1-1-1991

An empirical examination of the relationship between competitive strategy and process technology in the tooling and machining industry.

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AN EMPIRICAL EXAMINATION OF THE RELATIONSHIP BETWEEN COMPETITIVE STRATEGY AND PROCESS TECHNOLOGY IN THE TOOLING AND MACHINING INDUSTRY

A Dissertation Presented

by

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Submitted to the Graduate School of the University of Massachusetts in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

May 1991

School of Management

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This study is dedicated to my wife Kimberly Ann,
to my son, Sean Thomas, and to their patience.

ACKNOWLEDGMENTS

I would like to offer thanks to each member of my committee for their time and input in seeing me through this project. Thanks also goes to the National Tooling and Machining Association, for providing the mailing list and feedback on the survey instrument, and to its members for their time in responding. I would especially like to thank my Chair, Dean Schroeder for his contribution in putting together the mail survey, and for his patience, encouragement, and input in general.

ABSTRACT

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MAY 1991

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A considerable segment of the business literature has espoused the importance of appropriately using *process* or *manufacturing* technology to support competitive strategy. This literature implicitly and explicitly suggests the importance of "fit" between a firm's business level strategy and its process technology.

Three gaps remain with respect to the "fit" assertion: (1) The nature of fit is insufficiently specified. (2) No empirical research has attempted to statistically validate the existence of fit within an industry. (3) No empirical research has attempted to statistically link fit to firm performance.

To address these issues, this dissertation surveys firms in the U.S. tooling and machining industry to test hypotheses on the nature, existence, and impact on performance of fit. Strategy is assessed as membership in one of six strategic groups derived from clustering eight strategy factors. Factor analysis results in four technology

factors, Dedicated Automation, Non-Dedicated Automation, Range of Capabilities, and Computer Aided Design. Performance comprises ROS and average annual sales growth.

Findings regarding the nature of fit suggest: (1) Dedicated <u>and</u> non-dedicated automation relate positively to new and existing product stability. Broad product range (products very different from each other) relates negatively to dedicated automation, but does not relate to non-dedicated automation. (2) Linkages may be obscured because multiple capabilities are often bundled in a given technology so that different strategies use the same technology for different reasons. (3) Process technology appears to relate primarily to strategic dimensions concerning physical product characteristics, and very little to service dimensions.

The existence of fit is demonstrated by highly significant differences in technology between groups, combined with the qualitative plausibility with which these differences appear to correspond to each strategic group.

Although insufficient support was found for fit linked to performance (technology moderating strategic group membership's impact on performance), results suggest that performance advantage from a technology is gained not in the group where it is most appropriate or a given, but in a group where it is also appropriate, but less widespread.

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CHAPTER 1

INTRODUCTION

This decade has witnessed many calls proclaiming the importance of "technology" to firm strategy, and more generally to the relative strength of the world's economies. While such references range from product technology, to information technology, to materials technology, a considerable segment of the business literature has espoused the importance of appropriately using *process* or *manufacturing* technology to support competitive strategy (e.g., Hayes & Schmenner, 1978; Hayes and Wheelwright, 1979; Jelinek & Goldhar, 1983; Kantrow, 1980; Kotha & Orne, 1989; Schroeder, 1990; Skinner, 1974, 1984; Wheelwright, 1984, 1978). This literature explicitly and implicitly suggests the importance of "fit" between firms' process technology and competitive strategy. In such a relationship, a given process technology may or may not be appropriate for particular firms within an industry.

The problems regarding this frequent assertion are that 1) the nature of what constitutes fit is generally either too broadly or insufficiently specified, and 2) no statistically validated research has shown such a contingency relationship to exist within an industry. Prior empirical research has shown that process technology changes predictably over the course of product life-cycles (see Abernathy & Townsend, 1975), but has not focused on the appropriateness of a given process technology for different strategic positions at a point in time. The strategy-technology gestalts of Freeman (1974) and Miles & Snow (1978) make broad connections with efficient versus flexible processes but are experienced based (not broadly validated), and thus considered "conceptual" (Miller, 1988). Miller's (1988) strategy-technology typology does include manufacturing technology in terms of batch, assembly line, and continuous process, but is derived from cross-industry data (PIMS) and thus has limited relevance to "fit" within an industry. Interesting connections between process technology and strategy have been observed in several industries (i.e., Schroeder, 1990; Schroeder, Gopinath, & Congden, 1989) but have not been validated statistically. This research gap is further elaborated in Chapter 2.

