however, because of the predicament the company found itself in. Having spent many years on the shop-floor working with the company's machinists, Deming's teachings resonated deeply with Lyons; he believed employees wanted to do a good job but needed better tools to improve internal quality. For a solid week following the business downturn, Lyons met with department heads, watched Deming tapes with them, and discussed the merits of TQM.
The second development precipitating organizational change was a new job Brimfield received from Johnson and Johnson. Brimfield so impressed J&J with the hip stem order that the company came back to BPI in less than a year with a knee instrument set that required manufacturing. The knee instrument order was precisely what Brimfield needed to develop expertise in the instrument side of the orthopedic market (something Lyons had been trying to figure out how to do for some time). However, the company had no prior experience making instruments and was entirely overwhelmed by the complexity of the order: 16,000 component parts comprising 1,200 instrument assemblies.

The new J&J order was generating internal production problems because there was now a large difference in quality standards among Brimfield's key products: orthopedic implants and medical instruments. Orthopedic implants are single machined pieces with extremely high tolerances and quality standards; instruments, on the other hand, require less precision but consist of multiple parts that require complex assembly. Under the company's existing form of work organization, employees worked daily on both implants and instruments. With over 16,000 component parts and 1,200 instruments in the J&J order alone, employees were mixing up tolerances and quality standards, contributing to high internal scrap rates and costs.

Lyons felt that the company's organizational structure was ill-suited to such a large, complex order. He believed that reorganizing the company into business units that focused people on product areas would help solve the problem. Shortly after the company began to manufacture the J&J instrument order, Lyons hired a management consultant (whom he identified through the local chapter of the National Tooling and Machining Association) to help him think through a new organizational strategy. Shortly thereafter, the company reorganized into four business units (implantable products, general instrumentation, minimally invasive surgery, and general services) and did away with its quality control department.18

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18 Implantable products, general instrumentation, and minimally invasive surgery are all production business units. General services is an administrative business unit. The business unit manager of the general services unit is the chief financial officer of the company. The unit is composed of administrative support staff and a Development Systems Coordinator who coordinates quality, training, and human resource activities across the production business units.
The New Work Organization

Each business unit at BPI currently employs between 20 and 30 people. Within each unit, cellular manufacturing has been implemented. Workers assigned to cells are organized into teams of 4 to 7 people. Team members are cross-trained in the tasks of the team and rotate jobs within their team on a regular basis. Team members, who typically work three or four machines, are responsible for designing and documenting their work methods and for scheduling production of their work. Each business unit has a "support team" which consists of a unit manager, a quality manager, an engineering manager and a production control manager. The support team's role is to facilitate the work of individual teams and to coordinate the workload of the business unit across teams. The support team also serves as the initial point of contact for customers. Customer feedback is routinely shared with teams and team members deal directly with customers when there are questions or concerns about particular orders or parts they have worked on.

Production teams interact with the support team on a continuous basis. Each team meets weekly with the business unit's production control manager to discuss scheduling. If team members have ideas about how to improve a production process, they meet with the engineering manager to discuss how to implement the changes. The quality control manager of the business units works with teams on paperwork, documentation, tracking and inspection techniques. Throughout the company, team members are encouraged to make changes to the production process that will improve performance. If the changes are small, employees are empowered to make them on their own; if the changes are large (e.g. require new tooling or reorganization of machines) the employee (or team) will meet with the engineering manager of the business unit to discuss the idea. Each business unit meets once a month to review on-time delivery, scrap rates, customer return rates and new business. At monthly meetings, team members are encouraged to share their ideas about how to improve work methods, decrease costs, and meet delivery schedules on time.

Results of Reorganization on Performance

BPI is now six years into the reorganization process. Combined with Lyons' aggressive commitment to customer expansion, the strategy appears to have paid off dramatically if measured in terms of company performance. Sales have nearly tripled
since the company reorganized (from annual sales of $5 million in 1992 to annual sales of $13 million in 1997). Between 1992 and 1997, the company's customer base also grew dramatically. While the company had only 3 major orthopedic customers in 1992, it has 12 today. According to Bill Lyons the company has experienced a 30% improvement in the costs of goods sold and has reduced customer returns from 8 to 2 percent of all goods shipped. Lyons reports that the company has also experienced considerable improvement in on-time delivery though this continues to be the company's largest performance challenge.\textsuperscript{19}

The best examples of how the new work organization has improved company performance came from interviews with employees of the business units. According to Daniel Szall, Business Unit Manager of Implants, employees in this unit decided from the beginning that the unit would be customer-focused. Currently, the unit consists of three teams. Each team is focused on a single customer and their products. The advantage to this approach, according to Szall, is that employees gain specialized knowledge of the customer and their product. This knowledge enables team members to continuously think about how to cut costs and improve the production process. In addition, because team members often get to know the customer on a personal basis, they are more willing to take the extra step when a customer requests a change or needs an order sooner than anticipated. "Teams have an incentive to come up with the best solution if there is a customer change," said Szall. "This willingness come from the team's relationship with the customer. In many cases, a strong relationship has been formed."

One team within the implants business unit is responsible for producing hip stems for Johnson and Johnson. This is one of Brimfield's oldest and most important contracts. The business unit produces 1,000 hip stems per month on average and can make as many as 1,600 per month in peak periods. In an effort to figure out how to increase the volume of the product without increasing the time, team members responsible for the hip stem measured the distance the product traveled through the company: altogether, the product was traveling 5,000 feet. In order to cut this down, team members reorganized

\textsuperscript{19} The source of on-time delivery problems is the complex nature of assemblies in the instruments department. Jobs in this business unit can consist of 80 or 90 components. Parts must all be ready at the same time in order to be assembled and shipped to the customer. Coordinating the flow of work through the shop on jobs of this magnitude presents real challenges in terms of scheduling and delivery.
equipment into a manufacturing cell to consolidate the production process. Now CNC machines and manual machines (both of which are required to make the product) are in the same cell and the product moves a total of 27 feet. Prior to cellular production it took 2.5 hours to make a single hip stem; today it takes 27 minutes. The number of employees it takes to produce the product has been reduced from 8 to 5. Following this example, the entire business unit was organized into manufacturing cells.

After several years of experimentation with different methods of organizing production, employees in the general instrumentation business unit determined that their work needed to be process focused as opposed to customer focused. Today, teams in this business unit are organized around the different processes that each part must go through (e.g. a milling team, a turning team, a toolmaker team, and a polishing and assembly team). Within teams, most employees are cross-trained to work on both CNC and manual machines. The instrument sets made by this business unit can consist of up to 43 pieces. Because there are so many parts made in small lot sizes, the key to productivity improvements in this business unit is reducing set-up time on machines. Prior to the reorganization, engineers who did not work on the shop floor prescribed the production process. Today, the machinists who set-up and breakdown the machines determine their own work processes with support from the business unit's engineering manager. "The engineering department used to call the shots but they didn't understand the product or the process," said one tool and die maker. "Now the people who have to do the jobs are involved in designing the work."

Impact of Reorganization on the Workforce

The impact of the reorganization on Brimfield's workforce has been decidedly mixed. While many employees find BPI a more rewarding environment to work in as a result of the reorganization, many others rejected the new work organization and either quit or were fired.

Immediately following the changeover to business units, 10 employees were laid off because they resisted the new work practices. By 1993, with the business units firmly in place, the company experienced 45 percent turnover. According to both managers and workers, many people were uncomfortable working in an environment that required
employees to communicate with one another and take responsibility for their work. According to several machinists who successfully made the transition to team production, the individuals who were fired or left were insecure about their abilities. "Some people just need to be told what to do everyday," said one machinist. "You have to be able to make decisions on your own in the new environment; some people just didn't fit in."

On the positive side, the benefits of decentralized team production for the individuals who made the transition are considerable. Employees who have been at Brimfield before and after the reorganization describe dramatic differences between the two work cultures. "This environment is more healthy, more encouraging, more stimulating, and more nurturing than the old ways," said one machinist who has worked in the trade for 32 years. "I can't say enough for it. There's no more boot-in-the-butt management." Another said, "I love the way the company is focused now in the team environment. Before you would go to a manager and they would say, 'you're a piece of garbage.' Now you are taken seriously." While employees expressed pride in their ability to improve production processes, save the company money, and meet customer due dates, the most beneficial aspect of the new work reorganization for shop-floor workers is clearly the sense of self-worth that stems from being able to "run with things," as one employee put it. Another benefit cited by employees was the increase in communication between shop-floor workers that resulted from team-oriented production. The new system requires workers to share information and communicate with one another on a regular basis. Many employees regard this as a benefit rather than a burden. "It's much more stimulating to deal with other people throughout the day," said one machinist. Describing monthly meetings, one employee in implants said, "Everyone is allowed to speak. There are lots of ideas, there are conflicting ideas, but its is a creative process if you structure it correctly. Nobody is put down for their ideas."

**Linking Organizational Change to Human Resources**

As a result of the employee turnover that occurred in 1993, the company developed and implemented an extensive employee screening process. Business unit managers now screen all incoming resumes. Once resumes make it past the business unit manager they go directly to the relevant team leader. Team members then review the
applicant and decide whether they want to proceed with an interview. Hiring decisions are made directly by the team. Once hired, new employees go through a two or three day orientation program in which they watch Deming tapes, learn about statistical process control, and are introduced to the company's philosophy. Recently, the Developmental Systems Coordinator of the company put together an interviewing handbook to help team members think systematically about what to look for in new hires. Team members who have been involved in the hiring process said that interviews now focus less on an individual's technical skills and more on personal attributes (e.g. will they be a good team member, are they comfortable expressing ideas and communicating with others etc.). As a result of the new screening, hiring and orientation procedures, both management and workers agree that the majority of people who work at the company today are people who like the company philosophy and want to work in an environment where independent thinking is valued.

The most problematic aspect of Brimfield Precision's organizational transformation is in the area of performance-based compensation. While management recognized early on that reorganizing the company into business units and production teams would require changes in the firm's incentive system, these changes were slow to take place. According to employees, many of the individuals who left the company in 1993 were frustrated by that fact that wages were stagnant for the first two years under the new system. Many employees simply felt they were being asked to do more work for the same pay.

In response to employee dissatisfaction, the company established an eight-person committee to research and recommend a compensation system that would promote the behavioral changes sought by the company. In 1993, the company implemented a profit-sharing plan and a high achievement award system. The original profit-sharing plan worked as follows: employees agreed to be paid 10% below average market wages in exchange for a profit sharing plan in which the first eight percent of profits went to stockholders and in which profits beyond eight percent were split 70/30 between employees and stockholders. The compensation committee determined that profit sharing checks would be distributed on a quarterly basis and that all employees would receive the same amount of profit regardless of their position in the company. To
complement the profit sharing scheme, the high achievement award was established to recognize employees who make outstanding contributions to the company through productivity improvements. Each month, the company accepts nominations for employee high achievement and one individual is recognized through receipt of a monetary award. Nominations are based on employee suggestions that have been implemented at the business unit level. At the end of the year, the 12 employees who have received awards are put into a pool and one employee is selected as the High Achiever of the year at which point the employee receives another monetary award.

Because the company did not exceed eight percent profits in the first two years of the program, employees received no profit sharing bonuses. At the beginning of 1995, however, because employees were working extremely hard to meet their profit-sharing goals, the board agreed to give a one time bonus of $500 to every employee. By the second quarter of 1995, the plan began to kick in: in the second quarter employees received an $800 bonus; in the third quarter employees received a $1000 profit-sharing check; and by the final quarter of the year they received $1700. According to employees, the profit-sharing plan provided a real incentive to "work smart" and figure out how to improve production processes. "The profit sharing plan was very lucrative," said a CNC machinist. "It took us a long time to meet our goals but when we did we made tons of money."

With the profit sharing plan finally producing significant bonuses for employees, it came as a real shock to the workforce when Bill Lyons doubled the amount of profit the company must make before profit-sharing kicks in. At a company-wide meeting in the fall of 1996, Lyons announced that the company needed more money to fund company expansion and growth and that that the first 16% of profits would now go directly to stakeholders. Lyons told employees that all of the additional profits reserved for stakeholders would be pumped back into the company in the form of new technology, product development, and marketing in an effort to further diversify and strengthen the company's market position.

