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An Empirical Investigation of the Impact of Advanced Manufacturing Technology on Business Performance

by

DEVRAJ AGARWAL

**A dissertation submitted to the Graduate Faculty in Business
in partial fulfillment of the requirements for the degree of
Doctor of Philosophy, The City University of New York**

1997

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This manuscript has been read and accepted for the Graduate Faculty in Business in satisfaction of the dissertation requirement for the degree of Doctor of Philosophy.

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ABSTRACT

An Empirical Investigation of the Impact of Advanced Manufacturing Technology on Business Performance

by

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Advisor: Professor Michael N. Chanin

Many have argued that adoption of advanced manufacturing technology (AMT) leads to better business performance. Firms using AMT, however, report mixed results ranging from increased quality and flexibility to absolute failure. What makes a firm more able to achieve the strategic benefits of AMT is still elusive to us.

The basic objective of this study is to examine why some firms are better able to use AMT to improve their competitive strength. The central premise of our research is that the influence of AMT on a firm's business performance depends on the extent to which it is supported by the appropriate organizational structure, business strategy, manufacturing proactiveness, and industrial environmental conditions.

The hypothesized relationships were empirically tested by collecting data from 145 U.S. manufacturing firms belonging to six different industrial groups, that is, SIC groups 33 to 38. The relationships were examined using moderated

regression analysis, cluster analysis, and multivariate analysis of variance (MANOVA).

Regression results show that firms with integrated use of manufacturing technologies achieve higher performance. Influence of technology on firm performance, however, do not depend upon the type of organizational structure. Both organic and mechanistic organizational structures are equally effective with AMT. Technology interacts positively with business strategy. Both cost leadership and differentiation strategies are positively related to a firm's technological strength. Firms make more effective use of manufacturing technologies if manufacturing managers proactively participate in the strategic planning process. The effects of proactive manufacturing participation, however, do not differ by the level or type of uncertainty in the external environment of the firm.

Relationships were also examined with a holistic perspective using the configurational approach. Cluster analysis was used to form clusters or configurations of firms. MANOVA was then used to determine if the clusters significantly differed. Results confirm the concept of equifinality, that is, firms with different strategic profiles can be equally effective. Firms with more intensive and integrated use of technology tend to use complex innovation strategy. Cost leadership strategy is more likely to be pursued by firms with low technological strength, which perceive environment as highly hostile.

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Chapter 1

INTRODUCTION

This chapter describes the purpose and importance of this research. It then outlines the organization of this study.

The rapid developments in manufacturing technologies such as computer aided design/computer aided manufacturing (CAD/CAM), flexible manufacturing systems (FMS), Robotics, and others, known collectively as advanced manufacturing technology (AMT) or flexible automation (FA), have changed the very concept of competition and manufacturing's role in it (Craven & Slatter, 1988; Goldhar & Jelinek, 1985; Meredith, 1987d). Today, manufacturing technology has acquired a strategic significance that is unparalleled in the industrial history so far.

The importance of manufacturing in achieving competitive advantage was recognized as early as 1969 by Prof. Wickham Skinner in his seminal article -- "Manufacturing: Missing Link in Corporate Strategy." However, it was not until recently that manufacturing could proactively influence the strategic planning of a business (Hayes & Wheelwright, 1984). Adoption of FA not only offers the potential of competing successfully in global markets but also helps in redefining the market itself. For instance, FA has largely been instrumental in the shift of

the automotive industry from maturity to change and turbulence (Abernathy, Clark, & Kantrow, 1983).

Several firms have adopted new technologies to cope with increasing competition, changing markets, shorter product life cycles, and increasing consumer sophistication. By offering a wide range of potential benefits such as reduced lead time, increased quality, increased flexibility, more variety, increased machine utilization, shorter set-up time, and so forth, new technologies enable manufacturers to compete successfully in today's novel and discontinuous business environment (Bessant & Haywood, 1986; Ettlie, 1988; King & Ramamurthy, 1992; Swamidass & Newell, 1987; Thompson & Paris, 1982).

However, firms have been reluctant to adopt AMT (Sheridan, 1990). Moreover, those who have adopted it, have had limited success in realizing the benefits of AMT. General Motors, for example, failed to achieve any benefits even after investing in automation a sum greater than the gross national product of many countries (cited in Son, 1991). Sinking \$30 million into automation and faster tire-building machines, the Firestone tire plant in Albany, Georgia, was ultimately closed after failing to report any profits (Schonberger, 1987).

Various reasons have been cited for the failure of U.S. manufacturers in adopting FA successfully such as inherent organizational weaknesses, faulty managerial roles and policies, inadequate preparation, short-term vision, economic justification techniques, administrative rigidity, lack of enhanced skills,

and inappropriate organizational structure and work culture (Ettlie, 1988; Hayes & Wheelwright, 1984; Huang & Sakurai, 1990; Jaikumar, 1986; Son, 1991; Zammuto & O'Connor, 1992).

Literature on AMT reveals mixed findings, ranging from increased quality and flexibility to absolute failure. Our purpose is not to find out the causes of implementation failures. Rather the focus is on determining the right mix of strategic and organizational elements that leads to effective use of AMT in enhancing business performance.

1.1 Problem Statement

Of late, AMT has been an issue of serious concern among the practitioners as well as the academicians. For the first time we have recognized manufacturing technology as a strategic factor in improving a firm's competitiveness.

Unfortunately, research on AMT is still in its infancy. Though several attempts have been made to analyze the strategic significance of AMT and its impact on organizations, our understanding of AMT is rather limited and fragmented. The fact is that AMT is relatively new and is assuming new configurations gradually (Liu et al., 1990; Tranfield et al., 1991). Our knowledge of manufacturing technology within the socio-economic framework is largely

based on literature which pertains to either dedicated systems or stand alone technologies.

Historically, research on manufacturing technology was mostly the concern of two distinct groups: the organization theorists and the business strategists. Organization theorists concentrated largely on the organizational and behavioral issues resulting from the use of technology on the shop floor. Strategists, on the other hand, viewed technology only as a supportive and implemental tool for the strategies formulated by the top management. Until recently, there were, however, few attempts to integrate the two fields.

1.1.1 Technology and the Organization Theorists

To the organization theorists, manufacturing technology has for long been a major research field. They have mainly been concerned with the impact of technology on the organizational and behavioral factors such as employee motivation and satisfaction, job design, and organizational structure.

Perhaps the most controversial issue in organization theory is the one initiated by the seminal work of Woodward in 1958. Based upon her empirical study, she concluded that organizational structure of a firm varies by the type of manufacturing technology being used by it. Research following Woodward (Blau, Falbey, McKinley, & Tracy, 1976; Child & Mansfield, 1972; Hickson, Pugh, & Pheysey, 1969; Marsh & Manari, 1981) provided rather contradictory and

confounding results. It was argued by others (Ford & Slocum, 1977; Fry, 1982; Stanfield, 1976) that the problem lay more with the conceptual and methodological ambiguities of such studies than with the proposed relationship itself.

In particular, the more serious problem is rooted in the contingency framework on which the hypothesized relationship between technology and structure is largely based. According to contingency theory, organizations develop appropriate structural form and management style to cope with the uncertainties generated by the contingent factors such technology, size, and environment.

The concept of contingency theory of fit has been criticized for its deterministic bivariate assumptions, reductionistic mode of inquiry, that is, its treatment of organizations as loosely coupled aggregates with linear unidirectional relationships, and its neglect of complex nonlinear interactions between several organizational entities (Galunic & Eisenhardt, 1994; Meyer, Tsui, & Hinnings, 1993; Miller & Friesen, 1984). In fact, the decline of technology as an important contingency factor had led to a virtual abandonment of research in this field in favor of the new and more interesting contingent dimension, environment (Perrow, 1979).

In response to such criticisms, researchers did approach the contingency relations with a new and richer systems perspective of ***configuration theory*** -- a collection of interdependent and supportive elements that commonly occur

together, and the concept of **equifinality** – the idea that different forms can be equally effective (Doty, Glick, & Huber, 1993; Meyer et al., 1993). However, conceptual studies relating technology to the new concepts of organization theory have not been forthcoming so far.

1.1.2 Technology and the Strategists

The importance of relating manufacturing technology to business strategy has been documented by many researchers (Buffa, 1984; Goldhar et al., 1991; Hayes & Schmenner, 1978; Hayes & Wheelwright, 1979a,b; Skinner, 1969; Skinner, 1974; Stobaugh & Telessio, 1983; Utterback & Abernathy, 1975).

These studies, however, were centered around the top-down approach proposed by Skinner (1969). Although technology was linked to strategy, it assumed a supportive role. The strategic goals formulated at the top served as guidelines for performance at the factory floor. The sole concern of top management was to enhance manufacturing capabilities so that products could be manufactured at low cost.

However, recent developments in manufacturing technology (AMT) have made the traditional passive view of manufacturing largely inappropriate. Today, technological capabilities can be strategically used to achieve sustainable competitive advantage (Hayes et al., 1988; Morone, 1989; Skinner, 1985; Wheelwright, 1985). But there is little empirical work done to examine the nature

of these relationships and their impact on business performance (Kantrow, 1980; Lefebvre et al., 1992; Zahra & Covin, 1993). The technology-strategy literature does not answer what makes a company more adept at incorporating technology based opportunities into its overall competitive strategy (Morone, 1989).

1.1.3 Advanced Manufacturing Technology

According to Einstein, "It is the theory which decides what we can observe" (cited in Meyer et al., 1993). Unfortunately, the existing theoretical underpinnings rest largely on stand-alone or mass-production technologies, whereby technology is viewed merely as a supportive and implemental tool with its impact confined to the factory floor.

As Miller & Friesen (1984) say, research on organizations have traditionally encouraged analysis in the absence of synthesis by focusing on simple unidirectional relationships among a few variables in search of direct causation.

Viewing AMT from the same traditional yardstick and perspective is largely inappropriate. AMT with its organization-wide implications is strikingly different from the technologies of the Taylor and Woodward era. The organization-wide integration and co-ordination required by new technologies is a novel phenomenon. And so is the influence of manufacturing in the strategic planning of business.

The changing facets of manufacturing technology do get reflected in writings by authors such as Adler (1988); Attaran (1989); Bessant and Haywood (1986); Ettlie and Pefier (1987); Goldhar and Jelinek (1985); Meredith (1987); and Singhal, Fine, Meredith, and Suri (1987). Most of these studies are, however, speculative, providing general guidelines, with little or no effort to develop an analytical framework which could be empirically tested. Nevertheless, some empirical research efforts have been directed to understand the impact of AMT on workforce, job design, and organization structure. Surprisingly, only a few studies have addressed the issue of strategic significance of AMT.

Ironically, despite a voluminous literature on AMT, research is anything but scientific. First, most of the literature is replete with idealistic conceptualizations, speculations, anecdotal evidences, and case studies. Few studies have focused on AMT in its integrated form. Most deal with only a few narrow technological dimensions in a limited industrial setting. Considering the fact that different components of AMT have quite distinct impact on organization and workforce, comparison of studies based on different technologies is inappropriate and highly misleading.

Second, empirical testing based on outmoded theoretical concepts and traditional organizational constructs can hardly generate valid results. Such

efforts with their methodological shortcomings can only lead to unwarranted generalizations and contradictory findings.

Finally, a holistic and integrated approach with new analytical techniques is badly needed to examine the way AMT interacts with various organizational and environmental elements to influence business performance.

Though we do not discount the contributions of past studies, we do need new, richer theoretical models with empirically validated results to address the issues of organizational design and strategy in firms using AMT.

1.2 Purpose of this Research

The basic purpose of this research is to develop and empirically examine an integrated framework of AMT encompassing knowledge from the three fields of production management, business policy, and organization theory.

Specifically, we wish to examine why some firms are more competitive and better able to reap AMT advantage.

Our objective is to examine the impact of AMT on firms' performance from a micro perspective. In particular, we wish to analyze the interaction of AMT with several organizational and strategic factors, and the compatibility between them as an indicator of a firm's performance. In other words, the focus of this study is to determine those most critical organizational and strategic elements which if

present can make a firm better able to use AMT in enhancing business performance.

Part of AMT's impact is, however, not well understood. It is, for example, argued that organizations adopting AMT can compete on both cost and differentiation dimensions (Nemetz & Fry, 1988). But what type of organizational structure is associated with this mixed strategy is elusive to us (White, 1986). Therefore, considering the novel impact of AMT on organizations, our study is likely to be exploratory to a certain extent.

Finally, we wish to synthesize our micro level findings by looking at our study with a holistic perspective. By examining the inter-relationships among all variables within the integrated framework we can get rather a richer understanding of the way in which more successful organizations manage AMT.

1.3 Research Question

Our main research questions are:

1. What are the organizational and strategic factors which make a firm more competitive and adept at using AMT in improving its competitive strength?
2. Do firms with successful use of AMT exhibit a distinct pattern of strategic and organizational configurations?

The research questions can be better understood by focusing on the following more specific questions:

- ▶ Do firms with higher intensity and integration of AMT display better manufacturing performance?
- ▶ Is AMT's impact on manufacturing performance more pronounced if associated with a compatible organizational structure?
- ▶ Are different levels of AMT use (i.e., the degree of AMT intensity and integration) associated with different types of business strategies?
- ▶ Is AMT's impact on business performance more pronounced if manufacturing technology is supportive of the corresponding business strategy?
- ▶ Do firms with proactive manufacturing involvement in the strategic decision making process perform better than those with reactive involvement only?
- ▶ Does the moderating effect of the proactive involvement of manufacturing in the strategic decision making process vary by the level of uncertainty in the external environment of the firm?

1.4 Significance of this Research

This research, we believe, will be of both theoretical and practical significance. To the researchers, the implications of our study are many.

First, by empirically examining the hitherto untested but promising claims, this research will provide the much needed scientific validity to such speculations.

Second, a partially exploratory nature of this research may add something relatively new to the existing body of knowledge that may create a base for further knowledge building.

Third, this will be the only study of its kind that integrates knowledge from production management, business policy, and organization theory and links them to business performance. Though a few attempts to integrate the three fields have been made in the past (Parthasarthy & Sethi, 1993; Ward, Leong, & Boyer, 1994), several questions are still unanswered.

Finally, by synthesizing the existing fragmented knowledge, this research will fill the gap in the current literature and will provide a richer understanding of the complex interaction of AMT with the rest of the business forces.

To the practitioners, this research may provide the answer to what they ought to do to make AMT work in their organizations. Specifically, the study would indicate those organizational and strategic configurations which if associated with AMT may lead to better business outcomes. In other words, the findings of this research will allow the managers to find the inconsistencies in their organizations, if any.

Moreover, by highlighting the strategic significance of AMT, this study may be instrumental in forcing managers to change their passive view of manufacturing.

1.5 Organization of the Dissertation

This dissertation is divided into six chapters. In the first chapter, the purpose and significance of this research were presented. The remaining chapters are organized as follows.

Chapter two reviews the existing literature on AMT and its relationships with other strategic and organizational elements.

Chapter three describes the research model and explains the hypothesized relationships among the relevant variables.

Chapter four presents the research design and describes the methodologies used to test the relationships. It also presents the sample characteristics and explains the instruments and measures used in this study.

Chapter five presents the research results. The results are explained and discussed using both contingency and configurational perspectives. Some limitations of this study and future research directions are also presented.

Chapter six concludes by summarizing the major findings of this research. Some implications for both researchers and practitioners are also described.

Chapter 2

LITERATURE REVIEW

This chapter reviews the existing literature on advanced manufacturing technology (AMT). It first describes the current classification of production systems and highlights the emerging importance and role of AMT. It then analyzes the strategic and organizational correlates of AMT and highlights the need for empirical investigation.

Recently, manufacturing has acquired a significant attention due in part to the declining nature of American corporations and in part to the unsurpassed manufacturing excellence of Japanese companies. The decline of American manufacturing has been an issue of great concern in popular press in recent times. The dominant world leaders of yesteryears have, today, bowed down to the pressures of international competition. Companies after companies have lost their market shares to the ingenuity, innovativeness, and competitiveness of Japanese, European, and other newly industrialized countries' business organizations.

One can cite a host of reasons ranging from economic disruptions, caused by factors like oil price fluctuations, to government's macro-economic policies. But, no one can deny the fact that these manufacturing organizations

have been the victims of their own success. The rapid success achieved in the past through high productivity and efficiency made the corporations oblivious and ignorant of the new dimensions of competition: quality, flexibility, and innovation.

According to Clark, Hayes, and Lorenz (1985),

... there is still far from sufficient recognition of how deeply the attitudes, structures, and behavior of American manufacturing firms have become locked by historical influences into a pattern unsuited to today's social and business environment. (p. 13)

Similar perspective has been provided by Skinner (1985),

... we have a management problem in American manufacturing today which is due to a "mind-set" of mistaken premises and implicit objectives which are rooted in the history of production management and are now inappropriate and dysfunctional. (p. 63)

Alas! the dynamism and craftsmanship of the early industrial entrepreneurs, like Henry Ford, got lost in the complacency and inability of the new breed of modern corporate managers.

Today we are undergoing a transition from the era of mass production to that of flexible production (Bianchi, 1991), or to what Piore and Sabel (1984) call "flexible specialization" - "a revival of craft forms of production...a strategy of permanent innovation: accommodation to ceaseless change, rather than an effort to control it."

Rapid advancements in computer technologies, information systems, and production processes have led to revolutionary changes in the field of

manufacturing process technology. The new technologies, available under the rubric name of advanced manufacturing technology (AMT) or flexible automation, offer a wide range of potential benefits, such as increased quality, increased flexibility, more variety, shorter set up time, and so forth. The importance of AMT is quite evident from what Cyert (1985) says: automate, migrate, or evaporate (Cited in Weill, Samson, & Sohal, 1991).

Notwithstanding these promising opportunities, there has been a reluctance among manufacturers in adopting AMT (Thurow, 1987). Few production engineers, top managers' technology aversion and ignorance, less educated and trained workforce, resistance to change, traditional evaluation technique, and short term vision are some of the reasons often cited for this slow adoption of flexible technologies (Hayes & Wheelwright, 1984; Thurow, 1987).

This is clear from the Report of the President's Commission on Industrial competitiveness: "Perhaps the most glaring deficiency in America's technological capabilities has been our failure to devote enough attention to manufacturing or process technology" (cited in The U.S. Department of Commerce, 1989). This contention is further supported by Mansfield (1993) in a study of 175 firms in Japan, Western Europe and the United States, where he finds that the rate of intrafirm diffusion of flexible manufacturing systems (FMS) has been lower in the U.S. than in Japan.

The Japanese manufacturing, with its lean and flexible production process and participative work culture, is much more agile and flexible than the massive

U.S. plants with inflexible and rigid automation. Today, the competition is on all dimensions of cost, quality, and flexibility, which is in sharp contrast to the conventional wisdom of the tradeoff theory inherent in Skinner's (1974) concept of focused factory.

As discussed above, manufacturing has evolved over time from a rigid state of static optimization under mass production (Wheelwright, 1985) to a more fluid state of dynamic competitiveness under flexible specialization. The objective of this study is to find out those strategic and organizational elements which leads to successful use of AMT.

2.1 A Classification of Production Systems

According to Kim and Lee (1993),

The purpose of developing a typology for production systems is to provide a meaningful methodology for reappraisal, integration, and synthesis within production and operations management. (p. 4)

The earliest typology of production system can be traced back to Woodward's (1965) work on technology and organizational characteristics. Based on a survey of 100 manufacturing firms in England, Woodward classified the production process into: unit and small batch production, large batch and mass production, and continuous process production, along the dimensions of technical complexity, and size and nature of products. Though Woodward's

work encountered as much criticism as recognition, it was the first study of its kind which provided a meaningful classification of manufacturing technology and its impact on organizational design.

The post Woodward era has seen many variations of Woodward's typology. Utterback and Abernathy (1975) describe three different stages of process development - Uncoordinated, Segmental, and Systemic - based on technical and organizational changes associated with the production process as the process progresses on its life cycle. Hayes and Wheelwright (1979) classify process technology into four groups: Jumbled flow (job shop), disconnected line flow (batch), connected line flow (assembly line), and continuous flow.

The traditional classification scheme of the production processes, however, fails to capture the important aspects of the real world production processes (Hull & Collins, 1987; Schmitt et al., 1985). Increasing customer sophistication and revolutionary developments in manufacturing technologies - FMS, CAD/CAM, etc. - which are more knowledge intensive, integrated, flexible, and cost adaptive, render the conventional scheme inappropriate and ineffective (Hull & Collins, 1987; Kim & Lee, 1993). Hull and Collins (1987) propose an alternative scheme by subdividing Woodward's batch technology into traditional and technical batch categories along two dimensions of scale of processes and knowledge complexity (degree of technical expertise involved in production).

2.2 Manufacturing Technology

Though technology is a critical factor in achieving manufacturing excellence, there is a lack of clarity and agreement as to the exact meaning of technology and its parameters (Dvir, Segev, & Shenhar, 1993).

Stanfield (1976) indicates that technology usually includes the following elements: 1. Characteristics of raw materials, 2. suppliers other than raw materials, 3. techniques used in directly handling and transforming raw materials, 4. facilities and plant layout, and 5. the rate(s) of change in production methods.

Hayes and Wheelwright (1984) say that the meanings of the word technology vary tremendously in their scope, depth, and usefulness, depending on the organizational level of the individual interpreting it.

Depending on the workflow pattern, Hayes and Wheelwright, however, divide manufacturing process technologies into five categories: project, job shop, batch, assembly line, and continuous flow. These categories range from general purpose, highly flexible fluid systems, manufacturing one of a kind product, to specialized, highly interrelated rigid systems, producing standardized items. Revolutionary developments in computer and information technology and the associated systems have, however, changed the very nature of manufacturing process (Economic Commission for Europe, 1986). The smokestack factory has, today, changed into, what can be called, the computerized factory, the automated factory, or the factory of the future (Goldhar, Jelinek, & Schlie, 1991;

Meredith 1987d). The rapid, novel, and discontinuous changes in the business environment: shorter product life cycle; greater product diversity, variety, and complexity; fragmented markets; sophisticated customers; increasing international competition; rapid technological advances and so forth, have placed new demands on manufacturing (Abernathy, Clark, & Kantrow, 1981; Ayres, 1992; Craven & Slatter, 1988; Goldhar et al., 1981), changing it from large, inflexible, rigid and monolithic plants to one which is more knowledge intensive, automated, integrated, cost-effective, and adaptive (Goldhar & Jelinek, 1990; Hull & Collins, 1987).

2.2.1 Automation

The word automation was coined in 1947 by Del Harder of the Ford Motor Company to describe the "automatic handling of parts between production processes" (cited in Roy, 1986). Groover (1987) takes a broader view. He defines automation as a technology that is concerned with the application of mechanical, electronic, and computer-based systems to operate and control production.

Automation has been playing a crucial role in the rationalization of the production process ever since the breakthrough of industrialism, for example, the steam-engine, the electric motor, and the transfer machine (Economic Commission for Europe, 1986). Nevertheless, owing to large investment

requirements, high technical complexity, and built-in rigidity, strict product standardization and large scale production were prerequisites (Craven & Slatter, 1988; Economic Commission for Europe, 1986; Hayes & Wheelwright, 1984). Automation, therefore, was mainly concentrated on the high volume, low part-variety end of the manufacturing spectrum, primarily in the automotive industry and household appliances sector (Craven & Slatter, 1988; Economic Commission for Europe, 1986; Groover, 1987).

Groover (1987), Tonkay (1991) and others classify automated production systems into three basic types:

- * Fixed Automation
- * Programmable Automation
- * Flexible Automation

Fixed automation or hard automation, as discussed above, is mainly applied for mass production of nearly identical products (Groover, 1987; Tonkay, 1991). Because of specialized equipments, stable product designs and large scale operations, high productivity and efficiency can be achieved at a very low cost, though only at the cost of flexibility. Examples of fixed automation include mechanized assembly lines (starting around 1913) and machining transfer lines (beginning around 1924) (Groover, 1987).

With the introduction of computer controlled manufacturing in early 1950s, programmable automation or stand alone machine automation acquired significant importance in the range of high variety low volume work (Craven & Slatter, 1988; Economic Commission for Europe, 1986; Groover, 1987).

Programmable automation is most suitable for batch production in low to medium volume production. Though it is more flexible than hard automation, a period of set up and reprogramming is required to configure the machine for each new part. Examples of programmable automation include (Economic Commission for Europe, 1986; Groover, 1987):

- * Numerically controlled machine tools (NC-machines);
- * Direct numerical control (DNC) developed in the mid to late 1960s;
- * Computer controlled industrial robots developed in the late 1960s;
- * Computerized numerical control (CNC) developed in early to mid-1970s;

Automation in manufacturing assumed great importance with a drive toward systems integration. Integration in manufacturing started in the late 1960s with DNC, under which a large central computer is used to control the operations of a number of separate NC machines (Economic Commission for Europe, 1986).

With developments in computer technology and several production techniques, integration in manufacturing reached to new heights in the form of computer-aided design/computer-aided manufacturing (CAD/CAM) systems and flexible manufacturing systems (FMS).

Flexible automation (FA) or advanced manufacturing technologies (AMT) is a rubric term which includes a host of new technologies such as CAD, CAM, FMS, etc. (Parthasarthy, 1991). FA is used for batch production of a variety of products (or parts) with little time lost in changeovers from one product to next. It

fills the automation gap along the manufacturing spectrum by bringing together the efficiency of mass production while retaining the flexibility of stand alone machine tools (Craven & Slatter, 1988; Gilbert & Winter, 1986).

There is, however, no unanimity regarding the concept of AMT. Differences exist even over the subcomponents of AMT, for example, FMS and CAD (Ettlie & Reifies, 1987).

According to the Advisory Council for Applied Research and Development (ACARD, 1983), AMT is defined as: "Any new technique, which, when adopted, is likely to require a change not only in manufacturing practice, but also in management systems and the manufacturer's approach to the design and production engineering of the product" (cited in Craven & Slatter, 1988).

"The new technologies integrate computer hardware, software, and database with computer-controlled machine tools, automated material handling, and robotics to form a highly automated and flexible manufacturing system," says Attaran (1989).

In spite of differences among the above approaches, they all focus on the same issue - AMT consists of several technologies which need to be integrated for an efficient and effective operation of the manufacturing system.

Integration, that is, bridging the islands of automation, is the foremost challenge facing firms, today (Attaran, 1989; Meredith, 1987). CAD/CAM is a major step forward in this direction, wherein products are simultaneously managed at all stages - design, engineering, and manufacturing - instead of

tossing the product, created in the lab, over the wall to manufacturing (Ettlie & Refies, 1987; Wheelwright, 1985).

Achieving integration of several technologies and managing the resulting interaction among many hardware and software components is a formidable task in FA (Singhal, Fine, Meredith, & Suri, 1987). According to an expert from a survey of factory automation technologies' practitioners, conducted by Rosenthal (1984):

The physical technology exists. The logical technology doesn't. The systems engineering or integration of the "islands of automation" is one, two or three orders of magnitude greater in difficulty than creating the islands. (p. 224)

Meredith and Camm (1989) claim that synergies and learning resulting from the integration of manufacturing technologies can significantly improve the competitiveness of a firm. Roth, Gaimon, and Krajewski (1991), on the other hand, believe that the rate of learning itself can be modified due to system synergy.

The importance of learning in achieving the most out of AMT has been observed by others, too (Adler, 1988; Bessant & Haywood, 1986; Weil et al., 1991). According to Adler (1988), "the level or type of learning required to realize the benefits of a new technology varies systematically with the magnitude of the technological step being taken" (p. 44). The change required, says Adler, can range from the development of some new skills for simple technical

changes, to changes in strategy and culture for major technological changes required by flexible automation.

2.2.1.1 Computer Integrated Manufacturing (CIM)

The ultimate integration sought after, today, is exemplified by computer integrated manufacturing (CIM). CIM is the convergence point of the three strands - design automation, manufacturing automation, and administrative (or control) automation, says Adler (1988). Craven and Slatter (1988) say that CIM is the latest stage in the trend toward gradual automation and integration of discrete manufacturing activities.

Like AMT, CIM also suffers from many definitions and interpretations (Craven & Slatter, 1988). Unlike AMT, CIM is not limited to shop floor only, but involves the integration of all functions throughout the factory.

According to Warndorf and Merchant (1986), "the integration and automation of data, information, and the control of product, from perception through production, to shipment and support, is referred to as computer integrated manufacturing."

Despite the growing importance of CIM, it is as yet a theoretical concept; to some a 'factory of the future' and to others their only hope for survival (Craven & Slatter, 1988; Economic Commission for Europe, 1986; Warndorf & Merchant, 1986). On the contrary, among the current realities, the area where integration

has advanced furthest is flexible manufacturing systems (FMS); "a microcosm of the future computer-automated, optimized and integrated factory" (Craven & Slatter, 1988). "CIM is a bit too fancy and futuristic to warrant all the press it gets. FMS is all we can handle for the rest of this century," says Schonberger (1986).

2.2.1.2 Flexible Manufacturing Systems (FMS)

There is no universally accepted definition of FMS. After reviewing the literature, we believe that the most appropriate and comprehensive definition of FMS is the one provided by the Economic Commission for Europe in a report on the recent trends in FMS. According to the report (1986),

A flexible manufacturing system (FMS) is an integrated computer-controlled complex of numerically controlled machine tools, automated material and tool-handling devices and automated measuring and testing equipment that, with a minimum of manual intervention and short change-over time, can process any product belonging to certain families of products within its stated capability and to a predetermined schedule. (p. 13)

In practice, FMS classification varies considerably with respect to, for example, machine configuration, number of machines controlled by the system and investment costs (Economic Commission for Europe, 1986; Groover, 1987). A classification normally based on the number of machines in the grouping involves - flexible manufacturing unit (FMU), flexible manufacturing cell (FMC), and flexible manufacturing system (FMS). (For explanation of these terms, see

the report by the Economic Commission of Europe, p. 13). FA is not a substitute for one of a kind of job shop environment or traditional mass production, as some claims. FMS rather fills the vacuum along the manufacturing technology continuum by eliminating the necessity of choosing between high-production transfer lines dedicated to a single product and low production stand alone NC machines (Blois, 1986; Economic Commission for Europe, 1986; Groover, 1987).

The real potential of FMS lies in batch production of a large number of parts in the low to mid-volume range. Using the concepts of group technology (GT) and cellular manufacturing, FMS can turn out a large variety of work while maintaining a high throughput, small lead time, and virtually no loss of time in changeovers (Groover, 1987; Hyer, 1984; Warndorf & Merchant, 1986).

2.2.1.3 The Automation Advantage

Flexible automation offers a wide range of benefits; the most significant being the achievement of the three conflicting objectives of cost, quality, and flexibility (Attaran, 1989; Huang & Sakurai, 1990; King & Ramamurthy, 1992; Lim, 1987; Meredith, 1987d; Rosenthal, 1984; Warndorf & Merchant, 1986).

Some categorize them as strategic and operational, while others as tangible and intangible or as internal and external benefit measures.

As Meredith (1987d) says:

...[advanced] technology provides not only the opportunity to offer a premium product, but also the potential to lower costs, greatly expand variety, significantly improve response time to both customers and markets, and, possibly most important of all, the opportunity to work "shoulder to shoulder" with customers. (p. 37)

In a recent study of five of the leading US companies in the development of CIM, the CAD/CAM Interface Committee of the Manufacturing Studies Board of the National Research Council found the following intermediate benefits of CIM achieved so far (cited in Warndorf & Merchant, 1986, p. 164):

*	Reduction in engineering design cost	15-30%
*	Reduction in overall lead time	30-60%
*	Increased product quality as measured by yield of acceptable product	2-5 times previous level
*	Increased capability of engineers as measured by extent and depth of analysis in same or less time than previously	3-35 times
*	Increased productivity of production operations (complete assemblies)	40-70%
*	Increased productivity (operating time) of capital equipment	2-3 times
*	Reduction of work in process	30-60%
*	Reduction of personnel costs	5-20%

In a survey of 222 U.S. manufacturing firms using AMT, King and Ramamurthy (1992) find that firms are more concerned with micro-level operational benefits than with strategic benefits. Also, a considerable gap exists between firms' expectations and perceived achievements. The results indicate that the benefits achieved vary by the type of technology adopted. FMS/FAS

system adopters, however, derive higher level of satisfaction followed by adopters of CAD/CAM and MRP systems.

2.2.1.4 Diffusion of Automation

The current era of manufacturing is witnessing a widespread diffusion of flexible automation, though at a slower rate. As per a study done by IIASA, the number of FMS in use increased from 39 in Japan and 12 in U.S. in 1976 to 213 and 139 respectively in 1988 (cited in Ayres, 1992). However, the study shows that the U.S. has a significant lead over Japan in the use of CAD systems, though far behind in the use of robots and NC machines.

According to the 1988 survey of manufacturing technology in the U.S., only 10.7%, of the 9,682 establishments surveyed, use FMC/FMS, compared with 39% and 41.4% for CAD/CAE and NC/CNC respectively. The least used are the two material handling technologies, automatic guided vehicle systems (AGVS) and automatic storage and retrieval systems (AS/RS), at 1.5% and 3.2% respectively. 46% of the plants, however, do not use FMS because of non-applicability. Overall, out of 17 technologies surveyed, 68.4% of the plants use at least one technology, whereas 23.1% use five or more of these technologies.

It is found that adoption of these technologies occur mostly in large companies. In the above survey, 93.7% and 79.4% of the plants with 500 or more employees use at least one and at least five technologies respectively,

compared with 60.9% and 13.2% for establishments with under 100 employees. This finding is further supported by King and Ramamurthy (1992) and Mansfield (1993). Given the high investment requirement for AMT, it is obvious that new technologies can be justified by large companies with medium to high volume production (Craven & Slatter, 1988; King & Ramamurthy, 1992).

Though FMS is widely accepted today, the rate of diffusion of FMS in the U.S. has been slower in comparison to other important industrial innovations, says Mansfield (1993).

2.2.1.5 What's Wrong With Flexible Automation?

The problems inherent with flexible automation are increasingly being surfaced today. The reasons often cited for this lackluster performance are - inherent organizational weaknesses, lack of top management support, inadequate training, incoherent strategy, short-term vision, and a wrong approach (Attaran, 1989; Bessant & Haywood, 1986; Huang & Sakurai, 1990; Jaikumar, 1986).

In their study of 222 U.S. manufacturing firms, King and Ramamurthy (1992) find that the firms failed to achieve even their stated objectives fully - a sign of overpromise and underselling.

"We are currently at grave risk of overshooting," say Grant, Krishnan, Shani, and Baer (1991). According to Bessant and Haywood (1985), most

existing FMS are not really flexible. They provide volume flexibility but often lack product flexibility (cited in Craven and Slatter, 1988). Meredith (1987), on the other hand, says that although AMT have limited flexibility, within their designed capability, they can produce varied products at the speed of identical products.

Companies are often blamed for using traditional accounting techniques, such as payback, rate of return, and various other discounted cash flow techniques, for evaluating AMT (Finnie, 1988; Kaplan, 1983; Son & Park, 1987). Roth et al. (1991) assert that

Traditional methods for justifying new technology often do not quantify its potential long-term market and process benefits; these methods fail to take into consideration the strategic opportunity cost of not investing in new technology, the impact of learning, and the cost-effectiveness of its synergy with other operations or technologies (p. 308).

2.3 The Appropriate Technology

There is no best technology. The impact of a particular technology depends on many factors ranging from technology specific characteristics to the nature of competitive forces prevailing in the industry. According to Grant et al. (1991), "the appropriate manufacturing technology for a business depends critically on the circumstances of that business with regard to its strategic goals, its resources, the resource availability within its regional and national economy, and the characteristics of its product-market environment" (p. 53). This section

will focus on the nature of interaction between manufacturing technology and product-market environment.