While process technology-strategy research is recognized as important by both scholars and practitioners, performance issues are often overlooked. Kotha & Orne (1989) assert that the main research question regarding competitive strategy and manufacturing is to explore whether firms which exhibit "fit" or "congruence" among strategy and process technology outperform competitors without fit. At this point, scholars need to move beyond acknowledgment of a need for fit, to statistical demonstration that the concept of fit exists and makes a difference in performance*. In the process, more would be learned about the nature of fit (e.g., which aspects are universal and which might be contingent on industry or other factors). Managers would be able to better co-align this core area of an organization with its domain by using successful firms with like strategies as a frame of reference to highlight differences in technology important to success. Potentially wasteful investment in inappropriate technology might be averted. Competitiveness promotion or attempts at industrial policy by policy makers would benefit to the extent that "new" technologies are not promoted for situations where inappropriate.

This dissertation empirically explores the nature, existence, and impact on performance of fit between process technology and competitive strategy. Due to the pervasive nature and wide variety of process technologies, focus is on one industry, the machining and tooling industry**. This allows thorough attention to the contingency question, and minimizes the impact of extraneous variables. Data gathered by mail questionnaires to members of the National Tooling

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*Strategy-Technology literature usage of "performance" is typically vague but tends toward "financial performance." This study also uses a financial conception, assessing performance in terms of profitability and growth. Chapter III reviews the basis for this choice. Chapter IV notes difficulties of measurement and interpretation.

**See Chapter 4, section 4.2, for a description of the machining and tooling industry.

and Machining Association (NTMA) are analyzed to determine whether firms following different strategies use significantly different types of process technologies. If this fit is important as the literature suggests, firms following similar strategies should show significant variance in performance in relation to variation in their process technologies. Key strategic dimensions suggested by prior exploratory research on this industry (Schroeder, Gopinath, & Congden, 1989) as related to process technology are also tested to examine the nature of fit.

This dissertation is organized around seven chapters. Chapter 1 has introduced the dissertation. Chapter 2 reviews the literature to identify gaps, highlight areas which need more research, and demonstrate the role this research will play. Chapter 3 further explores the literature to sort out ambiguities surrounding the major constructs of this research question. Definitions and a model appropriate for this dissertation's questions are presented. Chapter 4 proposes specific hypotheses related to the model, and methodological procedures to test them. Chapter 5 presents the results of hypothesis testing. Chapter 6 discuses the results in relation to the literature. Chapter 7 concludes with a summary of findings, followed by discussions of the limitations and the broader significance of the findings.

CHAPTER 2

LITERATURE

This chapter examines the existing literature on strategy and process technology. It begins with recognition of technology's strategic importance, and examination of generalized, broad natured research in which "technology" is used rather loosely. This is followed by a review of research which focuses specifically on the strategic importance of manufacturing technology. Traditionally, the strategic impact of process technology was seen as a trade-off between flexible and efficient processes. More recently, manufacturing strategy literature has recognized a wider and more detailed range of dimensions where strategy and technology interact. However, research on computer controlled technologies reports changes in these relationships. The chapter ends with a review of empirical works on this topic, and concludes that a gap exists between normative claims of strategy-technology fit and empirical demonstration of the phenomena.

2.1 The Strategic Importance of Technology

The role of new technologies in altering the competitive structure of industries has long been recognized.

Schumpeter's (1934) observation that innovation acts as a creatively destructive force which restructures industries, and thus the basic nature of competition, is typically cited as one of the early recognitions of the power in the link between competitive strategy and technological innovation. Porter (1983) warns that despite this recognition, the study of strategy and the study of technological innovation have too often been decoupled. He asserts that "...technological change is perhaps the single most important source of major market share changes among competitors [because it can change the competitive rules of the game]"(p3).

2.2 Technology in General

The importance of a company's overall 'technology' to its competitive strategy is well recognized by managers and scholars alike (Kantrow, 1980). Yet when examining this relationship, researchers confront challenges embedded in the very nature of technology. It is a broad concept affecting every facet of an organization and its dealings. Porter (1985), for example, notes that many different types of technology are embodied in the activities of every value stage of the organization. Technological leadership in these value stages (or followership depending on industry characteristics) can be used to support any of Porter's

(1980) generic strategies (i.e. cost leadership, differentiation, or focus) (Porter, 1983).

To deal with this pervasive nature, some scholars use typologies or taxonomies of strategy-technology gestalts to capture broad meta-relationships (e.g. Ansoff & Stewart, 1967; Freeman, 1974; Miles & Snow, 1978; Malekzadeh et al., 1989; Miller, 1988). The resulting connections with process technology are quite generalized. Ansoff focuses solely on product technology while Freeman, Miles & Snow, and Malekzadeh et al. make only a very broad connection with process technology in the form of a distinction between efficient versus flexible processes. Miller's taxonomy includes manufacturing technology in terms of Woodward's (1965) categories of batch, assembly line, and continuous process. In an effort to identify global patterns, the cross-industry origins of these typologies and taxonomies (Miller's taxonomy, for example, is PIMS based and the others are conceptual or experience based) sacrifices the depth of their usefulness, if not their validity in particular intra-industry settings.