The change in the profit sharing plan had a large negative impact on employee morale and motivation. Employees felt angry and betrayed by the announcement: after working for five years to improve productivity and processes in the plant to cut costs and
increase profits, their share of the pie was cut in half in one day. The upshot of the change in profit-sharing for employees is that they simply aren't motivated to work as hard. According to the System's Development Coordinator who oversees the high achievement award, nominations for high achievement have decreased 50 percent since the profit-sharing announcement. As one machinist put it, "now you know you're just going to get your paycheck whether you put your all into it or not." While none of the employees interviewed are contemplating employment alternatives, they believe people will leave if the situation is not addressed.

Another compensation problem cited repeatedly in interviews is the lack of team-based compensation. While it is primarily at the team level that productivity improvements are made, the company has no system in place to recognize team performance. Several employees said that team-based compensation was more important to them than profit-sharing and would provide a greater incentive to improve performance. While management is aware of the frustration over the lack of team-based compensation, it is unclear whether the company will implement changes in the near future.20

Enabling Factors in the Reorganization

Throughout the reorganization process, Bill Lyons' thinking and strategic planning was facilitated by a number of external resources. In addition to being a voracious reader of management literature, Lyons has also been very active in the local metalworking trade association—the National Tooling and Machining Association (NTMA). In the early 1990's, he represented the NTMA in a public-private industrial modernization program designed to provide training and technical services to small metalworking firms in western Massachusetts. In this capacity, he came into regular contact with consultants, trainers and academics focused on workplace transformation.

Lyons has utilized management literature, consultants, training and workshops on a regular basis to implement new forms of work organization. As noted earlier in the case study, Brimfield initially worked with a consultant identified through the NTMA to

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20 According to management, team-based compensation is extremely difficult to implement because the work of the teams is not comparable (e.g. parts vs. assemblies).
develop the business unit strategy. The consultant worked with BPI over a six-month period in 1992 to provide training to employees and implement the new shop-floor organization. In 1993, BPI participated in an NTMA-sponsored training in the principles of Kaizen/continuous improvement. BPI initially sent a team of employees to a large company in the region that had implemented Kaizen for a three-day intensive training. The training was so successful that two more teams of Brimfield employees attended. Following the off-site training, the three teams conducted in-house training once a month until the entire Brimfield workforce was trained in Kaizen principles. The Kaizen training resulted in the implementation of cellular manufacturing throughout the plant.

The company has also drawn steadily on the NTMA to identify qualified consultants to facilitate in-plant modernization projects that improve productivity. BPI has undertaken a number of projects in this category over the past six years including: the reorganization into business units; the purchase and implementation of multiple station CAD and CAM systems; and the automation of an existing assembly line. According to Lyons, each of these projects has had dramatic results for the company in terms of performance.

Conclusion

Brimfield Precision’s journey from contract machine shop into a precision manufacture with distinctive capabilities and products provides important lessons regarding firm-level change. As the case study demonstrates, BPI’s organizational transformation was a strategic response by the company president to changing market conditions. While the company enjoyed stable customer relations for its first 15 years, it found itself suffering repeated customer losses throughout the 1980’s. The company’s 1991 customer collapse could easily have led to collapse; that it did not is testimony to Lyon’s leadership skills and love of challenges. Lyons turned adversity into opportunity by using the customer collapse to assess internal production processes and rethink the company’s core activities. The assessment quickly led to the reorganization of production and employment structures within the firm.

Brimfield Precision represents a case in which market forces and managerial strategy/thinking came together to produce radical organizational change. What is particularly striking about the case is the absence of customer influence on the change
process. While many small firms adopt organizational innovations due to customer requirements, BPI anticipated changes in the medical supply market and organized itself to respond effectively to these changes. None of the changes BPI made were at the insistence of customers. Initially, in fact, many of BPI's customers were uncomfortable with the fact that the company had gotten rid of its quality control department. Today, however, BPI is at a large advantage among suppliers to the medical industry because customers are now demanding that suppliers demonstrate mastery of technologies such as TQM, SPC and ISO 9000. BPI is able to market itself as a small, flexible firm that has all of the newly required documentation procedures already in place. In addition, due to its business unit strategy, BPI is able to serve both the implants market and the instruments market; typically suppliers serve one sector or the other.

Bill Lyons active participation in community-based activities to develop and provide services to small metalworking firms in the greater Springfield area played an important facilitating role in the transformation process. His participation in these activities did not, however, cause him to undertake the reorganization. What Lyons' participation in the network did provide was a continuous venue for learning and a steady stream of reliable and cost-effective technical assistance. BPI's transformation effort has been long and hard and has required an incredible commitment from both Lyons and his employees. As the case study describes, employee turnover has been dramatic at times and moral continues to ebb and flow. Striking the right balance between employee motivation and compensation continues to be problematic as does recruitment of new employees. While BPI is a living, breathing example of how complex and difficult organizational change can be, it also demonstrates that small manufacturing firms are capable (with a great deal of determination) of moving from a position of market dependency to a position of market distinction.
Dienes Corporation

Introduction/Overview

Dienes Corporation, located in Spencer Massachusetts, is a manufacturer of machined compressor parts and circular slitting knives. It is also the North American distributor of computerized slitting machine tools for its parent company Dienes Werk, GMBH. From 1978 to 1990, the plant specialized in build-to-print compressor parts for the air conditioning industry. Throughout this period, Dienes Corporation adhered to a traditional form of work organization in which machine set-up, machine operation, and piece inspection were broken down and performed by separate employees. In 1991 as demand for compressor parts waned, the parent company decided to utilize the machine shop as a production facility for its growing line of circular slitting knives which are used in conjunction with computerized slitting machine tools.

Production of circular slitting knives required higher levels of accuracy and quality than compressor parts. The introduction of a new product line provided a catalyst for Dienes management to upgrade employee skill levels and reorganize the way work was performed in the shop. Beginning in 1992, Dienes embarked on a series of changes in work organization aimed at improving skills, quality, and efficiency on the shop-floor. These efforts included the integration of production job functions, reorganization of the shop floor into manufacturing cells, performance-based compensation, and documentation of work procedures through ISO 9000.

Dienes' experience with work reorganization has been decidedly mixed. Overall, skill levels at the company have increased over the last few years. Production workers have been transformed from low-skill machine operators to well-rounded machinists capable of machine set-up and inspection. This change has enabled the company to increase the volume, efficiency and quality of circular knife production. In other areas of work reorganization, however, the company has had limited success. Efforts to implement cellular manufacturing and performance-based compensation were ill conceived and fell apart rapidly. Rather than improve employee performance, these short-lived reforms demoralized the work force resulting in widespread cynicism and mistrust. The failure of these efforts—combined with poor shop-floor management—
have led to low morale and motivation among production employees. These problems, in turn, have inhibited progress in other areas of work reorganization such as the company’s ongoing effort to achieve ISO 9000 certification.

Today, the machined parts side of the business is in decline. As the competitive dynamics of manufacturing intensified in the early 1990’s, the contract manufacturing side of the company failed to define a target market or develop a specialty niche leaving itself vulnerable to competition from low cost competitors. Unable to meet customer performance requirements or offer customers price-cuts through productivity improvements, Dienes began to lose contracts steadily in the mid-1990’s. Dienes’ failure to respond to the new competition became painfully clear in 1997 when the company lost its single largest customer and contract—a $3 million order from Carrier Corporation for 50,000 oil pumps annually.

In 1995 the German owners decided to utilize Dienes Corporation as a North American distributor of its computerized slitting systems. These complex machine tools—which cost up to $600,000 a piece—are purchased by manufacturers who make products in sheet form. The slitting systems consist of circular knives in pneumatic holders controlled by electronic positioning systems that adjust the width of the cut automatically. The systems are built in Germany at the company’s headquarters. Dienes brokers the sale of the systems from start to finish and provides ongoing technical support to North American customers. Thus, for an increasing share of its business, Dienes employees are engaged in sales, technical assistance, and customer support as opposed to production. Over the past three years, all new hires at the company have been to support capital equipment sales.

Currently, Dienes management has no plans to invigorate the contract manufacturing side of the business; rather, it has decided the company should invest its time and energy in expanding the market reach of its specialized capital equipment. Dienes’ internal market shift is a telling example of the challenges facing industrial suppliers today. Parts suppliers that fail to differentiate themselves from the competition – either through unique products and services or productivity improvements that lower costs and prices – face the losing battle of price-based competition. Those firms that manage to develop distinctive products and services, however, stand a greater chance of succeeding in today’s competitive marketplace. Dienes Corporation
embodies both trends as it makes the difficult transition from a build-to-print machine shop to a customer-oriented provider of specialized machinery.

**Company Background**

Dienes Corporation is a wholly owned subsidiary of Dienes Werk, GMBH a family-owned company located in Overath Germany. The parent company makes computerized slitting tools, slitting knives and compressor valves. Dienes Werk acquired Dienes Corporation in 1978. Prior to acquisition by Dienes Werk, the Spencer machine shop specialized in the production of compressor components for over 30 years. Dienes Werk purchased the company because it sought a U.S. production and distribution outlet for its intake and exhaust compressor valves. The parent company made no changes in terms of company management or employment and the existing Vice President of the Spencer plant maintained decision-making autonomy.

From 1978-1990, Dienes continued to function as a large job shop, producing compressor components (including valves, lubricating pumps, and connecting rods) from blueprints for the air conditioning OEM market. Carrier Company and Hartford Compressors were among the company’s largest customers. The work was high precision and high volume but involved limited engineering and design work. According to employees who worked at the plant in this period, the organization of production had no rhyme or reason. The shop was disorganized, jobs didn’t have work packets, parts bounced around from department to department until finished, and shop-floor employees understood little about the manufacturing process because their jobs were broken down into repetitive tasks. According to the Sales Manager who has worked at the plant since the mid-1980’s, the lack of organization was possible due to “an endless supply of (contract machining) work.”

Beginning in the late 1980’s the ‘endless supply of work’ began to dwindle. In response, the parent company decided to utilize the Spencer facility to produce replacement slitting knives for its computerized slitting systems. The addition of circular slitter knives to the company’s product line coincided with a change in management. In

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21 Dienes Corporation is composed of four facilities: the company headquarters, located in Overath Germany, employs 200 people. This facility builds and assembles the computerized slitting systems.; a second Germany manufacturing employing 30 people makes replacement knives for the European
1989, Tom Weber, the Vice President and General Manager throughout the 1980’s left the company. The plant manager, Bill Shea, was promoted to the Vice President and General Manager role. Shea had come to Dienes from Warner Swasey where he had worked as an engineer. According to employees, Shea had a different management philosophy than Weber. Unlike Weber, Shea believed that shop-floor employees were capable of higher performance and would be more productive if they possessed a more comprehensive understanding of the manufacturing process. In addition, Shea recognized that the heightened competition of the 1990’s required the shop to become more systematic and organized in order to get a better handle on work processes, costs and delivery dates.

**Work Reorganization Efforts: 1992-1995**

The introduction of circular slitting knives to the company’s product line in 1991 provided the catalyst Shea needed to upgrade knowledge and skills on the shop-floor. The production of circular slitting knives required higher levels of accuracy and quality than compressor parts. Most shop floor employees, however, were unskilled machine operators. As Shea contemplated how to organize knife production, he concluded that skill upgrading on the shop-floor was an essential first step.

*Integration of Production Job Functions*

The first change implemented to respond to the need for greater accuracy and quality was the integration of shop-floor production functions. Historically, Dienes’ production workers were divided into three job categories: machine set-up, machine operator, and inspector. The result of this form of work organization was that machine operators understood very little about the product or process they were working on. According to one employee who has worked on the shop-floor for 18 years, the old system enabled people to “get away with not knowing the process.” For example, most operators did not understand set-up or calibration and were not able to read a micrometer (measuring instrument). Under this fragmented system, machine set-up people adjusted

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*metalworking market; a new manufacturing facility which produces knives for customers in other industries is located in Hungary. With 75 employees, this division of the company is growing rapidly.*
the machines to produce a specific part and roving quality inspectors conducted first
piece and final inspection; operators had neither the knowledge nor the incentive to take
on greater responsibility for the job.