2.3.1 Technology - Market Link

According to Schmenner (1983), a flaw in technology choice often causes a mismatch between a plant's actual capabilities and the demands of the market place, resulting into manufacturing disasters. In a survey of 171 plant closing by Fortune 500 industrials, Schmenner finds that an inefficient or outdated production technology has been the main reason for such closing.

Illustrating three different types of markets - local monopoly markets, traditional commercial markets, and rapidly changing markets, Williams and Novak (1990) emphasize that the relevance of CIM varies by what the customer wants, the type of competitive forces at work in the market and the company's ability to manage them.

Hayes and Wheelwright (1979a), in their landmark study on manufacturing-marketing interface, provide a framework called "product-process matrix," in which the process life cycle is linked to the product life cycle. This model illustrates that as a product progresses on its life cycle, the changes in product characteristics and market requirements place a corresponding change on manufacturing processes. The manufacturing processes range from jumbled flow job shop, producing low volume one-of-a-kind product in the early life cycle

stage, to batch processing and assembly line, producing multiple low volume and a few higher volume products respectively in the intermediate stages, and finally to continuous flow, producing high volume standardized commodity.

The ideal match lies along the diagonal, say Hayes and Wheelwright. An unintentional drift away from the diagonal makes a company increasingly dissimilar from its competitors and might make it vulnerable to attack depending upon its resources and ability to achieve distinctive competences.

The life cycle concept inherent in the product-process matrix largely corresponds to Utterback and Abernathy's product-process innovation. Utterback and Abernathy (1975) describe three different stages of process development: uncoordinated, segmental, and systemic.

In an early stage, the focus is on product innovation with the process being highly fluid and organic but less cost efficient. With further progress on life cycle, the product becomes more standardized and the process more integrated and automated. Eventually the process becomes systemic, highly interrelated, and efficient but less flexible.

These models are based mainly on the assumption underlying the conventional trade-off theory, that is, a conflict exists between flexibility and efficiency. The introduction of flexible automation, however, largely undermines this conventional wisdom (Adler, 1988). By providing cost, quality, and flexibility simultaneously, flexible automation solves the so called productivity paradox and makes the focused factory irrelevant (Ayres, 1992; Skinner, 1974, 1986).

Hayes and Wheelwright (1984), too, recognize the limitation of product-process matrix to incorporate flexible automation. They suggest flexibility as a third dimension to the matrix. Adler (1988) says that the new matrix's diagonal should be flattened or bowed out downward.

The technology itself can force a change throwing a mature industry back into a stage characterized by intense competition and uncertainty. Abernathy et al. (1983) coin the term "de-maturity" to describe this process as happened, for example, in the auto industry.

2.4 Manufacturing Strategy

Strategy, in simple terms, is the sequence of decisions and actions intended for the attainment of goals (Swamidass & Newell, 1987). To an organization, strategy formulation is the development of specific goals and objectives by creating a fit between internal and external environment. These goals and objectives determine the way the organization will compete in its industry (Buffa, 1984).

Formulating and implementing such strategic plans are, however, complicated tasks. Fortunately, there exists a wide body of literature on corporate and business strategy, that depict the intricacies of such strategic processes as well as their relationships with other fields such as organization theory and development.

Manufacturing strategy is a relatively new field. Skinner (1969) first recognized the strategic significance of manufacturing in his pioneering work: "Manufacturing: The Missing Link in Corporate Strategy." Since then, several authors have attempted to further develop and refine Skinner's work on manufacturing strategy. Recently, manufacturing has increasingly been identified as a potential source of competitive advantage.

Although there is no widely accepted definition of manufacturing strategy, it can generally be defined as an efficient and effective use of corporate resources to support the strategic goals defined by a firm's business strategy (Hayes & Wheelwright, 1984). It is through a consistent pattern of strategic decisions that manufacturing function contributes to the long-term competitive advantage and performance of the business (Hayes & Wheelwright, 1984; Swamidass & Newell, 1987).

In general, manufacturing strategy is assumed to be a part of the widely accepted hierarchy of strategy suggested by Hofer and Schendel (1978) (cited in Swamidass and Newell, 1987). The hierarchy consists of three levels. At the highest level corporate strategy dictates the products or businesses the corporation should be in, and the allocation of resources to those businesses. At the second level, the business strategy refers to the way that particular business will compete to achieve distinctive competences. The third level consists of functional strategies, including manufacturing strategy, which support the business and corporate strategy.

The notion that manufacturing strategy and business strategy should be tightly linked together, with the former supporting the latter, is widely accepted today. In a study of 169 manufacturing units in the Swedish engineering industry, Tunalv (1992) finds that firms with a formulated manufacturing strategy, aligned with the business strategy, achieve higher business performance than firms without such a strategy. Similar findings were reported by Richardson et al. (1985).

However, literature on manufacturing strategy fails to provide a solid foundation on which further knowledge can be developed. The term manufacturing strategy is rather loosely defined and poorly understood, say authors such as Swamidass and Newell (1987) and Schroeder, Anderson, and Cleveland (1986).

Most studies on manufacturing strategy focus on the content of manufacturing strategy. Little work has been done on the process by which manufacturing strategy is developed and implemented, say Anderson, Schroeder, and Cleveland (1991). Also, research mainly provide a mixed illustration of both process and content notions (Leong et al., 1990).

Though both process and content dimensions are equally important, distinction between them is important for a greater clarity, understanding, and further development of the concept of manufacturing strategy (Leong et al., 1990; Swamidass & Newell, 1987).

2.4.1 Process Model

Process refers to how the manufacturing strategy is analyzed, developed, and implemented (Anderson et al., 1991). The process of manufacturing strategy was first formulated by Skinner (1969). Later, others such as Hayes and Wheelwright (1984) and Fine and Hax (1985) further developed the concept.

Skinner suggested a top-down approach in which manufacturing strategy is derived from the business and corporate strategy. Work done by others such as Anderson et al. (1991) and Leong et al. (1990) reinforces Skinner's concept of manufacturing strategy process.

Although top-down approach is still widely prevalent, Hayes and Wheelwright (1984) propose an interactive (top-down--bottom-up) approach to manufacturing strategy. In fact, interactive approach is getting some support recently. In an analysis of the process of formulating and implementing manufacturing strategy, as practiced by six leading-edge firms, Marucheck, Pannesi, and Anderson (1990) find that manufacturing is getting increasingly involved in the corporate strategic planning process, although top-down approach is still practiced most.

The top-down view of manufacturing strategy has been questioned by many recently. This view suggests that functional capabilities follow if strategies are realized (Leong et al., 1990). However, capabilities may be acquired through activities other than that of strategic plans. Miller and Hayslip (1989), on the

other hand, propose that capability development and strategic plan development are two separate processes which should be pursued independently though in an integrated way to achieve distinctive competences.

Hayes (1985) argue that under uncertain and unstable environment manufacturing capabilities may drive corporate strategy. Wheelwright and Hayes (1985) assert that to be truly competitive, manufacturing should take a more aggressive and proactive role rather than assuming a reactive mode, as suggested by the top-down approach. They propose four stages in the evolution of manufacturing's strategic role. Manufacturing evolve from a passive and internally neutral role in Stage 1 to an aggressive and externally supportive role in Stage 4. It is Stage 4 firm in which the competitive strategy is based to a significant degree on its manufacturing capabilities, say Wheelwright and Hayes.

2.4.2 Content Model

Anderson et al. (1991) define content as "the what of strategy: the objectives, the decisions, and the final result of the manufacturing strategy."

Leong et al. (1990) categorize the content elements into two groups: 1. Decision areas that are of long term importance in the manufacturing function; and 2. competitive priorities based on corporate and/or business unit goals. Here the focus of discussion will be mainly on strategic decision areas. For an analysis of competitive priorities see the section on manufacturing performance.

The birth of manufacturing content should be credited to Skinner, say Leong et al. (1990). Skinner identified four competitive priorities: cost, quality, delivery, and flexibility. He also suggested that a fit between manufacturing and business strategy need to be made by making certain key strategic decisions in the following five areas: Plant and equipment; production and planning control; labor and staffing; product design/engineering; and organization and management.

The content of manufacturing strategy has been further elaborated by authors such as Hayes and Wheelwright (1984), Buffa (1984), Fine and Hax (1985), Abernathy et al. (1983), Beckman et al. (1990), and Schroeder et al. (1986).

Hayes and Wheelwright (1984) categorize the strategic decision areas into two groups: Structural and infrastructural, as follows (p. 31):

Structural

- * Capacity -- amount, timing, type.
- * Facilities -- size, location, specialization.
- * Technology -- equipment, automation, linkages.
- * Vertical integration -- direction, extent, balance.

Infrastructural

- * Workforce -- skill level, wage policies, employment security.
- * Quality -- defect prevention, monitoring, intervention.
- * Production planning/materials control -- sourcing policies, centralization, decision rules.
- * Organization -- structure, control/reward systems, role of staff groups.

Hayes and Wheelwright call the structural decisions as "bricks and mortar" which are of long-term impact and are difficult to change once installed. By infrastructure, they refer to the management policies and systems that determine how the bricks and mortar are managed. They define manufacturing strategy as a collective pattern of structural and infrastructural decisions that determines the strategic capabilities of a manufacturing operation.

Abernathy et al. (1983) assert that the infrastructural decisions, which they call micro-software, are of critical importance for the resurgence of American industry.

Buffa (1984) takes the view that manufacturing strategy lies along a continuum with minimum-cost/high-availability strategy on one end and high-quality/flexibility strategy on the other. The choice along these two extremes is determined by the interaction of six basic elements:

- * Positioning the production system.
- * Capacity location decisions.
- * Product and process technology.
- * The workforce and job design.
- * Strategic implications of operation decisions.
- * Suppliers and vertical integration.

In summary, both conceptual and empirical studies have focused more on content of manufacturing strategy, whereas process has received little attention. Within content, studies tend to focus on a single content area and ignore interactions with other content areas or overall performance (Leong et al., 1990).

Manufacturing strategy literature lacks the necessary substance that can stimulate empirical research, say Swamidass and Newell (1987). They further add that

Although many concepts have been identified, it lacks the scientific development of these concepts, integration of relevant literature from several disciplines, operationalization of manufacturing strategy variables from empirical analyses, empirically validated models of manufacturing strategy, and empirical findings relating to manufacturing strategy which can sprout new hypothesis for investigation. (p. 511)

2.5 Strategy - Technology Interface and Business Performance

The strategic role of technology in improving business performance has been documented by many researchers (Buffa, 1984; Goldhar et al., 1991; Meredith, 1987; Weil et al., 1991). But, so is the increasing recognition of the importance of ensuring a fit between technology and business strategy (Dvir et al., 1993; Hayes & Schmenner, 1978; Kantrow, 1980; Lefebvre, Langley, Harvey, & Lefebvre, 1992; Morone, 1989; Weiss & Birnbaum, 1989; William & Novak, 1990). According to Kantrow (1980), linking technological decision to company's strategic thinking is of fundamental importance.

Ensuring a fit between technology and strategy enables a company to strategically use its technological capabilities in pursuit of the goals of business strategy (Zahra & Covin, 1993). On the other hand, this consistency is also crucial for the proactive exploitation of technological resources in order to create

a sustainable competitive advantage (Kantrow, 1990; Wheelwright & Hayes, 1985) that enhances firm's performance (Porter, 1985).

Until recently, manufacturing technology was of little strategic concern (Parthasarthy, 1991). It had been viewed mainly as a tool to implement the strategies conceived by the top management. The sole concern of top management was to enhance manufacturing capabilities so that products could be manufactured at low cost.

Nevertheless, since Skinner's (1969) recognition of the strategic significance of manufacturing, several attempts have been made to conceptualize the relationship between technology and strategy. Prominent among them are: Utterback and Abernathy's (1975) "process-product innovation" model; Skinner's (1974) "focused factory"; and Hayes and Wheelwright's (1979a, 1979b) "process-product life cycles" framework. These works were followed by others to further develop the conceptual knowledge as well as to empirically test them (Hayes & Schmenner, 1978; Stobaugh & Telessio, 1983).

These studies, however, were centered around the top-down approach proposed by Skinner (1969). Although technology was linked to strategy, it assumed a supportive role. The strategic goals formulated at the top served as guidelines for performances at the factory floor. The concept of focus and trade-off inherent in scholarly papers further augmented the complacency and conservatism of practitioners.

However, recent advancements in manufacturing technology (flexible automation) and the well known Japanese manufacturing excellence have made the traditional sequential view of manufacturing largely inappropriate. The dynamic view of manufacturing technology proposed by authors such as Hayes et al. (1988) and Wheelwright (1985) has led to a new line of research on strategy-technology interface. Scholars such as Wheelwright and Hayes (1985), Morone (1989), Skinner (1985) and others assert that technological capabilities can be strategically used to achieve sustainable competitive advantage. According to Morone (1989),

What distinguishes the innovative firm is not just that it is more efficient in applying technology to meet its ends, but that its ends are themselves shaped by technology. Technology creates strategic opportunities; innovative companies recognize these opportunities and build corporate strategy around them. (p. 96)

Similar perspectives are placed by others, too. Edmondson and Wheelwright (1989) contend that to achieve manufacturing excellence, manufacturing process technology need to be changed from an art to a science. Mitchell (1990) asserts that integrating the business and technical perspectives within a single framework will better equip us to deal with changes resulting from technological innovations. This argument is central to Kantrow's (1980) technology strategy.

Kantrow (1980) argues that the development of technology strategy would provide a greater clarity and understanding of the strategic importance of technology by bringing the organizational and environmental factors together.

He says that it is "plain common sense" to view a company's technology strategy within the context of its general business orientation.

These propositions are further corroborated by empirical testing, too. In a survey of 103 manufacturing firms in 28 mature industries, Zahra and Covin (1993) find that a fit between business strategy and technology policy leads to better performance. Also, the strength of the relationship between the technology policies and performance varies across firms with different business strategy configurations.

Offering a very different perspective, Morone (1989) argues that the technology strategy literature does not answer what makes a company more adept at incorporating technology-based opportunities into their overall competitive strategy. As Morone says:

It is one thing to make technology decisions consistent with corporate strategy, and quite another to bring the potential opportunities that technology creates to bear on the formulation of corporate strategy. If the former is technology strategy, the latter is strategic use of technology. (p. 96)

However, despite the increasing recognition of the strategic importance of the fit between technology and strategy, there is little empirical work done to examine the nature of these relationships and their impact on business performance (Lefebvre et al., 1992; Zahra & Covin, 1993). In conceptual literature, too, material relating technology to strategic concerns of business is sparse (Kantrow, 1980). The lack of conceptual knowledge makes it difficult to conduct systematic empirical tests. As Kantrow (1980) notes: "Even today no

universal agreement exists about which data are relevant or which techniques of analysis are appropriate, although the area of disagreement has narrowed."

Moreover, the recent trends in manufacturing technology, for example, the computerized integration of technology, requires new perspectives and approaches to conceptualize the technology-strategy relationship.

2.6 Manufacturing Performance

Assessing manufacturing performance is crucial for determining the competitive strength of a firm. For a firm, manufacturing performance is an indicator of where the firm is, how far it has achieved its prespecified plans, and, more importantly, how it can effectively use its capability to enhance its performance in comparison to its competitors (Youssef, 1991).

The strength and importance of manufacturing performance measurements are determined by the degree to which they support the business strategy. "Each strategy creates a unique manufacturing task. Manufacturing management's ability to meet that task is the key measure of its success," says Skinner (1978). These manufacturing tasks or competitive priorities indicate what manufacturing must do well to meet the demands placed on it by a firm's strategic plans (Hayes & Wheelwright, 1984; Richardson, Taylor, & Gordon, 1985; Schmenner, 1990). In fact, the toughest part is the translation of a firm's business unit strategy to a set of manufacturing tasks, says Schmenner (1990).

Many authors have recognized cost, quality, responsiveness, and flexibility as the four main competitive priorities (De Meyer & Ferdows, 1990; De Meyer et al., 1989; Hayes & Wheelwright, 1984; Maskell, 1991; Skinner, 1984). The emphasis placed on these priorities varies by firms, depending on a large number of factors including availability of resources, business strategy, existing capability, managerial behavior, nature and intensity of competition, and environmental conditions.

In the 1986 manufacturing survey of large firms in Europe, North America, and Japan, De Meyer et al. (1989) find that Europeans and North Americans are preoccupied with quality and dependable delivery, whereas Japanese have cost as their number one priority, and flexibility number two. The authors argue that Japanese having significant edge in quality have turned their focus on resolving the trade-off between flexibility and cost-efficiency, whereas Americans and Europeans are still fighting with quality and traditional cost-cutting measures.

Traditionally, trade-offs have been assumed among these choices (Skinner, 1974). It is argued that because of inherent limitations of people, equipment, and process technology, all tasks cannot be accomplished equally well. Only by focusing on a few tasks can one achieve distinctive competences. These views are further supported by authors such as Hayes and Wheelwright (1984), and Richardson et al. (1985).

However, the trade-off theory has increasingly been questioned by many authors recently (De Meyer et al., 1989; Goldhar & Jelinek, 1985, 1990). The

simultaneous achievement of cost, quality, delivery, and flexibility by many Japanese companies has highlighted this new possibility that can be realized by adopting advanced process technologies and management techniques.

Nevertheless, there exist two contradictory claims on relationships among these strategic priorities: tradeoffs (Skinner, 1969; Hayes & Wheelwright, 1984; and Richardson et al., 1985) and non-tradeoffs (Ferdows & De Meyer, 1990; Son & Park, 1987; and De Meyer et al., 1989).

Furthermore, there is widespread disagreement as to what these priorities mean and how they are to be measured. A brief introduction to cost, responsiveness, quality, and flexibility.

2.6.1 Cost

Cost efficiency is crucial for the survival of a firm (Buffa, 1984). It not only determines the efficiency of operation but also affects the degree of realization of other performance dimensions.

Cost in simple terms is the value of resources used to produce a product. The higher the productivity of these resources - labor, capital (equipment), material, and overhead, the more competitive a firm will be. However, the recent changes in manufacturing have made the conventional cost accounting largely inappropriate.

The conventional wisdom of improving cost through learning effect has also been questioned by some authors. They claim that with automation the first product can be made with as much efficiency as the thousandth product, thereby nullifying the effect of learning curve. They, however, ignore the fact that learning has rather extended into the design stage (Jelinek & Goldhar, 1983). Designing a simple product which can be manufactured easily is crucial for automation. Moreover, learning has become more complex with all systemwide integration under automation (Meredith & Camm, 1989).

2.6.2 Responsiveness

Responsiveness refers to delivery reliability and the speed of delivery (Maskell, 1991; Schmenner, 1990). Schmenner (1990) include volume flexibility (ability to change output quantity quickly), too, in delivery related tasks. Here, we consider it under flexibility.

Delivery performance depends upon a large number of factors, including correct scheduling, supplier reliability, error free manufacturing, high quality, reliable distribution channel, and, in particular, customer satisfaction.

Delivery reliability means delivering goods in the right quantity on time every time (Maskell, 1991). The meaning of 'on-time,' however, varies according to the type of market and the type of products involved, says Maskell. Usually, if

a delivery is dispatched prior to a planned delivery date, it would be considered 'on-time.'

Speed of delivery refers to the speed at which a product can be manufactured and delivered to the customer. It depends on manufacturing lead time. The shorter the lead time, the faster the service will be.

Automation has greatly facilitated the speed of delivery. One doesn't have to wait for long production runs to be finished. Now, variety of products can be manufactured with economic order quantity as low as one.

2.6.3 Quality

Quality is another critical dimension of performance. Improving competitive position through quality is well exemplified by the Japanese case.

Ferdows and De Meyer (1990) see quality as the basis for all other improvements. They say: "A precondition to all lasting improvements in manufacturing capabilities is improvements in the quality performance of the company." Explaining the Japanese approach, Wheelwright (1981), too, indicates that quality is viewed as the means to the cost efficiency end, not as the opposite to cost. Miller and Roth (1988) claims that quality may serve less to distinguish competences than as a qualifying criterion to be in the market place.

However, the word quality has been defined in several ways, making it more ambiguous and difficult to measure.

Crosby defines quality as "conformance to requirements" (cited in Maskell, 1991). Juran, however, believes that such definitions though clarify workers' role, they do not specify company's responsibility. He defines quality as "fitness for use"; the extent to which a product meets customer needs (Juran & Gryna, 1988). Fitness for use is determined by - product features; product design and degree of conformance to that design; product availability (available in an operative state when needed); product reliability (free from deficiencies); and product maintainability (ease with which maintenance can be conducted).

Garvin (1984) says that quality has been viewed by different groups from a different perspective, making it more difficult to understand and practice.

Reliance on a single definition of quality often leads to problems, says Garvin. For example, even after achieving excellent conformance to specifications, poor acceptance in the market can be a disaster. Recognizing the limitations, Garvin identifies 8 dimensions as the basic elements of product quality:

1. Performance
2. Features
3. Reliability
4. Conformance
5. Durability
6. Serviceability
7. Aesthetics
8. Perceived quality

Firms may pursue a narrow quality niche based on a few dimensions rather than all eight at once, says Garvin. The selection, however, depends on the strategic requirements of a firm.

Measuring quality is a difficult task. Many authors have made an attempt to quantify quality by measuring the cost of quality. Nevertheless, these measures suffer from certain limitations. First, there is no reliable method to give accurate measure of costs associated with prevention, appraisal, internal, and external failure.

Second, a plant manufacturing several products would have significantly different quality costs both across products and for each subcomponent, too. There is no way to differentiate between quality costs for these products in a reliable manner.

Third, the concept of quality itself is at best customers' perceptions and expectations for products, which is again difficult to quantify.

Finally, the quality measures currently available largely measure only the tangible costs incurred. There is no attempt to measure the intangible costs, for example, the costs of losing customers because of poor quality or the gains from attracting new customers because of excellent quality.

2.6.4 Flexibility

Perhaps of all performance measures flexibility is the most ill-defined and ambiguous one. Gupta and Goyal (1989) define flexibility as "the ability of a manufacturing system to cope with changing circumstances or instability caused by the environment." Beckman (1990), too, define flexibility as "the ability of a

manufacturing organization to deploy and redeploy its resources effectively in response to changing conditions."

These definitions portray flexibility in a reactive mode; the ability to respond to environmental uncertainty. However, flexibility can also be used in a proactive form to redefine environmental uncertainties or even to create new ones (Gerwin, 1993). Gerwin (1993) also considers flexibility as a reserve resource to meet future needs. He further claims that through proactive approaches to environmental uncertainty, one can reduce the need for flexibility itself.

Slack (1983) considers flexibility with respect to three dimensions: Range, time, and cost (cited in Gupta & Goyal, 1989). A production system is considered to be more flexible than another if it can adopt a wide range of states within a shorter period of time and at low cost.

Several authors have classified manufacturing flexibility. The purpose of this study is not to analyze them in detail. For a literature review on manufacturing flexibility, see Gupta & Goyal (1989).

Flexibility has been classified in several ways. Some authors classify the same flexibility into different categories while others group several flexibilities into one (Gupta & Goyal, 1989; Son, 1991). As Swamidass (1988) indicates (cited in Ramasesh & Jayakumar, 1991):

1. The scope of flexibility related terms used by various authors overlap considerably;
2. Some flexibility terms are aggregate of other flexibility terms used; and

3. Identical flexibility related terms used by more than one writer do not necessarily mean the same thing.

Nevertheless, there exist several approaches to quantify flexibility. Some are qualitative whereas others are quantitative. Some are based on physical characteristics of the manufacturing process whereas others focus on the impact of flexibility on performance criteria (Gupta & Goyal, 1989). For a classification of flexibility literature according to these measure types, see Gupta & Goyal (1989).

The problems associated with flexibility measures are well documented in the literature. Ramasesh & Jayakumar (1991) indicate that most of these measures are non-financial measures. Gupta & Goyal (1989) say that a majority of these measures do not consider job characteristics, are too complex, and have no specified units of measurement.

Most of the studies focus on defining and measuring flexibility in isolation to the environment (Ramasesh & Jayakumar, 1991). Flexibility on all dimensions is seldom needed by a firm. It is more a function of the strategic objectives of a firm and its environmental conditions. A supplier with uncertain demand, for example, might be more concerned with volume flexibility than with the ability to introduce new products quickly.

Moreover, flexibility on all dimensions cannot be achieved with the same intensity. Certain flexibilities can only be achieved at the cost of some other flexibilities (Gupta & Goyal, 1989; Gunasekhran, Martikainen, & Yli-Olli, 1993). Knowledge of this tradeoff is important to prioritize the flexibility requirements.

The available measures, however, fail to measure the tradeoff aspect (Ramasesh & Jayakumar, 1991).

2.7 Interactions Among Manufacturing and Business Performance Measures

Many have argued that increase in manufacturing performance might lead to enhanced business performance. Garvin (1983) indicates that a strong relationship among quality, market share, and return on investment (ROI) has been demonstrated by the PIMS (Profit Impact of Marketing Strategies) data. He adds that:

Not only does good quality yield a higher ROI for any given market share (among business with less than 12% of the market, those with inferior product quality averaged an ROI of 4.5%, those with average product quality an ROI of 10.4%, and those with superior product quality an ROI of 17.4%); it also leads directly to market share gains. Those businesses in the PIMS study that improved in quality during the 1970s increased their market share five to six times faster than those that declined - and three times faster than those whose quality remained unchanged. (p. 68)

Garvin (1984) relates quality and profitability through two means: market gains and cost savings. He argues that improved image for quality may lead to increased market share, or to higher prices due to inelastic demand. Increased market share results into lower cost as a result of greater economies of scale. Improved profits, therefore, follow either from higher prices or reduced costs.

Improved quality can also lead to increased profits through cost savings either by lowering manufacturing costs due to increased productivity and less rework and scrap costs, or through lower service costs due to reduced warranty and product liability costs.

Findings on the relationship between flexibility and business performance show mixed results. In an empirical study, Kekre and Srinivasan (1990) showed that a broader product line was associated with higher market share and profitability (cited in Gerwin, 1993). On the other hand, Feigenbaum and Karnani (1991) found no relationship between volume flexibility and return on assets (cited in Gerwin, 1993).

Although the relationship between manufacturing and business performance is widely accepted, there exists little research to capture how this interaction works. Recently, Cleveland, Schroeder, and Anderson (1989) tried to explain this relationship by developing a construct called production competence. They defined production competence as a variable that determines a manufacturer's overall ability to support and implement its business strategy. Production competence refers to the strength of manufacturing performance in a particular area and the importance of that area as specified by a firm's business strategy. On the basis of a study of 6 hard good manufacturers, Cleveland et al. came to the conclusion that production competence was indeed a link between a firm's manufacturing capability and its business performance.

In a subsequent study, Vickery, Droge, and Markland (1993) redefined production competence by including three critical factors: 1. The strategic importance of the competitive elements in the firm's strategic profile, 2. manufacturing's responsibility for areas in the strategic profile, and 3. the measurement of manufacturing performance. Applying the redefined production competence construct to a sample of 65 firms in furniture industry, Vickery et al. found positive relationship between production competence and business performance.

In summary, manufacturing performance contributes to enhanced business performance only to the extent that it supports the overall business strategy. The development of production competence construct, to examine the link between manufacturing and business performance, by Cleveland et al. (1989) and Vickery et al. (1993) is an important step forward in this direction. However, research in this area is still in its infancy.

2.8 Technology and Organizational Design

Concern with the relationship between technology and organizational design is not new. What is new is the new dimension this relationship has assumed recently. Organizations adopting flexible automation are strikingly different than that of the Taylor era. The organization-wide integration and coordination required by new technology is a novel phenomenon. The lean, agile,

or the so called horizontal corporations portray a completely new dimension of organizational design.

Need for a change in organizational design has been recognized by both conceptual and empirical literature (Adler, 1988; Bessant & Haywood, 1986; Ettlie, 1988; Meredith, 1987; Rolland, 1985). Ettlie (1988), for example, argues for what he calls synchronous innovation, that is, the simultaneous adoption of both technological and administrative innovation. The need for a faster administrative change becomes more critical in a hostile environment, he adds. Importance of organizational adaption is further highlighted in conceptual writings by authors such as Adler (1988), Meredith (1987), Rolland (1985), and Parthasarathi and Sethi (1992).

Empirically, too, the findings well support the conceptual writings. On the basis of interviews with 29 senior manufacturing executives in large US companies, Farley, Kahn, Lehman, and Moore (1987) indicate that the main reason for delay in implementing automation is the incompatibility of existing organizational practices.

However, the changes required are quite different today. Organizations are undergoing a change of magnitude much more than what we have seen in the past. The change is not confined to labor only but is impacting each and every aspect of an organization. What we are witnessing is a complex composite of the triangular relationship between flexibility, integration, and environmental uncertainty.

According to Tranfield, Smith, Ley, Bessant, and Levy (1991), "the main problem is variety--different firms are confronted by different strategic contingencies, and choices (by managers another key strategic actors) vary widely even in response to the same set of contingencies" (p. 214). Child (1987), too, holds the same opinion. He argues that the relationship between AMT and organizational design is shaped by two levels of strategic contingencies: One is general that affects most industries at a macro-economic level; and the other is specific that relates to an organization's internal characteristics and competencies.

Though different organizations pursue different organizational changes, a fit between technology, organization, and environment is crucial for successful implementation of new technologies. As Jelinek and Burstein (1982) note: "...little thought to matching them [production systems] either with other administrative systems within the firm or to the firm's strategy...result in dysfunctional lack of fit, needless confusion, conflict, and waste" (p. 250).

However, what particular fit can lead to better performance is an elusive concept. There is little empirical research done to address the issue of technology and organizational design in firms using AMT; not to mention of effectiveness in terms of performance.

There are few conceptual studies on technology-organization interface under integrated automation, on which one can rest the empirical testing (Tranfield et al., 1991). Whatever knowledge we have is related to the stand-

alone or mass production technologies. Moreover, flexible automation is currently passing through a transitional phase, and is not matured and established (Liu et al., 1990; Tranfield et al., 1991). According to Tranfield et al., "...[new technologies] are characterized by a high level of potential choice about their design and organizational implementation. They are essentially 'configurational' technologies, and are subject to a high degree of organizational and social shaping" (p. 219).

Nevertheless, a clear understanding of historical findings is often the basis for future knowledge building. We, therefore, present a review of the literature on technology's impact on organizational structure.

2.8.1 Technology and Organizational Structure

Since the 1950s researchers have been attempting to relate the manufacturing technology of a firm to its organizational structure. The relationship was first established by Joan Woodward in a 1958 study of 100 manufacturing firms in South Essex, England. After failing in her initial attempt to establish any significant relationship between structure and other organizational characteristics, Woodward re-examined the data on the basis of technical complexity, defined as the extent to which the production process was controllable and predictable. The findings led to the conclusion that the structure of organizations are likely to vary by the type of manufacturing technology used (Woodward, 1965).

More specifically, Woodward (1965) came to the following conclusions:

1. Increase in technical complexity was directly related to the length of the line of command, the span of control of the chief executive, the percentage of total turnover allocated to the payment of wages and salaries, etc.
2. A curvilinear relationship was found between a firm's technical complexity and the type of management systems. Organic management systems with high degree of delegation of authority and responsibility predominated in unit and process technologies, whereas mechanistic systems with rigid control and precise duties prevailed in large batch and mass production.
3. There appeared to be a particular type of organizational structure most appropriate to each technology type.

The point worth noting is that Woodward never claimed that technology was the only variable that determined structure. Other factors such as company history and people were equally important.

Research following Woodward (1965) provided rather confounding and contradictory results. Among her contemporaries, Harvey (1968) and Zwerman (1970) supported Woodward's findings in their respective studies (cited in Ford & Slocum, 1977). On the other hand, research by Hickson, Pugh, and Pheysey (1969) revealed that though technology influenced structure, size was the major

determining factor (cited in Skinner & Chakraborty, 1982). Technology was found to have a major impact at the operating level; but had little effect on the upper hierarchical levels. Woodward's study was criticized on grounds of relating technology to organizations only at the lower technical core of an organization (Skinner & Chakraborty, 1982).

In a subsequent replication of Hickson et al.'s (1969) study, Child and Mansfield (1972) corroborated Hickson et al.'s findings (cited in Skinner & Chakraborty, 1982). In a sample of 82 British firms they found that size had a significant influence on organizational structure and design, with technology having little role to play.

In a survey of 110 New Jersey manufacturing concerns, Blau, Falbe, McKinley, and Tracy (1976) failed to establish Hickson et al.'s (1969) hypothesis of a interaction effect between size, technology, and structure. Rather a strong curvilinear relationship, independent of size, was found between technology and organizational structure.

Khandwala (1974), on the other hand, rejected the findings of both Woodward (1965) and Hickson et al. (1969). In a survey of 79 manufacturing firms, he found mixed results. The impact of technology on structure was found to be modest and selective for the whole group, but quite strong for a group of relatively profitable firms. Size was found to be independent of, and at least as important as technology, in influencing structure.

Marsh and Mannari (1981) further confounded the controversy over size and technology as determinants of structure. In a survey of 50 Japanese factories, they found that size affected only two dimensions of structure -- structural differentiation (complexity) and formalization -- more than technology did. Technology had a stronger impact than size on all other dimensions -- labor inputs, the proportion of university graduates among personnel, costs and wages, the differentiation of management from ownership, the span of control of the factory chief executive, and union recognition.

In a reanalysis of Marsh and Mannari's (1981) study, Singh (1986) questioned the validity of their findings on grounds of methodological ambiguity. An examination of the construct validity of the measures, using multiple measures of constructs, revealed that no convergent solution could be obtained except the positive relationship between size and differentiation. According to Singh, the reason might be the inconsistency between the model and the data collected. Including wide dimensions as structural aspects are often the cause of erroneous results.

The literature clearly shows that there is no unanimity over the relationship between technology and structure. However, authors such as Stanfield (1976), and Ford and Slocum (1977) question the validity of the findings itself. The contradictory findings are more the result of unrationalized categorization of variables, assuming homogeneity within categories, than because of the nature of relationship between technology and structure, says

Stanfield. Both Stanfield, and Ford and Slocum are of the opinion that conclusion should be drawn only in terms of a few structural dimensions rather than about the overall relationship between technology and organizational structure. Technology impacts structure selectively, some more than others.

Fry (1982), too, takes the view that conceptual and methodological shortcomings are the main causes of confusion and contradictory results. In a review of 140 studies of technology-structure relationship, he observes that there is a considerable overlap concerning the conceptualization of technology and structure. Moreover, the studies are conducted at several levels: organizational, subunit, and individual, with little attempt to control the level effects, says Fry. He further indicates that there is a wide variation in the operationalization of technology variable.

However, on the basis of an analysis of the 140 studies, Fry (1982) argues that technology-structure relationship does exist. Also, he found little effect of the type of measures used in the literature. The relationship was found to be more pronounced at the subunit level than at the organizational or individual level.

The emerging consensus seems to be that technology does affect structure. But the question is how and at what level of the organization is the impact more pronounced (Parthasarthy, 1991). Skinner and Chakraborty (1982) say the relationship between technology and structure is a complex one and is affected by several factors such as control system, firm size, and industry type.

According to the contingency theory of fit, an organization can employ the structure along a continuum, with organic structure on the one end mechanistic on the other. The increase in environmental uncertainty demand for an organic structure that is more adaptable, whereas stable environment need to be matched with mechanistic or formalized structures.

In summary, despite contradictory findings, literature does reveal a relationship between manufacturing technology and organizational structure. The relationship is more pronounced at the technical core or operations level of an organization, but the effect dissipates at the institutional level. Technology is related to structure through the certainty-uncertainty continuum, leading to mechanistic-organic management systems. This relationship is likely to be affected by a host of other factors such as culture, size, people, and so forth.