Much of the work relating 'technology' to strategy only remotely deals with *process* technologies. Beginning with Ansoff & Stewart (1967), there is a strong research tradition examining the relationship between R&D to develop new product technologies, and market strategies (e.g., Foster, 1988; Frohman, 1982, 1985; Hariharan & Kazanjian, 1987; Harris, Shaw, & Sommers, 1984; Hoffmann, 1976; Hambrick et al., 1983; Ketteringham & White, 1984; Maidique & Patch, 1982; Petrov, 1982; Sethi et al., 1985). Because much of this work uses 'technology' in a general sense, it may appear to be relevant to the more specific case of process technology. However, although the application of R&D know-how to processes is nominally recognized by some of these works, the predominant emphasis is on product development.

2.3 Process Technology

Concurrently, a significant vein of literature, much of it labeled "Manufacturing Strategy," has arisen from heightened awareness of process or *manufacturing* technology's direct relevance to competitive strategy. Skinner (1969) is often cited as an early voice for the strategic importance of process technology. In recent years, with the decline in U.S. manufacturing competitiveness, this area has received increasing attention. Japanese firms are said to have gained their lead in many industries through closely integrating manufacturing process technologies into their competitive strategies (Buffa, 1984; De Meyer et al., 1989; Jaikumar, 1986; Wheelwright, 1981). In addition, the advent of computer controlled process technologies promises striking implications for competitive strategy (Jelinek &

Goldhar, 1983). This dissertation likewise focuses on process technology.

2.4 Flexibility versus Efficiency

Perhaps the most prevalent or 'traditional' view of the strategic role of process technology involved a trade-off between flexibility to produce different types or variations of products versus efficiency or low cost. A stream of research initiated by Abernathy (e.g., Abernathy, 1976; Abernathy & Townsend, 1975; Abernathy & Utterback, 1978) found that this trade-off in production processes evolves in a predictable pattern over a product's life cycle. Initially, when competition centers around product innovation, flexible, general purpose processes are required to accommodate a variety of products and frequent design changes. Later, as products become standardized and volume increases, production systems become more dedicated (less flexible) in an effort to increase efficiency as it increasingly becomes the basis for competition. In the end, processes become complex, integrated, rigid, and capital intensive. Because processes become more intertwined and systematic, more costly major process innovations give way to increasingly incremental and minor change (Abernathy & Utterback, 1978; Utterback, 1979). Hayes and Wheelwright (1979a,b) provide a clear way of viewing this pattern strategically by placing the stages of the product life cycle and the process life cycle on sides of a matrix such that the diagonal represents the ‘normal’ pattern of evolution. Operating "off diagonal" may result in a significant strategic disadvantage if not closely associated with an appropriate competitive strategy.

This evolution of processes increases entry barriers in the form of capital intensive processes and large market share requirements. In addition, "because process innovations tend to reduce production costs, greater gains tend to accrue to holders of larger market shares" (Utterback, 1979, p. 52). Therefore, new entrants tend toward niche strategies by stressing uniqueness in product rather than competing on cost with process technology (Utterback, 1979).

In focusing on the evolution of process technology within an industry, this product-process evolution research emphasizes the "sameness" in process technology of players in particular product-markets. It allows for some variation in that firms can lead the pack in pursuing low-cost efficiency, or lag the pack in retaining more flexibility and following differentiation or niche strategies. In sum, at any point in time, flexibility versus efficiency of processes seems to be the key strategic question raised by this research.

2.5 Fit More Than Flexibility Versus Efficiency

Other works, in pointing out strategic impacts in addition to flexibility and low cost efficiency, implicitly recognize the differences in process technologies appropriate for different strategies at a point in time. Skinner's (1974) idea of the "Focused Factory" is that manufacturing has to be focused around the needs of particular product-/market strategies. Dimensions on which manufacturing can perform are low costs, product quality, dependable delivery promises, short delivery cycles, flexibility to produce new products quickly, flexibility in adjusting to volume changes, and low investment. Others list similar subsets while adding product consistency (Hayes & Schmenner, 1978; Stobaugh & Telesio, 1983; Swamidass, 1987; Wheelwright, 1984). Evidently, these authors see process technology playing a broader role than just low cost. Likewise, Porter (1983, 1985) asserts that, although the traditional view is that product innovation supports a differentiation strategy while process innovation supports a low cost strategy, examples can be found of process innovation supporting differentiation strategies.