Beginning in 1992, the company began the process of integrating the three
separate job functions into a single upgraded machinist position with responsibility for
machine set-up, machine operation, and inspection. The goal was that each operator
would eventually set-up his or her own machine, perform inspection and pass the job on
to the next work-station. The philosophy behind the change was that employees who
understood the production process would take greater responsibility for their output in
terms of accuracy and quality. In addition, it was believed that the new work
organization would decrease production lead times.

Integration of the separate job functions occurred gradually. The company spent
time and money training machine operators in set-up and inspection. In addition, existing
machine operators were made aware of the company’s new direction and were
encouraged to enroll in company-sponsored courses with local training providers to
expand and improve their skills. When new jobs opened up, the job description changed
and the company sought to hire individuals with higher skills. While most production
workers responded positively to the job change, a portion of employees was resistant.
According to Quality Assurance Manager Sandra Krasnecky, older workers (those 5-10
years from retirement) were the most reluctant to learn new skills or attend school.
Generally speaking, older employees were fearful of the change while younger workers
viewed the change as an opportunity to gain new skills and advance.

The integration of separate job functions into a single skilled machinist position
has changed the production workforce in several ways. The production workforce today
has a higher skill level enabling workers to take on more responsibilities. The company
no longer employs straight machine operators or roving quality inspectors. The quality
department which consisted of 6 employees prior to the change now consists of the
Quality Assurance Manager and one temporary employee. Another significant change as
a result of skill upgrading is the gender composition of the shop-floor. When the
majority of production workers were machine operators, the production workforce was
predominantly female; today the company’s production workforce is predominantly male
(though a number of female machine operators advanced to machinist through the job integration process). Through a combination of attrition and new hires, the integration of production jobs is now more or less complete.\textsuperscript{21}

\textit{Cellular Manufacturing}

With the production workforce taking on increasing responsibility for set-up and quality, Shea decided to take employee responsibility a step further and reorganize the shop floor into self-directed work cells.\textsuperscript{22} Shea's objective in implementing the cell structure was twofold: first, cells would increase workers' awareness of the product and work process, thereby increasing quality and productivity; second, cells would help the company get a better handle on costs associated with different products and processes. This latter objective was important because the company now engaged in two different kinds of production work: slitting knives and compressor parts.

The basic idea was that each work cell would function as a small business with its own product or process, employees and budget. To provide performance incentives, Shea determined that cell members would be rewarded with bonuses when the cell increased production, decreased rejects and/or increased quality. Cell leaders were recruited from the shop floor. These individuals worked with management representatives for several months to determine the cell structure and to physically reorganize the shop floor. This planning group determined that cells would be organized by process. For example, Cell #1 would be responsible for preparing all raw materials. Once prepared, the materials would be moved to Cell #2 where basic machining would take place. Cell #3 would then grind the materials and so forth. The only exception to this process orientation was the "Carrier" cell which was devoted to a single product for a

\textsuperscript{21} A number of employees commented that the company still has some "dead wood" in the production ranks (i.e. individuals who can't be motivated, pay no attention to quality, and repeatedly make mistakes despite the availability of training and direction from supervisors). Shop-floor leaders estimated that 20\% of production workers fit into this category.

\textsuperscript{22} The impetus for self-directed work cells and gainsharing came from a series of articles the company president read in a trade magazine. Shea spoke with the author of the article on the phone and they set up a meeting to discuss the concepts.
single customer. This cell, the group determined, would be dedicated to producing the Carrier pump from start to finish. In total, the shop floor was organized into nine cells each assigned the following tasks: determining work processes and documenting them; hiring and training new employees, incorporating inspection equipment into the cell, managing a budget, and determining new equipment needs.

Management and shop-floor employees had high hopes for cellular manufacturing. The cells were granted a tremendous amount of autonomy and responsibility for their own work and employees were excited at the prospect of performance-based bonuses. Disappointingly, however, the company’s foray into cellular manufacturing disintegrated before it ever really got off the ground. While the cells functioned to some extent for the first year, they deteriorated rapidly after that. Employees interviewed for this case study (including representatives of management) agreed that lack of management support doomed the cells to failure.

The major problem recounted by employees was management’s faulty assumption that employees would know what to do once they were given greater authority. In reality, employees found increased responsibility daunting and felt ill equipped to make production-related decisions. While these problems could have been addressed through ongoing training, supervision and coaching, management failed to provide consistent support of this nature to the cells. Nor did management foster an environment in which employees felt safe to express their concerns about the lack of support. Several employees complained that the plant manager at the time did not get involved in the cells or champion them. Rather than drive change, the plant manager adhered to an authoritarian management style that was both condescending and intimidating.

According to Sandra Krasnecky, the Quality Assurance Manager, people simply did not know what was expected of them and were afraid or embarrassed to ask. “The company needed to hold the hands of the cells for at least 18 months and it didn’t,” said Krasnecky. “A lot more support was needed. It’s not the employees’ fault that the cells didn’t take off, it’s management’s fault for not providing more support.”

Another problem that quickly arose was competition among the cells. While the cells functioned autonomously in many respects, they were also interdependent as each

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23 From 1993 to 1998, Dienes produced 50,000 pumps annually for the Carrier Corporation.
cell depended on the cells preceding it to deliver the job on time and to specification. When a cell received a job from the preceding cell with a problem, blame made its way around the shop. For example, if Cell 3 received materials from Cell 2 that had to be reworked, Cell 3 would charge Cell 2 for that work. Cell 2, in turn, would contest the charge claiming the problem occurred in Cell 1. In addition, some cells felt they were working harder than others. The Carrier Cell, for example, made the same product on a repeat basis while other cells were constantly setting up and breaking down machines to produce different orders. As a result of these problems, cells were pitted against one another just months after they were implemented. The competition divided the shop and contributed to employee stress. Rather than address these issues head on through shop floor meetings, management drifted, leaving the cells to fend for themselves.

The final blow to the cell structure came with management’s failure to follow through on promises of financial bonuses for productivity improvements. Though performance bonuses formed the centerpiece of the original plan, management was unable to devise a system for measuring cell performance. There were two components to the measurement problem: first, management had no baseline data against which to measure productivity improvements; second, cells were performing different procedures on different products making it difficult to compare performance across cells. Rather than address these difficult problems and work toward solutions, management simply ignored them.

ISO 9000 Documentation

At the same time Dienes undertook work cells, it also undertook an effort to conform to the international quality standard, ISO 9000. The impetus for ISO came from Dienes’ largest customer, Carrier Corporation. In the early 1990’s, Carrier began establishing performance standards for vendors including ISO 9000. Representatives from Carrier came to Dienes on two separate occasions to survey the shop and administered questionnaires to managers regarding quality and documentation procedures. These audits highlighted something Dienes management already knew: that documentation of work procedures throughout the company was poor. After some consideration, Shea decided that Dienes would pursue ISO 9000 certification. ISO certification would serve a twofold purpose: it would satisfy Carrier’s request that the
company become more systematic while increasing employee awareness of procedures and work processes. Furthermore, responsibility for ISO procedures could be integrated into the work of the cells.

In the Spring of 1994, Shea and Sales Manager Allen Gamache, attended an ISO training consortium with representatives from four other local companies.\textsuperscript{24} Upon course completion Shea and Gamache showed videotapes describing the ISO process to small groups of shop-floor employees. The idea was to familiarize the production workforce with ISO and gain their support for the undertaking. In theory, each cell would have responsibility for documentation of work instructions and procedures and for filling out the paperwork associated with ISO. In practice, however, it didn’t turn out this way. According to Gamache, shop-floor employees never bought into the ISO process. For employees—already uncertain of their new responsibilities as cell members—ISO was a burdensome load of paperwork that took time away from the job. In addition, employees were intimidated by the possibility of audits. Despite these problems, management persevered and company president Shea worked diligently with Quality Assurance Manager Sandra Krasnecky to produce the required work instructions.

As the company came closer to anticipating a formal audit, Shea asked Gamache to form an internal audit team to evaluate cell performance. The audit team picked the Carrier cell because it was considered exemplary. From the beginning, this cell had been hardworking, organized and receptive to change. The audit’s results were discouraging: the cell didn’t conform precisely enough to ISO; pieces were missing from work packets; and work tasks were not signed off. At this point, the ISO effort lost momentum and the formal audit was postponed indefinitely. As a result, Dienes failed to meet supplier performance requirements established by Carrier Corporation – its single largest customer.

Results of Reorganization on Performance

Dienes Corporation’s experiments with work reorganization fell far short of expectations. Employees note that the integration of job functions has led to a general

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\textsuperscript{24} According to Gamache the group was called the New England Consortium, a public-private effort that received state money. Dienes participated in the training in 1994.
upgrading of skills, quality, and productivity and that the shop has become more systematic through the partial documentation of work processes and conformance to ISO 9000 principles. Jobs now have work packets and make their way through the shop in a more orderly way. Knife production which began with 10 a day in 1992 had increased to 100 a day by 1998. According to employees, the quality of the knives has improved significantly and machinists have achieved much greater tolerance and accuracy levels.

These improvements have not been enough however, to maintain contracts in the compressor parts division of the company. While contracts for machined parts had been stagnant since the early 1990's, this side of the business declined rapidly with the loss of two big contracts in 1997. Without warning, in early 1997, Carrier Corporation yanked the $3 million pump contract from Dienes and gave it to an English company that produces the pump for 25 percent less per unit.26 Later that year, a key customer located in nearby Worcester, MA informed Dienes it was negotiating with an Indian company to produce a high volume order (50,000 pieces annually) that Dienes currently supplies. As with the Carrier order, Dienes is being undercut on price: the Indian company proposes to supply the part at 30 percent less per unit than Dienes.

Impact of Reorganization on the Workforce

Employees recognize that skill levels have increased throughout the shop and that the organization of production is more systematic than before. These improvements, however, are outweighed by the far-reaching negative impact the demise of the manufacturing cells had on employees. Instead of spurring creativity and motivation on the shop floor—as both management and employees hoped—the cell experiment led to widespread cynicism and diminished morale.

Employees expressed a range of emotions—from disappointment to relief—when asked about the failed cells. A former cell leader who has been at the company 16 years recalled the anger he felt toward management. “A lot of us were trying and we put a lot of time and effort into the cells. We were pissed off at the way everything just went

26 According to the Sales Manager of contract manufacturing, Carrier provided no warning, “they just pulled the plug.” It should be noted, however, that Dienes failed to comply with Carrier’s requests for ISO 9000 certification. Furthermore, due to failure of the manufacturing cells, Dienes was unable to get a
away.” The Quality Manager expressed disappointment at a lost opportunity. When the cells began she envisioned herself traveling to other companies to provide seminars on the benefits of self-directed work teams. Today, she said, she could “only teach about their pitfalls.” A machinist who worked at a large aerospace shop before coming to Dienes four years ago, believes the cells were premature. “The company wasn’t ready for cells. We didn’t know our product well enough. I was relieved when they fell apart. They divided the shop terribly.”

Perhaps the most damaging, long-term consequence of the failed cells, however, is the lack of trust it generated among shop-floor employees. Employees repeatedly noted that the past two shop-floor managers lacked people skills, were unapproachable, and did not support either the cell concept or ISO 9000. As a result, shop-floor employees no longer have faith in management’s word and this has led to morale problems. A female machinist with 18 years at the company, said that shop-floor employees are now skeptical of management. “People are past anger to apathy,” she said. “They don’t care anymore—management lost credibility.” Similarly, another machinist said, “Management has lost some credibility with employees. People don’t trust management anymore.” These themes—broken trust and low morale—were sounded repeatedly in employee interviews.

**The Failure of Management to Support Organizational Change**

As noted earlier, both employees and management representatives attribute the cells’ failure to lack of management support. But this begs the question of why management didn’t do more to insure the success of the cells. After all, it was the President of the company that initiated cellular manufacturing in the first place. Through interviews, three themes emerged that help explain what happened.