These findings, however, rest on a narrow definition of manufacturing automation. Automation in the past was more rigid, with its effect confined to the operational level. This might be a reason behind so many studies' failure to establish any relationship at the organizational level. But, today, automation is more flexible impacting operations as well as other business functions in the organization. The increasing automation intensity is associated with flexible and discrete production than with Woodward's (1965) standardized and specific production. The level of integration and co-ordination that is required today was unknown in the earlier era.

Chapter 3

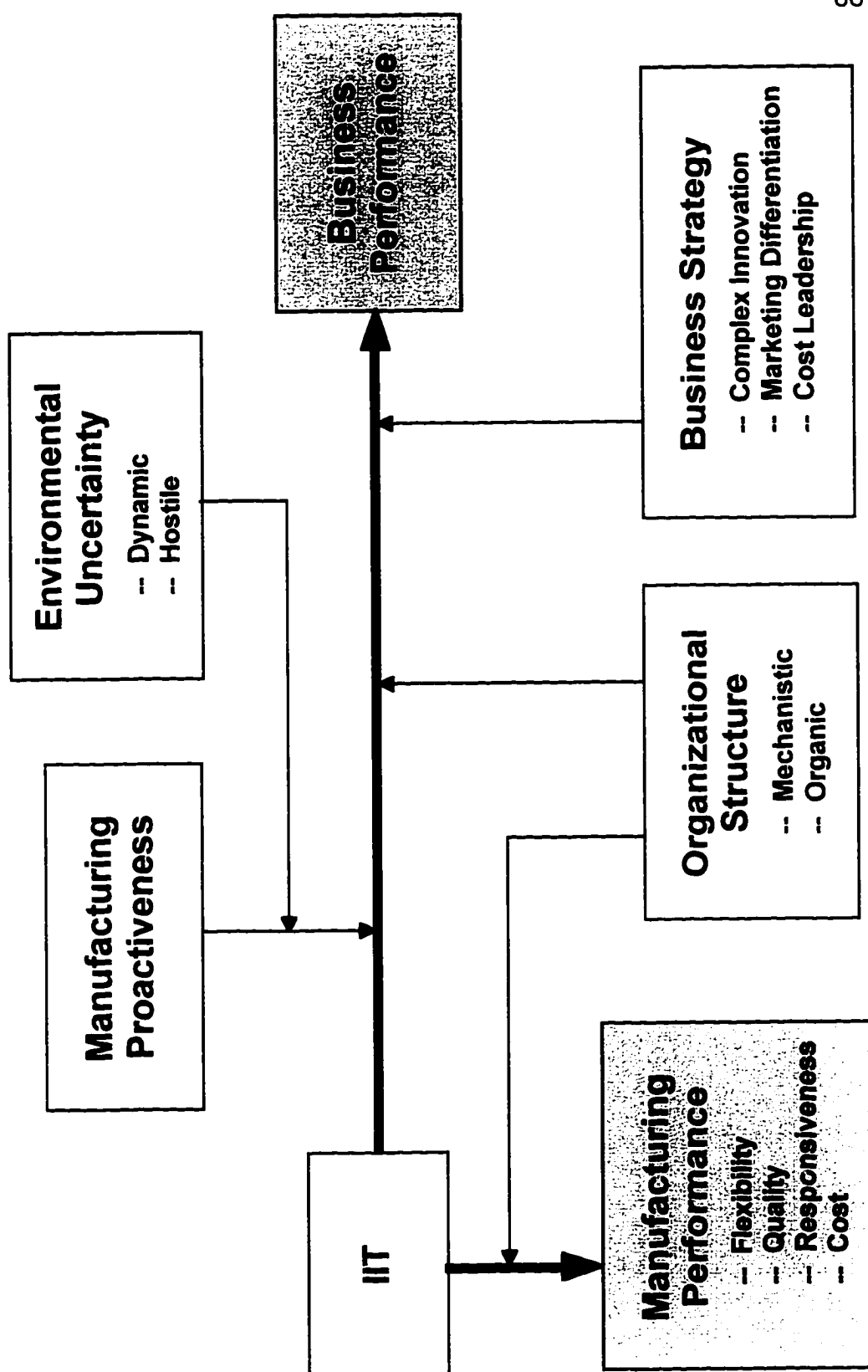
RESEARCH MODEL AND THEORY

This chapter first describes the theoretical framework on which this research is based. Using the existing body of research, we then explain the interrelationships among the elements of the proposed framework and hypothesize the relationships to be tested.

3.1 Theoretical Framework

The research model is illustrated in figure 3.1. Advanced Manufacturing Technology (AMT) is the only independent variable included in the model. The dependent variables examined are manufacturing performance and business performance. As indicated in the model, the relationship between AMT and the performance variables is moderated by the type of organizational structure, business strategy, manufacturing proactiveness, and environmental uncertainty. These variables are explained below.

Figure 3.1 Research Model



3.1.1 Independent Variable

Advanced Manufacturing Technology (AMT)

Although there is no unanimity over AMT concept, it is generally defined to include a host of technologies such as CAD, CAM, FMS, etc. Though illdefined, AMT is quite distinct from the traditional technologies used for mass production. AMT is used mainly for the production of small to medium batches of a variety of products and/or parts by bringing together the efficiency of mass production technologies while retaining the flexibility of stand-alone machine tools (Craven & Slatter, 1988; Goldhar & Jelinek, 1990).

We can categorize AMT into more specific groups. The most common AMT classification found in the literature is based upon the functions served by these technologies. Using classification schemes of Attaran (1989) and Meredith (1987), we have categorized AMTs into three groups in terms of their area of application: engineering or designing, manufacturing, and production planning. The details of the classification scheme is presented in section 4.2 in chapter four.

3.1.2 Moderating Variables

The moderating variables included in this research are: organizational structure, business strategy, manufacturing proactiveness, and environmental uncertainty.

Organizational Structure

The structure of an organization is the pattern of peoples' roles and relationships designed to get work done through proper direction and co-ordination. Organizational structure has been conceptualized in numerous ways. Some of the central dimensions used to classify structure are: structuring of activities (formalization and specialization), concentration of authority (centralization), size of the line and staff component, and the level and degree of integration used.

Research on organizational structure assumed a new direction with the study of Burns and Stalker (1961). Burns and Stalker classified structure along a mechanistic-organic continuum. A mechanistic structure is one with rigidly defined tasks, centralized authority, and a bureaucratic system with use of formal rules, programs and procedures for coordination. An organic structure, on the other hand, has complex and flexible tasks, decentralized authority, and frequent vertical and cross-functional communication.

Business Strategy

The word strategy comes from the Greek **strategos**, meaning "a general." The word stratego means "to plan the destruction of one's enemies through effective use of resources" (Mintzberg, Quinn, & Voyer, 1995).

In a business context, strategy refers to a comprehensive masterplan designed and implemented to make a business more competitive. The concept of strategy though studied and described in detail by many (Andrews, 1971; Hofer, 1975; Miles & Snow, 1978; Miller & Friesen, 1977; Snow & Hrebiniak, 1980; Schendel & Hofer, 1979), it was Porter (1980) who offered the more simplified and sophisticated model of strategy (Miller, 1988).

According to Porter (1980), a firm's choice of business strategy is determined by its relative competitive position within an industry. The three generic business strategies defined by Porter are: Cost leadership, differentiation, and focus. Research following Porter's work has provided the much needed empirical validity to Porter's classification of business strategies (Dess & Davis, 1984; Hambrick, 1983; White, 1986).

Miller (1986) has further classified Porter's differentiation type into – complex innovation and marketing differentiation. Considering the scope of our research, we limit our study to the following three types of business strategy: Complex innovation, marketing differentiation, and cost leadership.

Complex Innovation: The strategy of complex innovation refers to rapid introduction of new products or services. An innovating differentiator strives to be the pioneer. It leads its competitors in quality, design, and product features. Engineering and R&D functions play a key role in organizations pursuing this approach.

Marketing Differentiation: A marketing differentiator attempts to create a unique and favorable image for its products through aggressive marketing efforts. "The firm does not necessarily produce a higher quality product or a more up-to-date product. It may just sell harder, says Miller (1988). The firm uniquely positions itself to meet the buyers' needs through advertising, better delivery and reliability, or excellent service.

Cost Leadership: A firm adopting the cost leadership strategy strives to be the low-cost producer in the industry. It provides standardized, high volume products at highly competitive prices. Low prices are attained through large scale continuous production facilities, minimizing expenses, or through preferential access to supplies.

Porter (1980) claims that firms trying to pursue both differentiation and cost leadership strategy are "stuck in the middle" – a position whereby they fail to realize the benefits of either strategy. Others, however, have established that firms can pursue several strategies simultaneously (Dess & Davis, 1984; Hambrick, 1983). "Strategies are really dimensions along which firms can score high or low," says Miller (1988).

Manufacturing Proactiveness

Though some authors have addressed the concept of manufacturing proactiveness, few have examined it empirically. The reason lies to a great

extent in our perception of manufacturing whereby we view manufacturing as a passive implementor of strategies formulated by top management.

It was Skinner (1969) who first codified the strategic importance of manufacturing. However, it was the recent technological advancement that led to proactive involvement of manufacturing in business. Several authors have argued for a change in our attitude towards manufacturing (Hayes & Wheelwright, 1984; Hayes, 1985; Miller & Hayslip, 1989). Hayes and Wheelwright (1984) argue that proactive manufacturing participation in the strategic planning of business is the true characteristics of a world class manufacturer. They contend that these firms, which the authors call as stage IV organizations, achieve higher performance than ones in which manufacturing assumes a subordinate or reactive role.

Manufacturing proactiveness has been empirically examined by a few researchers, namely Swamidass and Newell (1987), Venkatraman (1989), and Ward, Leong, and Boyer (1994). Ward et al. measured manufacturing proactiveness along two dimensions: (1). the degree of manufacturing involvement in the strategic process of a business unit; and (2). the degree of commitment to a long-term program of investments in manufacturing structure and infrastructure aimed at building capabilities in anticipation of their need (p. 339).

In this study, we have measured manufacturing proactiveness using Ward et al's. (1994) first dimension only, that is, the degree of manufacturing involvement in the strategic process of a business unit.

Environmental Uncertainty

Ever since the popularity of the contingency theory, environment has been the most important contextual factor underlying research on strategy (Bourgeois, 1980; Hitt, Ireland, & Palia, 1982; McArthur & Nystrom, 1991; Prescott, 1986; Tan & Litschert, 1994), and structure (Child, 1972; Lawrence & Lorsch, 1967).

Environmental uncertainty has generally been defined as an organization's inability to perceive or predict changes accurately. Milliken (1987) defines three types of uncertainty: State, effect, and response uncertainty. State uncertainty occurs when environmental changes are difficult to predict. Effect uncertainty refers to the inability to predict the impact of future changes in the environment of an organization. Response uncertainty relates to the inability to predict the likely consequences of a response choice.

Literature on environmental uncertainty reveals two distinct perspectives: Information perspective (Duncan, 1972; Lawrence & Lorsch, 1967) and resource perspective (Pfeffer & Salancik, 1978). Information perspective focuses on the inability of a decision maker to perceive or predict the environmental changes and the consequences of the decisions taken. Resource perspective focuses on

the dependency of organizations on environment for scarce resources.

Environmental hostility or munificence is explained by the competition among organizations to acquire and control critical resources.

There exist wide dimensions of environmental uncertainty. Studies, nevertheless, show an emerging consensus on the following three dimensions (Dess & Beard, 1984): Dynamism, complexity, and munificence.

A dynamic environment is one in which changes in the environmental conditions are hard to predict. The constant change in the environmental factors along with their high degree of unpredictability lowers the decision making ability of an individual.

Environmental complexity refers to the heterogeneity and the range of organizational activities. In a complex environment, the decision makers perceive greater uncertainty because of high degree of abstraction and information processing requirements.

Environmental munificence refers to the extent to which an environment can support sustained growth of organizations. An organization in a less munificent (hostile) environment, competing fiercely for scarce resources, will have less maneuverability in the decision making process.

3.1.3 Dependent Variables

The dependent variables included in this study are: Manufacturing performance and business performance.

Manufacturing Performance

The strength of the manufacturing function is determined by the degree to which it meets the tasks placed on it by a firm's strategic plans. These manufacturing tasks or competitive priorities are indicators of a firm's manufacturing capabilities or competitiveness (Skinner, 1978; Buffa, 1984). The four main competitive priorities, frequently cited in the literature, are: cost, quality, responsiveness, and flexibility (De Meyer & Ferdows, 1990; Hayes & Wheelwright, 1984; Skinner, 1984).

Controlling cost is critical to the success of a firm. Cost is mainly an efficiency measure which indicates how well the resources are being used to produce a product. Cost efficiency, however, is influenced to a great degree by the improvements in other competitive dimensions – quality, responsiveness, and flexibility.

Importance of quality as a critical competitive dimension is well exemplified by the Japanese case. In fact, quality serves less to distinguish competences than as a qualifying criterion to be in the market place (Miller & Roth, 1988). The word quality has been defined in several ways, making it more ambiguous and difficult to measure. Quality is rather a concept or a philosophy which is reflected throughout the system ranging from the factory floor and product design and features to the customer in the market place.

Responsiveness refers to the speed with which a firm can meet customers' requirements. Responsiveness can be measured by delivery reliability and the speed of delivery (Maskell, 1991; Schmenner, 1990).

Delivery reliability means delivering goods in the right quantity on time every time (Maskell, 1991). Although, there are several factors which can influence delivery reliability, manufacturing lead time variability can directly influence competitiveness on this dimension.

Speed of delivery refers to the speed at which a product can be manufactured and delivered to the customer. Speed, too, depends on manufacturing lead time among others. The shorter the lead time, the faster the service will be.

Flexibility is perhaps the most ambiguous and ill-defined measure of manufacturing competitiveness. Flexibility has been conceptualized and measured in numerous ways in the literature. Some of the commonly agreed upon dimensions of flexibility are: volume flexibility, product flexibility, and process flexibility.

In short, measuring manufacturing performance requires quantification of both quantitative and qualitative dimensions of competitiveness. The absence of well defined concepts and operational constructs of such performance measures make our task all the more difficult and vague. Nevertheless, several studies have tried to quantify these abstract dimensions and we hope to achieve more refined and integrated measures in future.

Business Performance

Measuring business performance as an indicator of organizational effectiveness has for long been an issue of much concern as well as controversy. This is very much evident by the inattentiveness to effectiveness by a number of organization theory streams such as institutional organizational theory and organizational strategy (Meyer & Gupta, 1994).

Performance measures demonstrate the present competitive position of an organization. In addition, performance measures also reflect the ability of an organization to adapt and compete in the long term (Chakravarty, 1986).

There is little agreement on the appropriate indicators of business performance. The most widely used financial measures are: ROI, ROS, and sales growth. These measures, however, do not reflect the strategic potential of a firm to compete and adapt in the future. Moreover, such measures do not serve the interests of other stakeholders besides the stockholder. Chakravarty (1986) recommends to use a multifactor measure of performance which he believes can be a true discriminator of excellence.

Nevertheless, in a research setting, measurements of business performance are determined by, among others, data availability -- primary or secondary, and mode of performance assessment -- objective or perceptual (Venkatraman & Ramanujam, 1987). In this study, performance measures will be based upon perceptual assessment of organizational performance by senior

managers. Methods using perceptual measures are, however, likely to suffer from personal bias of the respondents.

On the contrary, performance data at the unit level is seldom published in the secondary sources. Using data aggregated at the corporate level would be quite inappropriate for our analysis. Moreover, study by Venkatraman & Ramanujam (1987) shows that perceptual data strongly correlates with secondary data and thus can be used to measure business performance.

3.2 Contingency Theory

For the last three decades, contingency theory has greatly influenced research in several areas such as strategic management, organizational design, organization behavior, and industrial psychology (Arnold, 1982; Burns & Stalker, 1961; Child, 1975; Chandler, 1962; Galunic & Eisenhardt, 1994; Hambrick & Lei, 1985; Lawrence & Lorsch, 1967; Miles & Snow, 1978; Perrow, 1967; Thompson, 1967; Van de Ven & Drazin, 1985; Venkatraman & Prescott, 1990; Woodward, 1965). Contingency theory was initially accepted largely due to its negation of the one best way of organizing and managing, proposed by the classical theorists (Tosi & Slocum, 1984). Theoretical and empirical support provided by research in 1960s further strengthened our faith in contingency theory. This was very much evident by what Hofer (1975) said, "any theory of business (corporate) strategy must be a contingency theory (p. 786)."

The basic premise of contingency theory is that for an organization to be effective or to survive, its organizational or strategic elements must fit the situational demands placed upon it by the relevant contingency factors such as technology, size, and environmental conditions (Galunic & Eisenhardt, 1994; Van de Ven & Drazin, 1985). The concept of fit is thus central to contingency theory. The greater the fit between contingency factors and internal organizational characteristics, the better the performance or organizational effectiveness.

Fit, in the literature, has been conceptualized in several ways. Each perspective of fit connotes a different meaning of contingency theory and thus requires different methodological scheme to measure it empirically (Van de Ven & Drazin, 1985; Venkatraman, 1989).

Early research, using contingency approach, largely interpreted fit as the congruency between organizational characteristics and its context. It was argued that organizations must adapt to their context in order to survive (Van de Ven & Drazin, 1985). However, no reference was made to performance as a logical outcome of such relationships or was assumed to be implicit in such investigations.

Some conceptualize fit as the match between two variables. Advocates of the matching perspective propose fit as an ideal linear relationship between organizational elements and the contingency factors. Any departure from this linear relationship results in a lack of fit. The analytical schemes used for this

approach are: Deviation score analysis, residual analysis, and analysis of variance (ANOVA). For further details on these methods, see Hoffman, Cullen, Carter, and Hofacker, 1992; Drazin and Van de Ven, 1985; and Venkatraman, 1989.

Another perspective, adopted by this research, is the interaction or moderation perspective. Here, performance is explicitly included in the model and is assumed to be determined by the interaction effect of organizational characteristics and its context. Thus, the impact of internal organizational characteristics on performance is expected to vary by the type of organizational context. For example, the impact of Porter's differentiation strategy on performance is likely to vary by the stage of product life cycle.

In statistical terms, we say that an interaction effect or a fit exists if the relationship between the independent variable **X** and the dependent variable **Y** changes across different values of **Z**, the moderator variable.

The two widely used analytical methods to examine the interaction effect are: subgroup analysis and moderated regression analysis. Considering the relevance of the interaction approach of fit to our study, we briefly describe these two methods below:

3.2.1 Subgroup Analysis

Subgroup analysis is conducted if one hypothesizes that the degree of relationship between two variables X and Y varies with values of the moderator variable Z (Arnold, 1982). In other words, one is examining whether the strength or magnitude of correlation between X and Y varies significantly for different values of the moderator variable Z.

Using this approach, one splits the sample into two or more subgroups on the basis of the moderator variable. Next, regression analysis is conducted for each subgroup to examine the relationship between X and Y. A comparison of the correlation co-efficient r_{xy} across subgroups, if found statistically significant, would imply that the strength of the relationship between X and Y differs significantly among the subgroups. The appropriate test for comparison is t-statistic for two groups and chi-squared for multiple groups.

Some researchers caution against the use of subgroup analysis on grounds of substantial loss of information. They normally identify low and high groups based on the moderator variable and conduct tests for differences in correlation co-efficient for these two extreme groups. Arnold (1984) strongly argues against such non-linear monotonic transformation of data and the dropping of subjects with non-extreme values from the analysis, unless otherwise warranted. Moreover, such reduction in sample size reduces statistical power, too.

3.2.2 Moderated Regression Analysis

This approach is used to determine if the form of relationship between X and Y varies with Z, that is, to examine whether the regression slopes of X (continuous variable) are not parallel across all levels of the moderator variable Z (Arnold, 1982; Hoffman et al., 1992). If the relationship between X and Y varies with Z, we can say that X and Z interact and jointly determine Y.

In moderated regression analysis (or hierarchical multiple regression analysis), the regression equation used to analyze the interaction effect must include the independent variable X, moderator variable Z, and the interaction term XZ, especially when the variables are measured on interval rather than ratio scales (Southwood, 1978). The appropriate regression equation to be used is:

$$Y = b_0 + b_1X + b_2Z + b_3XZ$$

The interaction effect is said to exist if b_3 is found to be significantly different from zero. One must note that it is important to partial out the main effects of X and Z in order to test the statistical significance of the interaction term XZ. Entering the cross-product term XZ into the regression equation prior to the entry of the main term X and Z would only result in confusing and uninterpretable results (Arnold, 1984; Stone & Hollenbeck, 1984).

At times, we may be interested in the contribution of a set of moderating variables to the dependent variable. The procedure to examine the significance of the interaction effect of the moderating variable as a set is exactly as

explained above. The difference is that the moderating variable will be included in the equation as a set for both the main effect and the interaction effect. Also, the significance test will be based on the change in R^2 , the squared multiple correlation, and the appropriate test would be the F test (Cohen & Cohen, 1975). The equation for testing the significance of a set of variables is:

$$F = \frac{R^2_{Y.F} - R^2_{Y.R}}{k_F - k_R} \times \frac{1 - R^2_{Y.F}}{k_F}$$

where

$R^2_{Y.F}$ = squared multiple correlation for the full model with all variables included

$R^2_{Y.R}$ = squared multiple correlation for the restricted model excluding the set of variables to be tested

k_F = degrees of freedom for the full model

k_R = degrees of freedom for the restricted model

The F value can be tested using the source (numerator) degrees of freedom, $df = k_F - k_R$, and the error (denominator) degrees of freedom, $df = k_F$.

3.2.3 A Critique of Contingency Theory

Despite a glorious start in the 1960s, contingency theory lost its charm in the later periods. The emerging divergent empirical results provided little support

to contingency theory (Tosi & Slocum, 1984; Van de Ven & Drazin, 1985).

Contingency theory received serious criticisms for its conceptual and methodological shortcomings.

3.2.3.1 Conceptual Problems

Contingency theory has been criticized for its simplistic view that better the fit, higher the performance. Tosi & Slocum (1984) argue that fit may be necessary for an organization to adapt and survive but is not an adequate condition for high performance on narrower criteria, such as profitability. It is important to differentiate between different types of effectiveness, such as profitability and survival, with substantial theoretical evidence.

Furthermore, in search of direct causation, researchers focus on bivariate unidirectional linear relationships. Such an attempt seriously undermines the complex interaction and nonlinear relationships among several organizational and environmental entities. Schoonhoven (1981) argues that many researchers do not even properly specify the type of relationships among the variables.

The more glaring deficiency of contingency theory is its reductionistic mode of enquiry, whereby researchers treat organizations as loosely coupled aggregates and seek to understand the whole by separately analyzing its individual parts (Meyer, Tsui, & Hinnings, 1993; Miller & Friesen, 1984). Studies focus on single contingency factor and examine how it interacts with another

single organizational element to influence performance. This reductionism leads to misleading results and unwarranted generalizations (Miller & Friesen, 1984; Van de Ven & Drazin, 1985). In a sharp departure from this reductionistic mode of enquiry, a few have examined multiple contingencies simultaneously in their models (This aspect will be discussed later under systems perspective of fit).

3.2.3.2 Methodological Weaknesses

Methodological problems in contingency models arise largely due to the manner in which the concept of fit has been operationalized empirically (Arnold, 1982, 1984; Dewar & Werbel, 1979; Drazin & Van de Ven, 1985; Venkatraman, 1989). Researchers often conceptualize a different perspective of fit but use a different statistical technique to measure it. Different statistical methods are not interchangeable, says Venkatraman (1982). Appropriateness of a particular statistical technique can only be demonstrated if preceded by appropriate hypothesized relationships between variables and adequate theory to interpret it.

In an attempt to clarify the methodological fuzziness in literature using the moderation perspective of fit, Arnold (1982) distinguishes between two types of relationships: the degree and form of relationship between variables X and Y for different levels of variable Z.

If one hypothesizes that the strength or magnitude (i.e., the degree) of relationship between variables X and Y varies for different values of the moderator variable Z, then the appropriate statistical technique is subgroup

analysis, and one examines the differences in correlation co-efficient r_{xy} for different values of Z. If, on the other hand, one hypothesizes that the dependent variable Y is jointly determined by the interaction between X and Z, then the appropriate statistical technique is moderated regression analysis, and one examines the form of relationship by comparing the regression co-efficient b_{yx} for different values of Z.

Arnold (1982) says that correlation co-efficient r_{xy} and regression co-efficient b_{yx} carry different information regarding the relationship between X and Y and different analytical techniques are required for different hypothesized relationships. In a reply to Stone & Hollenbeck (1984), Arnold (1984) strongly asserts that hierarchical multiple regression (or moderated regression) is the most elegant method for testing the form of relationship but it "tells us nothing whatsoever regarding whether correlation co-efficient r_{xy} differ significantly for different values of a moderator (p. 216)."

Some tend to discount the subgroup method because of reduction in power and the degradation and loss of information resulting from categorizing the quantitative variables and dropping the nonextreme subjects after splitting the sample (Sharma, Durand, & Gur-Arie, 1981; Stone & Hollenbeck, 1984). It is assumed that moderated regression analysis is a better analytic approach which maintains the integrity of the sample. However, in light of Arnold's (1982, 1984) arguments, we need to be more careful before applying moderated regression techniques to all hypothesized relationships.

Another potential shortcoming arises when researchers downgrade the regression technique because of misconception about the impact of multicollinearity of the cross-product terms XZ with the component variables X and Z (Dewar & Werbel, 1979; Drazin & Van de Ven, 1985). It is argued that high correlation of the cross-product term with the independent variables should not be a matter of great concern. For interval scale measurement, the test for significance of the interaction term is valid even in the presence of high multicollinearity (Cohen & Cohen, 1975; Southwood, 1978). Southwood (1978) argues that it is possible to reduce $R_{3(12)}$ to low values by changing the origins of X_1 and X_2 , and this would have no effect on the test for interaction unless singularity of the matrix occurs. However, change of origins of X_1 and X_2 is not a solution to high $R_{3(12)}$, adds Southwood. Thus, moderated regression analysis is a valid method to examine fit under moderation perspective irrespective of multicollinearity issues.

In summary, contingency approaches suffer from some conceptual and methodological weaknesses. Conceptual weaknesses can be overcome by refining the theoretical concepts as well as supplementing the contingency analysis with richer, more comprehensive models.

Methodologically, the problem is more with carelessness on the part of researchers than with the available analytical techniques. We must select correct analytical methods for the hypothesis we verbalize. There is no alternative to a careful and sophisticated analysis.

3.3 Systems Perspective of Fit

In contrast to the earlier perspectives of fit based on bivariate relationships, systems approach conceptualize fit as a holistic pattern of multidimensional characteristics that are coherently related under a given contextual factor (Van de Ven & Drazin, 1985). This pattern of interrelationship is referred to as an ideal type and any deviation from this ideal type is expected to lower the performance.

The ideal type patterns can be derived theoretically (Doty, Glick, & Huber, 1993) or empirically from high performing organizations (Drazin & Van de Ven, 1985; Vankatraman & Prescott, 1990). Next, the rest of the sampled organizations' deviation from their respective ideal type can be determined by using the Euclidean distance formula (Van de Ven & Drazin, 1985, p. 350):

$$d_{ij} = \sqrt{\sum_{s=1}^N (x_{is} - x_{js})^2}$$

where

d_{ij} = euclidean distance from the j th focal unit to its ideal type (i)

x_{is} = score of the ideal type (i) unit on the s th structural dimension

x_{js} = score of the j th unit on the s th structural dimension

Finally, distance measures d_{ij} are correlated with performance to determine fit. A significant and negative correlation with performance would indicate fit.

In the above analysis, all dimensions' departure from the ideal pattern are weighed equally, which might be unrealistic. Later studies, for example, Venkatraman & Prescott (1990) and Doty et al. (1993) have incorporated a weighted scheme to measure deviation from the ideal type.

Pattern analysis assumes a single dominant contingent factor and derives an ideal pattern for that factor. Organizations, however, face multiple and often conflicting contingencies and respond to them in different ways (Galunic & Eisenhardt, 1994; Van de Ven & Drazin, 1985). Therefore, pattern analysis with single ideal pattern for a given context may not provide valid and consistent explanation of several feasible alternatives. **Equifinality** -- the idea that several feasible organizational forms can be equally effective, therefore, offers a much richer conceptual and analytical scheme than that of pattern analysis.

3.4 Configuration Theory

The central idea of configuration theory is that organizations are complex entities that consist of several interdependent, supportive, and reinforcing elements. And the interrelationships among elements can best be understood by

referring to the whole than to the loosely coupled aggregates of it (Miller & Friesen, 1984; Meyer et al., 1993).

In fact, the environmental, organizational, strategic, behavioral, and psychological dimensions have natural tendencies to cluster together into what are called configurations, typologies, archetypes, or gestalts. According to Miller and Friesen (1984), configurations are "commonly occurring clusters of attributes or relationships...that are internally cohesive such that the presence of some attributes suggest the reliable occurrence of others (p. 12)."

By examining organizations as a holistic pattern of interdependencies, configuration theory, therefore, provides a much richer perspective than that of the bivariate contingency approach. The two approaches are, however, not alternatives. As Hambrick (1984) says, multitiered taxonomic approach is the logical extension of the contingency view.

The concept of **equifinality** receives parallel importance under configuration approach. It is argued that different configurations can be equally effective.

Effectiveness, however, is not explicitly demonstrated in the taxonomic enquiry. The absence of performance as a resultant indicator of consistency or harmony among the concerned elements, lends little predictive validity to the configuration approach (Venkatraman, 1989). To incorporate performance in the analysis, Hambrick (1984) suggests to split the sample into high and low performing units and then conduct separate analysis for these subsamples. If we

cluster together businesses of all performance levels, the resulting clusters could be meaningless, and would not suggest ideals, says Hambrick.

There are, however, some difficulties associated with taxonomic enquiries which precludes its widespread application in empirical investigations. First, determining appropriate configurations is a daunting task. As Miller and Friesen (1984) note: "the likelihood of finding configurations will be a function of the variables or phenomena studied, the taxonomic methods that are attempted, and even the scope of the samples gathered (p. 3)." No wonder researchers are so reluctant to use the configurational approach.

The potential for large variety of clusters is, nevertheless, limited by the attributes' tendency to fall into coherent patterns (Meyer et al., 1993). Configurations are relatively few and distinct. According to Lehman (1979), normally the sample do not generate more than $n/30$ to $n/50$ reliable clusters, where n is the sample size (cited in Hambrick, 1984).

Choosing appropriate and adequate variables is critical for a through characterization of organizational configurations. Although inclusion of large number of variables is desirable to avoid specification error, in the interest of feasibility of study and meaningful interpretation of clusters, one need to maintain a balance between parsimony and detail. The selection of variables, obviously, depends on the scope of the research, but must be backed up by extensive theoretical considerations (Hambrick, 1984; Miller & Friesen, 1984).

Configurations can be derived both conceptually (Mintzberg, 1979; Miles & Snow, 1978) and empirically (Hambrick, 1983; Hambrick & Schechter, 1983; Miller & Friesen, 1984). Empirically derived configurations, called taxonomies, are generated by employing several clustering techniques such as cluster analysis, factor analysis, and multidimensional scaling (for details, see Miller & Friesen, 1984, ch. 2). The objective is to develop patterns or profiles of attributes that naturally coalesce together.

In summary, the bivariate contingency perspectives of fit are too limited in scope to explain the complex interactions and interdependencies among numerous business attributes in reality. A systems perspective, on the other hand, improves our understanding by taking a more holistic approach. We can understand and meaningfully interpret the fragmented analysis only by referring to the whole. Contingency analysis, thus, must be supplemented by configurational analysis and the idea of equifinality.

3.5 Hypotheses

Advanced Manufacturing Technology

Using AMT to improve competitiveness and meet new challenges is a common practice today. Reaping AMT advantage, though difficult, has been accomplished by many firms. Research on AMT clearly indicate that a manufacturing system can be efficiently and successfully operated only if the

individual technologies are integrated. Integration of different technologies, or the so called islands of automation, is extremely important to realize the true benefits of AMT (Adler, 1988; Ettlie & Refies, 1987; Meredith & Camm, 1989; Rosenthal, 1984; Singhal, Fine, Meredith, & Suri, 1987; Wheelwright, 1985).

Relationship between AMT and manufacturing performance -- cost, quality, responsiveness, and flexibility, has been established by many studies. Despite some failures in implementation, AMT is found to significantly improve manufacturing performance (De Meyer et al., 1989; Miller & Roth, 1988). The higher the intensity and integration of new technologies, the better the manufacturing performance (Attaran, 1988; Meredith & Camm, 1989). Integration is, however, required both within and across functions (Meredith, 1987d).

Traditionally, researchers assumed trade-offs among the different dimensions of manufacturing performance measures (Richardson et al., 1985; Skinner, 1974; Wheelwright, 1984). Recently, others have asserted that the simultaneous achievement of cost, quality, responsiveness, and flexibility could be realized by adopting new manufacturing technologies and management techniques (De Meyer et al., 1989; Goldhar & Jelinek, 1985, 1990; Son & Park, 1987).

Hypothesis 1

Business units that have high Intensity and Integration of AMT (IIT) are more likely to exhibit high level of manufacturing performance.

Hypothesis 1a

Business units that have high Intensity and Integration of AMT (IIT) are more likely to exhibit high level of flexibility.

Hypothesis 1b

Business units that have high Intensity and Integration of AMT (IIT) are more likely to exhibit high level of responsiveness.

Hypothesis 1c

Business units that have high Intensity and Integration of AMT (IIT) are more likely to exhibit high level of quality.

Hypothesis 1d

Business units that have high Intensity and Integration of AMT (IIT) are more likely to exhibit low level of cost.

Organizational Structure

Technology alone is not enough. It is the supporting infrastructure that determines the efficacy of AMT (Fine & Hax, 1985; Gerwin, 1982; Hayes & Wheelwright, 1984). A strong body of research exists on the relationship between manufacturing technology and organizational structure. Initiated by Woodward (1965), subsequent research established that the structure of an organization varies by the type of manufacturing technology used. Researchers asserted that fixed automation, using standardized processes, required mechanistic structure. Job shop manufacturing, on the other hand, required an organic structure to support the flexibility and innovativeness required on the job.

Though a fit between manufacturing technology and organizational structure was established by many researchers, the relationship was more apparent at the operating level, and had little effect on the upper hierarchical levels (Skinner & Chakraborty, 1982). This absence of relationship between technology and structure at the institutional level was due to the rigid nature of automation and its lack of integration with other inter-departmental functions.

AMT, on the other hand, is more flexible and requires an organizationwide interaction and integration. It is impossible to realize AMT's full potential if different functional departments work in a secluded environment.

Though AMT allows for greater flexibility and responsiveness, it itself creates new uncertainties posing new challenges for organizations to face with

(Zammuto & O'Connor, 1992). The problems of increasing complexity and learning require more delegation of autonomy and responsibility to employees. The need for greater cooperation and coordination both within and across functions can only be met under an environment characterized by less control, delegation of authority, and an organizationwide communication system. New technology's full potential can be achieved only by adopting an organic structure and a work force with high degree of responsibility, autonomy, and discretion (Buchanan & Bessant, 1985; Zammuto & O'Connor, 1992).

Hypothesis 2a

Business units with high IIT and an organic organizational structure are more likely to exhibit high level of manufacturing performance.

Hypothesis 2b

Business units with high IIT and an organic organizational structure are more likely to exhibit high level of business performance.

Business Strategy

"Good manufacturing does not necessarily lead to positive business outcomes, and positive business outcomes are not always associated with effective manufacturing," say Roth and Miller (1992). Manufacturing can be

a source of competitive advantage only to the extent that it supports the firm's business strategy (Vickery et al., 1993). Strategy pursued by a firm directly determines its business performance (White & Hamermesh, 1981).