Inherent in this expanded view of the role of process technology is the idea that a given process technology might only be suitable for certain strategies. If machines and/or procedures are tailored to specific dimensions of strategy such as delivery, quality, volume flexibility, etc., it stands to reason that they would be less than optimal with respect to other dimensions which might be chosen by competitors as a basis of strategic advantage. This is the rational behind "facilities focus" (Hill & Duke-Woolley, 1983) and "focused factories" (Skinner, 1974, 1984). Other authors express the inability for given process equipment to serve the needs of too many strategic dimensions (Hayes & Schmenner, 1978; Stobaugh & Telesio, 1983; Wheelwright, 1978). Terms such as "alignment," "consistency," "match," etc., imply the existence of a contingency nature "fit" between process technologies and competitive strategy.

2.6 Impact of Computer Controlled Technologies

The advent of computer controlled process technologies has also induced a more multifarious conception of the role of manufacturing technology, and has prompted authors to speculate on how the trade-off between flexibility and efficiency may be changing (Adler, 1988; Blois, 1985; De Meyer et al., 1989; Goldhar & Jelinek, 1983; Jelinek & Goldhar, 1983; Wheelwright, 1984; Meredith, 1987; Thompson & Paris, 1982; Voss, 1986). The main assertion is that computer controlled processes dramatically lower the cost of flexibility, making it nearly as efficient to manufacture product variations as it is to manufacture large volumes of standard products. In some cases, economies of scope may actually make it cheaper to produce products in combination than separately (Jelinek & Goldhar, 1983). Jelinek & Goldhar (1983) assert that the approach of economic order (batch) quantities toward one piece works against the trend toward homogenization and commodity oriented, price based competition. Instead competition can be based on special options, custom products, etc.

However, Jelinek and Goldhar (1983) warn that the low economic order quantity of computer controlled process technologies is only useful if it is part of a strategy catering to variety, customization, and frequent product changes. This is due to the significantly higher initial cost of computer controlled technologies. Jaikumar (1986) gives similar warnings of high start-up and learning costs in his comparison of U.S. and Japanese use of flexible manufacturing systems (FMS). These warnings imply a contingent nature fit in that strategies not taking advantage of these capabilities will suffer a penalty of unremunerated capital and/or learning costs. Although seldom explicitly acknowledged in the manufacturing strategy literature, this cost penalty is perhaps a primary countervailing factor which underlies the necessity of "fit".

2.7 Empirical Research on Strategy-Process Technology

While numerous normative works argue for strategic uses of process technology, little empirical work has been done. Of empirical works which have been done, some have focused on single process technologies in single industries (e.g., Schott & Muller, 1975; Schroeder, 1990). Schott & Muller's (1975) study of the international plastics trade found that, even with a mature process technology, competitive advantage was sustained where intensive process R&D led to continuous incremental process improvements.

A longitudinal study by Schroeder (1990) found the strategic impact of a new process technology in the foundry industry to change over time due to the complex interaction of dynamic forces. The dynamics he identified were the diffusion of the innovation to potential users, the continuing evolution of the technology after its initial introduction, and the development of complementary technologies. Schroeder did not find a relationship between different process technologies within the industry and the broad strategy types of Porter (1980) and Miles & Snow (1978). He did, however, find that the same new process technology could support different strategies, but it required adaptation and custom implementation to fit those purposes. He speculates that natural evolution in new process technologies makes them increasingly flexible and able to serve more strategies. Although this dissertation looks at fit in a cross section of time, Schroeder's contribution serves to remind us that "fit" for a particular industry and/or process technology changes over time in a complex fashion.

Several empirical studies have focused on the impact of new computer controlled process technologies. In a study of small British engineering firms, Dodgson (1987) finds that broader and higher skilled job roles are needed to achieved the greatest flexibility from CNC (computer numeric control) machine tools. Meredith (1987) asserts that small firms are really in as good, if not better, position to benefit from advanced computer controlled technologies than are larger firms because the technologies are most suited for supporting strategies traditionally followed more effectively by smaller firms.

In a longitudinal survey of the manufacturing strategies of U.S., Japanese, and European firms, De Meyer et al. (1989) find that U.S. firms have retreated from earlier aggressive pursuit of computer integrated manufacturing to concentrate on basics such as quality. Japanese firms, having achieved quality, are investing heavily in computer controlled technologies as a means to overcome the tradeoff between cost-efficiency and flexibility. This finding appears to support the idea of flexible efficiency offered by computer controlled technologies. It does not, however, demonstrate that this can be accomplished, only that it is a key goal of Japanese manufactures.

Other empirical works are less directly related to strategy. For example, Swamidass and Newell (1987) find that more flexible manufacturing processes perform better in conditions of higher perceived environmental uncertainty, but they leave us with a gap between environmental uncertainty and competitive strategy. Ettlie, Bridges, & O'Keefe (1984) find that a "long range strategy for technological innovation" (p684) increases the likelihood that organizations will adopt radical (significantly different) process innovations, while a "market growth strategy" increases the likelihood that organizations will adopt incremental process innovations. Their study focuses on firm characteristics as related to adoption of particular types of process technology, and says little about appropriateness for given strategies.