The first theme involves the underlying culture of the company. Despite a verbal commitment to workplace change from the President, Dienes remained a traditional company in most respects. Presumably, cells were charged with transforming company culture. However, besides the cells themselves, few mechanisms were in place that would enable this transformation to occur. Cells were given large degrees of autonomy, but

handle on work processes and costs associated with the contract and therefore made no effort to bring costs down on an extremely profitable job.
communication between the shop floor and management remained very poor. There were no company-wide meetings to discuss the progress of the cells, no mechanisms for company-wide problem-solving, and no mechanisms for ongoing employee input and feedback. In addition, shop-floor managers never bought into the concept of employee involvement. According to employees, shop-floor managers were routinely patronizing and critical and failed to display the very spirit of teamwork required of the cells. As a result of these organizational shortcomings, when cells faced problems—as they inevitably did—they were left to their own devices to solve them. While autonomy is a key ingredient of the new work organization, employees were simply unequipped to handle this level of responsibility at the beginning. By failing to foster an environment in which employees could safely voice their concerns and seek help, management undermined the growth and development of the cells.

The inability to forge fundamental changes in company culture is related to the second theme: management's lack of experience and skill in the realm of organizational change. Stated simply, Bill Shea bit off more than he could chew with the cells. Shea believed in the cell concept in theory. However, he lacked the knowledge or skills to work through the complicated implementation of cellular manufacturing and performance-based compensation. While this knowledge could have been developed internally over time or purchased through the use of consultants, it would have required a large commitment of time and resources—a commitment Shea was unwilling or unable to make. As the magnitude of the changes required—both organizational and cultural—became clear, Shea buckled. Rather than providing decisive leadership in the face these unanticipated and difficult challenges, he simply let reorganization effort collapse.

The third theme involves the company's lack of clarity in terms of product strategy. Overlapping the period in which organizational changes were being implemented on the shop-floor, Dienes' parent company decided to utilize the Spencer facility as the North American distributor of computerized slitter tooling. By using Dienes as a distributor, the parent company hoped to gain a larger foothold in the North American market. Because sales for contract manufacturing services were flat by this time, Shea agreed with the German owners that this was a sensible strategy. As a result of this shift in product emphasis, Shea began to focus his own energy and that of his sales
staff on marketing the slitting machinery to potential customers. Between 1994 and 1997, the capital equipment side of the business grew quickly. Within just two years, sales of the slitting systems came to represent a majority of company sales. In 1996, the manufacturing company 3M bought several Dienes slitting systems to convert its Scotch Tape—which is produced in rolls five feet wide—to the ¾ inch rolls packaged for retail sale. In 1997, Dienes sold two large systems to a Canadian newsprint company for $1 million a piece. As sales of these systems began to grow, greater attention was being paid—company wide—to sales, engineering and customer support as opposed to shop-floor production.

Conclusion

The combination of a demoralized shop-floor workforce and a rapidly shrinking customer base has led Dienes to abandon any serious thoughts of revitalizing the contract manufacturing side of the business. Instead, Dienes has now turned its attention to capturing a larger share of the North American market for computerized slitting systems.27 This internal product shift will require Dienes to hire different kinds of employees in the near future. As noted in the introduction of the case study, the slitter systems are built by the parent company in Germany. Dienes brokers the sale of the system from beginning to end and provides ongoing technical support to North American customers. As a result, the company’s core activities are moving away from manufacturing toward sales, engineering and customer support.

As Dienes makes the transition from a build-to-print machine shop to a supplier of high-end capital equipment, the need for customer focus and service is heightened. Bill Shea continues to insist that the company is committed to documenting internal work processes, improving upon them, and becoming customer focused. Whether the company will be able to accomplish these goals in the context of a new product market, however, remains to be seen.

27 According to the company Sales Manager, Dienes faces only a handful of competitors for computerized slitting systems in North America. The main competitor is a company called Tilden based in Washington State. Tilden is much larger than Dienes and has a much greater market presence but Dienes has managed to capture an increasing share of the market through an aggressive sales effort.
III. Analysis

Through the case studies presented in this chapter, I have attempted to demonstrate why adoption of new forms of work organization must be analyzed in the context of each firm’s market environment and overall strategy. Implementation of the new work organization does not typically occur in isolation; rather, as the case studies illustrate, it occurs in the context of a larger competitive strategy that is likely to include complimentary changes in technology, products, marketing and customer relations. The case studies do not indicate that changes in work organization alone are enough to insure firm survival and growth. They do indicate, however, that when changes in work organization are embedded in a broader strategy of product specialization and customization, firms stand a good chance of surviving and growing in the new industrial soil.

In the two ‘transformed’ firms—Brimfield and Interstate Design—changes in work organization are made in the context of broader strategic responses to new market dynamics. To escape cut-throat, price-based competition, Brimfield Precision pursued higher end markets by developing expertise in the design and engineering of complex medical implants. Employee-centered work organization enabled the firm to become highly customer-focused while simultaneously bringing costs down. Interstate Design’s organizational transformation was driven by the new customer-supplier paradigm—preferred supplier partnerships—that now characterizes the aerospace industry. IDC made a strategic decision to seek preferred supplier status and to implement the requisite changes in technology and work organization this entails.

In contrast to Brimfield and Interstate Design, Dienes and Stan-Allen failed to develop effective responses to new market dynamics. These firms lacked the strategic
vision and/or customer relationships that facilitate adoption of the new work organization. Dienes failed to develop a niche market for its contract manufacturing division and was unable to master new forms of work organization that might have enabled it to compete effectively in mass production markets. As a result, the company left itself wide open to low-cost competition and its contract manufacturing division declined. Stan-Allen also failed to anticipate the severity of price-based competition. In response to declining market share, the company lowered prices and intensified existing production practices; this strategy proved unsuccessful, however, as sales stagnated. After several unprofitable years, the company turned to new leadership. In the context of a sophisticated, market-driven strategy, new management began to modernize and streamline key aspects of the work process and implement new forms of work organization.

The case study evidence suggests that to succeed in the new economy, small firms must change in fundamental ways. Maintaining the status quo, as the cases of Dienes and Stan-Allen reveal, is akin to industrial decline. The widespread availability of computerized machine tools leaves production firms that fail to develop specialized products vulnerable to price-based competition. Competing on price for precision parts is a losing proposition for most firms because customers can seek out lower and lower prices around the globe. For capital equipment firms, change is equally necessary. Though capital equipment firms are specialty producers by nature, they too are increasingly subject to price-based competition. Many capital equipment firms have relied on their unique production capabilities and have failed to modernize other aspects of the business enterprise. As other firms develop more sophisticated marketing, pricing
and throughput strategies, product distinction no longer provides sufficient competitive advantage.

If what I have argued is true—that small firms must simultaneously adopt more flexible and systematic forms of work organization while customizing products and services—the question remains whether this is a strategy available to all firms. The case studies suggest two scenarios. In the first scenario, the firm pursues the two critical dimensions of change due to the presence of skilled leaders capable of conceptualizing and then implementing a strategic plan. In the second scenario, the firm pursues the two dimensions of change in the context of the customer-supplier partnership. In this case, the strategic response is shaped, and in many respects scripted, by explicit customer requirements. The next logical question is what proportion of small industrial firms fit either of these descriptions? While we can’t answer this question definitively, the survey data provides some indication. The survey data suggests that approximately half of all sampled firms are pursuing a strategy of innovation and growth (20 of 40 firms) and that 30 percent of this group (6 of 20 firms) are engaged in preferred supplier partnerships. While these attributes do not guarantee that firms will pursue the two necessary dimensions of change, they provide a helpful gage. Based on this rough calculation, we can assume that a large proportion of firms (at least 50 percent) are not equipped to launch an effective response to new market dynamics. What are the implications of this finding? Should firms that are unable to respond effectively to the new competition be eligible for assistance or should they be left to stagnate and/or fail? These questions are addressed in the concluding chapter of the dissertation.
Chapter Five: Conclusions and Policy Implications

Overview

The redistribution of manufacturing employment toward smaller units of production represents a major change in the industrial landscape of the United States over the past two decades. As noted in the Introduction, this shift is the result of three interrelated economic phenomena: de-industrialization; the globalization of production; and lean manufacturing. The rise of international competition in the 1970’s led to secular decline in traditional manufacturing industries throughout the 1980’s as U.S. markets were captured by lower cost producers abroad. The vast majority of this decline was in large manufacturing facilities committed to mass production. In addition, the globalization of manufacturing—enabled by breakthroughs in communication and transportation technologies—encouraged many remaining mass production manufacturers to seek out lower labor and regulatory costs through off-shore production strategies. Finally, beginning in the mid-1980’s, many large U.S. firms began to downsize as they pursued ‘lean production’ strategies and returned to ‘core competencies’ in an effort to reduce costs and improve productivity.1 Taken together, these three developments have led to a reconfiguration of manufacturing employment: since 1967, the proportion of American manufacturing workers employed in small establishments has risen from 54.5 to 65.7 percent.

1 Lean manufacturing strategies have resulted in more and more large manufacturers contracting out operations such as tool design, parts production, sub-assembly, and transportation to smaller, less expensive suppliers.
At a time when more Americans are employed in small manufacturing firms than ever before, this sector of the manufacturing economy faces daunting challenges. Throughout most of the post-war period, large U.S. manufacturers pursued mass production strategies characterized by slow product changes and subordinate supplier relations. As Phillip Shapira and others have noted, this production regime promoted a supply base that lacked technological or managerial dynamism (Shapira 1995, pg. 5). The increasingly competitive manufacturing environment of the past 15 years combined with the shift toward ‘lean’ production has driven fundamental change in the small firm environment. New customer requirements for continuous improvement in quality, delivery and price have placed intense pressure on small firms to modernize and systematize all aspects of production. And increasing demands by customers for co-engineering and sub-assembly have heightened the complexity and importance of suppliers’ role in the production chain.

My research has demonstrated that the adjustment process underway in the small firm sector is a complex one requiring dramatic change at many levels. The model of the small firm owner as technical expert fit well with the mass production manufacturing environment in which markets were predictable, work was abundant, technology didn’t change rapidly, and customer requirements were far less stringent. Under these stable conditions, many small firm owners were able to handle multiple aspects of the business including day-to-day management of the shop floor, customer relations, sales and marketing, and technology acquisition. Over the past decade, however, performance requirements have increased so dramatically that few firm owners can handle these same responsibilities alone. In contrast to large firms where management layers have been
reduced in an effort to unleash the creativity of front-line workers and/or downsize, the growing complexity of the small firm environment is causing management layers to multiply. Today, small firms must dedicate an increasing amount of time to strategic planning and marketing activities. In addition, customer documentation and quality requirements are driving a ‘bureaucratization’ of the small firm environment through a dramatic increase in paperwork. As a result of these changes, the managerial function in small firms is growing and requires a level of knowledge and sophistication unanticipated just a decade ago. While technical expertise is still essential, it is no longer sufficient to run a successful small company.

At the level of the shop floor change is also sweeping. For production employees, the new work organization represents a much more social model of work organization than its predecessor. Accustomed to working alone and secure in the knowledge of their technical expertise, shop floor employees are now expected to be communicative, responsive, flexible and team oriented. These changes are antithetical to the craft tradition of individualism and can generate stubborn, shop-floor resistance.

**Small Firms and ‘Industrial Policy’**

The ability of U.S. suppliers to navigate the adjustment from the ‘mom and pop’ shop to the ‘high performance’ small firm is of more than academic interest. Over the past decade, policymakers at the state and federal level have taken a keen interest in small firm modernization and in public policies that support industrial upgrading of the supply base.
The case for government support of small firm adjustment strategies varies at the state and federal levels. At the state level, the key driver of government support is the preservation of existing firms and manufacturing jobs (Feller, 1992; Teitz, 1994; Eisinger, 1995). As the case studies in Chapter 4 demonstrate, small firms that fail to meet customer requirements lose contracts—often to firms in other states. Repeated losses can and do result in lay-offs and plant closing. By supporting the development of capable suppliers, state policymakers strive to maintain (and expand) their states’ small firm manufacturing base which provides a larger share of manufacturing employment and revenue than ever before.