Hypothesis 3

The relationship between IIT and business performance will be moderated by a firm's business strategy.

For a firm pursuing complex innovation strategy, it is very logical to rely heavily on the use of AMT. Complex innovators compete on rapid introduction of new products, new designs and features, better quality, etc. AMT allows firms to meet these ends in the most efficient manner.

Hypothesis 3a

Business units with high IIT and complex innovation strategy are more likely to exhibit high level of business performance.

A firm pursuing marketing differentiation strategy tries to project a unique and favorable image to the customers. It may not offer a new, high quality product but creates a brand recognition by aggressively marketing the product. On time delivery, high reliability and excellent service are some of the factors a

firm may find critical under marketing differentiation strategy. A firm will be better able to achieve these objectives if accompanied by an aggressive technological posture (Zahra & Covin, 1993).

Hypothesis 3b

Business units with high IIT and marketing differentiation strategy are more likely to exhibit high level of business performance.

AMT may not seem to be a logical choice to a firm pursuing cost leadership strategy. A firm adopting cost leadership strategy seeks to achieve a low cost position with respect to its competitors in the industry. There are many possible ways to achieve this position. AMT may lead to a low cost position only if it allows a firm to achieve a unique position in the market based upon technological leadership. Nevertheless, AMT can enable a firm to minimize its costs through eliminating waste and time, and refining existing products and processes (Dess & Davis, 1984). Thus, a firm following cost leadership strategy can take advantage of AMT benefits to improve its competitive position.

Hypothesis 3c

Business units with high IIT and cost leadership strategy are likely to exhibit high level of business performance.

Proactiveness

Traditionally, manufacturing was not considered to be a source of competitive advantage. Manufacturing was only used as a supportive tool to implement the strategies formulated by top management. AMT, however, has changed this past scenario. It allows firms to offer new products and services in a way unthinkable of in the past. To use AMT in the same conventional way would be to defeat its main purpose. Top management need to understand the new possibilities that AMT can offer and must formulate strategies based on their firm's technological capabilities. Only manufacturing managers who are aware of the technological prowess of the firm can help top managers to realize this task. Proactive participation of manufacturing managers in the strategic decision making process is vital to improve business performance.

As Hayes and Wheelwright (1984) say, proactive manufacturing participation in the strategic planning of the business is the true characteristic of a world class manufacturer. They contend that these firms, which they call Stage IV organizations, achieve higher performance than one in which manufacturing assumes a subordinate role.

Hypothesis 4

Business units that have high IIT and a more proactive involvement of manufacturing managers in the strategic decision making process are more likely to exhibit high level of business performance.

Environmental Uncertainty

Proactive participation of manufacturing managers in the decision making process may not influence business performance all the time. Proactiveness is a function of environmental uncertainty. Hayes (1985) argues that manufacturing capabilities has the power to drive corporate strategy in an uncertain and unstable environment. Swamidass and Newell (1987) too found significant effect of environmental uncertainty on the role of manufacturing managers in the strategic decision making process of a firm.

Hypothesis 5

The moderating effect of manufacturing's proactiveness on the relationship between advanced manufacturing technology and business performance will vary by the level of uncertainty in the external environment of a firm.

Hypothesis 5a

The more dynamic the external environment of a firm, the higher will be the impact of manufacturing's proactive involvement in its strategic decision making process.

Hypothesis 5b

The more hostile the external environment of a firm, the higher will be the impact of manufacturing's proactive involvement in its strategic decision making process.

Configurations

Configurations are complex entities that exhibit a specific pattern of relationships among a number of attributes or variables. There exists certain interdependencies among the attributes such that the existence of one warrants the occurrence of others. Configurations may differ significantly on some attributes while showing similarity on other dimensions. An attribute in itself is not of much importance. It is the interrelationships and the cohesiveness among the attributes that make a configuration distinct.

Configurations with different pattern profiles may be equally effective. There is no single best way to success. By focussing on a single attribute, contingency approach misses this important concept of equifinality.

We, therefore, suggest that there exists configurations, called taxonomies or typologies, which exhibit different pattern profile of the relevant elements. Configurations with different patterns of attributes may be equally effective in terms of business performance.

Chapter 4

RESEARCH DESIGN AND METHODOLOGY

This chapter first describes the characteristics of the sample used for this study. It then details the instruments and measures used in this study. Finally, the analytical methods used to analyze the collected data are explained.

4.1 Sample

The target population selected for this study was manufacturing units using advanced manufacturing technology (AMT) for their manufacturing operations. More specifically, the units were defined to be an entire company, a division, or a subsidiary located within the boundaries of the United States.

An important step in this research was to identify the population of firms using AMT. Since there was no available directory or other material that could provide a list of AMT users, we had to resort to the available literature on AMT research. A manufacturing technology survey conducted by the U.S. Department of Commerce (1988) indicated a significant use of AMT by manufacturing firms in the Standard Industrial Classification (SIC) groups 34 to 38. After examining other pertinent literature (Majchrzak, 1988; Snell & Dean, 1994), we finally decided to restrict our study to manufacturing firms within the SIC groups 33 to 38. These industrial groups are: Primary metal industries,

fabricated metal products, industrial machinery and equipment, electronic and other electric equipment, transportation equipment, and instruments and related products.

Another issue highlighted by the survey conducted by the U.S. Department of Commerce (1988) was that AMT users were mostly medium to large size companies. Based upon the literature review, we defined a medium size company to be one with employee size greater than or equal to 200 and annual sales revenue greater than \$10 million. Thus, the population of firms targeted by this study belonged to SIC groups 33 to 38 and had at least 200 employees and annual sales revenue greater than \$10 million.

The subjects chosen for this study were chief operating officers, vice-presidents of manufacturing, or other senior manufacturing managers of similar status who were in charge of manufacturing. These individuals were expected to possess the relevant information pertaining to this study, that is, information about both the factory and the strategic issues at the institutional level.

Compact disclosure, the electronic database, was our source for sample construction. Other sources were: S&P, Million Dollar Directory, Ward's Industrial Directory, and the Directory of Corporate Affiliations. The final sample meeting the criteria mentioned above consisted of 976 firms.

Information required for this research was collected from the chosen companies through a questionnaire. The respondents were asked to be

consistent throughout the survey questionnaire and answer all questions with reference to the same business unit.

The study for this research was conducted in two stages. In the first stage, we conducted a pilot study on a randomly selected 100 companies from the final sample of 976 companies. In the pilot study, we also tried to solicit the respondents' ideas or comments, if any, on the study. The objective of the pilot study was to check for any inconsistencies in the questionnaire design. Additionally, we wanted to get feedback and comments from the practitioners of AMT on our research model and the constructs used to measure the variables in our model.

We received 24 responses from this mailing, representing an effective response rate of 24 percent. An analysis of the returned questionnaire gave us fairly good results. We, however, made some modifications to the questionnaire to make our study more robust and the questionnaire more understandable and easily interpretable.

In the second stage of this study, we mailed the modified questionnaire to the rest of the 876 firms in our sample. We received 147 completed questionnaires. Two were unusable because of large number of missing values. The rest 145 questionnaires were all usable. 71 questionnaires were returned because of reasons such as wrong address, person no longer with the company, person too busy, or company policy not to participate in surveys. If we remove the returned and unusable responses from our sample, the usable 145

responses out of the remaining sample size of 803 would represent an effective response rate of 18.1 percent.

4.1.1 Sample Characteristics

Table 4.1 shows the number and percentage of units in the sample by firm and industry characteristics. The data shown in the table indicates a fairly good representation of the target population. Figures 4.1 to 4.3 illustrate the sample characteristics graphically.

We would like to point out that though the sample was constructed to include companies with at least 200 employees, 21 companies had employee size less than 200 (see table 4.1). As we see, the respondents might have answered the questionnaire for a specific business segment of the company. Since this didn't invalidate the study, we decided to include these cases in our analysis.

Another point to note is that more than 50 percent of the sample is represented by medium size companies having employee size ranging from 201 to 1000. Table 4.2 provides a distribution of firm size by industry type, that is, SIC groups.

Table 4.1
Sample Characteristics

<u>Business Unit Characteristics</u>	<u>Number of Units</u>	<u>Percentage</u>
<u>Firm Type</u>		
Entire Company	64	44.1
Division	54	37.2
Subsidiary	19	13.1
Other	6	4.1
Missing Cases	2	1.4
TOTAL	145	100.0
<u>Major Industry Type</u> (Standard Industrial Classification)		
SIC 33 Primary Metal Industries	15	10.3
SIC 34 Fabricated Metal Products	17	11.7
SIC 35 Industrial Machinery & Equipment	48	33.1
SIC 36 Electronic & Other Electric Equipment	26	17.9
SIC 37 Transportation Equipment	17	11.7
SIC 38 Instruments & Related Products	20	13.8
Missing Cases	2	1.4
TOTAL	145	100.0
<u>Firm Size</u> (Number of Employees)		
Less than 201	21	14.5
201 - 500	49	33.8
501 - 1000	28	19.3
1001 - 5000	31	21.4
Over 5000	12	8.3
Missing Cases	4	2.8
TOTAL	145	100.0

Figure 4.1
Distribution of Firms by Business Unit Type

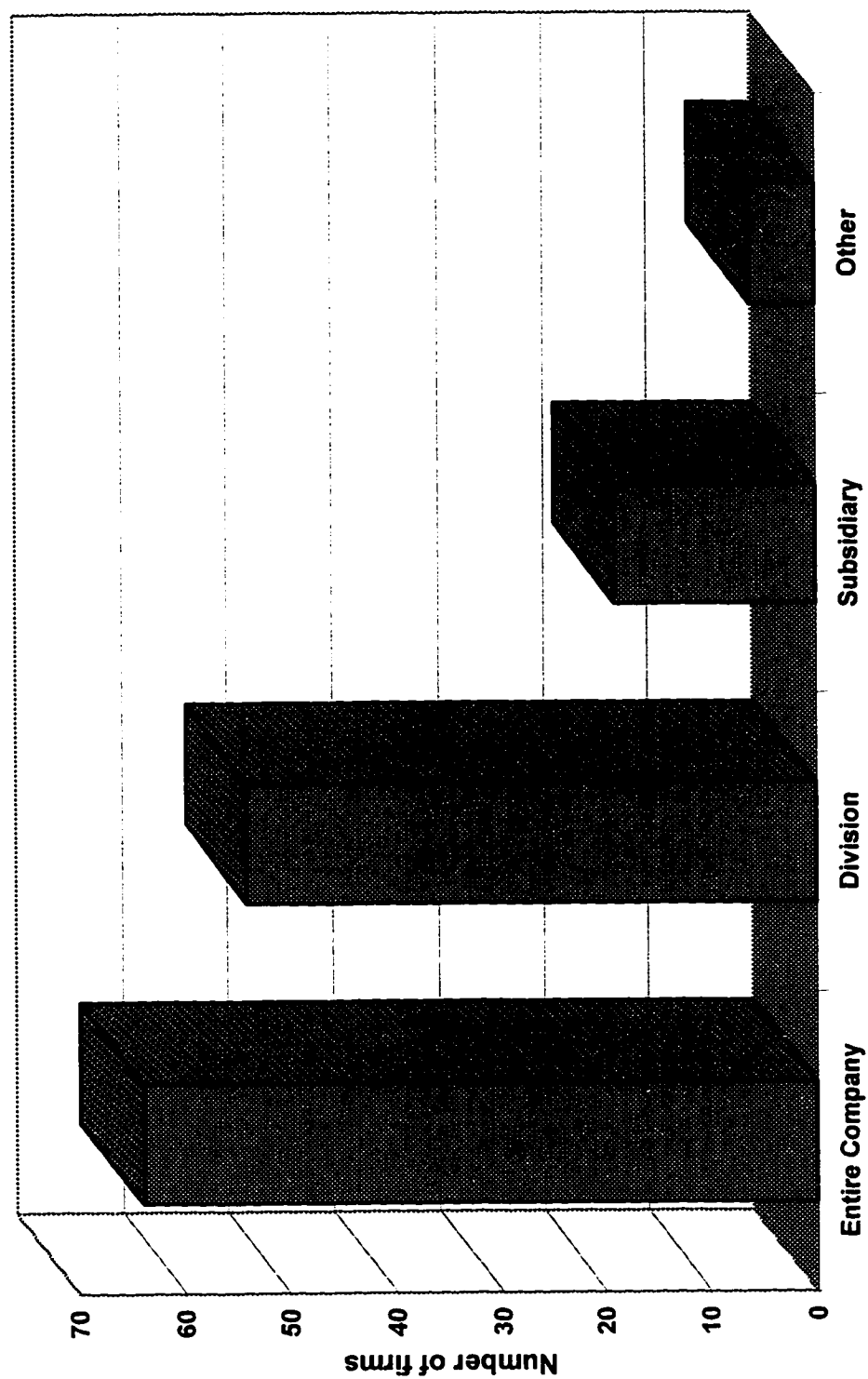


Figure 4.2
Distribution of Firms by Industry Type

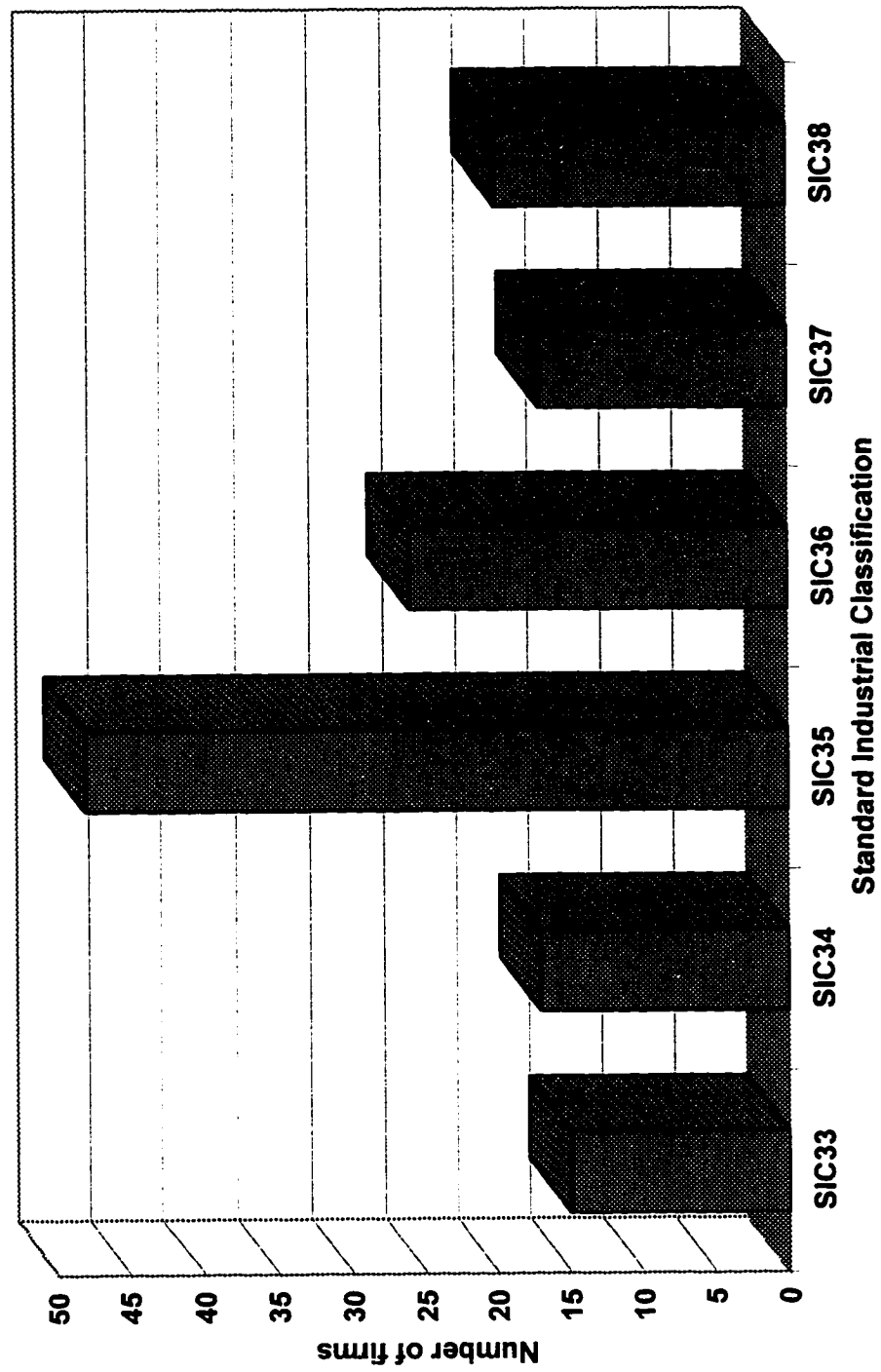


Figure 4.3
Distribution of Firms by Employee Size

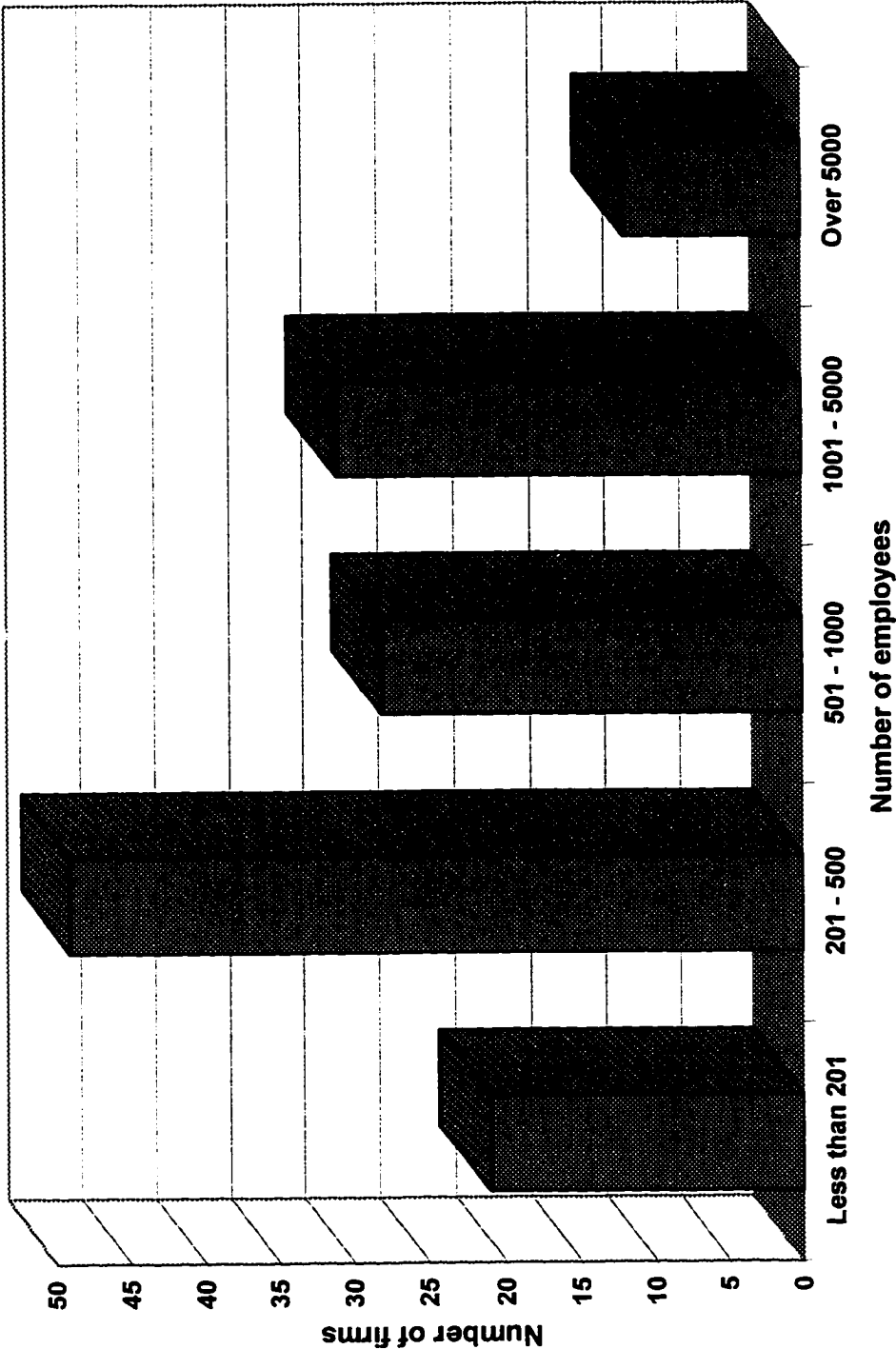


Table 4.2
Sample Distribution by Firm Size and Industry Type

Firm Size		Number of Firms in each Standard Industrial										
(Number of Employees)		Classification										
Range	Mean	S.D.	SIC33	SIC34	SIC35	SIC36	SIC37	SIC38	Total	Percentage		
Less than 201	162.0	45.7	2	4	7	3	1	4	21		15.0	
201 - 500	344.6	92.5	5	6	19	6	5	8	49		35.0	
501 - 1000	758.2	155.6	6	2	8	8	1	3	28		20.0	
1001 - 5000	2423.7	1244.3	2	4	8	6	6	4	30		21.4	
Over 5000	10841.7	4959.9	0	1	4	3	4	0	12		8.6	
Total			15	17	46	26	17	19	140			
Percentage			10.7	12.1	32.9	18.6	12.1	13.6				

Missing cases = 5

Manufacturing Technology Distribution

Tables 4.3 and 4.4 illustrate the number and percentage of firms using each type of technology by industry type and firm size respectively. Of all 14 technologies, the technologies used most were computer aided design (CAD) and manufacturing resource planning (MRP II), with 97.9 percent and 93.1 percent firms using them respectively. The technology used least was automated guided vehicles (AGV), being used by 61.4 percent of the firms. Figure 4.4 graphically shows the number of firms using each type of technology.

Table 4.5 shows the minimum number of technologies used by firms included in this survey. 97.2 percent of the firms used at least 3 technologies, whereas 55.2 percent indicated use of all 14 technologies. Among the industry groups, 66.7 percent firms of SIC35 group used all 14 technologies compared to 40 percent firms of SIC33 group. Larger firms reported use of technologies more than smaller firms. For firms with 1001 to 5000 employees, 70.9 percent firms used all 14 technologies compared to 42.9 percent firms with employee size less than 200. For use of 3 to 6 technologies, the difference between medium and large size companies was apparently insignificant.

Table 4.3
Percentage of Firms Using Each Type of Technology
by Industry Type

Technology	Used in Firms		Standard Industrial Classification					
	Number	%	SIC33	SIC34	SIC35	SIC36	SIC37	SIC38
CAD	142	97.9	93.3	94.1	100.0	100.0	100.0	95
CAE	123	84.8	80.0	82.4	87.5	84.6	94.1	80
FMC	110	75.9	73.3	76.4	79.2	76.9	76.5	70
FMS	100	69.0	73.3	64.7	72.9	73.1	64.7	60
CAM	121	83.4	86.7	70.6	91.7	88.5	82.4	70
AA	99	68.3	66.7	64.7	66.7	76.9	76.5	60
CNC	126	86.9	86.7	94.1	89.6	76.9	94.1	80
Robotics	101	69.7	73.3	76.5	68.8	65.4	76.5	65
AS/RS	97	66.9	66.7	64.7	66.7	69.2	76.5	60
AGV	89	61.4	66.7	64.7	64.6	65.4	58.8	45
CAPP	95	65.5	73.3	64.7	68.7	57.7	70.6	60
MRP II	135	93.1	93.3	94.1	93.8	88.4	94.1	95
ASBIT	99	68.3	66.7	70.6	66.7	69.2	76.5	65
SFM&C	120	82.8	86.7	76.5	77.1	84.6	94.1	85

Table 4.4
Percentage of Firms Using Each Type of Technology
by Firm Size

Technology	Used in Firms		Firm Size (Number of Employees)				
			Less than 200	201-500	501-1000	1001-5000	Over 5000
CAD	142	97.9	90.5	100.0	96.4	100.0	100.0
CAE	123	84.8	66.7	83.7	82.1	100.0	100.0
FMC	110	75.9	57.1	73.5	82.1	90.3	83.3
FMS	100	69.0	52.4	63.3	75.0	83.9	75.0
CAM	121	83.4	66.7	81.6	89.3	87.1	100.0
AA	99	68.3	61.9	63.3	71.4	77.4	75.0
CNC	126	86.9	66.7	89.8	85.7	93.6	91.7
Robotics	101	69.7	42.9	65.3	71.4	90.3	83.3
AS/RS	97	66.9	52.4	61.2	75.0	80.7	75.0
AGV	89	61.4	42.9	55.1	67.9	77.4	75.0
CAPP	95	65.5	42.9	59.2	75.0	83.9	75.0
MRP II	135	93.1	90.5	91.8	92.9	93.6	100.0
ASBIT	99	68.3	47.6	59.2	75.0	83.9	91.7
SFM&C	120	82.8	66.7	75.5	85.7	93.6	100.0

Figure 4.4
Number of Firms Using Advanced Manufacturing Technology

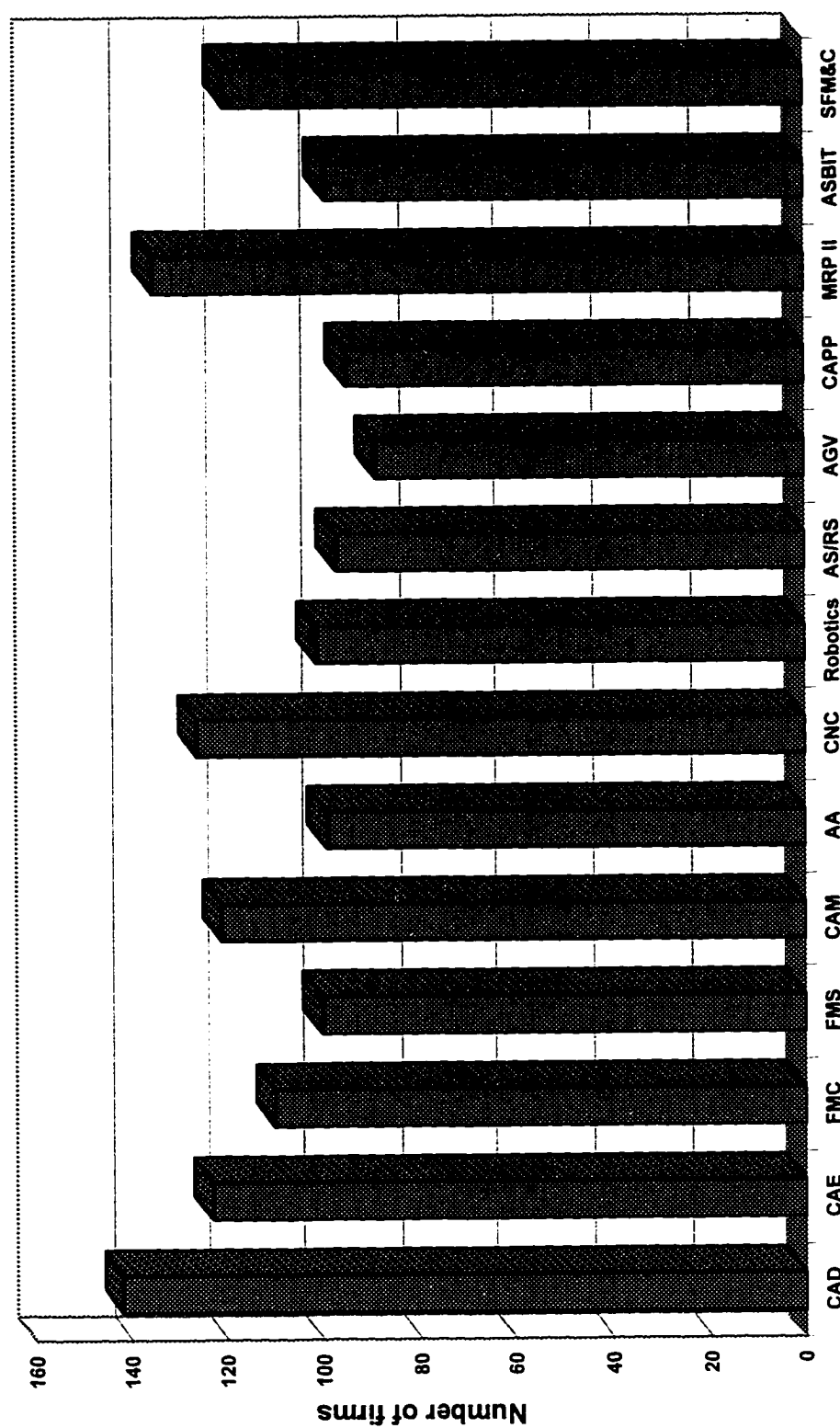


Table 4.5
Minimum Number of Technologies Used
by Business Groups

		Minimum Number of Technologies Used (Percent of Units)											
Business Unit	# of Characteristics Units	3	4	5	6	7	8	9	10	11	12	13	14
All Units	145	97.2	93.8	87.6	82.1	76.6	73.1	68.3	63.4	61.4	58.6	57.9	55.2
Industry Groups													
SIC33	17	93.3	86.7	80.0	80.0	73.3	73.3	66.7	66.7	66.7	66.7	66.7	66.7
SIC34	17	94.1	88.2	82.4	76.5	76.6	70.6	64.7	64.7	64.7	64.7	64.7	64.7
SIC35	48	97.9	95.8	95.8	85.4	77.1	70.8	66.7	62.5	62.5	60.4	60.4	54.2
SIC36	26	100	96.2	88.5	84.6	80.8	80.8	73.1	53.8	53.8	53.8	53.8	53.8
SIC37	17	94.1	94.1	88.2	88.2	82.4	76.5	76.5	76.5	76.5	64.7	58.8	58.8
SIC38	20	100	95.0	80.0	75.0	75.0	70.0	65.0	50.0	50.0	45.0	45.0	40.0
Firm Size (# of Employees)													
Less than 200	21	90.5	76.2	61.9	57.1	52.4	52.4	52.4	42.9	42.9	42.9	42.9	42.9
201 - 500	49	95.9	93.9	87.7	81.6	71.4	65.3	59.2	57.1	55.1	53.1	53.1	48.9
501 - 1000	28	100	96.4	92.8	82.1	75.0	75.0	71.4	67.9	67.8	67.8	64.3	64.3
1001 - 5000	31	100	100	96.8	96.8	96.8	90.3	80.6	77.4	77.4	74.2	74.2	70.9
Over 5000	12	100	100	100	100	100	100	100	83.3	75.0	58.3	58.3	50.0

Level of Integration

The average level of integration of each type of AMT is shown in table 4.6. Of all technologies, manufacturing resource planning (MRP II) and computer aided design (CAD) were integrated most with other technologies, having a mean integration value of 3.49 and 3.11 respectively. Automated guided vehicle (AGV) was the least integrated with a mean value of 1.3, followed by automated storage and retrieval systems (AS/RS) at 1.6. The mean value for each technology was found by averaging the integration level for each technology over all 145 cases. Figure 4.5 shows the average integration level of each type of manufacturing technology graphically.

Table 4.7 shows the distribution of firms by the level of AMT integration. The following equation was used to calculate the average level of AMT integration.

$$AVGINTG = \frac{\sum_{i=1}^{14} \alpha_i X_i}{\sum_{i=1}^{14} \alpha_i}$$

Where

$$\alpha_i = \begin{matrix} 1 & \text{if technology } i \text{ is used by the firm} \\ \text{or} \\ 0 & \text{if technology } i \text{ is not used by the firm} \end{matrix}$$

X_i = the degree of integration of technology i with all other technologies

60.7 percent of the firms showed low level of AMT integration, whereas 29 percent firms had manufacturing technologies which were moderately integrated with each other. Only 9.7 percent of the firms used AMT in a more or less fully integrated environment. Figure 4.6 shows the average integration level of manufacturing technologies in firms.