2.8 Gap - Lack of Empirical Work on Fit

It is difficult and perhaps meaningless to draw lines between what is empirical work and what is not. Many of the normative works discussed have an empirical component in that assertions are based on, and illustrated with, case studies and the practical experience of the authors (e.g., Skinner, 1974, Jelinek & Goldhar, 1983; Wheelwright, 1978).

What can be said is that few if any works have tested propositions linking strategy and process technology, attempting to assess validity within an industry using statistical tests. Furthermore, although many scholars espouse the importance of fit between strategy and process technology, none have specified in adequate detail (beyond flexibility versus efficiency) what constitutes fit, and tested to see whether good fit directly relates to performance. As Kotha & Orne (1989) assert, the main research question with regard to competitive strategy and manufacturing is to explore whether firms which exhibit "fit" or "congruence" among strategy and process technology outperform competitors without fit.

The shortage of empirical studies which specifically explore the linkages between competitive strategy and manufacturing technology indicates the need for more work in this important area. What we have so far is either only tangentially related, too narrow, or too broad. Single firm case studies and anecdotal illustrations certainly add to our understanding and help to develop theories, but it is hard to discern a satisfying whole or even a quasi-whole picture from a thousand points of light. On the other hand, broad, multi-industry endeavors result in only very generalized conclusions. This appears to be a result of the broadness of both the technology and strategy typologies necessary for universal applicability. Ambiguities as to what constitutes fit and what is meant by performance also add to the dilemma. The next chapter explores these constructs to derive a model which can begin to resolve the question of fit.

CHAPTER 3

STRATEGY-PROCESS TECHNOLOGY MODEL

To say that this study examines the impact on "performance" of "fit" between "strategy" and "manufacturing technology" is inadequate without further elaboration. One cannot begin to measure these constructs until their theoretical meaning is made clear. Literature usages of these terms vary widely depending on context. Even within contexts, such as within manufacturing strategy literature, usage is typically vague, with no definitions. Perhaps such ambiguity has inhibited empirical research in this area.

This chapter examines, in order, each of the constructs strategy, process technology, fit, and performance. The literature surrounding each construct is probed to determine definitions most theoretically appropriate for this study. This consists of determining which of many possible underlying dimensions capture the relevant essence of the construct and which approach to combining them is most relevant for this study. A model is then proposed which visually depicts the relationships between the constructs and which summarizes the construct usages chosen for this study.

3.1 Strategy

This section first looks at different approaches to the strategy construct (universal, mid-range, and intra-industry), and narrows in on the one most appropriate for this study. Next the underlying dimensions which constitute the content of strategy are discussed with respect to their compatibility with the approach chosen and relevance to our research question. Finally, the dimensions chosen are outlined in Table 3.1.

3.1.1 Global Approaches

Strategy consists of the integration of so many dimensions that there are seemingly endless possible combinations (Hambrick, 1984). The traditional, cased-based approach has treated strategy formulation as a highly firm specific craft (for a discussion of, see Mintzberg, 1990). However, for research purposes, the complex, idiosyncratic nature of cases makes it difficult to identify and verify patterns which are important on a more general level. More recently, scholars have sought to reduce this confusion by searching for global, archetype configurations, or generic strategies, which are relevant across almost all firms. Perhaps the most widely acknowledged are the Miles & Snow (1978) typology and Porter's (1980) generic strategies.

Although frequently employed in strategic management research, these universal strategy typologies appear to be too broad to adequately relate to process technology. The strategy typologies of Miles & Snow (1978) and Porter (1980) make only broad distinctions between efficiency and flexibility in appropriate process technologies. Assigning firms to Porter's categories obscures different approaches to the generic strategies which the manufacturing strategy literature as well as Porter himself suggest. Competitive priorities such as quality, delivery, etc., professed by scholars as being pertinent to process technology (e.g., Skinner, 1974, 1984; Wheelwright, 1978; Hayes & Schmenner, 1978; Stobaugh & Telesio, 1983) hint of strategy conceptions of finer detail.

Examples of this inability to differentiate at a finer level have been found in several studies searching for links between strategy and process technology. In a study of the relationship between strategy and manufacturing technology in the foundry industry, Schroeder (1985) found generic strategy typologies inadequate. He identified three viable approaches to differentiation (Product Specialization, Value Added, and Customer Focus) as well as two combinations of these approaches. This observation parallels the manufacturing strategy literature's assertion of different strategic priorities such as different degrees of new product flexibility, service, etc. In addition, Schroeder found two approaches to low cost strategies. One approach obtained low cost efficiency through high volume utilization of state-of-the-art manufacturing technologies, while the other obtained low cost primarily through low investment in inexpensive, mostly older technologies. This observation supports Skinner's (1984) distinction between low cost and low investment strategic priorities.