At the federal level, interest in small firm adjustment strategies is somewhat different. Here the goal is not to keep manufacturing jobs within state lines but rather to strengthen the supply base as a whole. Over the past fifteen years, U.S. firms have accelerated global sourcing because off-shore suppliers are frequently regarded as superior to U.S. suppliers in price, quality and service (Office of Technology Assessment, 1990; Simmons, 1993, Shapira, 1995)). Many routine types of production have already gone overseas and increasingly, complex, high-skill work is being sourced globally as well. Accordingly, unless U.S. suppliers can adjust their production strategies to meet or exceed those of off-shore competitors, they risk loosing more and more business and jeopardize the overall vitality of America’s manufacturing economy.

In *Empowering Technology: Implementing a U.S. Strategy* (an authoritative review of Clinton/Gore technology policies by an interdisciplinary working group at the

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2 In my interviews with General Electric Aircraft Engine suppliers, for example, I was told that GE is establishing training centers for suppliers in countries such as Israel, Spain and Ireland.
Center for Science and International Affairs (CSIA) at Harvard’s Kennedy School, Gene Simmons states that

the underlying premise (for a federal manufacturing initiative) is that the key cause of decline in U.S. manufacturing competitiveness has been the inability of smaller manufacturers to implement manufacturing process technologies and techniques which would support high-quality, low-cost production while allowing for rapid changes in product design. There is widespread acceptance of this belief. The large American original equipment manufacturers (OEM’s) have increasingly turned to off-shore suppliers because they are often considered superior to U.S. firms in price, quality and service. (Simmons 1993, pg. 169).

The CSIA working group reviewed the premises for an expanded federal role in small firm modernization, found them to be sound, and concluded that there is a rationale for government participation in industrial extension. In addition to the underlying premise noted above, the premises the CSIA group found compelling include the following (Simmons, 1993 pp. 175-176).

- Smaller manufacturers provide the infrastructure (supply base) of U.S. industry; improving their competitive capabilities is essential for expansion of industrial activity;

- Smaller manufacturers are increasingly being called on to participate in the design and redesign of their customers’ products, that is, the role of the smaller manufacturer has changed from ‘make-to-print’ to the sale of their knowledge or core competence.

- Many smaller manufacturers are deficient in modern manufacturing technology and practices, lagging their offshore counterparts, thus limiting their productivity and their contribution to the infrastructure;

- Improving the competitive capability of smaller manufacturers is a function of their ability to increase their productivity through the adoption of advanced manufacturing technologies and practices;

- Industrial extension services are able to transfer advanced manufacturing technologies to smaller manufacturers and assist them in implementing permanent improvements to their processing capabilities.
• Publicly funded industrial extension services operate for the public
good and provide a long-term economic benefit to their service
regions.

Federal involvement in small firm modernization is relatively new. Throughout
the 1980's, de-industrialization and its fall-out (i.e. plant closures, job loss, regional
decay) was met with inaction at the federal level. The explicit position of both the
Reagan and Bush administrations was that the economy would function best if
government did not interfere. Reagan and Bush limited the federal role to support for
basic research and to establishing market incentives (e.g. tax reduction and deregulation)
for business. (Dewar, 1992; Feller, 1992; Branscomb, 1993) According to Lewis
Branscomb, throughout the Reagan-Bush years “any hint of ‘industrial policy’ or of
picking ‘winners and losers’ or of strategic planning of the economy was castigated as
harmful to private industry and the economy.” (Branscomb, pg. 4)

The response to de-industrialization at the state and local level was quite different.
Throughout the 1980's, state governments became increasingly active in the realm of
economic development. Moving beyond traditional inducement policies to attract new
business (i.e. ‘smokestack chasing’), state governments began to develop a broad range
of technology and industrial policies to foster indigenous economic growth. The
modernization of existing small manufacturers quickly became a major thrust of new
state economic development efforts. Reeling from large firm job loss, state officials in

3 Though the explicit commitment of the Reagan administration was to laizes-faire, its implicit policy was
support of the defense-industrial complex through the largest, peace-time build-up of defense capability in
U.S. history.

4 In a review of state science and technology programs Feller (1992) notes that small firm modernization
policies and programs are part of a larger package of ‘demand-side’ state economic development policies
aimed at fostering economic growth. These include: 1) research infrastructure/human capital; 2)
generic/precompetitive research; 3) spin-off/product development; 4) technical assistance/manufacturing
modernization.
hard-hit regions such as the Midwest and Northeast quickly recognized that small firms anchored manufacturing employment in their states. In response, states such as Michigan, Pennsylvania and Massachusetts began to implement an array of technology and training programs aimed at enhancing the capabilities of these firms. Other states followed suit: by 1991, 28 states had implemented some type of manufacturing modernization program aimed at upgrading the technology and business practices of small manufacturers. (Clark and Dobson, 1991). Irwin Feller notes that state governments’ increasing activism in the 1980’s was spawned, in part, by federal inaction. Confronted by the Reagan administrations’ refusal to adopt ‘any semblance of an industrial or regional economic policy, state governments had to act if economic recovery initiatives were to be undertaken; they acted.’ (Feller, 1992)

The election of Bill Clinton and Al Gore in 1993 reversed the ideological bias against ‘industrial policy’ at the federal level. Clinton/Gore shifted the federal emphasis away from technology creation (i.e. R&D) toward increased support for the adoption and application of technology by firms and individuals (Branscomb,1993). An important thrust of Clinton/Gore’s more activist technology policies was federal support for state industrial extension through the establishment of the Manufacturing Extension Partnership (MEP). Through MEP, Clinton/Gore pledged to create a national system of manufacturing extension building from state-level experimentation. Importantly, the MEP recognized that small firm adjustment strategies must utilize local knowledge and be implemented by state and local organizations. Since 1993, existing state programs have been expanded and new centers have been established. By 1997, MEP operated in

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5 The MEP is administered by the National Institute of Standards and Technology (NIST) under the federal Department of Commerce.
all 50 states. Federal funding for MEP has increased steadily since 1993 though it remains quite low. In FY 1998, Congress allocated $112 million for MEP (to be matched by state funds and user fees)—a sixfold increase over 1993 funding (Shapira, 1998).

**Government Capacity**

While the case for state and federal activity in the realm of small firm adjustment is relatively straightforward, the ability of U.S. government at either level to impact the productivity and competitiveness of small firms is largely unknown. In a review of industrial policy debates (which raged in the 1980’s and early 1990’s) Margaret Dewar defines two key unresolved issues with respect to direct government intervention into the industrial economy:

The first is whether knowledge exists on which to base a policy either to revitalize industries or to facilitate the growth of others in ways that will result in net growth in the economy. The second is whether policies that target industries can be implemented successfully to enhance national growth. (Dewar 1992, pg. 214)

These two issues remain unresolved in the realm of small firm adjustment policies as well.

- **Does Knowledge Exist to Base Policy On?**

Over the past decade there has been an accumulation of knowledge (through surveys, case studies, and inventories) regarding the adoption and non-adoption of modern manufacturing technologies and business practices in the small firm sector (cites). Studies indicate that adoption rates are sub-optimal and there is a large degree of consensus in the literature regarding the barriers firms face. In chapter Three I provided a review of these obstacles which I grouped into three broad categories: incentives, resource constraints and limited learning opportunities. Overall, the small firm literature has provided a compelling definition of the 'problem.' There is far less knowledge or
consensus, however, about how public programs can reduce the barriers firms face or influence firm-level decision-making and behavior.

Despite fairly widespread experimentation at the state and local level in the 1980’s, manufacturing modernization efforts remained largely untested by the time the federal government stepped in. For the most part, existing evaluations of state programs were anecdotal and journalistic accounts that existed primarily to justify continued state support (Feller, 1992). In 1993, when Clinton/Gore released their technology policy statement—*Technology for America’s Economic Growth*—scant knowledge existed on which to base a federal program. As the CSIA working group at the Kennedy School stated at the time:

There exists little formal analysis of industrial extension to indicate which are the most effective approaches to providing these services, the extent to which services are already provided by the states or by large corporations for their suppliers, and whether these services have the desired impact on the small manufacturers’ productivity and competitiveness, resulting in an improvement of the manufacturing sector of the economy (Simmons 1993, pg. 175).

As the federal Manufacturing Extension Partnership ramped up between 1993 and 1995, concerns over program evaluation and design were raised by interested members of the academic and policy communities. Many of these concerns were voiced in a special edition of the Journal *Research Policy* which dedicated an entire issue to the evaluation of manufacturing modernization. An overarching concern expressed by authors was the fact that rapid expansion of the MEP system made it impossible to begin with an experimental design that could systematically permit tests of the variables and relationships likely to impact the effectiveness of industrial extension centers. An important example of this concern regards service delivery strategies. Without the benefit of rigorous evaluation or analysis, the MEP quickly settled on the ‘one-on-one’ field
agent approach to industrial extension as the dominant form of service delivery. Several observers of the program questioned this initial design choice noting that it might not be the most effective way to approach firms or influence their behavior. Based on their own review of 35 manufacturing modernization programs operating in 20 states, for example, Kelley and Arora (1996) found that public programs that promote inter-firm learning and stronger linkages between technology leaders and followers (i.e. customers and suppliers) are more likely to address the underlying problems thwarting technology adoption than ‘one-on-one’ approaches. Similarly, Feller et. al. (1996) noted that firms’ low response rates to offers of assistance from extension centers were more likely to reflect ‘limitations of dominant paradigms of what firms need and how to approach them’ than firms’ overall receptivity. Missing, as the MEP expanded, noted Feller et. al., were studies focusing on ‘the decisionmaking processes within firms that lead them to be receptive or indifferent to the overtures of manufacturing modernization services or related offers of improvement.’ (pg. 311).

Since 1994, evaluation of MEP performance and effectiveness has increased. MEP is measuring program outcomes using three different techniques including follow-up surveys with participating companies; a series of quasi-experimental studies that compare performance in participating and non-participating firms; and a series of case studies of exemplary firm ‘engagements’ based on a conceptual model linking services to program outcomes. (Oldsman and Luria, 1998). The main thrust of these efforts is to

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Feller (1992) notes that the current field agent or ‘one-on-one’ approach to industrial extension stems from the service delivery model adopted in the 1950’s by state engineering universities, such as Georgia Tech, that disseminated technical information to manufacturers. This model, in turn, was borrowed from Agricultural Cooperative Extension Service established in 1914 to communicate new technologies and products to farmers.
demonstrate whether (and how) firms benefit from participation in MEP. As such, existing evaluation efforts are not contributing to greater knowledge about the most effective ways to change firm behavior or performance; rather, their primary purpose is to provide a justification for continued funding of the MEP program. More complicated questions such as which delivery approaches are most effective, which services have the greatest impact on performance and what causes small companies to adopt practices that lead to higher performance in the first place have gone largely unanswered.8

- Can Policy Be Implemented Successfully to Enhance National Growth?

The United States' limited experience with 'industrial policy' suggests that direct government intervention into the economy can have perverse and unintended consequences. In his book When the Machine Stopped, Max Holland demonstrates how federal defense spending inadvertently damaged the competitiveness of the U.S. machine tool industry. Throughout the Reagan years, defense contracts absorbed 20 to 30 percent of domestic manufacturing output. Machine tool producers working on defense contracts put their best efforts into machines for defense purposes where they faced few cost constraints. As a result, they neglected large domestic and international markets for standardized, lower-cost numerically controlled machines. By the mid-1980's, foreign companies (particularly Japanese and German) had captured 50 percent of the American machine tool market (Holland, 1990; McKinsey, 1993). Today, only a handful of large, machine tool producers remain in the U.S.