Table 4.6
Average Integration of Advanced Manufacturing Technologies

Technology	Mean	Standard Deviation
1. CAD	3.11	1.12
2. CAE	2.83	1.19
3. FMC	2.15	1.28
4. FMS	2.05	1.20
5. CAM	2.57	1.20
6. AA	1.80	1.12
7. CNC	2.65	1.21
8. Robotics	1.73	0.98
9. AS/RS	1.60	1.01
10. AGV	1.30	0.71
11. CAPP	2.20	1.33
12. MRP II	3.49	1.34
13. ASBIT	2.01	1.15
14. SFM&C	2.82	1.30

Figure 4.5
Average Integration of Manufacturing Technologies

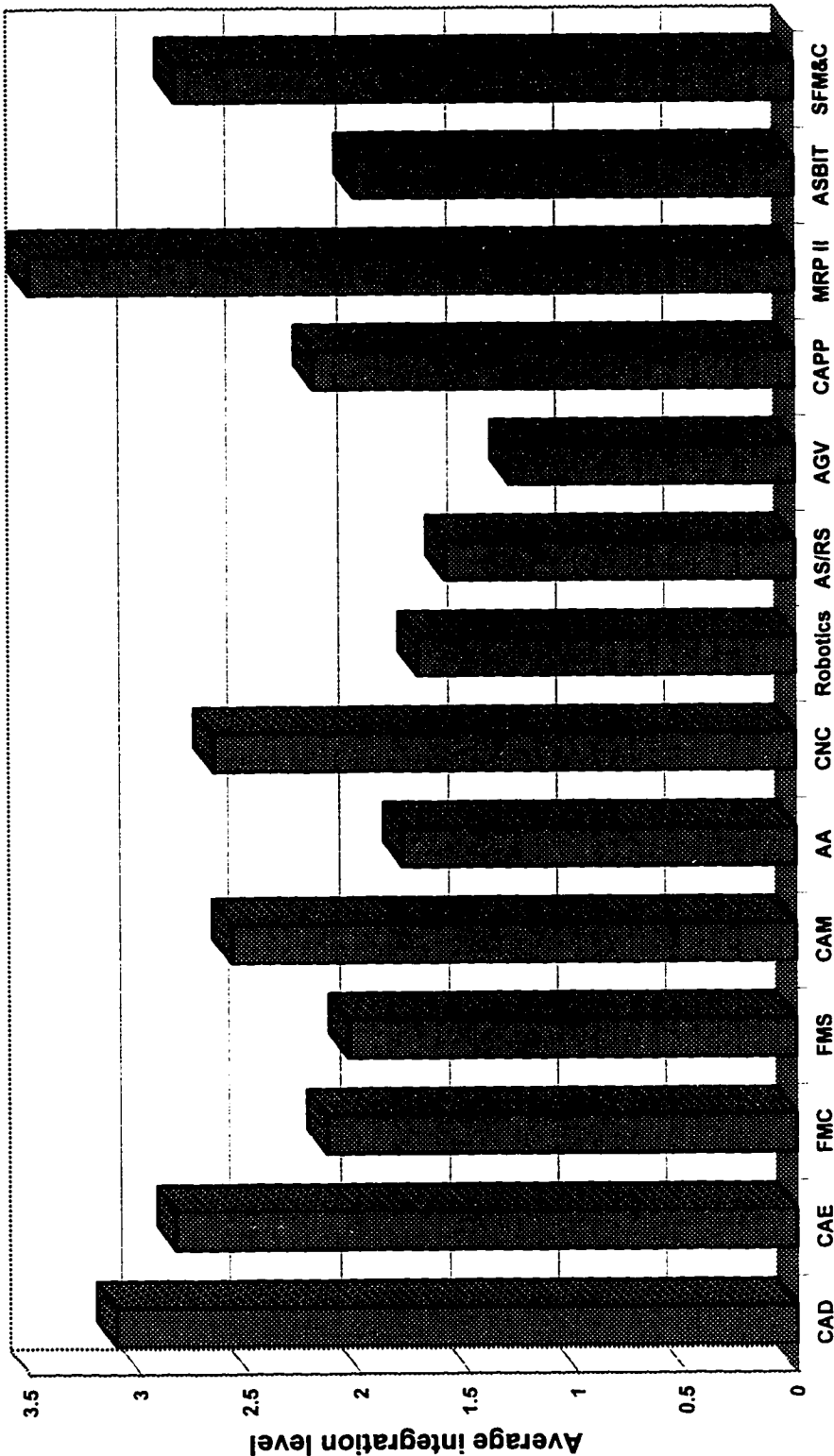
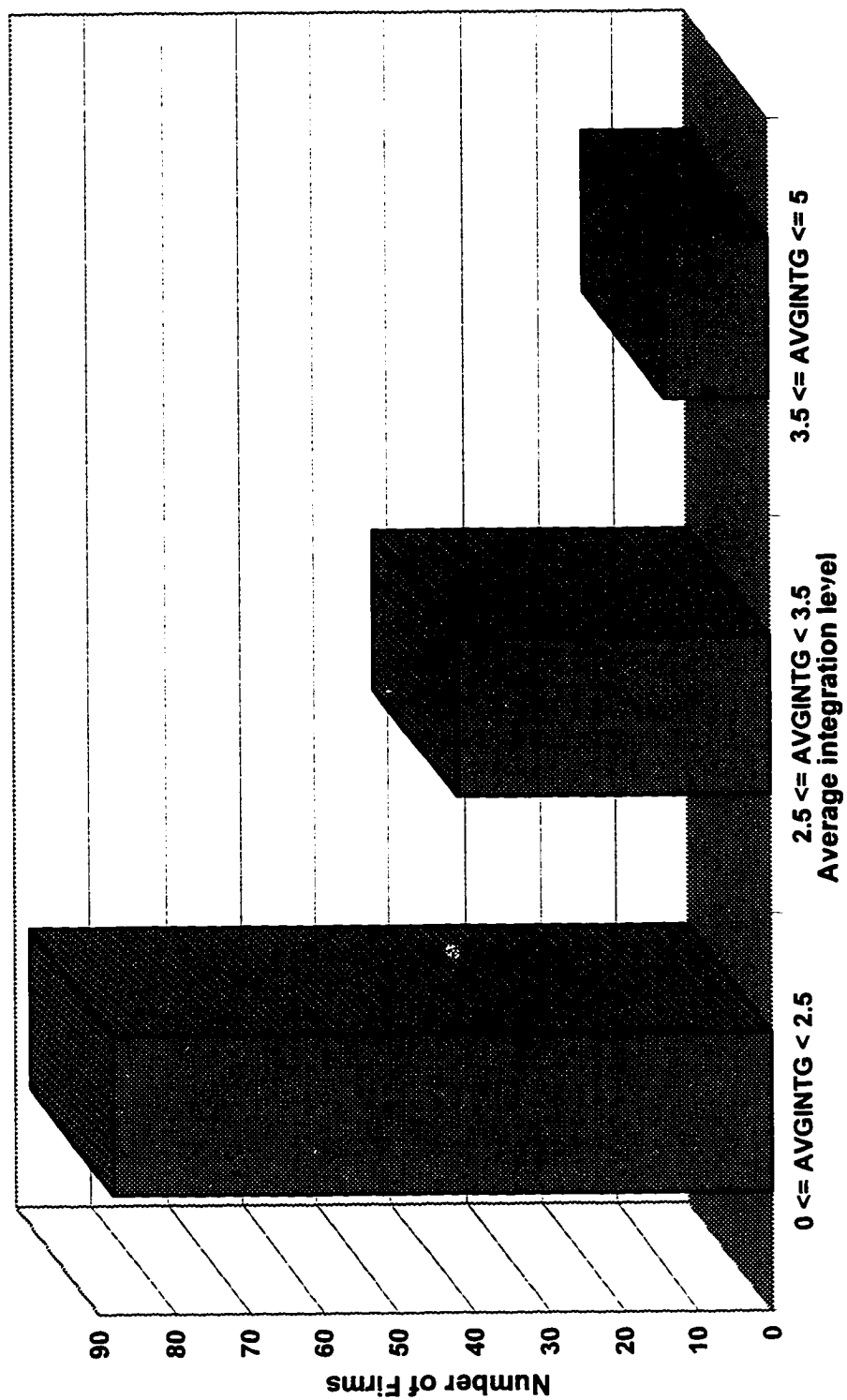


Table 4.7
Distribution of Firms by Level of AMT Integration

Level of Integration	Number of Units	Percent
0 <= AVGINTG < 2.5	88	60.7
2.5 <= AVGINTG < 3.5	42	29.0
3.5 <= AVGINTG <=5	14	9.7
Missing Cases	1	0.7
TOTAL	145	100.0

where AVGINTG = Average level of AMT integration

Figure 4.6
Average AMT Integration Level in Firms



Use of AMT

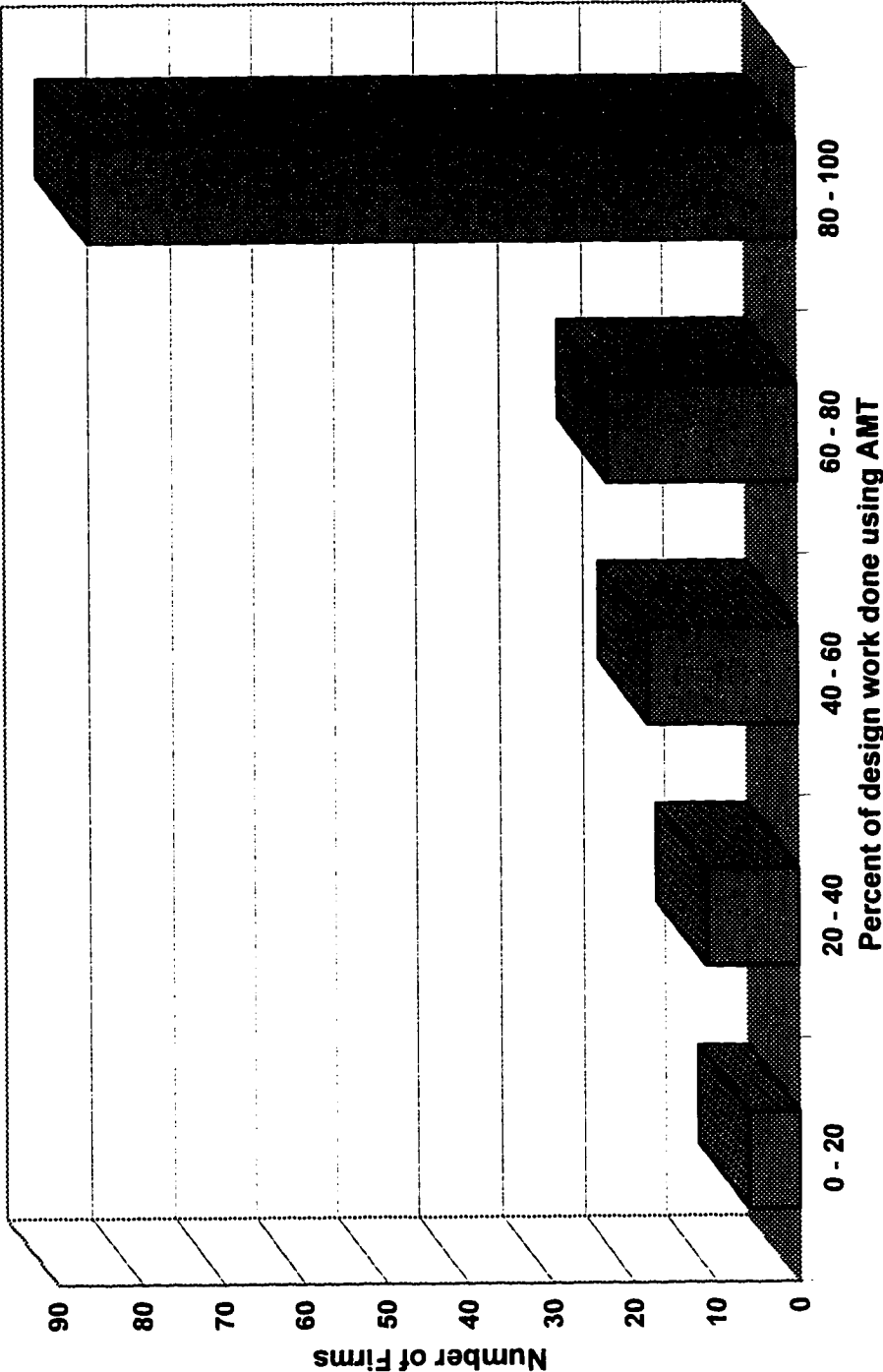
Respondents were asked to indicate the percentage of design work done using computer aided design (CAD), computer aided engineering (CAE), or other types of computer assisted technologies. Table 4.8 shows the distribution of firms using AMT for product designing. 59.3 percent of the firms reported that they used AMT for more than 80 percent of the design work done at their facilities. Figure 4.7 illustrates the number of firms using AMT for product designing.

Table 4.8
Distribution of Firms Using AMT for Product Designing

Percent of Design work done using AMT	Number of Units	Percent
0 <= DESP < 20	6	4.1
20 <= DESP < 40	11	7.6
40 <= DESP < 60	18	12.4
60 <= DESP < 80	23	15.9
80 <= DESP <= 100	86	59.3
Missing Cases	1	0.7
TOTAL	145	100.0

where DESP = Percent of design work done using AMT

Figure 4.7
Firms Using AMT for Product Designing



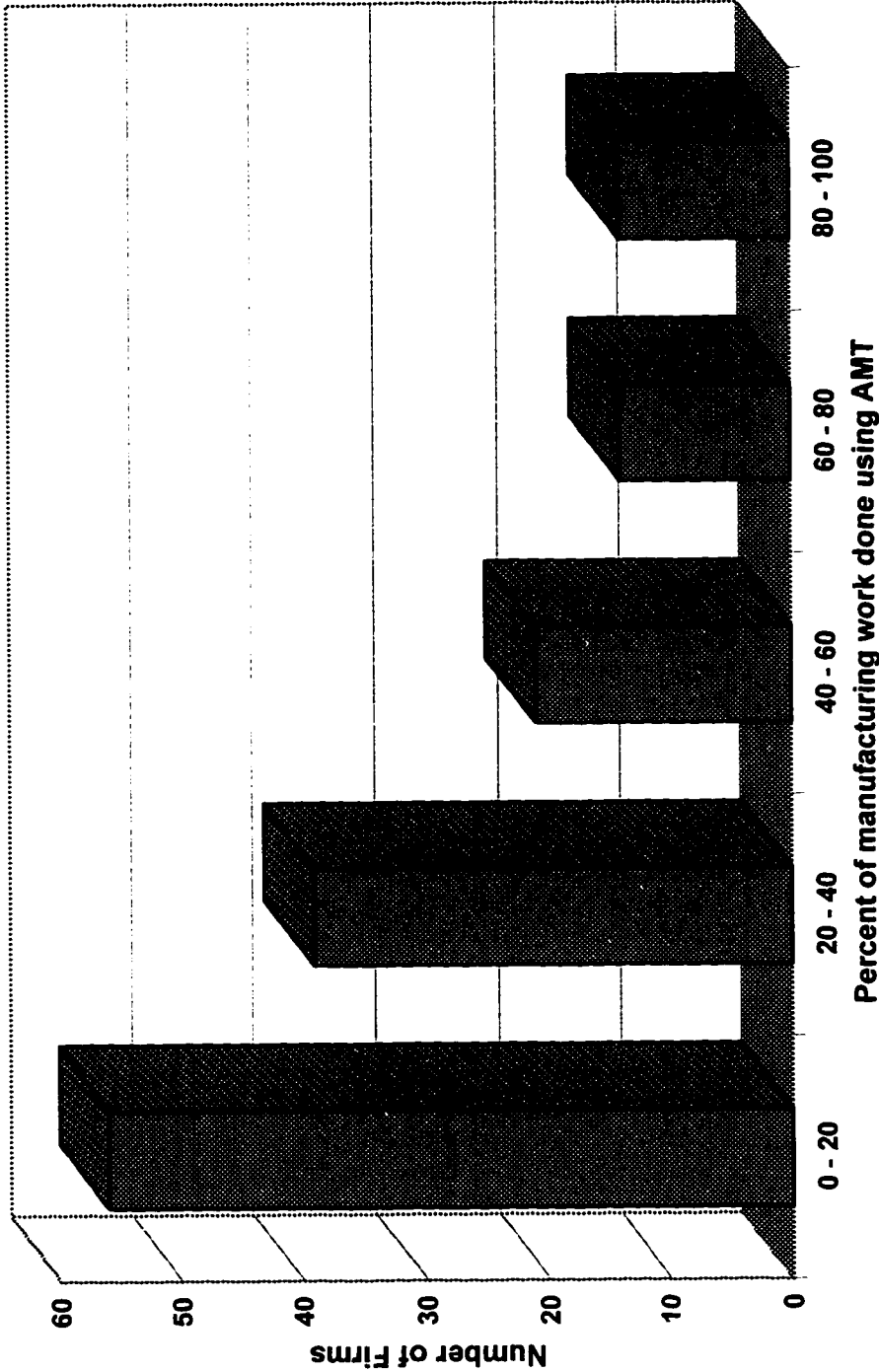
Respondents were asked to indicate the percentage of manufacturing work done using AMT. Table 4.9 shows the distribution of firms using AMT for product manufacturing. Only 9.7 percent of the firms reported use of AMT for more than 80 percent of manufacturing work. Around 40 percent of the firms used AMT for only 20 to 60 percent of manufacturing work. A fairly large percentage of the firms, 38.6 percent, reported less than 20 percent of manufacturing work done using AMT, a significantly low level of AMT use. Figure 4.8 shows the number of firms using AMT for product manufacturing.

Table 4.9
Distribution of Firms Using AMT for Product Manufacturing

Percent of manufacturing work done using AMT	Number of Units	Percent
0 <= MFGP < 20	56	38.6
20 <= MFGP < 40	39	26.9
40 <= MFGP < 60	21	14.5
60 <= MFGP < 80	14	9.7
80 <= MFGP <= 100	14	9.7
Missing Cases	1	0.7
TOTAL	145	100.0

where MFGP = Percent of manufacturing work done using AMT

Figure 4.8
Firms Using AMT for Product Manufacturing



Respondents were asked to indicate the percentage of planning and control work done using AMT. Firms reported a significantly large use of AMT for production planning and control. 68.3 percent of the firms used AMT for more than 80 percent of the planning work done at their facilities (see table 4.10). Less than 3 percent of the firms reported use of AMT for less than 40 percent of the planning work. Figure 4.9 illustrates the number of firms using AMT for production planning and control.

Table 4.10

Distribution of Firms Using AMT for Product Planning

Percent of planning work done using AMT	Number of Units	Percent
0 <= PLGP < 20	1	0.7
20 <= PLGP < 40	3	2.1
40 <= PLGP < 60	14	9.7
60 <= PLGP < 80	27	18.6
80 <= PLGP <= 100	99	68.3
Missing Cases	1	0.7
TOTAL	145	100.0

where PLGP = Percent of planning work done using AMT

Figure 4.9
Firms Using AMT for Product Planning

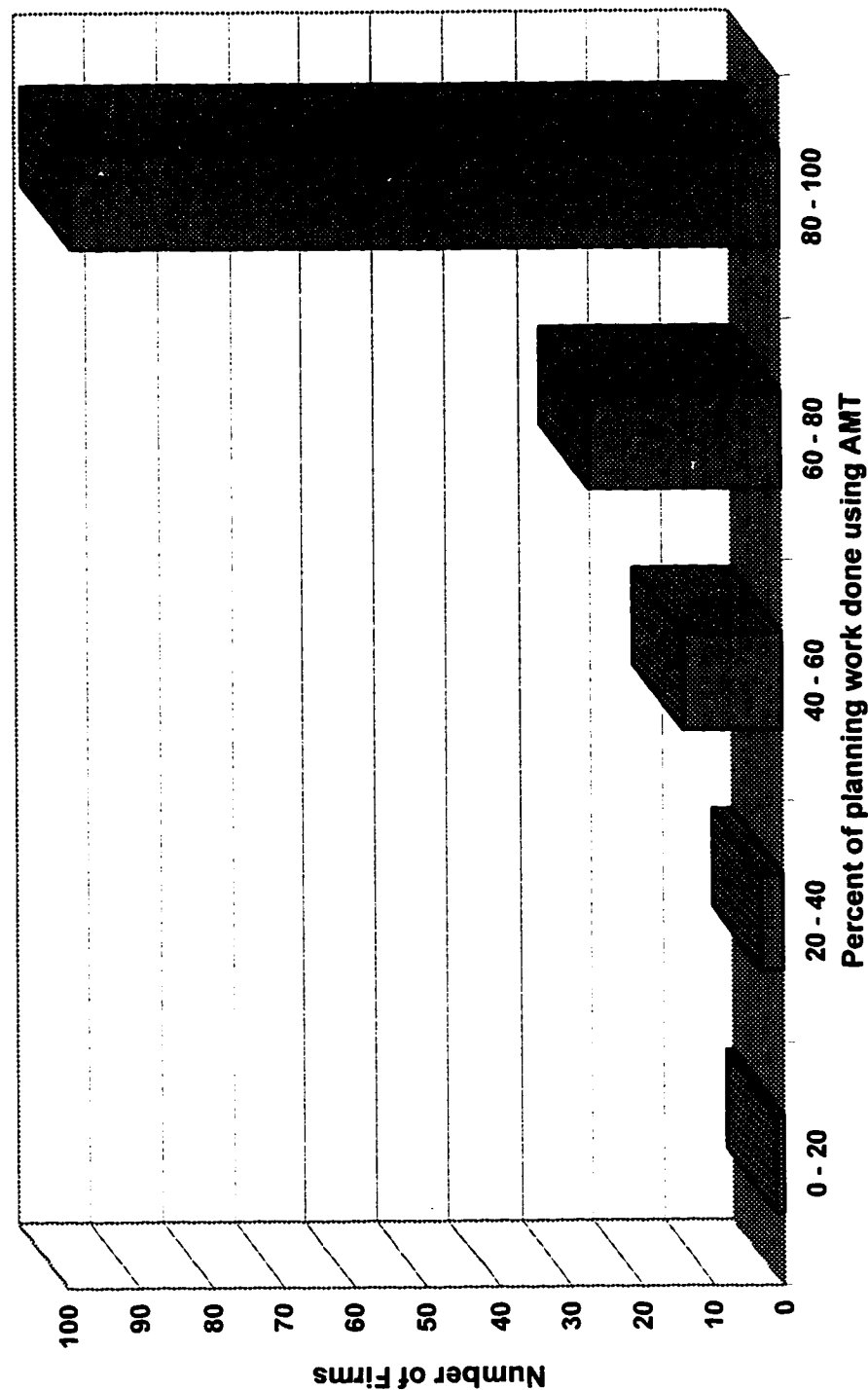


Table 4.11 classifies the use of AMT for business groups. Classification based upon industry type indicated fairly similar use of AMT for designing, manufacturing, and planning across all SIC groups. Industrial group SIC35, however, showed the maximum use of AMT for product design and manufacturing. Figure 4.10 illustrates the average use of AMT by industry type.

Classification based upon firm size indicated that larger firms made much use of AMT for all three purposes -- designing, manufacturing, and planning, with medium size firms trailing behind closely. Figure 4.11 illustrates the average use of AMT by firm size.

4.2 Measures

Information pertinent to this research was collected from the senior managers of the selected companies through a questionnaire. The questionnaire for this purpose was constructed based upon survey instruments of several authors. A few modifications were made to these instruments to suit our research problem. All items in the questionnaire were measured on a 5-point Likert scale. The questionnaire is presented in the appendix.

The variables included in the questionnaire and the items used to measure them are explained below. A brief description of the variables is presented in table 4.12.

Table 4.11**Classification of AMT Use by Business Groups**

Business Unit Categories	Percentage work done using AMT		
	Designing	Manufacturing	Planning
<u>Major Industry Type</u>			
SIC33	51.3	30.7	72.7
SIC34	70.6	30.6	69.7
SIC35	82.9	36.7	84.0
SIC36	78.1	32.7	85.4
SIC37	76.2	30.7	81.9
SIC38	63.3	18.3	83.5
<u>Firm Size</u> (Number of employees)			
Less than 201	73.5	20.3	77.8
201 - 500	77.6	28.6	83.3
501 - 1000	58.6	34.3	79.4
1001 - 5000	80.8	34.2	80.4
Over 5000	78.5	48.3	86.3

Figure 4.10
Average Use of AMT by Industry Type

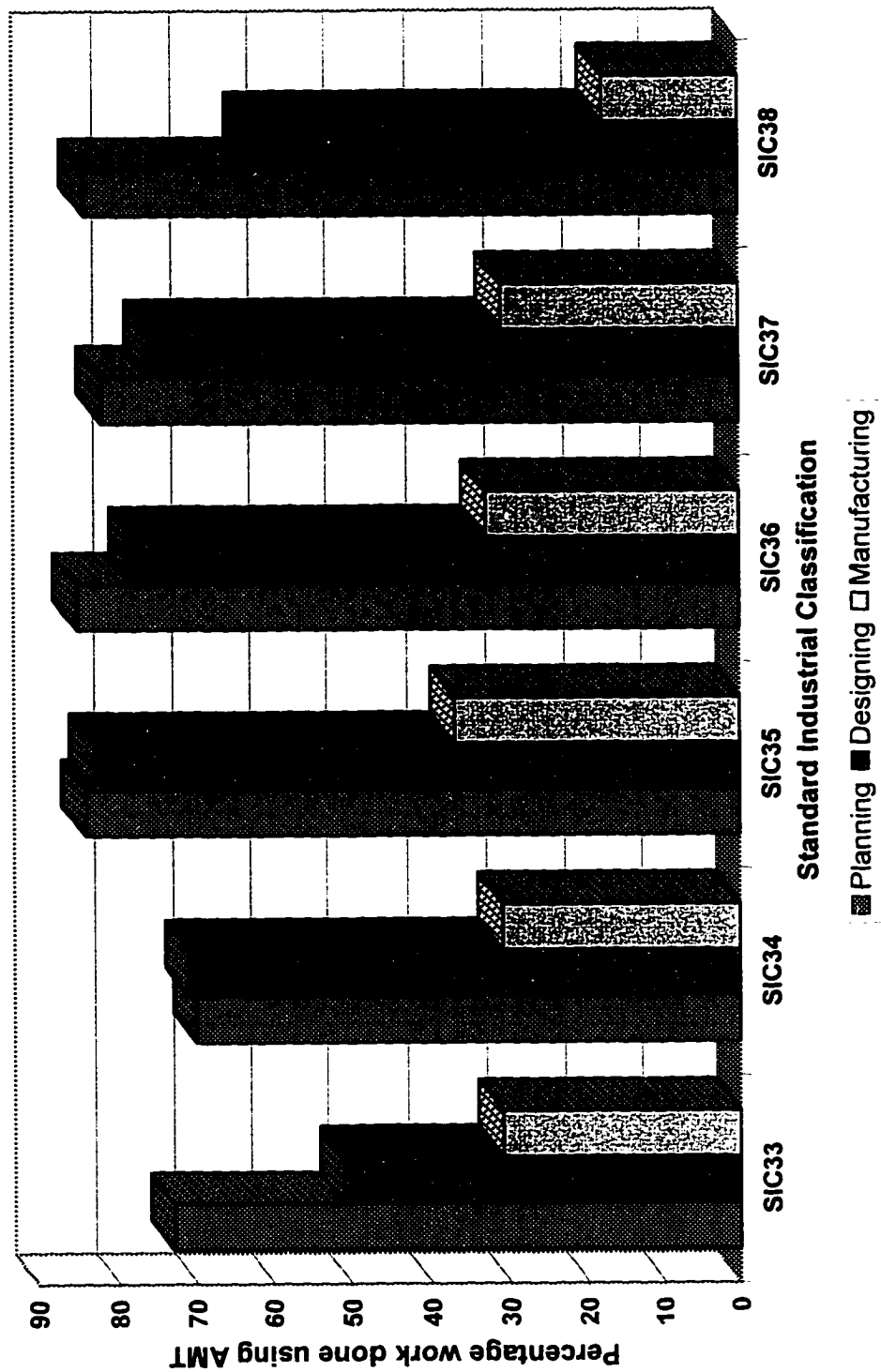


Figure 4.11
Average Use of AMT by Firm Size

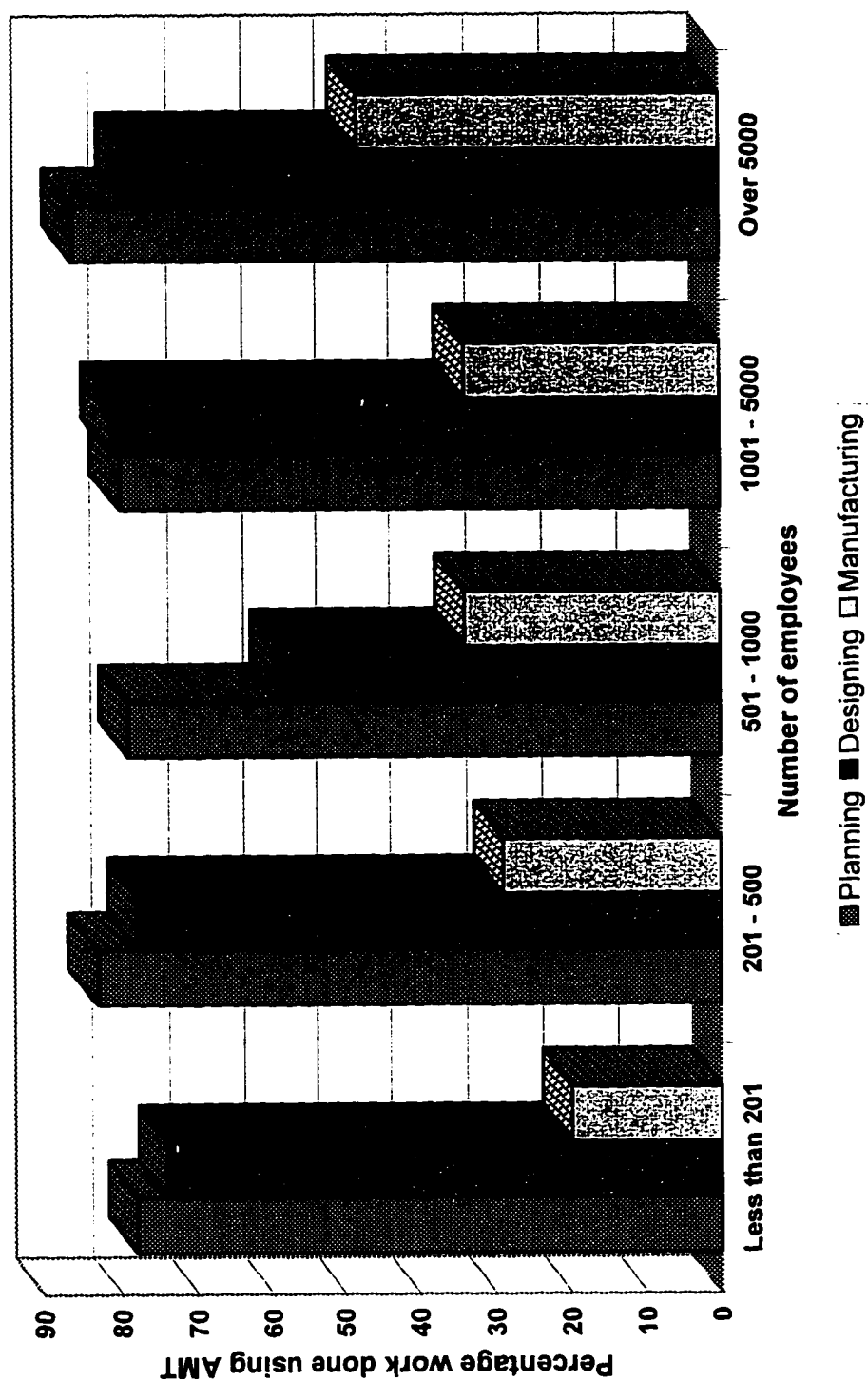


Table 4.12 Variables' Description

Variables	Items	Definition	Reference
1. Intensity & Integration of AMT (IIT)	14 items	IIT is defined as the extent to which a firm uses different types of AMTs and the degree to which they are integrated.	Youssef (1991); Manufacturing Technology Survey (1988).
2. Organizational Structure	9 items	Pattern of peoples' roles and relationships designed to get work done through proper direction and co-ordination. Several structural dimensions when summated can be characterized as organic or mechanistic structure.	Parthasarathy (1991).
4. MFG. PERFORMANCE Flexibility Responsiveness Quality Cost	5 items 4 items 6 items 4 items	The level of performance achieved by the firm in relation to its key competitors along the four priorities of flexibility, responsiveness, quality, and cost.	Youssef (1991); Vickery, Droge, & Markland (1993).

contd...

	Items	Definition	Reference
5. BUSINESS STRATEGY			
Complex Innovation (CI)	5 items	CI: Competing by rapid introduction of new products, better design, quality, etc.	Miller (1987);
Marketing Differentiation (MD)	5 items		Dess & Davis (1984);
Cost Leadership (CL)	7 items	MD: Competing by creating a unique and favorable image through aggressive marketing efforts. CL: Competing industrywide on the basis of low cost.	Galbraith & Schendel, (1983).
6. ENVIRONMENT			
Dynamism	5 items	Dynamism: The amount and unpredictability of change in the environment such as customer tastes, production technologies, etc.	Miller (1987);
Hostility	4 items	Hostility: The degree of competition in the market, severe regulatory restrictions, and shortage of scarce resources.	Ward, Leong, & Boyer (1994).
7. PROACTIVENESS	5 items	The extent to which manufacturing managers are involved in the strategic planning process of the firm. (1994).	Ward, Leong, & Boyer
8. BUSINESS PERFORMANCE	3 items	Objective and perceptual measures of: -- Market Share -- Sales Growth -- Return on Investment	Chakravarthy (1986); Miller & Toulouse (1986); Ward, Leong, & Boyer (1994).

Independent Variable

Advanced Manufacturing Technology (AMT)

AMT as defined in this study included fourteen different technologies.

These technologies were further categorized into three different groups based upon the functions served by these technologies: Designing, manufacturing, and production planning and control. The variables used to denote these technologies are as follows:

X_1	Computer aided design (CAD)
X_2	Computer aided engineering (CAE)
X_3	Flexible Manufacturing Cell (FMC)
X_4	Flexible Manufacturing Systems (FMS)
X_5	Computer Aided Manufacturing (CAM)
X_6	Automated Assembly (AA)
X_7	Computer Numerical Control (CNC)
X_8	Robotics
X_9	Automated Storage & Retrieval Systems (AS/RS)
X_{10}	Automated Guided Vehicles (AGV)
X_{11}	Computer Aided Process Planning (CAPP)
X_{12}	Manufacturing Resource Planning (MRPII)
X_{13}	Automated Sensor Based Inspection or Testing (ASBIT)
X_{14}	Shop Floor Monitoring & Control by Personal Computers (SFM&C)

Respondents were asked to indicate on a 5-point Likert scale the extent to which each technology, if used, was linked to the other technologies. The value of variables X_i indicated by the respondents thus show the level of integration of technology i with all other technologies. Respondents were also asked to indicate the percentage of design, manufacturing, and planning work done using AMT.

Using the responses received, a technological index was created to indicate the intensity and integration of AMT (IIT) in a firm. The equation used to construct the IIT index was adopted from Youssef (1991) with some modifications. The equation is given below.

$$IIT = \frac{\sum_{i=1}^2 \alpha_i X_i}{\sum_{i=1}^2 \alpha_i} \times desp + \frac{\sum_{i=3}^{10} \alpha_i X_i}{\sum_{i=3}^{10} \alpha_i} \times mfgp + \frac{\sum_{i=11}^{14} \alpha_i X_i}{\sum_{i=11}^{14} \alpha_i} \times plgp$$

where

IIT = intensity and integration of AMT

$n_1 = \{X_1, X_2\}$ is a set of technologies used for product designing

$n_2 = \{X_3, X_4, X_5, X_6, X_7, X_8, X_9, X_{10}\}$ is a set of technologies used for product manufacturing

$n_3 = \{X_{11}, X_{12}, X_{13}, X_{14}\}$ is a set of technologies used for production planning and control

$\alpha_i = \begin{cases} 1 & \text{if technology } i \text{ is used by the firm} \end{cases}$

or

$\alpha_i = \begin{cases} 0 & \text{if technology } i \text{ is not used by the firm} \end{cases}$

$desp$ = the percentage of design work done using AMT

$mfgp$ = the percentage of manufacturing work done using AMT

$plgp$ = the percentage of planning and control work done using AMT

Moderator Variables

Organizational Structure

Organizational structure was measured using a 9 item construct developed by Parthasarathi (1991). Some modifications were made to the items to suit this study. The scale was constructed using the bi-polar dimensions of decision-making, control systems, task forces and/or committees, line-staff responsibilities, etc. The scales were measured on a 5-point Likert scale such that the extreme values of the items represented organic or mechanistic characteristics. Item 8, management control and information systems, was measured using a reverse score. Average of all 9 items was taken to represent the overall organizational structure. A high value of the average would indicate an organic structure whereas a low value would indicate a mechanistic structure.

Business Strategy

Three types of business strategies are defined in this study: Complex innovation, marketing differentiation, and cost leadership. The measures used for these three strategies were based on works by Dess and Davis (1984), Galbraith and Schendel (1983), and Miller (1987).

Respondents were asked to indicate on a 5-point Likert scale the importance of a competitive method for their business units in relation to their major competitors. Complex innovation strategy was measured using 5 items,

marketing differentiation strategy with 5 items, and cost leadership with 7 items.

The final values of the measures were determined by averaging the values of the respective items.

Proactiveness

Proactiveness of manufacturing managers in the strategic decision making process was measured using a 5-item construct. The items were derived from work done by Ward, Leong, and Boyer (1994). Respondents were asked to indicate on a 5-point Likert scale the manufacturing managers' degree of involvement and responsibility for the business unit strategy, and the extent of cross-functional participation and cooperation. The average of the 5 items was used to represent the proactiveness value for the firm.

Environmental Uncertainty

The two measures of environmental uncertainty: Dynamism and hostility, were derived from work done by Miller (1987), and Ward et al. (1994).

Environmental dynamism was measured using 5 items assessing the rate of change and innovation of new products and services, operations processes etc.

Environmental hostility was measured using 2 items assessing the rate of change in the predictability and hostility of the key competitors over the past

three years. Average of the respective items represented the final value of the dynamic and hostile environment of a firm.

Dependent Variables

The measures for the two dependent variables used in this study, manufacturing performance and business performance, are explained below.

Manufacturing Performance

The four measures of manufacturing performance: Flexibility, responsiveness, quality, and cost, were based on work by Vickery, Droge, and Markland (1993), and Youssef (1991). Respondents were asked to indicate on a 5-point Likert scale their business unit's manufacturing performance on several dimensions in relation to their major competitors. Flexibility was measured with 5 items, responsiveness with 4 items, quality with 6 items, and cost with 4 items. The final value for each measure was determined by averaging the respective items.

Business Performance

Firm's business performance was measured using both objective and perceptual measurements. The dimensions selected were market share, sales growth, and return on investment. Though the objective measures were

collected, we decided not to use them because of large number of missing values.

For perceptual measures, the respondents were asked to indicate their firm's position on the above three dimensions in comparison to their competitors. The average of the three items was used as a business performance measure for the firm.

4.3 Analytical Techniques

This section presents the statistical techniques used to analyze the hypothesized relationships presented in our model. The model was examined using two different approaches -- the contingency approach and the configurational approach. The contingency approach examines relationships with a moderating perspective, whereas the configurational approach adopts a systems perspective. The analytical techniques for both approaches are explained below.