The inadequacy of universal typologies to address detail was also found in an exploratory study searching for links between process technology and strategy in the job shop machining, metal cutting tools, and plastic injection molding industries (Schroeder, Congden, & Gopinath, 1988). A generic strategy of "low cost" was observed to have tenuous meaning. Most firms reported low price as being most important, but this was clearly only with respect to other firms who had similar technological capabilities to compete in similar market segments. Given low price among a group of similar competitors, differentiation in the form of delivery, quality, service, etc. was important. Still other firms produced prototype or very customized products and had very close relationships with customers. Price became secondary to things such as service and design assistance. Overall, competition seemed to occur more within sub-groups than with the broader industry.

It may be possible to shoehorn these observations into Porter's strategy types but it is not clear that this is sufficient. Refinements of Porter's strategy types (Wright, 1987), which demonstrate that industry-wide differentiation can co-exist with either focused differentiation or focused cost leadership in large firms, might allow an even better correspondence. However, questions remain. Is it meaningful to equate a firm which focuses on the needs of a particular local customer with a firm which serves many customers nationwide with a very narrow custom/precision orientation? Both would be classified as focus-differentiators but they hardly seem to be competing with "like" strategies. From the manager's point of view, the more relevant strategic comparison is between more direct competitors. From this perspective, strategy might be better thought of as choice of market segment and competitive priorities on which to gain advantage within that market segment.

In sum, universal typologies leave meaningful complexity unaccounted for. While it may not be possible for a generic level typology to deal with such detail, particular strategic dimensions may nonetheless be key in particular industries and/or with regard to particular process technologies. Harrigan (1983) agrees with this, and argues that "coarse grained," cross-industry studies can make only limited distinctions between strategies within a particular industry. She points out the need for "mid-range" research that addresses one or a limited number of industries so that richer insight is gained as well as some generalizability.

3.1.2 Mid-Range Approaches

Hambrick (1984) appears to follow Harrigan's (1983) mid-range proposal when he suggests delimiting research to specific strategic environments. He asserts that because the contingency perspective is a key precept of strategy, taxonomic research (specifically cluster analysis) to identify strategy archetypes should be done within specified strategic environments. Like Miles & Snow, Hambrick sees strategy as a "gestalt" of interdependent strategic choices, any one of which might relate to performance differently within the context of different strategic gestalts.

Hambrick's application of cluster analysis (1983b) to higher performing firms in two strategic environments ("disciplined capital goods makers" and "aggressive makers of complex capital goods," - also developed with cluster analysis; Hambrick, 1983a) results in strategy types which he concludes are comparable with variations to Porter's and Miles & Snow's strategy types. He labels them "Pure cost leadership," "Asset-conscious focuser" (comparable to a focus strategy), and three differentiation type strategies, "Quality-based gendarme," "Broad-based differentiation," and "Prospector". While still rather broad, Hambrick's strategy types demonstrate strategy refinements, such as different approaches to differentiation, derived from a narrower focus.

Still, Hambrick's environments or "industries" go beyond what most firms would consider relevant competitors. Given the importance of analyzing competitive strategy at the intra-industry level (Porter, 1980), perhaps an industry focus is needed for the question of strategy-technology fit. Intra-industry research would provide an appropriate theoretical context for investigating "fit" as well as a finer focus from which new linkages appropriate for more detailed but generalizable frameworks might emerge. Intra-industry research also overcomes the limitation of researchers becoming sufficiently versed in the process technology choices for variety of industries.

3.1.3 Intra-Industry Approaches

Within an industry, the concept of strategic groups offers a useful, intermediate analytical framework between a case approach and cross-industry strategic analysis (Porter, 1980). Roughly speaking, strategic groups are composed of firms with similar strategies within a specific industry (Porter, 1980; Harrigan, 1985). Porter (1980) says that his generic strategies are really just generalized types of strategic groups that are viable in most industries.

While the emergence of the concept of strategic groups is credited to work by Hunt (1972), Caves & Porter (1977) offered the first clear set of rationale for the phenomena in the form of mobility barriers. Mobility barriers are structural forces which impede firms from changing competitive position and thus prevent the coalescence of industry participants into virtually the same competitive posture (Caves & Porter, 1977). In reviewing works on strategic groups, McGee & Thomas (1986) classify the sources of mobility barriers as market related strategies, industry supply characteristics, and firm characteristics. They argue that mobility barriers reflect the strategic decisions of the firm and are a way of defining the set of key strategies available to the firm. Consistent with Porter's advice (1980), much strategic group research has differentiated groups on various "strategic dimensions" which are difficult to change or imitate, and are thus mobility barriers for the industry in question.