7 Youtie and Shapria (1998) have assembled a Summary of Manufacturing Extension Impact Studies 1994-1998 which lists a total of 30 studies. The majority of studies are conducted by researchers affiliated with state programs or by MEP.
8 See Oldsman and Luria (1998) for a review of MEP's evaluation efforts and recommendations for how to improve the current evaluation system. Overall, they recommend a greater emphasis on learning within the evaluation system.
Unlike the story above, the effort to establish a national system of manufacturing modernization centers is unlikely to have a dramatic negative impact on the performance of small firms. Given the system’s limited funding, its dispersed geographic nature and its low-level of penetration into the industrial community, it runs the opposite risk: having no impact at all. As currently funded and implemented, the MEP is a tepid public policy unlikely to impact manufacturing productivity or growth. This stems from the program’s ‘universal’ (vs. ‘targeted’) nature. To make ‘industrial policy’ palatable, all states and localities have been eligible for federal MEP money through several funding rounds beginning in 1993. Variations in the ability of state and local actors to prepare winning proposals and find matching state funds—as opposed to industrial density or a track record in industrial extension—have driven the allocation of resources and the geographic placement of manufacturing centers across the country. As a result, there is a mismatch between the allocation of federal dollars and the distribution of industry. For example, dense concentrations of manufacturers in California and the Northeast are relatively underserved. (Luria, 1994; Shapira, 1998). In addition, hastily organized centers and sub-par regional offices have proliferated as inexperienced states chased federal money (Shapira, 1998).

Another critical problem stemming from the ‘universal’ nature of the program is that extension centers are charged with serving as many firms as possible in a state or region. This is driven by the fact that center performance is commonly evaluated by the number of ‘engagements’ field agents complete. This evaluation criteria encourages extension centers to provide ‘quick-hit’ services in order to sustain project volume. Small changes in plant lay-out to remove bottlenecks, pre-packaged quality audits, web
site development and discreet technical training projects are all low-priced, easy to sell staples of manufacturing extension. Thus, while evaluation studies generally indicate that MEP services lead to positive business and economic outcomes in the firms that receive them, they also suggest that the vast majority of MEP engagements are limited to discrete, low-cost projects that are unlikely to drive fundamental change in firm behavior or culture (Shapira, 1998; Oldsman and Luria, 1998).

Summary of Findings and Implications for Policy

Through the lens of work organization, this dissertation has explored the capacity of small U.S. suppliers to adapt to the new manufacturing environment. I have sought to further our understanding of the factors that facilitate and impede the adoption of new work practices and systems through an in-depth examination of small metalworking firms in western Massachusetts. By contributing to the growing knowledge base about small firm-level decision-making and behavior, I hope to contribute to ongoing policy debates about how to expedite movement toward high performance work organization in the small firm sector.

Overview of Findings

Overall, my research indicates that a significant proportion of firms are making the transition from the ‘mom and pop’ shop to the ‘high performance’ small firm on their own. Survey data indicates that 35 percent of small metalworking firms have ‘transformed’ production organization through the implementation of integrated work systems and that 23 percent of firms are in a stage of organizational ‘transition’. At the
same time, however, the research indicates that 42 percent of firms have made no fundamental changes in how they organize work.

Theories of work organization posit that it is only when new work practices are integrated into a whole that firms will increase productivity and improve performance. But the factors that facilitate or impede diffusion of integrated work systems are not well understood. Based on detailed analysis of survey data, I have argued that variation in work reorganization across firms must be understood in the context of each firms’ market environment and overall strategy. Firms don’t adopt new work systems in isolation; rather, they adopt them in response to direct market pressure from customers and/or in the context of broader strategic choices.

In terms of market environment, the industry sector a firm supplies to and the quality of customer-supplier relations (i.e. cost-driven vs. partnership) are critical determinants of adoption. Firms that supply to industries that impose organizational reform as a precondition of conducting business are far more likely to transform their work organization. Similarly, firms engaged in ‘production partnerships’ with their customers are more likely to implement work systems to improve performance. In terms of strategy, the orientation of firm leadership (i.e. innovative and investment oriented vs. traditional and ‘lifestyle’ oriented) emerges as a critical determinant of adoption. Innovative, investment-oriented firm leaders pursue organizational reform as part and parcel of a broader set of strategic choices that include the manufacturing and marketing strategies of the firm and its key customers. Traditional, life-style oriented firm leaders are far less likely to have, let alone implement, a strategic vision that requires related changes in production, marketing, customer relations and work organization.
In addition to the survey findings, case study research revealed that successful pursuit of new work systems is likely to occur when the firm pursues an adjustment strategy characterized by product specialization and customization. By embedding new work systems that improve quality and lower costs in a strategy of product and service distinction, firms strive to insulate themselves from the cost-based competition that increasingly characterizes the machining sector due to the widespread availability of programmable technology.

The case studies also revealed that firm leaders do not automatically know how to make adjustments in work organization, products or services. In all four cases, market signals alert firm leaders to the need for change. Through the loss of major contracts, flat or declining sales, or customer requirements for improvement, firm leaders become aware of new market dynamics and recognize the need for adjustment. But firm leaders often don’t know how to interpret these signals or how to respond effectively to them. I argue that firms engaged in ‘partnership’ with their customers and firms headed by ‘innovative’ leaders are capable of navigating the adjustment process from the ‘mom and pop’ shop to the ‘high performance’ small firm due to their ability to formulate—and implement—an alternate vision about how to compete. Firms without these characteristics (i.e. firms engaged in ‘adversarial’ relations with customers and/or led by ‘traditional’ managers) are far less likely to mount a successful adjustment strategy when market signals alert them to the need for change.

**Policy Implications**

What are the implications of these findings for current policy debates and practice? In what ways do they contribute to the knowledge base on which policy
interventions might be based? My research has identified two key mechanisms of change in the small firm sector: the customer-supplier ‘partnership’ and ‘innovative’ firm leadership. The power of the mechanisms of change I have identified lies in their ability to reorient firm strategy. The conceptualization of an alternative strategy—one that responds to new market dynamics by simultaneously upgrading products and services and work systems—is, I argue, the single most important change that can take place in the small firm.

Can government help forge this kind of deep change on a widespread basis in the small firm sector? My answer is a qualified ‘yes.’ I argue, however, that direct service provision along the lines of the MEP is not the right starting point. My research suggests that the key to firm-level change is learning. Firms that successfully make the transition from the ‘mom and pop’ shop to the ‘high performance’ small firm learn as they interact with their market environment (i.e. customers and prospective customers) and fail doing things the old way. Innovative firm leaders seek out and incorporate new information into their production process and organization as they adapt to new and changing circumstances. By harnessing the power of the indigenous mechanisms of change identified through my research, I believe government can expedite learning in the small firm sector and stimulate demand for innovation. Specifically, government can catalyze change by 1) bringing customers and suppliers together to articulate and achieve ‘world-class’ standards; and 2) by systematically promoting ‘firm-to-firm’ learning about innovative business practices.

In order to have any impact on small firm performance and the manufacturing economy as a whole, I believe these efforts need to be highly targeted (both by industry
sector and region), **amply funded** and **long-term**. In addition, these efforts need to be **high-level**, that is, they need buy-in and support from the highest levels of business and government. A small firm adjustment policy with teeth is politically more challenging than the federal-state system of industrial extension system now in place. First of all, it requires both a geographic and industrial orientation (i.e. it requires picking ‘winners’ and ‘losers’). Secondly, it requires policymakers to think beyond state boundaries. Industrial suppliers locate around ‘anchor’ firms in regional agglomerations which may or may not correspond to state lines.\(^9\) In a high impact adjustment strategy, federal and state resources would be targeted to agglomerations of firms in key industries—for example, aerospace suppliers in Los Angeles and New England, auto suppliers in Michigan, industrial machinery suppliers in Wisconsin, electronics suppliers in Silicon Valley and Boston etc. The overarching goal of these efforts would be to upgrade regional supply bases in order to keep high-wage/high-skill manufacturing work in the region/country. While some industries/firms would be left out of these targeted efforts, they would still be eligible for assistance through the existing industrial extension system.

The emphasis of regional supply consortia would not initially be service delivery, but the development (and eventually institutionalization) of closer working partnerships between customers and suppliers and deep ‘firm-to-firm’ learning networks that utilize the knowledge and insight of innovative managers and firm owners (from both large and small firms). The focus of this learning and relationship building would be two-fold: 1) to help small firms formulate strategies driven by product distinction; 2) to help them operationalize these strategies through the implementation of new, more efficient work.

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\(^9\) In my study, for example, United Technologies serves as an ‘anchor’ firm around which suppliers locate. The regional agglomeration of metalworking suppliers spans the Connecticut River Valley region from
systems. Highly skilled and sophisticated staff with deep industry knowledge and contacts would spearhead regional efforts. Regional supply consortia could be affiliated with existing state manufacturing extension centers (depending on the reputation and visibility of the system which varies dramatically from state to state).

In Chapter One I noted that the majority of firms in my sample are pursuing the ‘high road’ of high skills and high technology (as opposed to the ‘low-road’ of cheap labor and minimal capital or workforce investment). Yet 56 percent of these ‘high road’ firms are ‘build-to-print’ shops without design and engineering capability. As the case studies of Dienes and Stan-Allen in Chapter 4 illustrated, without distinctive attributes such as design and engineering capability, even ‘high road’ firms are increasingly subject to price-based competition. Accordingly, a critical role for small firm adjustment policy is to help firms move beyond standard build-to-print contracts toward the development of distinctive capabilities such as designing or co-designing products for customers and/or specializing in highly complex processes, assemblies and/or tolerances. As the cases of Interstate Design and Brimfield Precision illustrated, firms that develop these capabilities are not interchangeable and are therefore of greater value to customers and less likely to be undercut by price-based competitors.

The second goal of small firm adjustment policy should be to assist firms as they work these strategies out through practice using the most efficient and cost effective work practices/systems available. Firms engaged in complex design and assembly work are likely to have high prices due to costly computerized machinery and higher wages. To keep internal costs down, these firms need to master new forms of work organization that maximize worker skills and minimize costs. In addition, these firms need to comply with

Stamford, CT to Springfield, MA.
customer requirements for on-time delivery and quality documentation. This is where organizational innovations such as quality assurance, benchmarking, ISO 9000, team production, cellular manufacturing, and Kaizen play a role and where human resource innovations—such as performance-based compensation and gainsharing—can be critical in motivating employees to work in new ways.

**Industrial Adjustment as a Learning Process**

An ongoing criticism of the current manufacturing extension system is the seeming lack of demand by firms for center services. My research suggests that the rate and extent of adoption is conditioned by market pressure and firm strategy—variables that are fluid and subject to change. Low demand for extension services may reflect the fact that many traditional firms don’t feel pressure to change or are not pursuing an investment and growth strategy. But small, discreet interventions are unlikely to change this situation because they don’t address the underlying issues thwarting change. As the case studies in chapter four illustrate, many firms reach a point of crisis before they conceptualize and begin to implement an alternate strategy. For some firms (e.g. Dienes), change comes too late and firms enter rapid decline. An important goal of regional supply consortia should be to build awareness of innovative business strategies among firms and facilitate the process of learning and change before crisis hits.

Taking a long-term view of industrial adjustment and working intensively with agglomerations of suppliers on complex issues of firm strategy could, ironically, stimulate demand for industrial extension services. As the case studies demonstrate, firms that have conceptualized a new approach to their business have a built in demand for assistance. Firm owners upgrading product and services and making simultaneous
changes in work organization are likely to utilize external consultants to help develop
design capabilities, upgrade computer systems, purchase new technology, reorganize the
shop-floor, provide training and assist with documentation compliance. While the
'learning' approach to small firm adjustment may not yield immediate firm-level change,
it is likely to spur more fundamental transformation in management behavior and firm
organization over the long run than current extension approaches.

Though my research findings still don't answer the question of whether
government intervention can have a positive impact on the productivity and
competitiveness of America's small manufacturing firms, the findings do increase the
knowledge base upon which sensible policy can be based. The creation of a national
system of manufacturing extension over the past seven years demonstrates a commitment
by the federal and state governments to upgrade the supply base. The next step is to use
the knowledge we do have to push policy a step further and target it sharply for higher
impact.
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APPENDICES
APPENDIX PART 1:

Description of Survey Methodology and Implementation

Efforts to measure the extent of change in a given population of firms must draw on industry specific knowledge. To gain a clearer understanding of why and how practices associated with the new work organization were being implemented in the population of firms I was interested in, I conducted in-depth interviews with owners and managers at six small metalworking companies in the Spring of 1996.