4.3.1 Contingency Approach

The primary purpose of this research was to examine the relationship between AMT and business performance. Secondly, we intended to determine if this relationship varied systematically with changes in other contextual variables. Statistically, the contextual variables, called the moderating variables, interact

with the independent variable (AMT) in determining the variation in the dependent variable.

Though a long controversy exists over the appropriate statistical technique to determine the interaction effect of the moderating variables, a consensus seemed to emerge over the past few years. The two analytical techniques frequently used by researchers are: Moderated regression analysis (MRA) and subgroup analysis (Arnold, 1982, 1984; Cohen & Cohen, 1975; Stone & Hollenbeck, 1984; Venkatraman, 1989). Though both analytical techniques measure the interaction effect of the moderating variables, the two are not interchangeable. The use of a particular method depends on the research setting and the relationship examined.

Arnold (1982, 1984) clarified the issue by asserting that the appropriateness of a technique is determined by the relationship examined between the independent and dependent variable for different levels of the moderating variable. If one examines the strength or magnitude (i.e., the degree) of relationship then the appropriate statistical technique is subgroup analysis. If one examines the form of relationship then the appropriate statistical technique is MRA. Researchers are specifically advised to use MRA if the variables are measured on interval rather than ratio scales (Southwood, 1978). For further discussion, see chapter 3, section 3.2.

Considering the research issues and the relationships we had to examine, we selected MRA as the statistical technique to analyze the data collected for

this study. A detailed description of the MRA is presented in chapter 3, section 3.2.2.

We selected two different approaches to examine the hypotheses using MRA -- the discrete model and the full model. Under discrete model, the interaction effect was examined separately for each moderating variable. Under full model, all variables were included in the equation at a time as a set. While the discrete model allows to make meaningful inference about the effect of the interaction term, it does not contain simultaneous effect of other variables. The full model, on the other hand, allows for simultaneous presence of all variables but presents the problem of multicollinearity, making it difficult to identify the effect of a specific variable. To avoid the pitfalls, we have used both methods in this study.

Next, following a procedure suggested by Cohen and Cohen (1975), we calculated plus and minus two standard deviations from the means of the moderating variables, creating two levels to represent high and low moderating situation. For each value of the moderating variables, we then derived a simple regression equation, illustrating the relationship between the independent and dependent variables. The equations were then graphed to illustrate the moderating effects. The slope of the two regression equations denote different degree of predictability of the dependent variable for different levels of the moderating variables. If the slopes are different, representing non-parallel lines, then they will cross each other although not necessarily within the range of

observed values (Cohen & Cohen, 1975). The presence of interaction effect, in other words, suggest that the slopes of the regression equations for different levels of moderating variables would be significantly different.

4.3.2 Configurational Approach

Under configurational approach, one strives to derive classifications or taxonomies such that elements within a taxonomy are more alike and display similar characteristics than elements in other taxonomies. A wide variety of statistical techniques are available to form such configurations such as factor analysis, discriminant analysis, cluster analysis, and multidimensional scaling. We decided to use cluster analysis, a technique specifically designed to form such groups.

Cluster analysis partitions a set of objects into subgroups based on inter-object similarities. The objective is to form clusters that display small within-cluster variation relative to the between-cluster variation (Dillon & Goldstein, 1984).

The two major problems in applying cluster analysis is the determination of a measure of inter-object similarity, and a procedure for forming the clusters. There exists large number of proximity measures and clustering algorithms to choose from. But the issue of which similarity measure and algorithm to apply is still unresolved. This makes cluster analysis extremely sensitive to the type and

quality of data used (Galbraith & Schendel, 1983). Nevertheless, the existence of high-speed computers and wide variety of statistical packages have made it possible to experiment with different options and arrive at meaningful clusters backed up by theoretical justifications.

There exists two main types of clustering techniques or algorithms: Hierarchical and nonhierarchical. In hierarchical technique, a series of fusions or divisions of the data are performed. Agglomerative methods start with each object as a single cluster and forms a series of fusions of the objects into groups. All objects are eventually merged into a single cluster. The distinguishing feature of agglomerative methods is that once an object is allocated to a group it is never removed. Divisive methods partition the data into finer and finer subdivisions and eventually results into each object as a cluster.

Given the variety of clustering algorithms, the important issue is to determine the appropriate number of clusters. The objective is to derive clusters with high degree of within group homogeneity. The normal practice is to examine a number of statistics at each step of new cluster formulation. Some of the statistics commonly used by researchers are:

1. Root mean square standard deviation (RMSSTD)
2. Semi-partial R-squared (SPRSQ)
3. R-squared (RSQ)
4. Distance between two clusters
5. Pseudo F
6. Pseudo t^2

Each of the above statistical criteria provide information regarding the homogeneity or heterogeneity of the newly formed cluster at each successive level. For details, see Sharma (1996). For visual analysis, one can plot the statistics against the number of clusters and look for a jump or elbow in the plot. A jump in the value of the statistical coefficient implies that the clusters merged were dissimilar. The number of clusters prior to the merger is, therefore, the probable solution. Alternatively, one can also use a dendrogram, a tree like structure that illustrates the fusions of clusters at each successive level.

Nonhierarchical clustering technique partitions the data into k groups based upon some predefined convergence criterion. Unlike hierarchical methods, the number of final clusters must be specified in advance. Also, the allocation of objects to groups is not irrevocable. Objects are allowed to be reassigned to different groups. As usual, there exists a number of clustering algorithms with variety of options to choose from.

Both hierarchical and nonhierarchical methods have their advantages and disadvantages. The choice depends upon the objective of the study and the nature of data available. Sharma (1996) suggests that the two methods must be viewed as complementary clustering methods rather than as competing methods. Hierarchical methods do not require a prior knowledge of the number of clusters. However, observations once assigned to a group cannot be reassigned to another group. Nonhierarchical methods, on the other hand, require prior knowledge of the number of clusters, and are very sensitive to the

initial cluster seeds of partition. Studies have shown that nonhierarchical techniques perform poorly if random initial partitions are used. Performance can be improved significantly if hierarchical methods are used to form the initial cluster partitions (Sharma, 1996).

Following Sharma's (1996) advice and the technique suggested by him, we first used hierarchical analysis to determine the appropriate number of clusters. Then the resulting clustering solution was refined by submitting it to nonhierarchical clustering technique.

For hierarchical cluster analysis, the clustering algorithm selected was Ward's Minimum-variance method, an agglomerative hierarchical clustering technique. Ward's method tend to maximize within-cluster homogeneity. This is achieved by forming clusters such that the within group sums of square, also known as error sums of square, is minimized. For details, see Dillon & Goldstein (1984). In this study, Ward's clustering method was applied to standardized variables with mean zero and standard deviation equal to one. This was done to avoid variables with large variances having more effect on the resulting clusters than those with small variances.

As discussed above, nonhierarchical clustering technique was then used to refine the initial solution obtained from Ward's method. The procedure used was FASTCLUS given in SAS, a statistical software. The cluster means from the initial solution were used as the initial or starting seeds. The FASTCLUS procedure uses a standard iterative algorithm to minimize the sum of squared

deviations from the cluster means. The observations are assigned to the nearest seed to form temporary clusters. The means of the temporary clusters are then used as the new seeds and the process is repeated. The process terminates when the convergence criterion is met.

The clusters obtained were then compared by profiling the means and standard deviation of the variables of interest. Finally, multivariate analysis of variance (MANOVA) was used to examine inter-cluster differences for each variable present in the model.

For a brief description of the hypotheses to be tested, the associated variables, and the analytical techniques, see table 4.13.

Table 4.13
Hypotheses, Variables, and the Analytical Techniques

Hypotheses	Dependent Variable	Independent Variable	Moderating Variable	Analytical Method
I. 1, and 1a-1d	Manufacturing Performance Flexibility, Quality, Responsiveness, & Cost	IIT	--	Simple Regression Analysis
II. 2a	Manufacturing Performance	IIT	Organizational Structure	Moderated Regression Analysis (MRA)
III. 2b	Business Performance (BUSP)	IIT	Organizational Structure	MRA
IV. 3, and 3a-3c	BUSP	IIT	Business Strategy	MRA
V. 4	BUSP	IIT	Mfg. Proactiveness	MRA
VI. 5, 5a and 5b	BUSP	IIT	Mfg. Proactiveness Environment - Dynamism - Hostility	MRA

Chapter 5

RESEARCH RESULTS AND DISCUSSION

The data collected for this study was examined from two different perspectives: Contingency and configurational. Moderated regression analysis was used to examine contingency relationships. Configurations, on the other hand, were studied using cluster analysis and MANOVA. This chapter presents the research results, followed by a discussion of the findings. Some limitations and future research directions are then suggested.

5.1 Results

Table 5.1 shows the means, standard deviations, and zero-order correlations among the variables measured for this study. Most variables were significantly correlated with each other but did not indicate any presence of multicollinearity. Manufacturing performance variable was, however, highly correlated with some of the other variables -- flexibility, responsiveness, quality, and cost. Since manufacturing performance was measured as an average of the above four variables, a high correlation value was expected. This did not create any problem as the model was designed to examine the above dependent variables separately.

Table 5.1
Descriptive Statistics and Correlations

Variables	Means	S.D.	1	2	3	4	5	6	7	8	9	10	11	12	13
1. IIT	5.22	2.43													
2. CI	3.66	0.83	.34***												
3. MD	3.07	0.85	.16*	.38***											
4. CL	4.09	0.50	.06	.18**	.12										
5. ORGSTR	3.26	0.42	-.02	.04	.08	.12									
6. PROACT	3.86	0.71	.18**	.07	.07	.16*	.29***								
7. DYNA	2.89	0.87	.27***	.41***	.09	.11	.17**	.13							
8. HOST	3.28	0.63	-.20**	-.02	-.01	.06	.14	.08	.08						
9. FLEX	3.48	0.69	.31***	.32***	.20**	.18**	.13	.32***	.28***	.03					
10. RESP	3.66	0.80	.22**	.06	.04	.14	.22**	.28***	.21**	-.09	.42***				
11. QUAL	3.92	0.58	.22***	.21**	.18**	.09	-.05	.22**	.09	-.11	.39***	.19**			
12. COST	3.10	0.68	.10	.03	-.01	.23***	.26***	.20**	.21**	-.07	.30***	.38***	.15*		
13. MFGPER	3.58	0.47	.32***	.24***	.16*	.23***	.19**	.37***	.28***	-.08	.78***	.71***	.65***	.62***	
14. BUSP	3.40	0.71	.22**	.20**	-.01	.26***	.22**	.21**	.31***	.08	.47***	.35***	.24***	.21**	.46***

N = 132

* p < .10

**

p < .05

p < .01

IIT = Intensity and Integration of AMT; CI = Complex Innovation Strategy; MD = Marketing Differentiation Strategy;
 CL = Cost Leadership Strategy; ORGSTR = Organizational Structure; PROACT = Manufacturing Proactiveness;
 DYNA = Dynamic Environment; HOST = Hostile Environment; FLEX = Flexibility; RESP = Responsiveness;
 QUAL = Quality; COST = Cost; MFGPER = Manufacturing Performance; BUSP = Business Performance

5.1.1 Moderated Regression Analysis Results

Hypotheses 1 and 1a-1d

In hypotheses 1 and 1a-1d, IIT was related to performance at the operational level. The hypotheses were tested using simple regression analysis. Table 5.2 presents the regression results. Hypothesis 1 suggested a positive relationship between IIT and overall manufacturing performance. The beta coefficient was found to be positive and statistically significant ($b = 0.06$, $p < 0.01$), indicating a strong influence of technology on manufacturing performance. IIT accounted for a substantial variance ($R^2 = 0.0974$) in manufacturing performance.

In hypotheses 1a-1d, influence of IIT was examined for individual dimensions of manufacturing performance. It was argued that higher IIT would lead to improved flexibility, responsiveness, quality, and reduced cost. Regression analyses presented in table 5.2 indicated support for three of the four hypotheses. The beta coefficients showed significant impact of IIT on flexibility ($b = 0.09$, $p < 0.01$), responsiveness ($b = 0.07$, $p < 0.05$), and quality ($b = 0.05$, $p < 0.01$). The relationship between IIT and flexibility was found to be stronger with $R^2 = 0.101$ compared to $R^2 = 0.0462$ for responsiveness and $R^2 = 0.0468$ for quality. Hypothesis 1d, suggesting a negative relationship between IIT and cost, was not supported by this study.

Table 5.2
Simple Regression Analysis Results
Hypotheses 1, 1a to 1d

Dependent Variable	Independent Variable	b_0	b_1	R^2	F
Mfgper	IIT	3.27***	0.06***	.0974	15.00***
Flexibility	IIT	3.02***	0.09***	.1010	15.62***
Responsiveness	IIT	3.30***	0.07**	.0462	6.73**
Quality	IIT	3.67***	0.05***	.0468	6.83***
Cost	IIT	2.97***	0.02	.0071	0.99

N = 141

* $p < .10$

** $p < .05$

*** $p < .01$

Mfgper Manufacturing Performance
IIT Intensity and Integration of AMT

Hypotheses 2a and 2b

Hypotheses 2a and 2b addressed the moderating effect of organizational structure on the relationship between IIT and manufacturing and business performance. Hypothesis 2a stated that business units with higher IIT and an organic organizational structure will have higher manufacturing performance. Hypothesis 2b stated that business units with higher IIT and an organic organizational structure will have higher business performance.

Table 5.3 shows the regression results for hypothesis 2a. With manufacturing performance as the dependent variable, organizational structure did not indicate significant moderating effect. Therefore, the interaction claim of IIT and organizational structure was not supported by this study ($b = -0.01$, $p = 0.42$). However, organizational structure was found to have significant influence on manufacturing performance independent of IIT as evidenced by organizational structure's main effect in the regression equation ($b = 0.20$, $p < 0.05$). Organizational structure made a significant contribution to manufacturing performance variance as indicated by the increment in R^2 shown in table 5.3 ($\Delta R^2 = 0.03$).

Table 5.4 presents the regression results for the interaction effect of IIT and organizational structure on business performance (Hypothesis 2b). The beta coefficient for the interaction term, IIT x ATORG, did not show significant moderating effect of organizational structure ($b = 0.01$, $p = 0.61$). Therefore,

Table 5.3
Moderated Regression Analysis Results
Hypothesis 2a

Dependent Variable: Manufacturing Performance

Variables	Unstandardized Regression Coefficients		
	Step 1	Step 2	Step 3
IIT	0.06***	0.06***	0.10**
ORGSTR		0.20**	0.26**
IIT x ORGSTR			-0.01
Constant	3.27***	2.62***	2.41***
R ²	0.10***	0.13***	0.14***
ΔR^2	0.10***	0.03**	0.01

N = 142 * p < .10 ** p < .05 *** p < .01

IIT Intensity and Integration of AMT
 Orgstr Organizational Structure

Table 5.4
Moderated Regression Analysis Results
Hypothesis 2b

Dependent Variable: Business Performance

Variables	Unstandardized Regression Coefficients		
	Step 1	Step 2	Step 3
IIT	0.07***	0.07***	0.03
ORGSTR		0.38***	0.31*
IIT x ORGSTR			0.01
Constant	3.05***	1.82***	2.02***
R²	0.05***	0.10***	0.104***
ΔR²	0.05***	0.05	0.004

N = 133 * p < .10 ** p < .05 *** p < .01

IIT Intensity and Integration of AMT
 Orgstr Organizational Structure

hypothesis 2b was not supported, indicating that the impact of technology on business performance was independent of the type of organizational structure present in a firm. The main effect of organizational structure on business performance, however, showed high significance ($b = 0.38$, $p < 0.01$).

Therefore, the findings failed to support hypotheses 2a and 2b. A firm's organizational structure characteristics were not found to have any influence on the relationship between IIT and firm performance. However, organizational structure was found to influence firm performance independent of technology at both the operational and the institutional level.

Hypotheses 3 and 3a-3c

Hypothesis 3 suggested a moderating effect of business strategy on the relationship between IIT and business performance. Hypotheses 3a-3c addressed the interaction effect of each strategy individually. It was stated that firms with higher IIT and a specific business strategy will have higher business performance. Although a positive interaction effect was hypothesized for each strategy, the strength of the effect was expected to be different for different strategy.

Table 5.5 shows the regression results for hypothesis 3. The interaction terms for all three strategies, complex innovation, marketing differentiation, and cost leadership, were included as a set in the regression equation after partialling

Table 5.5
Moderated Regression Analysis Results
Hypothesis 3

Variables	Unstandardized Regression Coefficients		
	Step 1	Step 2	Step 3
IIT	0.07***	0.05**	-0.16*
CI		0.12	0.14
MD		-0.09	-0.35**
CL		0.35***	0.20
IIT x CI			-0.006
IIT x MD			0.05*
IIT x CL			0.02
Constant	3.05***	1.51***	2.85***
R ²	0.05***	0.14***	0.20***
ΔR^2	0.05***	0.09**	0.06**

N = 133 * p < .10 ** p < .05 *** p < .01

IIT Intensity and Integration of AMT
CI Complex Innovation Strategy
MD Marketing Differentiation Strategy
CL Cost Leadership Strategy

out their main effects. As indicated by the change in R^2 , the interaction terms accounted for a significant increment in the explained variance ($\Delta R^2 = 0.06$, $p < 0.05$). Hypothesis 3 was, therefore, supported, implying that the impact of IIT on business performance will vary by the type of business strategy pursued by a firm.

Regression results for hypotheses 3a-3c are presented in table 5.6 to 5.8. The regression equations in table 5.6 shows significant interaction effect of complex innovation strategy ($b = 0.03$, $p < 0.10$), thereby supporting hypothesis 3a. The moderating effect of complex innovation strategy accounted for a significant increase in R^2 ($\Delta R^2 = 0.02$, $p < 0.10$). Thus, firms competing on innovations are likely to exhibit higher business performance if supported by higher IIT. Table 5.6 also exhibits a significant main effect of complex innovation strategy on business performance, implying a direct independent influence on business performance ($b = 0.13$, $p < 0.10$).

Table 5.7 shows the regression results for hypothesis 3b. The beta coefficient for the interaction term, IIT x MD, was found to be statistically significant ($b = 0.07$, $p < 0.01$), indicating a strong moderating effect. This was further confirmed by a substantial increase in R^2 ($\Delta R^2 = 0.076$, $p < 0.01$). However, contrary to our expectations, the main effect of marketing differentiation strategy was not found to be significant. Nevertheless, a significant interaction effect implied support for hypothesis 3b, implying that IIT

Table 5.6
Moderated Regression Analysis Results
Hypothesis 3a

Variables	Unstandardized Regression Coefficients		
	Step 1	Step 2	Step 3
IIT	0.07***	0.05*	-0.05
CI		0.13*	0.0009
IIT x CI			0.03*
Constant	3.05***	2.67***	3.11***
R ²	0.05***	0.07***	0.09***
ΔR^2	0.05***	0.02*	0.02*

N = 133 * p < .10 ** p < .05 *** p < .01

IIT Intensity and Integration of AMT
CI Complex Innovation Strategy

Table 5.7
Moderated Regression Analysis Results
Hypothesis 3b

Variables	Unstandardized Regression Coefficients		
	Step 1	Step 2	Step 3
IIT	0.07***	0.07***	-0.14**
MD		-0.02	-0.37***
IIT x MD			0.07***
Constant	3.05***	3.12***	4.17***
R²	0.05***	0.054**	0.13***
ΔR²	0.05***	0.004	0.076***

N = 133 * p < .10 ** p < .05 *** p < .01

IIT Intensity and Integration of AMT
MD Marketing Differentiation Strategy

will have a strong influence on business performance under differentiated marketing strategy.

Regression results for hypothesis 3c are presented in table 5.8. The beta coefficient for the interaction term, IIT x CL, was found to be statistically significant ($b = 0.04$, $p < 0.10$). The variance accounted for by the interaction term was low ($\Delta R^2 = 0.03$, $p < 0.10$) compared to the main effect of cost leadership strategy ($\Delta R^2 = 0.07$, $p < 0.01$). The main effect of cost leadership strategy, as indicated by the beta coefficient, showed a strong and significant influence on business performance ($b = 0.37$, $p < 0.01$). Though hypothesis 3c was supported by the findings, it is clear that cost leadership strategy strongly influenced business performance independent of technology.

Overall, the findings provided strong as well as moderate support for hypotheses 3 and 3a-3c. Business strategies do moderate the influence of IIT on business performance. Firms making strategic use of manufacturing technologies should realize better business performance.

Hypothesis 4

Hypothesis 4 suggested that business units with higher IIT would achieve higher business performance if manufacturing managers were proactively involved in the strategic decision making process of the firm.

The results for hypothesis 4 are presented in table 5.9. The regression equation showed a significant beta coefficient for the interaction term ($b = 0.05$,

Table 5.8
Moderated Regression Analysis Results
Hypothesis 3c

Variables	Unstandardized Regression Coefficients		
	Step 1	Step 2	Step 3
IIT	0.07***	0.06**	-0.09
CL		0.37***	0.14
IIT x CL			0.04*
Constant	3.05***	1.57***	2.46***
R ²	0.05***	0.12***	0.15***
ΔR ²	0.05***	0.07***	0.03*

N = 133 * p < .10 ** p < .05 *** p < .01

IIT Intensity and Integration of AMT
CL Cost Leadership Strategy

Table 5.9
Moderated Regression Analysis Results
Hypothesis 4

Variables	Unstandardized Regression Coefficients		
	Step 1	Step 2	Step 3
IIT	0.07***	0.06**	-0.13
PROACT		0.17**	-0.11
IIT x PROACT			0.05**
Constant	3.05***	2.43***	3.51***
R ²	0.05***	0.08***	0.11***
ΔR^2	0.05***	0.03**	0.03**

N = 133 * p < .10 ** p < .05 *** p < .01

IIT Intensity and Integration of AMT
PROACT Manufacturing Proactiveness

$p < 0.05$), indicating that proactive involvement of manufacturing managers lead to more effective use of manufacturing technology in improving business performance. The interaction term, IIT x Proact, accounted for a significant increase in the explained variance ($\Delta R^2 = 0.03$, $p < 0.05$), attesting the moderating effect of the proactive participation of manufacturing managers in planning strategic choices.

Hypotheses 5, 5a and 5b

Hypothesis 5 stated that the moderating influence of manufacturing managers' proactiveness (claimed in hypothesis 4) will vary by the degree and type of uncertainty present in the external environment of a firm. Hypotheses 5a and 5b were used to examine the individual components of environmental uncertainty, stating that manufacturing managers' proactiveness would have a stronger moderating effect under dynamic and hostile environment respectively.

Tables 5.10 to 5.12 show the regression results for hypotheses 5, 5a and 5b. Tests for hypothesis 5 through 5b required a more complex multiple regression equation involving second degree of moderation. This was achieved by introducing the interaction among IIT, proactiveness, and environmental uncertainty in the regression equation after partialling out all main and first order interaction terms. As evidenced by change in R^2 in table 5.10, inclusion of second degree interaction terms did not produce significant results ($\Delta R^2 = 0.03$).

Table 5.10
Moderated Regression Analysis Results
Hypothesis 5

Variables	Unstandardized Regression Coefficients					
	Step 1	Step 2	Step 3	Step 4	Step 5	Step 6
IIT	0.07***	0.06**	-0.13	-0.15	-0.27*	-0.50
PROACT		0.17**	-0.11	-0.15	-0.54	-1.13
IIT x PROACT			0.05**	0.05**	0.06	0.15
DYNA				0.19***	0.35	-0.77
HOST				0.11	-0.57	0.17
IIT x DYNA					0.01	0.22
IIT x HOST					0.02	-0.09
PROACT x DYNA					-0.05	0.24
PROACT x HOST					0.15	0.09
IIT x PROACT x DYNA						-0.06
IIT x PROACT x HOST						0.02
Constant	3.05***	2.43***	3.51***	2.84***	4.76**	6.37*
R ²	0.05***	0.08***	0.11***	0.17***	0.18***	0.21***
ΔR ²	0.05***	0.03**	0.03**	0.06***	0.01	0.03

N = 133 * p < .10 ** p < .05 *** p < .01

IIT Intensity and Integration of AMT
PROACT Manufacturing Proactiveness
DYNA Dynamic Environment
Host Hostile Environment

Hypothesis 5 was, therefore, not supported, indicating that uncertain environments did not necessarily lead to improved influence of manufacturing managers' proactiveness on business performance.

Tables 5.11 and 5.12, showing the regression results for hypotheses 5a and 5b respectively, also failed to support the claims made. The beta coefficients for the second degree interaction term for both dynamic environment ($b = -0.02$ in table 5.11) and hostile environment ($b = -0.04$ in table 5.11) did not show significant effects.

Therefore, the findings of this study did not support hypotheses 5, 5a and 5b. Contrary to our expectations, it was found that proactive participation of manufacturing managers in the strategic decision making process had similar moderating effects on business performance in both stable and uncertain environments.

Table 5.13 shows the regression equations for the interaction effect of the moderating variables organizational structure, business strategies, and manufacturing proactiveness. The two equations for each moderating variable represent the influence of IIT on firm performance for the low and high moderating situations. The regression equations obtained were used to graphically illustrate the interaction effect in figures 5.1 to 5.6. The near parallel lines for both types of organizational structure -- organic and mechanistic in figures 5.1 and 5.2 indicated no support for hypotheses 2a and 2b, that is,

Table 5.11
Moderated Regression Analysis Results
Hypothesis 5a

Variables	Unstandardized Regression Coefficients					
	Step 1	Step 2	Step 3	Step 4	Step 5	Step 6
IIT	0.07***	0.06**	-0.13	-0.15	-0.15	-0.31*
PROACT		0.17**	-0.11	-0.12	-0.16	-0.53
IIT x PROACT			0.05**	0.05**	0.05*	0.10**
DYNA				0.20***	0.16	-0.47
IIT x DYNA					-0.0002	0.09
PROACT x DYNA					0.01	0.18
IIT x PROACT x DYNA						-0.02
Constant	3.05***	2.43***	3.51***	3.09***	3.22***	4.53***
R ²	0.05***	0.08***	0.11***	0.165***	0.166***	0.175***
ΔR ²	0.05***	0.03**	0.03**	0.055***	0.001	0.009

N = 133 * p < .10 ** p < .05 *** p < .01

IIT Intensity and Integration of AMT
PROACT Manufacturing Proactiveness
DYNA Dynamic Environment

Table 5.12
Moderated Regression Analysis Results
Hypothesis 5b

Variables	Unstandardized Regression Coefficients					
	Step 1	Step 2	Step 3	Step 4	Step 5	Step 6
IIT	0.07***	0.06**	-0.13	-0.14	-0.17	-0.57*
PROACT		0.17**	-0.11	0.14	-0.24	-1.26
IIT x PROACT			0.05**	0.05**	0.05	0.17*
HOST				0.14	-0.05	-1.16
IIT x HOST					0.01	0.15
PROACT x HOST					0.03	0.35
IIT x PROACT x HOST						-0.04
Constant	3.05***	2.43***	3.51***	3.16***	3.73*	7.26**
R ²	0.05***	0.08***	0.11***	0.125***	0.126***	0.14***
ΔR ²	0.05***	0.03**	0.03**	0.015	0.001	0.014

N = 133

* p < .10 ** p < .05 *** p < .01

IIT
PROACT
HOST

Intensity and Integration of AMT
Manufacturing Proactiveness
Hostile Environment

Table 5.13
Regression Equations Showing the Relationship
Between IIT and Business Performance For Firms With
Different Emphasis On the Moderator Variables

Moderator	Low Emphasis	High Emphasis
1. ORGSTR	$\text{Mfgper} = 3.04 + 0.08 \text{ (IIT)}$	$\text{Mfgper} = 3.48 + 0.06 \text{ (IIT)}$
2. ORGSTR	$\text{Busp} = 2.77 + 0.05 \text{ (IIT)}$	$\text{Busp} = 3.29 + 0.07 \text{ (IIT)}$
2. CI	$\text{Busp} = 3.11 + 0.01 \text{ (IIT)}$	$\text{Busp} = 3.11 + 0.11 \text{ (IIT)}$
3. MD	$\text{Busp} = 3.67 - 0.04 \text{ (IIT)}$	$\text{Busp} = 2.40 + 0.19 \text{ (IIT)}$
4. CL	$\text{Busp} = 2.89 + 0.03 \text{ (IIT)}$	$\text{Busp} = 3.17 + 0.11 \text{ (IIT)}$
5. PROACT	$\text{Busp} = 3.24 - 0.01 \text{ (IIT)}$	$\text{Busp} = 2.93 + 0.13 \text{ (IIT)}$