Because one would expect differences in relative advantage afforded by the barriers and structure of various groups, such research has predominantly concentrated on the existence of and performance differences associated with strategic groups (Cool & Schendel, 1988). The term "Strategic Groups" was coined by Hunt (1972) to explain performance variation in the 'white goods' industry. He observed four groups separated by differences in vertical integration, product diversification, and product differentiation. While other early work also demonstrated existence of strategic groups (e.g., Newman, 1973; Porter, 1973;

Hatten, 1974; Patton, 1976), their part in explaining performance differences within an industry has been mixed. Some have found support for performance differences across groups (Hunt, 1972; Newman, 1973; Oster, 1982; Fiegenbaum & Thomas, 1990), others mixed or non-significant results (Porter, 1973; Dess & Davis, 1984) and others, no support (Frazier & Howell, 1983; Cool & Schendel, 1987; Lawless, 1987). One study (Mascarenhas & Aaker, 1989) found profitability differences across groups attributable to the interaction of competitive forces such as customer and supplier power, and mobility barriers.

A few recent studies have taken a different approach by accounting for individual firm factors which cause performance variance within strategic groups. Such factors "moderate" the relationship between strategic group membership and performance. Cool & Schendel (1988) examined differences in "accumulated assets" of firms within strategic groups as an explanation of within groups performance variance in the pharmaceutical industry. Improper accumulated assets, which increase risk depending on the nature of the environmental change for an industry, correlated negatively with performance. They offer this as one of many theoretically possible moderators in the strategic group - performance relationship. Lawless et al. (1988) analyzed firms from four similarly structured industries by looking at individual firm "capabilities" as a moderator of the effect of strategic group members' shared strategy characteristics on performance. Capabilities in this study were reflected in financial stock measures such as liquidity, leverage, and activity. Using strategic groupings based on Porter's (1980) descriptions of low cost and differentiation strategies, Lawless et al. (1988) found capabilities to positively correlate with performance within each strategic group. They conclude that a model with "capability to carry out a strategy" as a moderator might improve consistency in the strategic group - performance research.

While these two studies did not actually test for interaction between the moderator and strategic group membership as their theory implied, they do suggest the appropriateness of the strategic group approach for this study. In this study, process equipment technologies can be viewed as either "accumulated assets" or "capabilities" of each firm which moderate the impact of strategy on performance. While the strategic group-performance model is not the focus of this study, perhaps some light might also be shed on this model.

The relevance of strategic grouping for this study lies in its usefulness for measuring strategy. First, as Harrigan (1985) notes, single industry study was the original spirit of strategic group analysis (i.e., Hunt, 1972; Newman, 1973; Hatten, 1974). Secondly, classification (typology or taxonomy) such as strategic grouping on a number of dimension is appropriate because it recognizes the interdependencies of variables or gestalts (Harrigan, 1985). While bivariate grouping emphasizes similarities and narrows the focus prematurely, multivariate approaches such as cluster analysis preserve information, as it is often the differences within groups which are important (Hatten & Hatten, 1987). Although Porter's generic strategies may be properly thought of as gestalts (Harrigan, 1985), they, like bi-variate mapping, reduce information prematurely.

3.1.4 Underlying Strategy Dimensions

A key question facing researchers is what dimensions should be used in grouping firms (McGee & Thomas, 1986; Cool & Schendel, 1987, 1988; Fiegenbaum, et al, 1987). This is more than a methodological issue because the dimensions chosen determine the conceptual nature of a particular grouping. There are certainly many to choose from. Porter (1980) lists thirteen dimensions along which strategic groups can be differentiated, including channel selection, product quality, vertical integration, cost position, service, etc. From a thorough review of strategic group studies, McGee & Thomas (1986) classify differentiating dimensions as market related strategies, industry supply characteristics, and firm characteristics. These categories are quite broad, including manufacturing processes, size, organizational structure, etc. In short, most characteristics of a firm can be argued to be the result of some strategic choice, and a mobility barrier of significance in some particular industries.

Perhaps this dilemma leads Cool & Schendel (1987, 1988) to assert that appropriateness depends on the specific industry being studied. They propose that at a minimum, dimensions specifying firms' scope and resource commitments are needed. Scope or domain commitments consist of 1) range of market segments targeted, 2) types of products or services offered, and 3) geographic reach. Resource commitments refer to priorities in outlays to functional areas which are key to competitive advantage in the targeted segment. Scope and resource commitments parallel McGee & Thomas' (1986) "market related strategies" and "supply characteristics." McGee & Thomas' "characteristics of firms" (e.g. size, organizational structure, management skills) appear more remote to the realm of competitive strategy.