The six firms had undertaken varying levels of work reorganization – from piecemeal change to comprehensive restructuring of the entire firm. These initial interviews were extremely informative. Specifically, they helped me to: 1) specify new work organization practices that are relevant to this industrial sector; 2) identify common characteristics of firms that have implemented these practices; and 3) specify the external firm relationships that appear to facilitate adoption of these practices. Once the interviews were transcribed and analyzed, I conducted a focus group discussion with the staff of the western Massachusetts Chapter of the National Tooling and Machining Association to review my field work findings and to further refine my variables.

In addition to the field work and focus group, I prepared for the development of the survey instrument in the following ways: 1) I read several survey research texts to gain an understanding of the basic mechanics of survey research; 2) I carefully reviewed a variety of existing survey instruments that deal with similar subject matter; 3) I consulted a survey methodologist at the Center for Survey Research at the University of Massachusetts, Boston who provided assistance with key issues such as length, wording, sampling, maximizing response rates etc.
In the spring of 1997, I pre-tested the survey instrument with three of the firm owners that participated in the preliminary round of field research. Their feedback was extremely helpful and resulted in a number of important changes to the instrument. Staff of the National Tooling and Machining Association also provided valuable feedback on the survey instrument.

Sampling Frame, Firm Contacts and Response Rate

The survey sampling frame drew from three private databases: Dunn and Bradstreet; Commerce Register; and the western Massachusetts Chapter of the National Tooling and Machining Association.

I purchased the Dunn and Bradstreet and Commerce Register databases, while the NTMA provided me with their membership mailing list of 56 firms. Together, these three sources generated 309, non-union firms between 10 and 250 employees in SIC Code 35 (Industrial Machinery) in Hampden and Worcester Counties.\(^1\) Out of the potential pool of 309, I created a database of 200 establishments to contact. I included all NTMA firms that met my size criteria (for a total of 30 firms). I stratified the remaining pool of 279 firms by size and selected the additional 170 firms at random.

The process of contacting firms and securing responses to the survey was fairly elaborate in an effort to increase response rates. Once the database was created, I called each company to identify the appropriate contact person. I then sent that person a letter

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\(^1\) The vast majority of smaller firms are non-union. Only a handful of firms in this size group in the region have a unionized labor force. These firms were identified and eliminated from the potential pool before the sample was drawn.
explaining the survey goals and requesting their participation. I then called the contact person to see if they were willing to participate. If they said yes, I faxed them a six-page survey which they were asked to fax back to me. Once the fax survey was complete, I contacted the individual again to conduct a phone interview that lasted approximately a half an hour.

I sent survey letters to groups of 20 firms staggered over a five month period in 1997 (June – October). Altogether, I sent letters to 149 establishments. Out of the 149 establishments contacted, 81 (54%) agreed to participate in the survey. However, only 48 valid surveys were returned for a response rate of 31%. Out of these 48 firms, 40 participated in the phone survey for a phone survey response rate of 26%.

Of the 87 firms contacted that did not participate, 31 refused, 19 had moved, were no longer at the address listed, were the wrong industry, or had gone out of business; 31 agreed to participate but never returned the fax survey; and in 20 cases I was unable to reach the contact person after 4 attempts.

Non-Response Analysis and Potential Biases in the survey sample

Among the 31 firms that declined to participate in the survey the most common reason given was lack of time. I suspect this was also the reason why many individuals who agreed to participate in the survey did not return it. A significant number of those that declined to participate, however, said the reason was that they ‘don’t do any of that

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2 The western Massachusetts Chapter of the National Tooling and Machining Association ‘co-sponsored’ the survey (i.e. I used their letterhead). This approach was pursued in order to give the survey some legitimacy in the eyes of firm owners.

3 While I intended to contact all 200 firms in the database, I underestimated the time intensity of the survey process. After 5 months of constant calling and dwindling return rates, I decided I would have to settle for a smaller data set than I had originally hoped for. I sent out groups of letters by township beginning in Hampden County and ending in Worcester. As a result, several towns in Worcester county are not represented in the survey results. Hampden County is considered the ‘heart’ of western, MA which is why I focused the survey there.
stuff" (i.e. quality initiatives, cell or team manufacturing, training etc.) and therefore would not be of any help. This suggests a potential bias in the survey. Firms that agreed to participate may have adopted new forms of work organization at higher rates than non-respondents and are therefore more willing to discuss these issues. In addition, firms that are interested in these issues but haven’t yet adopted new work organization systems may have been more willing to participate in the survey than firms that have no future plans to change their work organization. One possible bias is that my survey sample overestimates the proportion of firms that are ‘transformed’ or in ‘transition’ and underestimates the proportion of firms that remain organized along ‘traditional’ lines. Among refusers, there was a higher percentage of ‘one-of-a-kind’ shops than among the responders (which were more evenly split between ‘one-of-a-kind’ and production shops) and they tended to be smaller firms (i.e. 25 employees or less). The survey data indicates that these firms are the least likely to adopt new forms of work organization. Accordingly, they may also be the least interested in addressing these issues with strangers on the phone.

Data Quality

While the number of firms that completed the survey is limited, the quality of the data received is high. The fax portion of the survey provides detailed information on products, markets, customers and human resources. The phone interviews provided detailed information about each company’s experience (or non-experience) with work reorganization including why the company undertook changes and how they have gone about accomplishing these changes, providing the equivalent of 40 mini-case studies.
APPENDIX 2:

Participating Firms

<table>
<thead>
<tr>
<th>Firm Name</th>
<th>Employees</th>
<th>Sic Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Completed Written and Phone Survey:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accurate Machine and Tool Co</td>
<td>10</td>
<td>3599</td>
</tr>
<tr>
<td>Atlas Brass and Aluminum</td>
<td>9</td>
<td>3543; 3365</td>
</tr>
<tr>
<td>B&amp;E Tool</td>
<td>75</td>
<td>3599;3728</td>
</tr>
<tr>
<td>Belt Technologies</td>
<td>32</td>
<td>3568</td>
</tr>
<tr>
<td>Brimfield Precision</td>
<td>92</td>
<td>3599</td>
</tr>
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<td>CNC Specialties</td>
<td>15</td>
<td>3599</td>
</tr>
<tr>
<td>Chicopee Engineering Associates</td>
<td>20</td>
<td>3569</td>
</tr>
<tr>
<td>CalFran International</td>
<td>25</td>
<td>3589</td>
</tr>
<tr>
<td>City Stamp Works</td>
<td>100</td>
<td>3544</td>
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<tr>
<td>Curtis Universal Joint</td>
<td>46</td>
<td>3568</td>
</tr>
<tr>
<td>Dienes Corporation</td>
<td>50</td>
<td>3563;3523</td>
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<tr>
<td>FMK Manufacturing</td>
<td>25</td>
<td>3549</td>
</tr>
<tr>
<td>HM Spencer</td>
<td>19</td>
<td>3544</td>
</tr>
<tr>
<td>HT Machine</td>
<td>28</td>
<td>3599</td>
</tr>
<tr>
<td>Hayden Corporation</td>
<td>24</td>
<td>3599</td>
</tr>
<tr>
<td>Hole Specialists</td>
<td>20</td>
<td>3599</td>
</tr>
<tr>
<td>Harson Machine</td>
<td>3</td>
<td>3599</td>
</tr>
<tr>
<td>Hoppe Tool</td>
<td>69</td>
<td>3545;3544</td>
</tr>
<tr>
<td>Hutchins Tool and Engineering</td>
<td>22</td>
<td>3545</td>
</tr>
<tr>
<td>Industrial Precision</td>
<td>55</td>
<td>3599</td>
</tr>
<tr>
<td>Interstate Design Company</td>
<td>29</td>
<td>3544</td>
</tr>
<tr>
<td>Jadco</td>
<td>13</td>
<td>3599</td>
</tr>
<tr>
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<td>124</td>
<td>3554</td>
</tr>
<tr>
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<td>15</td>
<td>3568</td>
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<tr>
<td>Leominster Tool Co.</td>
<td>18</td>
<td>3544</td>
</tr>
<tr>
<td>Magnat Machinery</td>
<td>33</td>
<td>3554;3555</td>
</tr>
<tr>
<td>Mark Technical Mold</td>
<td>32</td>
<td>3544</td>
</tr>
<tr>
<td>Mitchell Machine Incorporated</td>
<td>40</td>
<td>3599;3554</td>
</tr>
<tr>
<td>Norgaard Machine Inc.</td>
<td>10</td>
<td>3599</td>
</tr>
<tr>
<td>O-A Inc.</td>
<td>44</td>
<td>3599;3769</td>
</tr>
<tr>
<td>Olympic Manufacturing</td>
<td>250</td>
<td>3531</td>
</tr>
<tr>
<td>Osley and Whitney</td>
<td>68</td>
<td>3544</td>
</tr>
<tr>
<td>Parts Tool and Die Company</td>
<td>18</td>
<td>3599</td>
</tr>
<tr>
<td>S.P. Steven Manufacturing Corp.</td>
<td>16</td>
<td>3599</td>
</tr>
<tr>
<td>Stan-Allen Co. Inc.</td>
<td>30</td>
<td>3544</td>
</tr>
<tr>
<td>True Precision</td>
<td>12</td>
<td>3545</td>
</tr>
<tr>
<td>Valley Gage Co. Inc.</td>
<td>18</td>
<td>3545</td>
</tr>
<tr>
<td>Firm Name</td>
<td>Employees</td>
<td>SIC</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>-----------</td>
<td>----------</td>
</tr>
<tr>
<td>Vogform Tool and Die</td>
<td>25</td>
<td>3544</td>
</tr>
<tr>
<td>Westfield Gage</td>
<td>125</td>
<td>3599</td>
</tr>
<tr>
<td>Westfield Tool and Die</td>
<td>13</td>
<td>3544</td>
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<tr>
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<td></td>
</tr>
<tr>
<td><strong>Completed Written Survey Only:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AVS Incorporated</td>
<td>75</td>
<td>3567</td>
</tr>
<tr>
<td>Arrow Precision Co. Inc.</td>
<td>3</td>
<td>3541;3599</td>
</tr>
<tr>
<td>Associated Electro-Mechanics</td>
<td>54</td>
<td></td>
</tr>
<tr>
<td>Berkshire Industries</td>
<td>135</td>
<td>3728;3599</td>
</tr>
<tr>
<td>Fairview Machine and Tool</td>
<td>60</td>
<td>3549;3554</td>
</tr>
<tr>
<td>General Machine and Tool Co.</td>
<td>19</td>
<td>3599</td>
</tr>
<tr>
<td>Innovative Mold and Machine</td>
<td>20</td>
<td>3544;3599</td>
</tr>
<tr>
<td>JT Machine Co. Inc.</td>
<td>17</td>
<td>3541;3599</td>
</tr>
<tr>
<td>Niagara Cutter – Athol Inc.</td>
<td>48</td>
<td>3545</td>
</tr>
<tr>
<td>Renz America Corporation</td>
<td>25</td>
<td>3555</td>
</tr>
</tbody>
</table>
Appendix 3: Written (fax) Survey
A: GENERAL PLANT INFORMATION

1) What year was this company established?

2) Is the current owner the founder of the company or did he/she acquire the company from someone else?

3) What is the current owner's relationship to the previous owner of the company (e.g. son or daughter, former employee, no relation etc)?

4) Is your plant a subsidiary or a branch plant? If yes, what is the name of your parent company and where is it located?

5) Is your company publicly held or privately owned?

6) Is your company family-owned?

7) What is the total employment at your company today?

8) What was the total employment at this time of year in:
   1994____? 1992____?
B. PRODUCTS AND MARKETS

1) What do you make at this plant (please list the top three products)?


2) Please indicate the percent of annual sales your company ships to following locations:

1) New England _____%  
2) Other U.S. _____%  
3) Canada _____%  
4) Mexico _____%  
5) Europe _____%  
6) Japan _____%  
7) Other _____%

3) In 1996, approximately what percentage of your annual sales fell into each of the following categories?