IIT = Intensity and Integration of AMT

CI = Complex Innovation Strategy

MD = Marketing Differentiation Strategy

CL = Cost Leadership Strategy

BUSP = Business Performance

PROACT = Manufacturing Proactiveness

ORGSTR = Organizational Structure

Figure 5.1
Organizational Structure

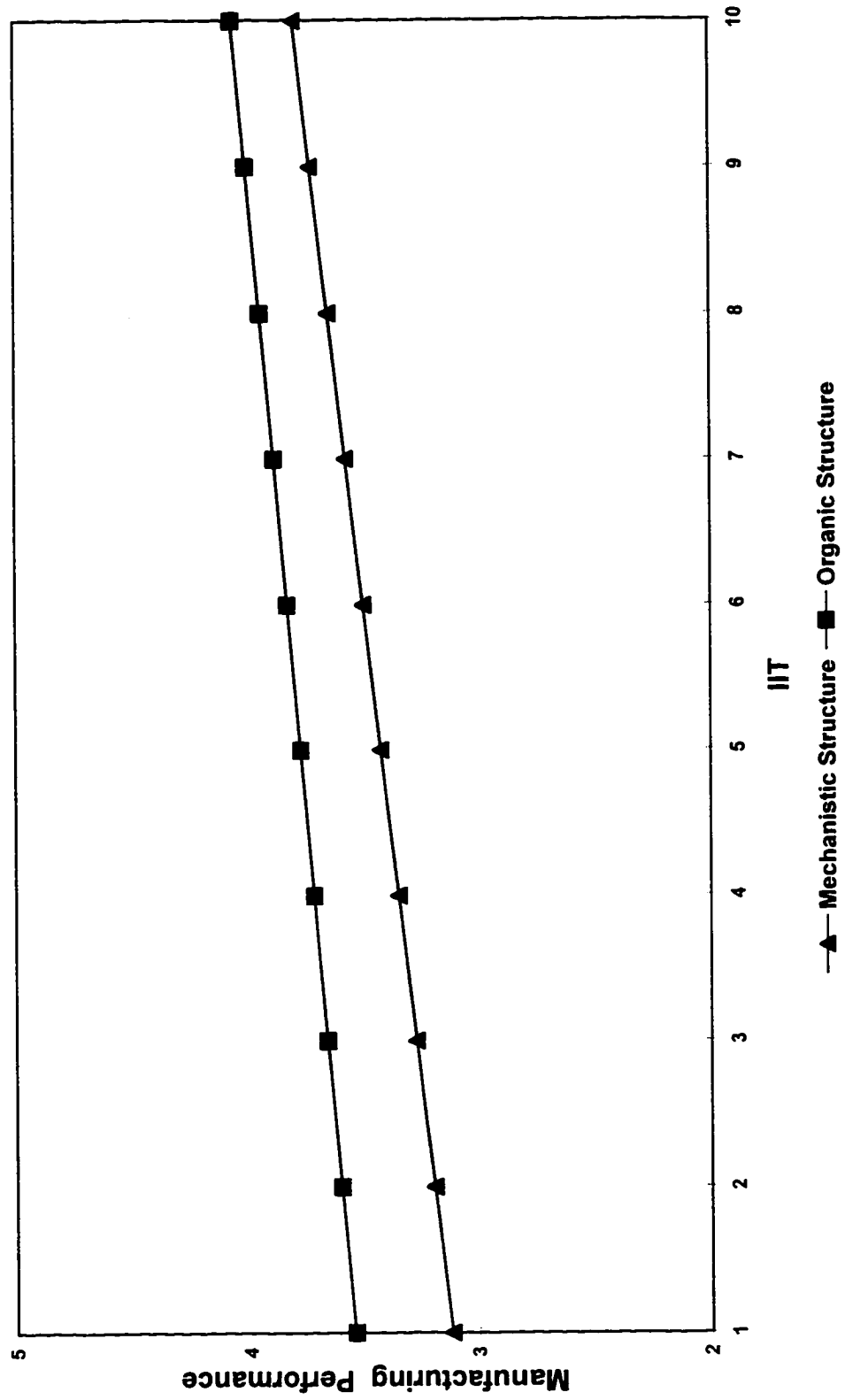


Figure 5.2
Organizational Structure

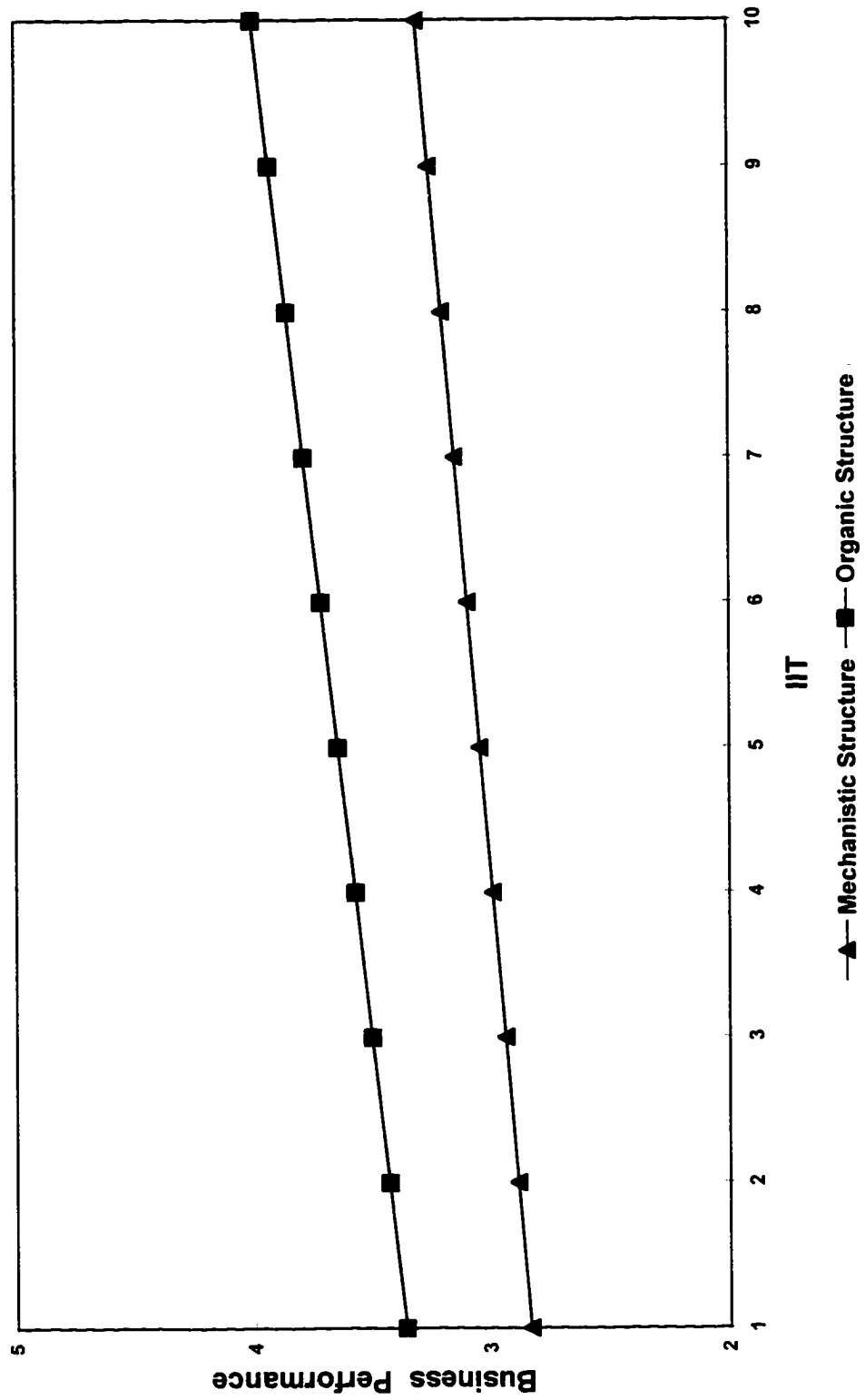


Figure 5.3
Complex Innovation Strategy

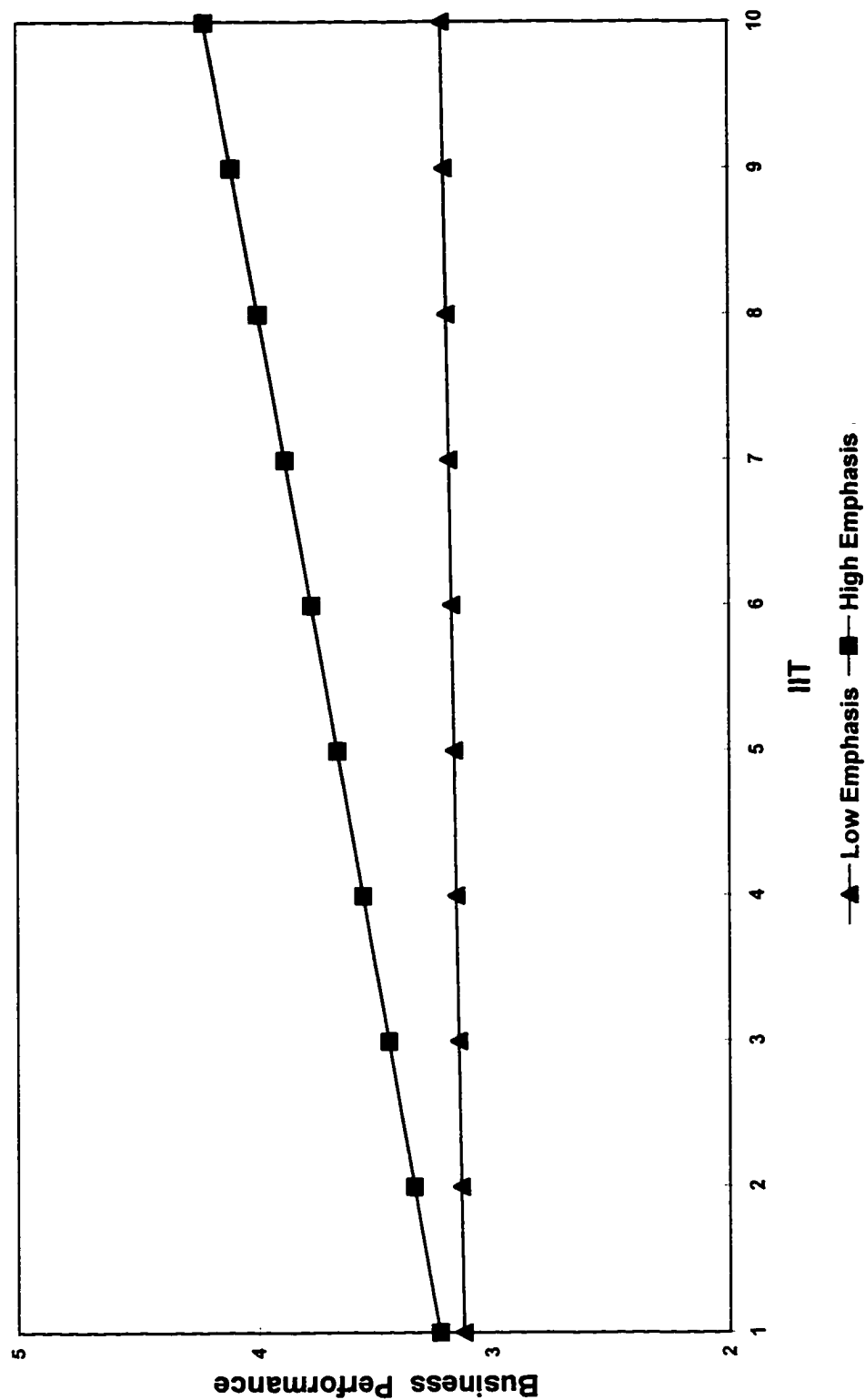


Figure 5.4
Marketing Differentiation Strategy

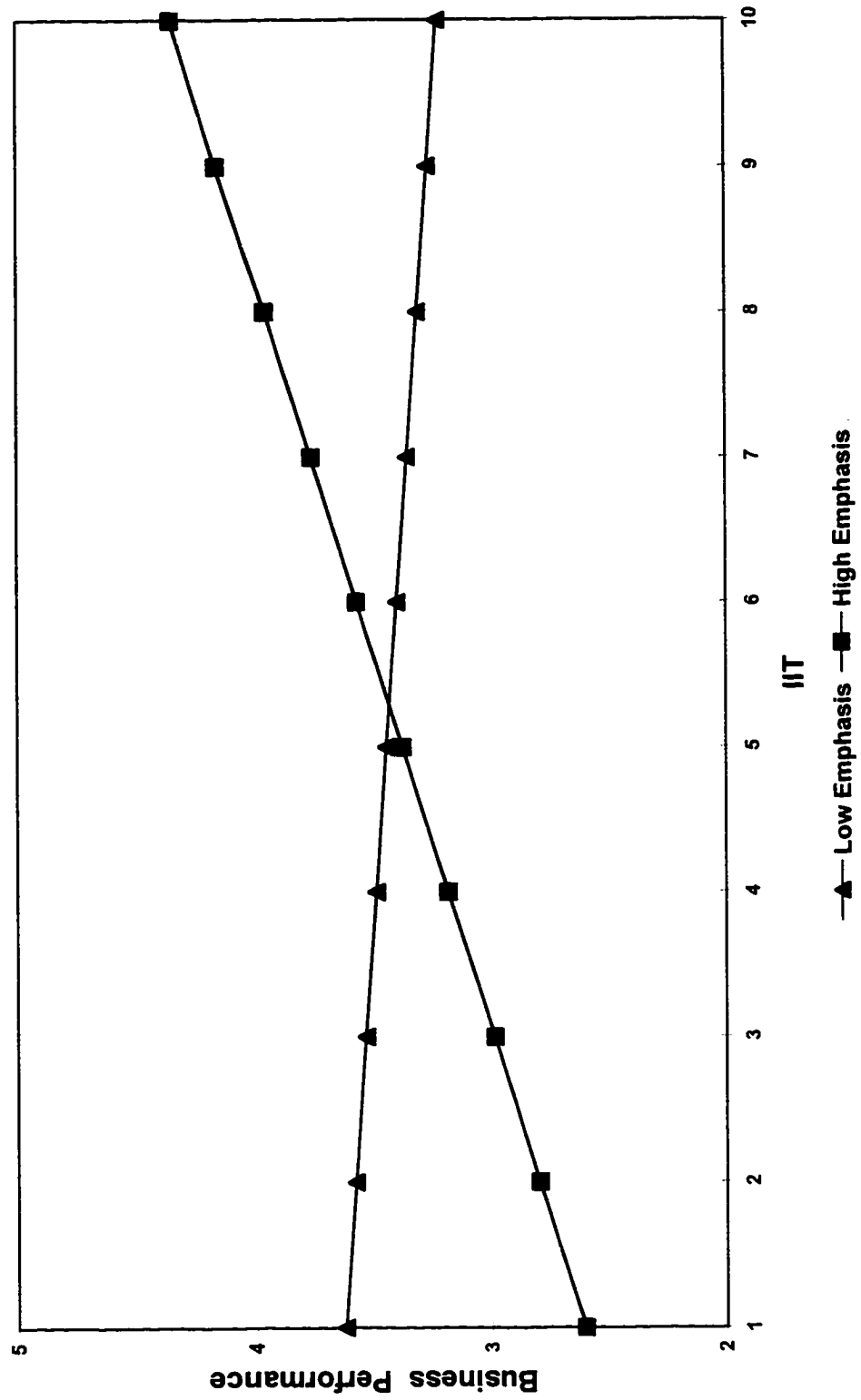


Figure 5.5
Cost Leadership Strategy

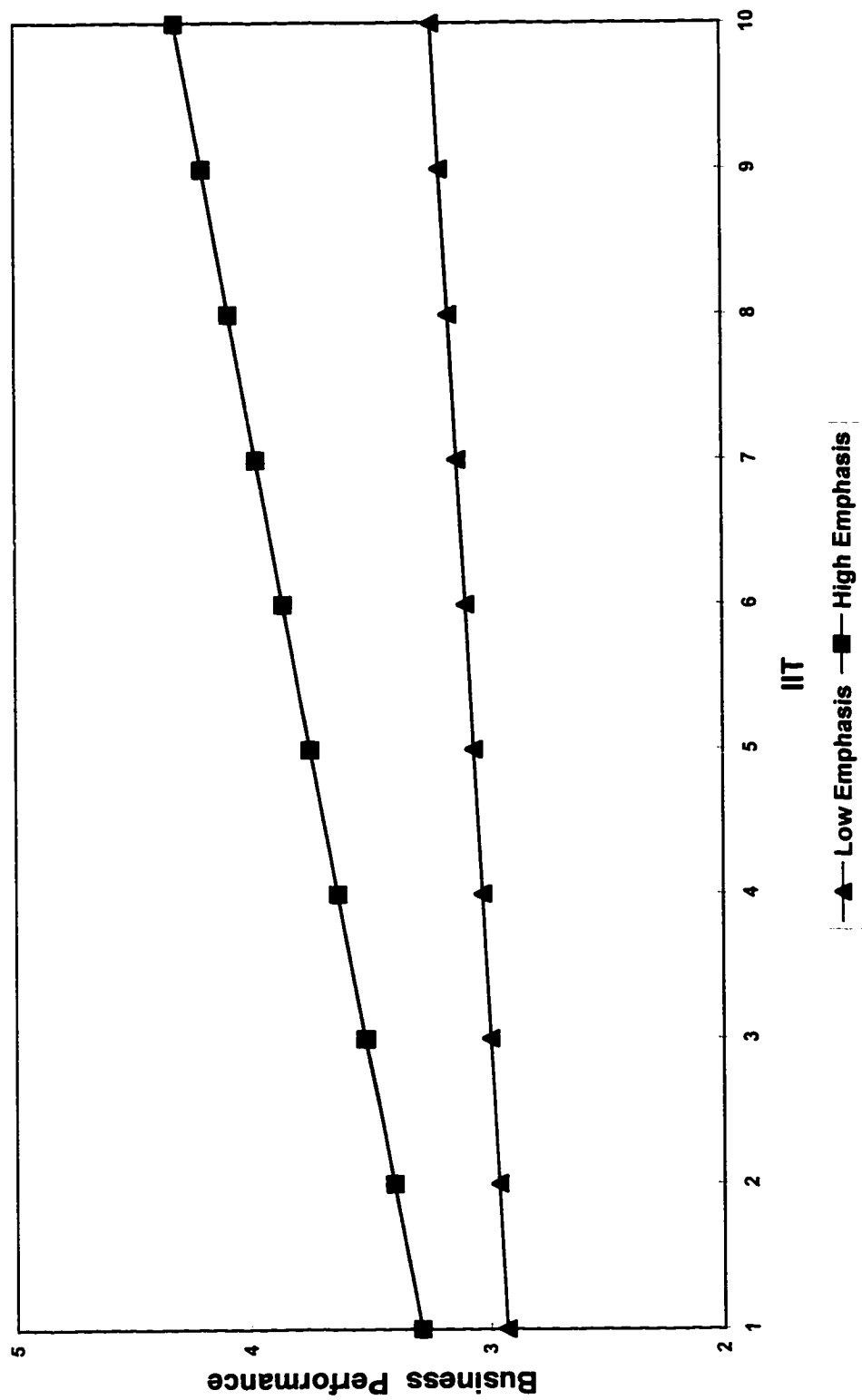
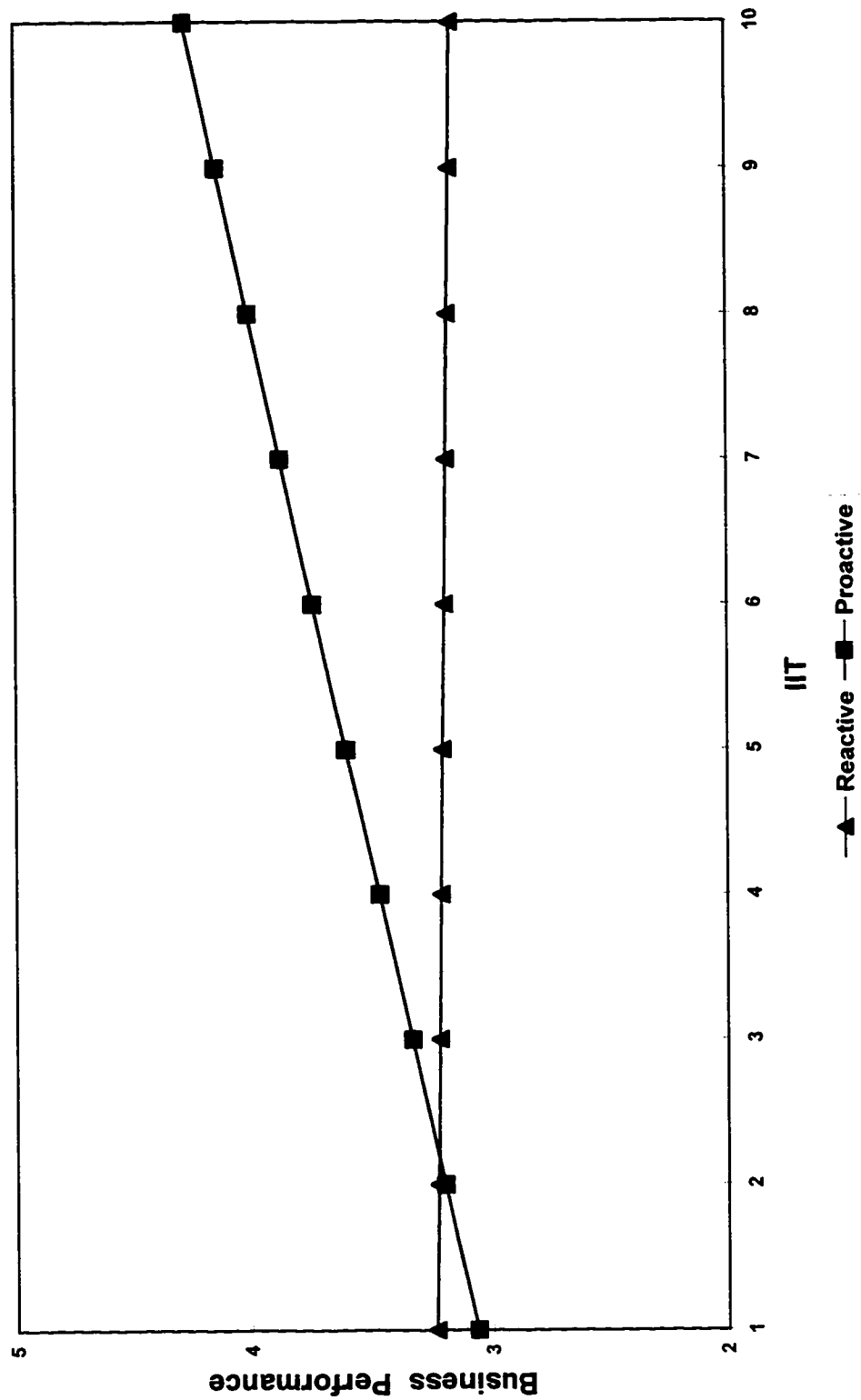


Figure 5.6
Manufacturing Proactiveness



organizational structure had no moderating effect on the relationship between IIT and firm performance -- manufacturing performance as well as business performance. In figures 5.3 to 5.6, the non-parallel lines for the high and low emphasis of the moderating variables provided further support for hypotheses 3a to 3c, and hypothesis 4.

Table 5.14 illustrates the moderated regression results using the full model approach. As indicated by the interaction terms in step 2 in table 5.14, only hypotheses 3b ($b = 0.08$, $p < 0.05$) and 4 ($b = 0.08$, $p < 0.05$) were supported. The beta coefficient for the interaction term, IIT x ORGSTR, also showed significant moderating effect ($b = -0.10$, $p < 0.05$), but did not support hypothesis 2b because the sign of the regression coefficient was opposite to the hypothesized direction. Therefore, using the full model approach, only hypotheses 3b and 4 were supported.

The striking differences between the regression results from the discrete models and the full model at first glance seemed to be confounding and misleading. In reality, as expected, regression results in the full model suffered from serious multicollinearity situation. One must exercise extreme caution when interpreting the regression coefficients for variables which are highly correlated. Table 5.15 illustrates the correlation matrix for the variables included in the full model. Most of the interaction terms were highly correlated with each other. Therefore, even though the main effect of the independent variables were

Table 5.14
Moderated Regression Analysis Results
Full Model

Variables	Unstandardized Regression Coefficients		
	Step 1	Step 2	Step 3
IIT	0.05*	-0.37**	-0.33
ORGSTR	0.24	0.73***	0.72***
CI	0.07	0.17	0.18
MD	-0.09	-0.47***	-0.43***
CL	0.30**	-0.05	-0.08
PROACT	0.08	-0.73	-0.60
DYNA	0.15*	0.47	-0.45
HOST	0.06	-0.77	-0.22
IIT x ORGSTR		-0.10**	-0.10**
IIT x CI		-0.03	-0.04
IIT x MD		0.08**	0.07**
IIT x CL		0.05	0.06
IIT x PROACT		0.08**	0.09
IIT x DYNA		0.01	0.21
IIT x HOST		0.02	-0.17
PROACT x DYNA		-0.09	0.13
PROACT x HOST		0.19	-0.03
IIT x PROACT x DYNA			-0.05
IIT x PROACT x HOST			0.04
Constant	0.28	4.36*	3.61
R ²	0.21***	0.33***	0.34***
ΔR ²	0.21***	0.12**	0.01

N = 133 * p < .10 ** p < .05 *** p < .01

IIT = Intensity and Integration of AMT
 CI = Complex Innovation Strategy
 MD = Marketing Differentiation Strategy
 CL = Cost Leadership Strategy
 DYNA = Dynamic Environment
 HOST = Hostile Environment
 BUSP = Business Performance
 PROACT = Manufacturing Proactiveness
 ORGSTR = Organizational Structure

Table 5.15: Correlations

Variables	1	2	3	4	5	6	7	8	9	10
1. IIT										
2. ORGSTR	-.03									
3. CI	.35***	.03								
4. MD	.17**	.07	.40***							
5. CL	.07	.11	.19**	.14						
6. PROACT	.18**	.29***	.08	.08	.17*					
7. DYNA	.27***	.17**	.40***	.09	.11	.13				
8. HOST	-.20**	.14*	-.02	-.02	.06	.08	.08			
9. ATORG	.91***	.24***	.32***	.19**	.08	.32***	.31***	-.19**		
10. ATCI	.90***	-.01	.60***	.32***	.12	.24***	.40***	-.20**	.88***	
11. ATMD	.84***	.03	.47***	.59***	.16*	.23***	.27***	-.19**	.84***	.90***
12. ATCL	.92***	.01	.36***	.23***	.33***	.27***	.31***	-.20**	.91***	.90***
13. ATPACT	.91***	.08	.33***	.19**	.11	.51***	.28***	-.17*	.93***	.88***
14. ATDYNA	.85***	.04	.45***	.18**	.11	.22**	.65***	-.17*	.85***	.90***
15. ATHOST	.86***	.04	.31***	.17**	.10	.27***	.30***	.19**	.86***	.82***
16. PRODYNA	.32***	.28***	.37***	.09	.17**	.56***	.87***	.10	.38***	.42***
17. PROHOST	.00	.30***	.03	.03	.13	.66***	.10	.76***	.04	-.02
18. ATPRDYNA	.83***	.10	.42***	.18**	.14	.44***	.60***	-.13	.85***	.87***
19. ATPRHOST	.81***	.13	.29***	.17*	.12	.52***	.27***	.19**	.84***	.78***
20. BUSP	.23***	.22**	.21**	.01	.27***	.21**	.30***	.07	.28***	.30***

N = 133

* p < .10

** p < .05

*** p < .01

IIT	=	Intensity and Integration of AMT
ORGSTR	=	Organizational Structure
CI	=	Complex Innovation
MD	=	Marketing Differentiation
CL	=	Cost Leadership
PROACT	=	Manufacturing Proactiveness
DYNA	=	Dynamic Environment
HOST	=	Hostile Environment
ATORG	=	IIT x Organizational Structure
ATCI	=	IIT x Complex Innovation
ATMD	=	IIT x Marketing Differentiation
ATCL	=	IIT x Cost Leadership
ATPACT	=	IIT x Manufacturing Proactiveness
ATDYNA	=	IIT x Dynamic Environment
ATHOST	=	IIT x Hostile Environment
PRODYNA	=	Manufacturing Proactiveness x Dynamic Environment
PROHOST	=	Manufacturing Proactiveness x Hostile Environment
ATPRDYNA	=	IIT x Manufacturing Proactiveness x Dynamic Environment
ATPRHOST	=	IIT x Manufacturing Proactiveness x Hostile Environment
BUSP	=	Business Performance

contd...

Table 5.15: Correlations

Variables	11	12	13	14	15	16	17	18	19
1. IIT									
2. ORGSTR									
3. CI									
4. MD									
5. CL									
6. PROACT									
7. DYNA									
8. HOST									
9. ATORG									
10. ATCI									
11. ATMD									
12. ATCL	.87***								
13. ATPACT	.83***	.91***							
14. ATDYNA	.79***	.87***	.84***						
15. ATHOST	.78***	.86***	.87***	.79***					
16. PRODYNA	.31***	.36***	.46***	.63***	.35***				
17. PROHOST	-.02	-.01	.18**	-.01	.27***	.42***			
18. ATPRDYNA	.76***	.85***	.90***	.96***	.79***	.71***	.16*		
19. ATPRHOST	.74***	.81***	.92***	.75***	.94***	.46***	.44***	.83***	
20. BUSP	.26***	.33***	.31***	.34***	.30***	.34***	.16*	.36***	.33***

N = 133 * p < .10 ** p < .05 *** p < .01

IIT	=	Intensity and Integration of AMT
ORGSTR	=	Organizational Structure
CI	=	Complex Innovation
MD	=	Marketing Differentiation
CL	=	Cost Leadership
PROACT	=	Manufacturing Proactiveness
DYNA	=	Dynamic Environment
HOST	=	Hostile Environment
ATORG	=	IIT x Organizational Structure
ATCI	=	IIT x Complex Innovation
ATMD	=	IIT x Marketing Differentiation
ATCL	=	IIT x Cost Leadership
ATPACT	=	IIT x Manufacturing Proactiveness
ATDYNA	=	IIT x Dynamic Environment
ATHOST	=	IIT x Hostile Environment
PRODYNA	=	Manufacturing Proactiveness x Dynamic Environment
PROHOST	=	Manufacturing Proactiveness x Hostile Environment
ATPRDYNA	=	IIT x Manufacturing Proactiveness x Dynamic Environment
ATPRHOST	=	IIT x Manufacturing Proactiveness x Hostile Environment
BUSP	=	Business Performance

partialled out, the interaction terms when entered in the regression equation as a set made each other redundant because of high collinearity.

High multicollinearity makes the standard error of individual regression coefficient larger than it would have been otherwise. The increase in standard error makes the corresponding t ratio small in value and thus hard to detect the importance of the variable. As Mendenhall and Sincich (1993) say, "...it is dangerous to interpret a β coefficient when the independent variables are correlated (p. 330)." Even the signs of the parameter estimates can be reversed because of multicollinearity. According to Frees (1996),

If our data are highly collinear, fitting a model [of the] data and making predictions from the model may be valid. However, the estimated regression coefficients are not reliable (p. 273).

Therefore, even though the F test is highly significant, suggesting a valid model, the t values for the individual regression coefficients may indicate nonsignificance. These contradictory results may be confusing and misleading but quite logical (Mendenhall & Sincich, 1993). The t test tells us that the β parameter of the variable is zero, that is, the contribution of the variable is not significant after the effect of the rest of the variables in the model are discounted. The F test, on the other hand, examines if at least one of the β parameters is non-zero, that is, at least one of the variables is making significant contribution to the explained variance. Each variable may be contributing to the explained variance, but the contribution overlaps with that of the other variables. The area of overlap reflects the redundancy of the independent variables, that is, the

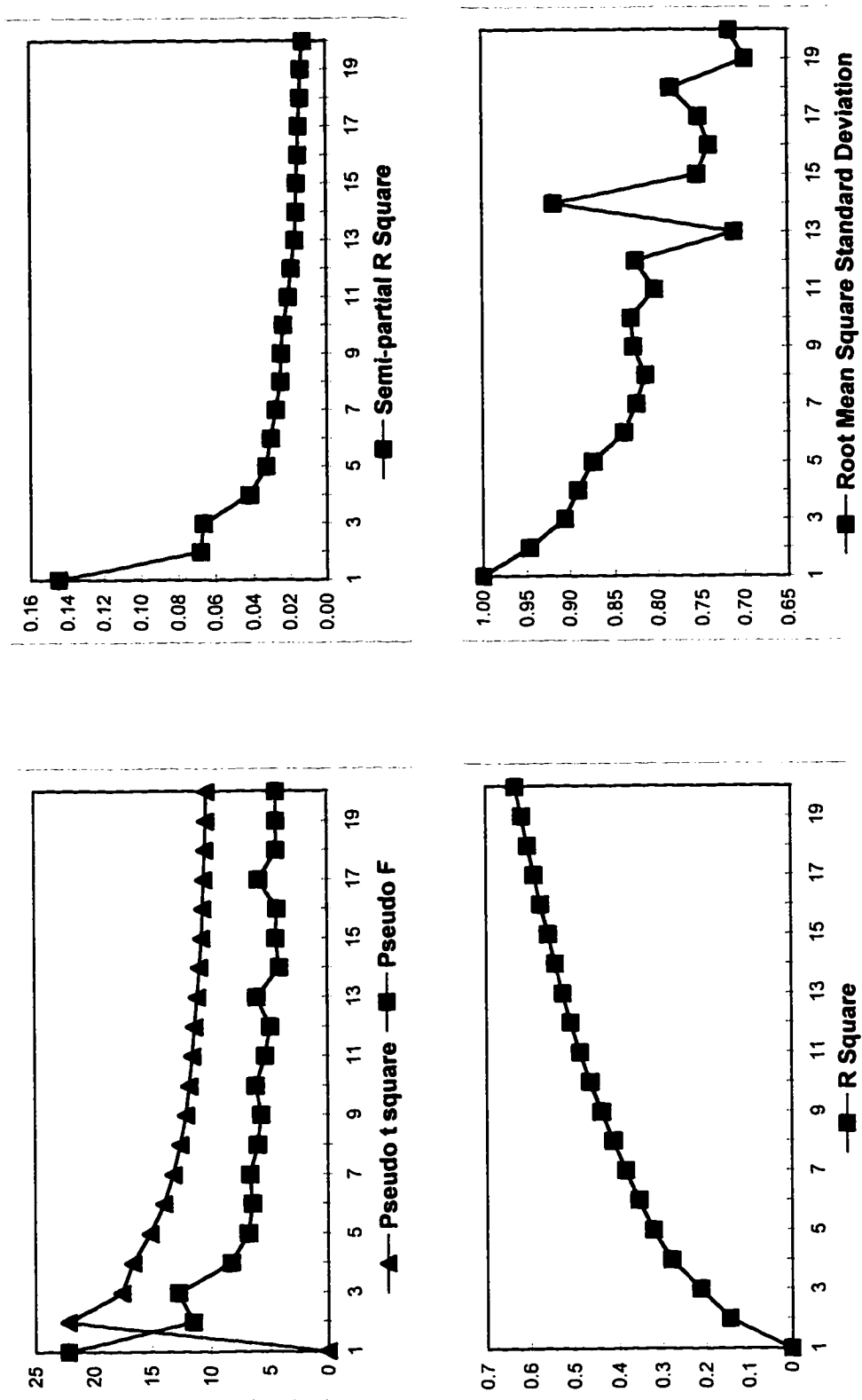
information provided by one variable is supplied by other variables as well (Cohen & Cohen, 1975).

In summary, the regression results for the data collected provided reasonable support for the hypotheses claimed in this study. Significant results were obtained for all hypotheses except hypotheses 2a, 2b, 5, 5a, and 5b. Though the full model regression results showed some differences with respect to the discrete model results, the full model approach provided additional support for hypotheses 3b and 4. The full model approach gives the conservative estimates as opposed to the discrete model approach which provides the marginal estimates. Nevertheless, the lack of support provided by the full model results to the rest of the hypotheses did not discount their importance. The presence of high multicollinearity among the interaction terms made it difficult to interpret them reliably.

5.1.2 Cluster Analysis Results

As discussed in chapter 4, cluster analysis was used to examine configurations. Ward's Minimum-variance method, an agglomerative hierarchical cluster technique, was used to determine the number of probable clusters or groups. Figure 5.7 shows the plots for (1) Pseudo t square and pseudo F, (2) Semi-partial R square, (3) R square, and (4) Root mean square standard deviation. To determine the number of clusters, we looked for a big change or

Figure 5.7
Plots of Statistical Coefficients for Evaluating Clusters



elbow in the plots. Plots for pseudo t square , pseudo F, and semi-partial R square indicated a five cluster solution. R square plot, on the other hand, suggested four clusters, and root mean square standard deviation suggested six clusters. Visual inspection of plots is, however, a subjective process.

Nevertheless, after careful examination of the data for four, five, and six cluster solutions, it was decided to select the five cluster solution. The number of observations in the initial cluster solution were distributed as follows:

<u>Cluster Number</u>	<u>Number of Observations</u>
1	18
2	31
3	26
4	43
5	15

The five cluster solution was then submitted to the FASTCLUS procedure, a nonhierarchical clustering technique. The means of the clusters obtained through Ward's method were used as the initial seeds for the FASTCLUS procedure.

Table 5.16 gives the cluster summary of the refined clusters obtained by applying the nonhierarchical clustering technique. The frequency of observations in the new clusters showed a slight variation from the initial cluster solution. As indicated by the root mean square standard deviation, the five clusters appeared to be quite homogeneous. The clusters were also well

Table 5.16
Cluster Summary

Cluster	Frequency	Percentage	Nearest Cluster	Root Mean Square Standard Deviation	Maximum Distance from Centroid to Observation	Distance between Cluster Centroids
1	19	0.14	4	0.82	3.83	2.40
2	34	0.26	4	0.87	3.55	2.18
3	22	0.16	2	0.73	2.99	2.18
4	41	0.31	2	0.82	3.85	2.18
5	17	0.13	3	0.86	3.95	2.20

Statistics for Variables

Variable	Total STD	Within STD	R-Squared	RSQ/(1-RSQ)
IIT	1.00	0.87	0.27	0.37
ORGSTR	1.00	0.90	0.22	0.28
CI	1.00	0.69	0.54	1.18
MD	1.00	0.87	0.27	0.38
CL	1.00	0.80	0.38	0.60
PROACT	1.00	0.77	0.43	0.76
HOST	1.00	0.90	0.20	0.26
DYNA	1.00	0.78	0.41	0.69
OVER-ALL	1.00	0.82	0.34	0.52

STD = Standard deviation

separated as shown by the distance between cluster centroids, implying the heterogeneity of clusters with respect to each other.

Evaluation of clusters with respect to each clustering variable indicated high homogeneity of clusters in terms of all variables. R square value, on the other hand, showed differences among clusters with respect to each variable. The clusters appeared to be more different from each other with respect to complex innovation strategy, manufacturing proactiveness, and environmental dynamism. Overall, the five clusters appeared to be quite homogeneous and well separated.

Table 5.17 shows cluster means and standard deviations for all variables used in forming clusters, as well as business performance. To test whether the clusters significantly differed, multivariate analysis of variance (MANOVA) technique was used. The MANOVA results are shown in table 5.18. All statistics showed significant results ($p < 0.0001$), indicating that the five clusters differed significantly with respect to the variables included in the model. One way ANOVAs were used to identify cluster differences for each variable separately. The F values and the test results are shown in table 5.17. All tests showed significant results ($p < 0.01$), implying significant differences across the five clusters for all variables.

Table 5.19 shows the cluster mean differences and significance tests using Tukey method. The results clearly indicated that for each variable examined, only a few clusters differed significantly. Even though the clusters

Table 5.17**Means and Standard Deviations of Variables in Each Cluster**

Cluster Means and Standard Deviations							
Variables	Sample mean and s.d.	Cluster Number					F ^a
		1 (n=19)	2 (n=34)	3 (n=22)	4 (n=41)	5 (n=17)	
IIT	5.22 2.43	6.75 2.86	4.68 1.97	4.31 1.45	6.40 2.06	3.05 2.31	11.70***
ORGSTR	3.66 0.83	3.60 0.33	3.00 0.31	3.32 0.41	3.22 0.44	3.42 0.32	8.94***
CI	3.07 0.85	4.40 0.54	3.35 0.62	3.86 0.65	4.05 0.52	2.34 0.56	37.61***
MD	4.09 0.50	4.01 0.79	3.08 0.89	2.63 0.61	3.15 0.61	2.49 0.87	12.02***
CL	3.26 0.42	4.65 0.39	3.92 0.48	4.46 0.25	3.87 0.41	3.93 0.37	19.31***
PROACT	3.86 0.71	4.46 0.38	3.13 0.69	4.01 0.43	3.97 0.55	4.25 0.47	24.29***
DYNA	2.89 0.87	3.49 0.76	2.33 0.64	2.44 0.63	3.50 0.59	2.44 0.88	21.97***
HOST	3.28 0.63	3.56 0.46	3.09 0.58	3.64 0.51	2.98 0.61	3.59 0.62	8.34***
BUSP	3.40 0.71	3.89 0.68	3.08 0.77	3.44 0.64	3.49 0.62	3.26 0.62	4.74***

*** p < 0.01

^a F values are One-way ANOVA results

For each cell:

First Line: Mean of the variable in the row for the cluster in the column

Second Line: Standard deviation of the variable in the row for the cluster in the column

Table 5.18

**Manova Test Criteria and F Approximations for the Hypothesis
of no Overall CLUSTER Effect**

Statistic	Value	F	Num DF	Den DF	Pr > F
Wilks' Lambda	0.05	15.75	36	451.43	0.0001
Pillai's Trace	1.97	13.20	36	492.00	0.0001
Hotelling-Lawley Trace	5.33	17.55	36	474.00	0.0001
Roy's Greatest Root	2.59	35.40	9	123.00	0.0001

Table 5.19
Cluster Mean Differences and Tukey Test Results

Variable: IIT

		CLUSTER			
C L U S T E R		1	2	3	4
	2	2.06***			
	3	2.44***	0.37		
	4	0.35	-1.72***	-2.09***	
	5	3.70***	1.64*	1.26	3.35***

Variable: ORGSTR

		CLUSTER			
C L U S T E R		1	2	3	4
	2	0.60***			
	3	0.28	-0.32**		
	4	0.38***	-0.22*	-0.10	
	5	0.18	-0.42***	-0.10	-0.20

Variable: CI

		CLUSTER			
C L U S T E R		1	2	3	4
	2	1.05***			
	3	0.54**	-0.50**		
	4	0.35	-0.70***	-0.19	
	5	2.06***	1.01***	1.52***	1.71***

Variable: MD

		CLUSTER			
C L U S T E R		1	2	3	4
	2	0.93***			
	3	1.38***	0.45		
	4	0.86***	-0.07	-0.52*	
	5	1.52***	0.58*	0.13	0.65**

Variable: CL

		CLUSTER			
C L U S T E R		1	2	3	4
	2	0.73***			
	3	0.19	-0.55***		
	4	0.78***	0.05	0.59***	
	5	0.71***	-0.02	0.53***	-0.07

Variable: PROACT

		CLUSTER			
C L U S T E R		1	2	3	4
	2	1.34***			
	3	0.45*	-0.89***		
	4	0.49**	-0.85***	0.04	
	5	0.22	-1.12***	-0.24	-0.28

* p < 0.10 ** p < 0.05 *** p < 0.01

contd...