- One-of-a-kind items engineered to order (e.g. dies, prototypes, and custom machines) _____%  
- Parts and products made in small batches (non-repeating orders) _____%  
- Parts and products made in small batches (repeating orders) _____%  
- Parts and products made in long production runs (repeating orders) _____%
4) Approximately what percentage of your sales in 1996 were from jobs where you helped design the part or product?

5) Does your company market itself as having design capabilities?

6) In 1996, approximately what percentage of your sales were shipped:
   as individual or component parts? ___%
   as assemblies of 2 or more individual or component parts? ___%

7) Please indicate your average unit price per piece. In addition, please indicate what percent of all sales each type of work represents.

   NOTE: If your company doesn't have a "typical" job, please list the unit prices and percent of sales for your low price jobs and your high price jobs only.

<table>
<thead>
<tr>
<th>Average unit/piece price</th>
<th>Percent of all sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Typical&quot; job</td>
<td></td>
</tr>
<tr>
<td>Low price job</td>
<td></td>
</tr>
<tr>
<td>High price job</td>
<td></td>
</tr>
</tbody>
</table>

8) Please indicate the approximate dollar value of sales at your company in:

<table>
<thead>
<tr>
<th>Year</th>
<th>Sales Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1996</td>
<td></td>
</tr>
<tr>
<td>1994</td>
<td></td>
</tr>
<tr>
<td>1992</td>
<td></td>
</tr>
</tbody>
</table>
C. CUSTOMERS

1) Over the past two years, what proportion of company sales were to customers in the following industries:

- Aircraft/Aerospace Companies and their Suppliers _____%  
- Industrial Machinery Companies and their Suppliers _____%  
- Computer, Communications, or Electronic Equipment and their Suppliers _____%  
- Defense Contractors and their Suppliers (non-aerospace) _____%  
- Medical Instrument Companies and their Suppliers _____%  
- Companies in other industries (please write-in below) _____%  

TOTAL = 100%  

2) Has the proportion of total sales in defense/military related work changed significantly over the past five years? If yes, from what to what percent of annual sales?

3) How many customers did you have in 1996?

4) How many customers (beginning with the largest) did it take to make up 75% of annual sales in 1996?

5) What proportion of total annual sales were shipped to your most important customer in 1996?

6) Does your company have “core” or “preferred” supplier status with any of your major customers? If yes, with how many?
7) Who is primarily responsible for designing the products you ship to your most important customer (please circle one)?

a. your customer   b. your company   c. products designed jointly

8) On average, how many times per year do representatives from your most important customer provide assistance to your plant?

9) On average, how many times per year do representatives from your company provide technical assistance to your most important customer?

10) Which of the following best describes your current contract with your most important customer (please circle one):

a. no contracts/per job basis   c. 1-3 year contract
b. less than a 1 year contract   d. 3-5 year contract

11) On a scale of 1-5 (with 1 being none and 5 being a lot) please describe your relationship with your most important customer in the following categories.

Cooperation on product development  1 2 3 4 5
Cooperation on schedule  1 2 3 4 5
Exchange of information  1 2 3 4 5
Provision of technical assistance  1 2 3 4 5
Customer commitment to your company  1 2 3 4 5
D. STRATEGIC PLANNING

1) For 1996, can you estimate the number of total hours top managers (including the owner) spent in meetings or projects addressing company strategy? How many people participated in these activities?

NOTE: strategy includes going after new business and customers, adding or dropping product lines, rethinking core capabilities, reorganizing production, planning ahead for the next 3-5 years etc. Please include strategic planning activities that took place on and off site.

Total hours for 1996_____; Number of managers participating_____.

E. HUMAN RESOURCES and TRAINING

1) Please indicate the number of persons currently employed at this company in the following categories:

   Production workers
   (non-trade/technician shop floor employees) _____

   Skilled trades and technicians _____

   First-line supervisors _____

   Total Shop Floor Employees ______

   Managers _____

   Engineers _____

   Drafters/designers _____

   Administrative and clerical staff _____

   Other _____

   Total Non-Shop Floor Employees ______
2) How are promotion decisions determined for shop floor employees in your plant? Out of a scale of 100, please estimate the weight of each of the following factors in determining promotions.

Length of service

Successful completion of formal training/courses

Superior job performance—technical skills

Superior job performance—interpersonal and organizational skills

Dependability

Supervisor recommendation

Other

Total = 100%

3) Please estimate the dollar amount your company spent on training for all employees in 1996? What percent of this was spent on shop-floor employees?

4) In the past three years, what percentage of your plant’s employees have received training in quality control or quality improvement methods?

Percent of management employees

Percent of shop-floor employees
5) Please estimate the percentage of total training that each area of training below has represented in your plant over the past three years for shop-floor employees:

<table>
<thead>
<tr>
<th>Type of training</th>
<th>% of total shop-floor training</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Basic or remedial skills:</strong></td>
<td></td>
</tr>
<tr>
<td>reading, writing, and math</td>
<td></td>
</tr>
<tr>
<td><strong>Communication skills:</strong></td>
<td></td>
</tr>
<tr>
<td>teamwork, problem-solving and interpersonal skills</td>
<td></td>
</tr>
<tr>
<td><strong>Quality control skills:</strong></td>
<td></td>
</tr>
<tr>
<td>gauging, inspection, documentation, testing and statistical methods</td>
<td></td>
</tr>
<tr>
<td><strong>Technical skills:</strong></td>
<td></td>
</tr>
<tr>
<td>machine set-up and operations, advanced math, interpreting blue prints; CNC; CAD/CAM</td>
<td></td>
</tr>
<tr>
<td><strong>Other</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100%</td>
</tr>
</tbody>
</table>
Appendix 4: Phone Survey
Precision Manufacturers Phone Survey

<table>
<thead>
<tr>
<th>COMPANY INFORMATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Company Name:</td>
</tr>
<tr>
<td>Company Address:</td>
</tr>
<tr>
<td>Phone Number:</td>
</tr>
<tr>
<td>Fax Number:</td>
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A. Firm Ownership/Owner Characteristics

1) Who has responsibility for the day-to-day management of the company?

2) Does he/she have final decision-making authority in the following areas? If not, who does (ask for title of person responsible in following areas)?

   Product design and engineering

   Technology acquisition

   Human resources (hiring, compensation, benefits, training)

3) Can you tell me which of the following best describes the firm owner's work experience prior to acquiring this company?

   Employed at this company (please indicate most recent position and years at company)

   Employed at another company in the same industry (please indicate most recent position and years at company)

   Employed in unrelated industry (please list industry and position)

4) Can you tell me the age of the current firm-owner?
5) Can you tell me which of the following statements best describes the current owner's future plans?

- Plans to be running the company in ten years
- Plans to sell the company within ten years
- Plans to retire within ten years
- Plans to pass the company to a family member within ten years

6) Can you tell me the educational background of the current owner (check all that apply)?

- High school graduate
- Vocational school graduate
- Apprenticeship
- Some college
- College Degree (ask for major)
- Graduate Degree (please indicate type, i.e. MS, MBA, Ph.D., etc. / ask what field degree is in)
B. Recent Efforts to Improve Quality, Productivity and Costs

Now I'd like to ask you about your company's recent efforts to improve performance and the kinds of assistance you may have drawn on to accomplish your goals.

1) In the past five years, has your company implemented a quality improvement program?

2) In the past five years, has your company undertaken ISO 9000 certification or other quality/documentation standards?
   a. Did you receive outside assistance to implement either program? From whom?

3) In the past five years, has your company implemented statistical process control (SPC)?
   a. Did you receive outside assistance?
   b. Does your company routinely use statistical quality assurance methods such as SPC to monitor chart variations in significant process or product characteristics?
   c. What proportion of machinists routinely use SPC in their work?
4) Does your company consistently track performance in the following areas? When did your company start tracking this information?

- On-time delivery? Y/N
- Internal scrap rates? Y/N
- Customer reject rates? Y/N

5) At what intervals do you track performance in these areas?

- On-time delivery
- Internal scrap rates
- Customer returns

6) Since you began tracking this information have you seen measurable improvement in these areas? Are you able to quantify the changes?

7) Does your company currently follow a Just-In-Time approach to reducing lead time to customers?

8) In the past five years, has your company undertaken a systematic approach to reducing machine set-up times?
9) Has your company significantly changed the layout of machines or production in the past five years to improve throughput or process flow?

10) Can you tell me how machines are currently organized in your plant?

- All or most machines of similar type are located in the same area
- All or most machines are organized into cells
- All or most machines are organized in a production line

11) Do production employees rotate between jobs (e.g. operate more than one machine) in your company or do they perform a single job (e.g. operate a single machine)?

12) Has your company implemented team production?

a. What proportion of your shop floor employees currently work in teams?

b. How many teams are currently operating in your plant?
15) Can you tell me which of the following forms of information are routinely shared with production workers in your plant? (check all that apply)

- Current plant financial performance [Y/N]
- Customer identities and requirements [Y/N]
- Customer feedback on performance on particular orders [Y/N]
- Quality performance on particular orders [Y/N]
- Reasons for quotes not won [Y/N]
- Company strategy and timing for going after new business [Y/N]
- Plans for new product development [Y/N]
- Training availability and procedures for accessing it [Y/N]
12) In the past five years has your company implemented any kind of incentive-based compensation? Which of the following apply?

- Hourly pay based on jobs class
- Bonus based on company financial performance
- Bonus based on team performance
- Bonus based on department performance
- Bonus based on individual performance
- Bonus based on employee suggestions
- Wage increase due to newly acquired skills

13) In the past five years has your company increased training for shop-floor workers?

a. In the past three years has your company conducted any type of skills assessment of your current production workforce?

b. Does your company track the amount of money it spends annually on training?

c. Does your company budget for training?

d. Does your company pay for all required employment-related training for shop floor workers?
e. Does the company pay for non-required, job-related training (e.g. skill upgrading courses at STCC or through NTMA)?

- company pays 100%
- company pays 50%
- company reimburses based on grade
- company doesn’t pay

14) In your efforts to improve quality, productivity and cost did you run into any of the following problems? For each case, please indicate whether it represented NO challenge; SOMewhat of a challenge; or a LARGE challenge.

- Resistance to new practices by production workers
- Resistance to new practices by supervisors or managers
- Inadequate skills or training of your workforce
- Lack of follow-through on new practices by workers (i.e. belief that new practices are just trends)
- Poor communication between employees/work groups
- Poor communication between managers and employees

N   S   L
F. OUTSIDE-ASSISTANCE

1) Which of the following off-site activities do top managers at your plant regularly participate in to learn about strategies for improving performance?

   Professional meetings  (ask for frequency and sponsor)

   Seminars on specific topics  (ask for frequency and sponsor)

   Conferences (over one day)  (ask for frequency and sponsor)

2) Have personnel from your company visited other companies (including customers) to learn about new production and organizational strategies?

   a. if yes, ask for frequency (i.e. approximately how many times per year)

3) Is the current owner of this plant involved in any sort of CEO membership group?

4) Is your company a member of an industry association/s? If yes, which ones?

5) Has your company ever participated in or utilized programs and services of the Western MA National Tooling and Machining Association?
6) If yes, which of the following NTMA activities has your plant participated in over the past three years? NOTE: ask for frequency in each case.

- attend seminars/workshops with invited speakers
- breakfast roundtable meetings
- management training
- evening skill upgrade courses
- contract training
- recruit entry-level workers through WMPI
- Mech-Tech apprenticeship program
- in-plant modernization projects

Ask the following question if the company is a member of the NTMA:

7) How active is the plant's owner/top management in the NTMA?

- Not active
  (e.g. pay dues and receive information but don't participate in activities)

- Somewhat active
  (e.g. attend NTMA meetings on sporadic basis, participate in some workshops and activities)

- Very Active
  (e.g. attend most monthly meetings, regularly participate in workshops and activities, active in NTMA governance)
8) Has your company ever utilized or participated in the services of the Manufacturing Partnership of Western Massachusetts?

If yes, ask for the types of activities the company has engaged in:
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