Table 5.19
Cluster Mean Differences and Tukey Test Results

Variable: DYNA

		CLUSTER			
C L U S T E R		1	2	3	4
	2	1.16***			
	3	1.04***	-0.11		
	4	-0.01	-1.17***	-1.06***	
	5	1.05***	-0.11	0.002	1.06***

Variable: HOST

		CLUSTER			
C L U S T E R		1	2	3	4
	2	0.47**			
	3	-0.08	-0.55***		
	4	0.58***	0.10	0.65***	
	5	-0.03	-0.50**	0.05	-0.60***

Variable: BUSP

		CLUSTER			
C L U S T E R		1	2	3	4
	2	0.80***			
	3	0.45	-0.36		
	4	0.39	-0.41*	-0.05	
	5	0.63**	-0.17	0.18	0.24

* $p < 0.10$ ** $p < 0.05$ *** $p < 0.01$

Note: Value in each cell represents the difference in the mean of the cluster in the column and the cluster in the row

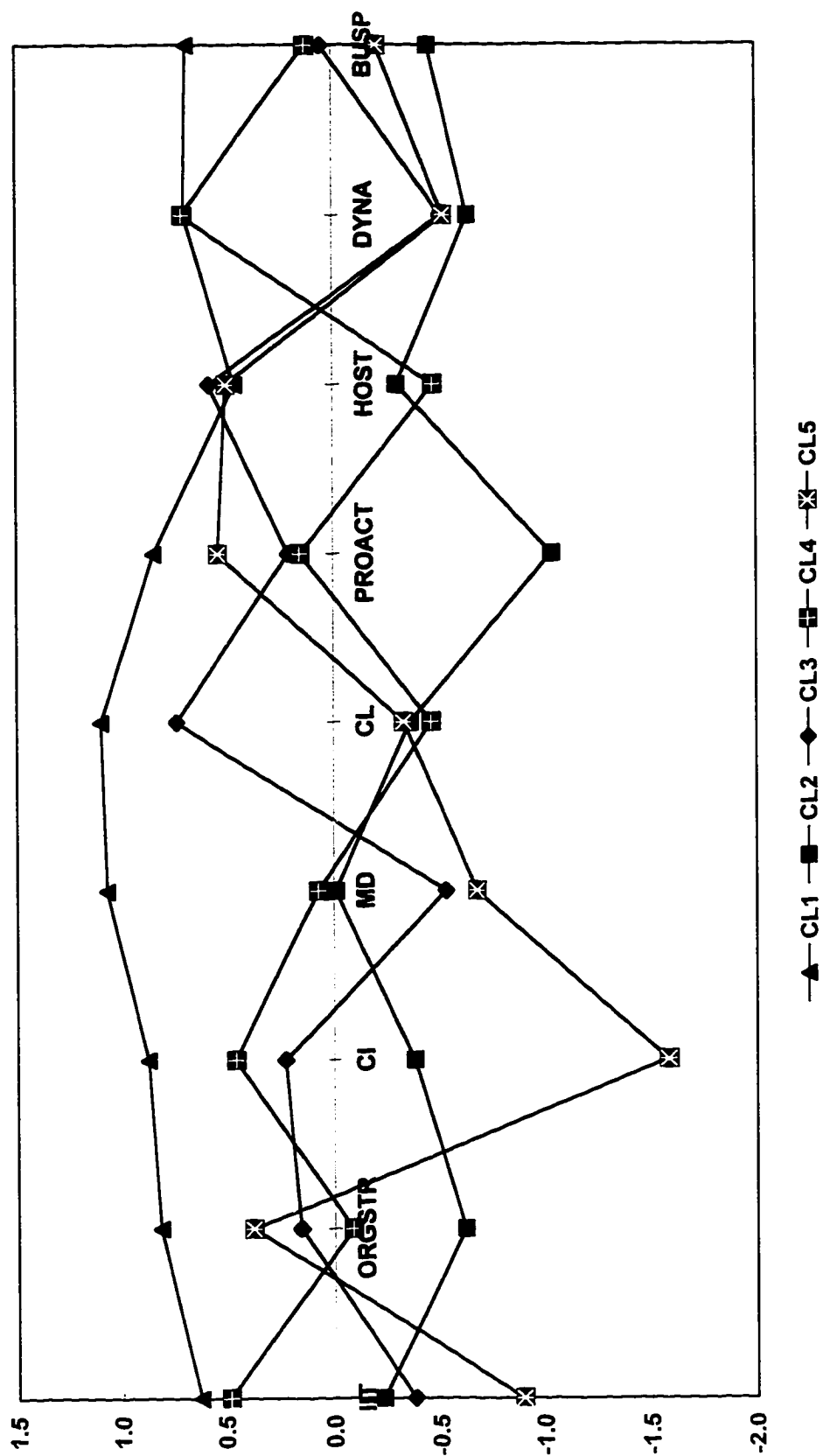
differed significantly with respect to some variables, they exhibited similar characteristics regarding other variables.

In short, the five clusters or configurations displayed different pattern profiles showing strikingly different interrelationships among all variables. Though each cluster had a different strategic profile, it shared some traits with a few other clusters whereas differed with respect to other characteristics. These findings supported the concept of configuration and equifinality, that is, firms with different configurations may be equally effective. The means of the five clusters for each variable are plotted in figure 5.8. The plots clearly indicate a different profile for each cluster and are explained below.

Cluster 1: High-tech, Aggressive Firms

Firms in cluster 1 made extensive use of advanced manufacturing technology (AMT). Perceiving environment as both hostile and dynamic, firms responded aggressively as evidenced by their strong emphasis on all three strategic dimensions - complex innovation, marketing differentiation, and cost leadership. Also, the presence of a highly organic structure and proactive involvement of manufacturing managers indicated the appropriateness of the infrastructural support required by such aggressive and integrated firms.

Figure 5.8
Pattern of Interrelationships for Five Configurations



Cluster 2: Passive, Control Oriented Firms

Cluster 2 firms perceived environment as less hostile and very stable. Firms in this cluster displayed characteristics of conservative, matured, and established firms. Highly mechanistic organizational structure was adopted with almost no participation of manufacturing managers in the strategic decision making process. Although equal emphasis was placed on all three business strategies, with marketing differentiation receiving a little more attention, firms did little to outperform their competitors on any singly strategic dimension. Overall, technology played little role to improve competitiveness of these firms. In fact, business performance was the lowest for firms in this cluster.

Cluster 3: Low-tech, Efficiency Seeking Firms

Cost leadership was the predominant business strategy for firms in this cluster. Also, firms had low intensity and integration of AMT, supporting the idea that standardized use of technology need to be made to achieve cost efficiency. Environment as perceived by these firms was stable but hostile, attesting the need to emphasize cost efficiency. Firms, however, also displayed some emphasis on complex innovation strategy. Apparently, this seemed to be supported by an organic structure and proactive involvement of manufacturing managers.

Cluster 4: High-tech, Innovative Firms

Cluster 4 firms had high intensity and integration of advanced manufacturing technology. Consequently, they adopted complex innovation strategy. As in cluster 1, cluster 4 firms, too, considered environment as highly unpredictable. Perceiving environment as less hostile, on the other hand, firms were less concerned with resource efficiency. A less organic organizational structure adopted by cluster 4 firms seemed to be contradictory at first glance. Firms, however, might have been able to achieve a high innovative position due to extensive use of technology supported by a proactive manufacturing participation.

Cluster 5: Low-tech, Dynamic Firms

Firms in cluster 5 showed the lowest use of technology and were the least integrated. They perceived environment to be predictable but very hostile. Resource efficiency was, therefore, highly emphasized as evidenced by a strong cost leadership strategy. Consequently, firms were expected to have a controlled structure. On the contrary, firms were found to have a highly organic structure and a high proactive involvement of manufacturing managers. A closer look at these firms revealed that these were small entrepreneurial firms with small number of employees, and relied on a few technologies but acted aggressively to improve their competitive position.

In summary, the research results obtained can be described as follows:

1. Firms making intensive and integrated use of AMT experience higher manufacturing as well as business performance.
 - a. The most significant impact of AMT is on flexibility, followed by responsiveness and quality.
 - b. Contrary to established belief, this study shows no significant relationship between AMT and cost.
2. Though organizational structure significantly influences both manufacturing and business performance, it does not moderate the impact of AMT on performance.
3. An existence of a fit between AMT and business strategy enables firms to achieve higher business performance.
4. Though firms with all three types of business strategies - complex innovation, marketing differentiation, and cost leadership, are able to achieve higher business performance with a higher level of IIT, the impact of AMT is most significant for firms pursuing marketing differentiation strategy.

- a. Firms with low emphasis on marketing differentiation strategy along with an increase in the level of IIT, in fact, experience a decline in business performance.
 - b. Compared to firms with low emphasis on marketing differentiation strategy, firms with high emphasis perform poorly if firms' use of IIT is quite low.
 - c. Firms with low emphasis on either complex innovation or cost leadership strategy do not experience any significant change in business performance irrespective of the level of IIT.
5. With an increasing level of IIT, a proactive participation of manufacturing managers in the strategic planning process of the firm improves its business performance.
6. The significance of the proactiveness of manufacturing managers does not depend on the level of uncertainty or hostility in the external environment of the firm.
7. There exist groups of firms with different strategic profiles. Yet firms in some of the groups are equally effective, thereby, supporting the idea of configuration and equifinality.

Though a significant positive relationship between IIT and business performance was found by this study, there seems to exist firms which are being able to achieve high performance even with low level of IIT. These firms compensate their lack of technological sophistication by having a flexible organizational structure and a proactive manufacturing participation in the business planning process.

For example, firms in cluster 3 and cluster 4 differ significantly with respect to IIT but has no significant difference in terms of performance (see table 5.19). Firms in cluster 3 are low-tech efficiency seeking firms whereas firms in cluster 4 are high-tech innovative firms.

5.2 Discussion

The primary focus of this study was to examine the influence of AMT on firm performance. Additionally, we intended to illustrate the way in which firms align their technological prowess with the strategic and organizational dimensions to improve business performance in different environmental contexts.

Most of the hypotheses of this study were supported. The findings corroborated the claims made by other researchers, suggesting that AMT significantly improves manufacturing capabilities (De Meyer et al., 1989; Miller & Roth, 1988). Consistent with prior research (Attaran, 1989; Meredith & Camm,

1989), it was established that firms with higher intensity and integration of AMT achieve higher flexibility, responsiveness, and quality. However, technology's impact on cost was not found to be significant, indicating that trade-off theory may not be completely erroneous. There could be many reasons for this lack of significant influence of IIT on cost. Though AMT can lower costs such as labor cost, inventory cost, manufacturing cost, etc., cost reduction may not be of overriding importance for firms using AMT in this sample. (Chen & Adam, 1991; De Meyer, Nakane, & Miller, 1989). Furthermore, firms use AMT primarily for achieving more flexibility, better quality, and quick responsiveness. After a reasonable period of AMT use, firms already realize cost reduction as their first achievement of AMT benefits (Ferdows & De Meyer, 1990). Realization of other higher level manufacturing capabilities such as flexibility, quality, and responsiveness, reduces inefficiency and waste which may further reduce cost but only marginally. Also, AMT may not be the major determinant of firm's cost factors. Costs can be influenced by many other forces such as availability of labor, easy accessibility to cheaper raw materials, bargaining power of suppliers, and overheads. Nevertheless, current accounting measures fail to take into account the intangible cost improvements (Finnie, 1988; Kaplan, 1983, 1986).

Organizational structure was found to have strong main effect but did not show any moderating effect on the relationship between technology and firm performance. Therefore, this study failed to support the claim that organizational structure determines the efficacy of AMT (Fine & Hax, 1985; Gerwin, 1982;

Hayes & Wheelwright, 1984). This, however, supported some of the early findings (Adler & Shenhar, 1990; Zammuto & O'Connor, 1992), suggesting that technology is not the only determinant of organizational design. Organizations respond in different ways depending on their resources, capabilities, culture, and managerial behavior. Furthermore, In the absence of an organization wide integration, a scenario under Computer Integrated Manufacturing (CIM), the structure at the organizational level is unlikely to influence the impact of AMT on performance. In the current sample, for example, a look at the integration of technologies alone reveals that 60.7 percent of the firms have an average integration level less than 2.5 on a scale of 1 to 5. Only 9.7 percent firms have a value more than 3.5 (see table 4.7).

Although a fit between technology and organizational structure was not evidenced, it was clear that firms with organic structure had the potential to improve performance irrespective of technological sophistication. Organizational structure if measured at the factory level may show some significant relationships.

The findings did indicate the moderating effect of business strategy, though at a modest level. Technology had a varying impact on business performance for different types of business strategies. Firms pursuing market differentiation strategy, however, were better able to reap the true potential of AMT. Though flexibility was found to be the most important AMT advantage, firms following complex innovation strategy realized only a marginal increase in

business performance. It seems that firms are unable to translate their flexibility advantage into a strategic advantage in the marketplace. Flexibility can be achieved in both product and process of manufacturing. Competing on only one dimension may not be enough to achieve success in the market. Further study of firms using complex innovation strategy is required to examine this aspect more clearly.

Proactive participation of manufacturing managers in the strategic decision making process indicated significant main and interaction effects. Firms which encourage proactive participation of manufacturing managers, therefore, realize better business performance as well as an enhancement in the effects of AMT. However, contrary to empirical findings, proactiveness did not seem to have higher influence in uncertain environments (Leong, Ward, & Boyer, 1993; Swamidass & Newell, 1987). In both stable and uncertain environments, manufacturing managers appeared to be proactively involved. Therefore, firms using AMT as a competitive strength seem to encourage manufacturing managers to act proactively irrespective of environmental conditions.

In short, it is suggested that firms must integrate the so called islands of automation. A strategic use of technology with proactive manufacturing participation in the strategic planning process can significantly enhance competitive position. The relationships examined using the contingency perspective, however, tested the hypotheses for linear bivariate relationships.

Firms may not emphasize all variables to the same extent. Different firms follow different combinations of strategic and organizational forces. These interrelationships among the variables were, therefore, examined using the configurational perspective.

The cluster analysis illustrated that firms with different strategic profiles exist. Firms may focus on different competitive methods and yet be equally effective. Even similar competitive choices can be supported by completely different contextual factors. Literature on organizational structure and business strategy provides enough evidence on the relationship between strategy, structure, and the environment. For example, in a synthesis of organizational theory and business policy, White and Hamermesh (1981) contend that "it is through strategy that the firm interprets its environment and that strategy guides the choice of organization structure (p.217)." They further add that structure can influence the strategic decisions as well, that is, "organization both shapes and is shaped by strategy." Similar views were suggested by others such as Hitt and Ireland (1984), McArthur and Nystrom (1991), Miller (1987, 1988), and White (1986).

This study attempted to integrate the above relationships with firm's choice of technological posture and the role of manufacturing in improving business performance. As inferred from the cluster analysis, firms displayed complex interrelationships among the chosen variables. The technological

sophistication of a firm did influence business performance, but technology alone did not determine other strategic and organizational dimensions.

Firms with more integrated and intensive use of technology chose to compete on product innovation, in general. Firms with low-tech profile, on the other hand, tried to seek cost efficiency. The choice of strategy was strongly influenced by the type of environmental uncertainty. Environmental uncertainty, however, did not affect firms uniformly. Firms facing a more unpredictable environment chose to place more emphasis on product innovation. Similar results were found by Miller and Toulouse (1986). Also, these same firms had a high technology profile. Apparently, environmental uncertainty could have been initiated or aggravated by the technological and strategic choices made by these firms. The innovative strategy selected was supported by an organic structure and more proactive involvement of manufacturing managers.

Environmental hostility, on the other hand, required firms to seek more efficiency and thus compete using cost leadership strategy. Firms using cost leadership were, however, not necessarily using a controlled structure. In fact, some small firms displayed more dynamism and were having an organic structure with active participation of manufacturing managers. Nevertheless, firms emphasizing cost efficiency were the ones having low intensity and integration of AMT.

This study's findings did not completely corroborate Porter's (1980) 'stuck in the middle' category of firms. In fact, in our study, firms competing on all three

strategic dimensions were highly aggressive and achieved the best business performance. On the other hand, another group of firms emphasizing more than one strategy had low technology profile, controlled structure, less proactiveness, and the lowest business performance. Therefore, although difficult to compete on different strategic dimensions simultaneously, it is not impossible. To achieve this daunting task, organizations need to be highly dynamic and aggressive.

In short, there are particular strategic and structural correlates of AMT that lead to better performance in certain environmental conditions. Firms may compete in similar environments using different strategic profiles. Choice of AMT may support the chosen strategy or in some cases even influence the choice of strategy. Different types of environmental uncertainty affect firms differently. Firms may use technology to withstand the uncertainty posed by environments or may even contribute to it. Choice of organizational structure, however, may not be determined by the environment. A firm's technological and strategic profile do play a role in determining the appropriate organizational structure. Further research is required to establish the relationship between organizational structure and manufacturing technology. Finally, proactive involvement of manufacturing managers can help a firm improve its business performance in stable as well as uncertain environments. Influence of AMT can definitely be improved if manufacturing proactively participates in the strategic decision making process of the firm.

5.3 Limitations

Despite our sincere efforts, this study had to face some limitations which are considered to be normal for a study of this magnitude. We therefore suggest to exercise caution in interpreting the findings.

First, the sample for this study was obtained from six manufacturing industries. The target population was selected based upon prior research in this area. However, in the absence of any official guide pertaining to AMT users, it is difficult to say that the sample correctly represented the major AMT users. In addition, the data was collected from firms located within the boundaries of the United States and was cross-sectional in nature.

Second, the business performance was operationalized using a three item scale. It is suggested to include additional measures to cover diverse objectives of firms. Moreover, the measures were subjective in nature. It was possible that the self-reported measures suffered from individual bias. Firms were, nevertheless, assured for confidentiality and anonymity to reduce this perceptual bias in the data.

Third, organizational structure was measured using bipolar index with a higher value representing an organic structure and a lower value indicating a mechanistic structure. Organizational structure consists of diverse, complex attributes. An analysis of individual organizational dimensions may provide more richer understanding of its influence of AMT.

Finally, given the restricted industrial groups targeted for this study, that is SIC groups 33 to 38, the findings of this study cannot be generalized to other industrial sections.

5.4 Future Research Directions

This study has examined and supported many of the hypothesized relationships among manufacturing technology, business strategy, organizational structure, manufacturing proactiveness, environmental uncertainty, and business performance. Several research projects can be undertaken to refine and widen the scope of the current research.

First, manufacturing technologies considered for this research were the hardware components only. Firms also use a large number of so called soft technologies or processes such as just in time (JIT), total quality control (TQC), and statistical process control (SPC). Schonberger (1986) argued that simplification of manufacturing processes should precede the adoption of AMT. Implementation of JIT and TQM, for example, makes the automation more effective. Future research must be directed to examine how the hard and soft technologies interrelate.

Second, the IIT construct was used in this study to measure the intensity and integration of AMT. The intensity and integration requirements, however, may vary across firms as well as industries. Also, not all firms may need to use

the whole set of AMT to the same extent. Moreover, the integration requirements for different functions across Porter's value chain is likely to be different. We, therefore, need a more robust measure which can take into account the above differences. Research based on heterogeneous sample may lead to misinterpretation of results and to the error of overgeneralization.

Third, the findings of this study indicated that firms respond differently to different environmental dimensions. Only two environmental dimensions, dynamism and hostility, were included in this research. It is suggested that future research should include other environmental dimensions, for example, environmental complexity. Also, the measures were based on respondents' perception which may differ across firms even though they belong to the same industry. Objective measures are recommended for future studies using environmental variables.

Fourth, organizational structure was not found to have any significant moderating effect on the relationship between technology and firm performance. This is contrary to some of the empirical findings. Nevertheless, research on the relationship between organizational structure and manufacturing technology is inconclusive. Future research efforts must examine organizational structure more carefully for its specific traits such as formalization, authority, and coordination.

Fifth, the significance of work design was completely ignored in this study. The concern with AMT's impact on jobs and skills has much increased recently.

The coexistence of both routine and non-routine tasks compounds the complexity of work design under AMT. Furthermore, the blurring of job boundaries, multi-skill requirements, increasing integration of jobs, and the use of work teams make it increasingly difficult to evaluate the impact of AMT on jobs on the factory floor. It is therefore important that future research examine the appropriate work design structure under AMT.

Sixth, it is extremely difficult for a survey study to analyze a wide array of technologies and their relationships with other strategic, organizational, and environmental forces. Even if the relationships can be determined, it would be erroneous to generalize them. Therefore, we strongly recommend the survey study to be substantiated by case studies.

Finally, successful implementation of AMT takes a long period of time. Organizations go through drastic changes and modifications in the process of adoption and implementation of AMT. For an in-depth study of this process, a longitudinal research is the only choice.

Chapter 6

CONCLUSION

This chapter highlights the major findings of this research. Implications of this research for both researchers and practitioners are then described.

AMT has recently been proposed by many researchers as the ultimate tool to improve business competitiveness. Literature is replete with anecdotes and evidences of AMT benefits. But so is the alarming rate at which organizations failed and got disillusioned with AMT. We examined the strategic aspects of AMT and investigated the factors which make a firm using AMT more competitive.

The findings of this study have confirmed that AMT can definitely improve firm performance if it is well integrated. Using new technologies in an isolated environment can only thwart our efforts and time. It is the synergy among different technologies which enables a firm to exploit AMT to its full extent.

The AMT benefits are easy to achieve on the factory floor. But firms find it difficult to translate these benefits into competitive advantage in the marketplace. Technology is a part of a firm's manufacturing strategy that should be linked to the marketplace via firm's business strategy. A fit between AMT and business strategy is very crucial to improve business performance. Firms with aggressive

technological posture tend to be more innovative. Efficiency seeking firms, on the other hand, are technologically less sophisticated.

No conclusive evidence has been found regarding the relationship between AMT and organizational structure. Firms may pursue varying structural forms depending on their strategy, environment, culture, and managerial behavior. We need further research to establish concrete results.

Finally, irrespective of the type of strategy and organizational structure, firms must encourage manufacturing managers to participate in their strategic planning process. Firms with proactive manufacturing involvement are more likely to compete on the basis of their technological strength. Proactiveness, however, is not a function of environmental uncertainty. Manufacturing proactiveness leads to better firm performance in both stable and uncertain environments.

6.1 Implications for Researchers and Executives

The current research has several implications for both researchers and practitioners.

We are currently passing through a transitional phase. AMT based on novel developments in computers, information technology, and associated systems is strikingly different from technologies of the past era. Analyzing AMT from the same old perspective is inappropriate and unjust. Researchers need to

use the current existing knowledge to develop new models but must not attempt to qualify their findings with the past conclusions. Relationships among strategy, structure, and environment, for example, need not be the same for firms using AMT. Firms compete in new ways using different types of strategic and organizational alignments.

The empirical findings of this study has provided support to the concept that integrated use of AMT leads to better performance. However, research using integrated models is sparse. Need for an integrative framework including technology and its concomitant strategy, structure, and environment can hardly be ignored today. Some research including the current study can be considered as an attempt in this direction but are far from exhaustive. Future research must direct its effort in this direction.

Researchers proposing a non-tradeoff relationship among different manufacturing capabilities received adequate support by our findings. This study has established that for AMT users a hierarchy of manufacturing capabilities exists with flexibility at the top followed by responsiveness and quality. No significant relationship was found with respect to cost reduction as AMT benefit. We need to rethink over our current efforts to justify AMT adoption based upon traditional economic and financial tools.

Finally, we need to be more careful at the methodological front. This study has confirmed that sole reliance on contingency approach can be misleading. A holistic and integrated perspective can be gained by using the

configurational approach. Both approaches, however, provide different insights and thus must be considered complementary. The taxonomy or configurations generated by this study may be used as the basis for further research.

To the practitioners, our message is that AMT is not the cure for their declining competitiveness, as believed or perceived by some. Heavy reliance on technology without the supporting infrastructure can only weaken a corporation rather than making it more competitive. AMT has the potential to improve a firm's performance. But technology alone is not enough. Technology is just a tool. It is the supporting organizational structure and business strategy that make AMT a viable competitive strength.

AMT works best under an integrated environment. An integration of manufacturing technologies on the factory floor as well as the rest of the organization will enable firms to be more competitive. But integration also increases the complexity and creates uncertainty. Managers thus need to be more careful when implementing AMT.

Firms using AMT should focus more on achieving the manufacturing capabilities such as flexibility, responsiveness, and quality. Since cost reduction is not the primary benefit of AMT, any effort to justify AMT adoption based upon traditional financial measures will only lead to erroneous decision.

Firms need to make strategic use of technology rather than using technology to just support the strategies formulated by the top management. A

lack of fit between technology and strategy will only thwart a firm's efforts and resources. An increase in the intensity and integration of AMT without supporting business strategy may make no significant difference to the performance of a firm. In fact, in some cases it may even lower the performance. Our results, for example, suggest that firms pursuing marketing differentiation strategy should use AMT more intensively. An attempt to differentiate without the supporting technology leads to poor business performance.

Finally, it is time to give up the passive view of manufacturing. Manufacturing should not be considered as a supportive tool to execute the strategies formulated by top management. Proactive participation of manufacturing managers in the strategic planning process can enable firms to make strategic use of technology. Manufacturing managers who are better informed about the technological prowess of the firm must be encouraged to participate in its strategic planning process.

CONFIDENTIAL

RESEARCH QUESTIONNAIRE

Impact of Advanced Manufacturing Technology (AMT) on Business Performance: A Strategic Perspective

General Instructions

This questionnaire is designed for easy completion. Please check the appropriate box ☐ for each category. If you are not sure of an answer, give us your best judgement. PLEASE, DO NOT LEAVE ANY QUESTION BLANK. Thank you for your help.

The information provided by you about your company will be kept strictly **CONFIDENTIAL**.

In this survey, we have used the word "unit" to represent the company, division, or subsidiary for which you are answering questions. Please be consistent throughout the survey and answer with reference to the same unit.

COMPANY DESCRIPTION

1. Business unit for which this questionnaire is being completed is best described as:

☐ Entire Company	☐ Division
☐ Subsidiary	☐ Other _____
2. Approximately how many employees work for this unit?
_____ employees
3. What is the primary industry for this unit? _____

PART I MANUFACTURING TECHNOLOGY

1. Listed below are several elements of Computer-Based Technology. **For the technologies being used in your facility**, please indicate the extent to which each is linked to the other technologies.

Technology	Linked to none at all	Linked to a few others	Linked to almost all		
1. Computer Aided Design (CAD)	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
2. Computer Aided Engineering (CAE)	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
3. Flexible Manufacturing Cell (FMC)	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
4. Flexible Manufacturing Systems (FMS)	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
5. Computer Aided Manufacturing (CAM)	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
6. Automated Assembly (AA)	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
7. Computer Numerical Control (CNC)	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
8. Robotics	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
9. Automated Storage & Retrieval Systems (AS/RS)	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
10. Automated Guided Vehicles (AGV)	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
11. Computer Aided Process Planning (CAPP)	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
12. Manufacturing Resource Planning (MRP II)	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
13. Automated Sensor Based Inspection or Testing	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
14. Shop Floor Monitoring & Control by Personal Computers	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐

2. Consider the product development, engineering and design work done in your facility. Approximately how much is done with Computer Aided Design (CAD), Computer Aided Engineering (CAE) or other types of computer assisted technologies?

Percent of work done with CAD, CAE, or other
computer assisted technologies _____ %

3. Approximately what percentage of your production is produced with programmable automation?

Percent of work done with programmable automation _____ %

4. Consider the following administrative work related to managing and controlling manufacturing activities: (1) Inventory control, (2) Accounting, and (3) Shop floor tracking system. Approximately how much is done on a computer?

Percent of work done on a computer _____ %

Part II BUSINESS STRATEGY

In competing in your chosen market segment, please indicate how important the following competitive choices are for your business unit in relation to your major competitors.

	Least Important		Somewhat Important		Highly Important
1. Rate of new product introduction	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
2. Tracking of market opportunities	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
3. Extent & frequency of product innovations	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
4. Product R&D	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
5. Innovation in marketing techniques & methods	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
6. Market segmentation	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
7. Advertising	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
8. Prestige pricing	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
9. Brand identification	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
10. Control of channels of distribution	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
11. Use of formal cost and financial controls	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
12. Operating efficiency	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
13. Product quality control	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
14. Developing/refining existing products	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
15. Efficiency in securing raw materials	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
16. Reputation in industry	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
17. Innovation in manufacturing processes	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐

PART III ORGANIZATIONAL STRUCTURE

Please indicate the characteristics of your business unit's overall organizational structure.

- | | | | | | | | |
|---|-------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------|
| 1. Decision-making | Centralized | 1 ☐ | 2 ☐ | 3 ☐ | 4 ☐ | 5 ☐ | Decentralized |
| 2. Control Systems | Formal | 1 ☐ | 2 ☐ | 3 ☐ | 4 ☐ | 5 ☐ | Informal |
| 3. Task Forces and/or committees | Rarely Used | 1 ☐ | 2 ☐ | 3 ☐ | 4 ☐ | 5 ☐ | Often Used |
| 4. Line-Staff Responsibilities | Distinct | 1 ☐ | 2 ☐ | 3 ☐ | 4 ☐ | 5 ☐ | Blurred |
| 5. Hierarchy | Many Levels | 1 ☐ | 2 ☐ | 3 ☐ | 4 ☐ | 5 ☐ | Minimal Levels |
| 6. Interdepartmental Communication | Formal | 1 ☐ | 2 ☐ | 3 ☐ | 4 ☐ | 5 ☐ | Informal |
| 7. Reward Criteria | Seniority | 1 ☐ | 2 ☐ | 3 ☐ | 4 ☐ | 5 ☐ | Expertise |
| 8. Management Control & Information Systems | Often used | 1 ☐ | 2 ☐ | 3 ☐ | 4 ☐ | 5 ☐ | Rarely Used |
| 9. Co-ordination | Formal | 1 ☐ | 2 ☐ | 3 ☐ | 4 ☐ | 5 ☐ | Informal |

PART IV PROACTIVENESS

- To what extent is the head of manufacturing involved in specifying the strategy of the business unit?
 No involvement 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ Total involvement
- To what extent is the head of manufacturing responsible for strategic changes in manufacturing?
 No responsibility 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ Total responsibility

To what extent are the following decisions based on participative, cross-functional discussions?

- | | Rarely | | | | Frequently |
|---|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|
| 3. Product or service decisions concerning production, marketing, and R&D strategies | 1 ☐ | 2 ☐ | 3 ☐ | 4 ☐ | 5 ☐ |
| 4. Capital budget decisions: the selection and financing of long-term investments | 1 ☐ | 2 ☐ | 3 ☐ | 4 ☐ | 5 ☐ |
| 5. Decisions related to changes in the business unit's operating philosophy and strategies for growth | 1 ☐ | 2 ☐ | 3 ☐ | 4 ☐ | 5 ☐ |

PART V MANUFACTURING PERFORMANCE

For each of the characteristics listed below, please indicate your business unit's performance in relation to your major competitors.

	Far worse than competitors	1	About the same as competitors	2	3	Far better than competitors	4	5		
1. New product introduction	1	☐	2	☐	3	☐	4	☐	5	☐
2. Speed in changing product volume	1	☐	2	☐	3	☐	4	☐	5	☐
3. Speed in developing new products	1	☐	2	☐	3	☐	4	☐	5	☐
4. Speed in making product changeover	1	☐	2	☐	3	☐	4	☐	5	☐
5. Research and development efforts	1	☐	2	☐	3	☐	4	☐	5	☐
6. Lead time of orders	1	☐	2	☐	3	☐	4	☐	5	☐
7. Delivery reliability	1	☐	2	☐	3	☐	4	☐	5	☐
8. Production lead time	1	☐	2	☐	3	☐	4	☐	5	☐
9. Response to customer requirements	1	☐	2	☐	3	☐	4	☐	5	☐
10. Product performance & reliability	1	☐	2	☐	3	☐	4	☐	5	☐
11. Product durability	1	☐	2	☐	3	☐	4	☐	5	☐
12. Conformance to specifications	1	☐	2	☐	3	☐	4	☐	5	☐
13. Design & engineering quality	1	☐	2	☐	3	☐	4	☐	5	☐
14. Product features	1	☐	2	☐	3	☐	4	☐	5	☐
15. Customers' perception of quality	1	☐	2	☐	3	☐	4	☐	5	☐
16. Unit production cost	1	☐	2	☐	3	☐	4	☐	5	☐
17. Unit material cost	1	☐	2	☐	3	☐	4	☐	5	☐
18. Unit labor cost	1	☐	2	☐	3	☐	4	☐	5	☐
19. Unit overhead cost	1	☐	2	☐	3	☐	4	☐	5	☐

PART VI EXTERNAL ENVIRONMENT

Please indicate the rate of change in the following factors over the past three years:

- | | Slow | | | | Rapid |
|--|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|
| 1. Rate at which products and services become outdated | 1 ☐ | 2 ☐ | 3 ☐ | 4 ☐ | 5 ☐ |
| 2. Rate of change in taste and preferences of customers in your industry | 1 ☐ | 2 ☐ | 3 ☐ | 4 ☐ | 5 ☐ |
| 3. Rate of innovation of new products and services | 1 ☐ | 2 ☐ | 3 ☐ | 4 ☐ | 5 ☐ |
| 4. Rate of innovation of new operation processes | 1 ☐ | 2 ☐ | 3 ☐ | 4 ☐ | 5 ☐ |

Please indicate if the market activities of your key competitors over the past three years have become

- | | | | | | | |
|--|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------|
| 5. Far less predictable | 1 ☐ | 2 ☐ | 3 ☐ | 4 ☐ | 5 ☐ | Far more predictable |
| 6. Far more hostile | 1 ☐ | 2 ☐ | 3 ☐ | 4 ☐ | 5 ☐ | Far less hostile |
| 7. Legal, political and economic constraints over the past three years | | | | | | |
| Have proliferated greatly | 1 ☐ | 2 ☐ | 3 ☐ | 4 ☐ | 5 ☐ | Almost no change |

PART VII BUSINESS PERFORMANCE

Please indicate the business performance of this unit for the year 1994.

1. Market Share (%) _____
2. Sales Growth (%) _____
3. Return on Investment (%) _____

Compared to your competitors, please indicate your position on the following dimensions:

	Significantly Lower		Equal	Significantly Higher	
1. Market Share	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
2. Return on Investment	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
3. Sales Growth	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐

Thank you for your participation in this study. If you would like to receive a copy of this study's findings, please write your name and mailing address below or attach your business card:

Name:	_____		
Title:	_____		
Company:	_____		
Address:	_____		

	City _____	State _____	Zip _____
Tel:	()	-	

Please return the questionnaire in the enclosed business reply envelope.

Devraj Agarwal, Management Department, Box F-1831, Baruch College, 17 Lexington Avenue,
New York, NY 10010
Tel. 718-760-5657

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