This broad perspective poses a dilemma for this study. If process technology is relatively important to an industry, can it be treated as separate from strategy or is it part of strategy? Process technology could be considered a 'resource commitment' or 'supply characteristic,' a strategic dimension on which to define strategies, rather than to juxtapose with strategy as this study attempts. Strategic group rationale calls for grouping on dimensions which are mobility barriers; indeed Mascarenhas & Aaker (1989) assert that "group definition should be driven by mobility barriers, exit and entry barriers between strategic groups, rather than strategies" (p475). Manufacturing technology is a likely mobility barrier for many industries and thus should be part of strategy from the strategic group perspective.

However, one can also argue that process technology and strategy should be separated for the research question pursued here. First, there is no practical way to test for fit if they are not separated. This study's question could be framed as one resource commitment (manufacturing technology) needing to be consistent with scope commitments and other resource commitments. This perspective is compatible with the literature on manufacturing technology and strategy, but does not offer an objective way to judge fit. One could only evaluate the fit between process technology and other strategic dimensions by subjectively comparing observed relationships within a gestalt to theoretical, bivariate relationships (Venkatramen, 1989). The interaction of dimensions, which is key to the gestalt concept, is difficult to judge.

Second, the manufacturing strategy literature which poses the question for this study does not use "strategy" in such a comprehensive way. While the strategic grouping perspective includes every conceivable choice dimension, the manufacturing strategy literature generally uses strategy to mean current product-market strategy. Wheelwright (1984) provides the best summary of this usage by defining strategy as first, the choice of product-market segment to compete in, and second, the choice of competitive priority (e.g., quality, delivery, cost, service, etc.) to emphasize in order to attain advantage in the chosen market segment. Empirical support has been found for this conceptualization for use in strategy-technology research (Schroeder et al., 1989). This more restricted conceptualization still lends itself to strategic grouping methodologies such as cluster analysis within a single industry, but allows fit with technology to be evaluated. The question addressed is simply "Is technology consistent with current product-market strategy?"

Another consideration in choosing strategic grouping dimensions concerns current strategy versus strategic position, which is more a reflection of past strategic choices. Mascarenhas & Aaker (1989) assert that strategic grouping should focus not on strategic activities - "what we do," but on firm assets and skills, "what we are" (p484). Other strategic group research recognizes this issue but advocates a current strategy approach (Cool & Schendel, 1988; Lawless et al., 1988). Cool & Schendel (1988) reason that a firm's "stock of accumulated assets" constrains the effectiveness of current strategy or "flow" decisions. Firms grouped as similar in current strategy may differ in performance due to differences in appropriateness of accumulated assets. Lawless et al. (1988) use the same approach where profit performance is a "function of strategic group membership based on similarity in strategy, or flow variables, and firm capabilities, or stock variables" (p9).

The current strategy approach makes sense for this study. Process technology is an accumulated asset or stock variable which constrains the effectiveness of other aspects of current strategy. Application, however, is less clear cut. Cool & Schendel's (1988) "current strategy" grouping includes several dimensions which appear to be stock variables such, as cumulative R&D capital stock. Perhaps measures of the cumulative manifestations of past decisions are sometimes used as surrogates for current strategy where the alternative is forfeiture of important information.

3.1.5 Approach and Dimensions Chosen for this Study

The approach to strategy assessment taken by this study is an intra-industry perspective using strategic grouping techniques. Given the importance of current product-market strategy to our question, the strategic content of our model should include dimensions related to products, markets, and current strategic priorities as suggested by the manufacturing strategy literature as important (i.e. product quality, dependability, and consistency; volume and new product flexibility; quick and dependable delivery; low cost, and low investment (Hayes & Schmenner, 1978; Skinner, 1974, 1984; Stobaugh & Telesio, 1983; Swamidass, 1987; Wheelwright, 1984). Including Porter's dimensions covers products and market segments, and adds thoroughness to coverage of the strategy concept. Cool & Schendel's scope and resource commitment guidelines should be taken into consideration as a check. Table 3.1 shows the conceptual overlap of the strategic dimensions from the literatures noted above, and offers construct labels for use in this study.

3.2 Process Technology

Although "process technology" can be broadly defined to include the know-how, procedures, and hardware used in a firm's conversion process, literature usages predominately vary between emphasis on hardware or machines, and the procedures or the nature of the human activities which involve the machines. Know-how or scientific knowledge aspects are seldom emphasized, much of it presumedly embedded in machines and procedures. This study is implicitly more oriented toward hardware than procedures

Table 3.1

Strategic Grouping Dimensions

1. Product Characteristics	- Types of product offered [C&S]* - Product quality, consistency, & dependability [MfLit] - Product quality, brand identification [Port]
2. Product Variability	- Flexibility to make new products quickly [MfLit] - Technological leadership [Port] - Width of product line [Port]
3. Target Markets	- Range of market segments targeted [C&S] - Target customer segments [Port]
4. Geographic Range	- Geographic reach [C&S] - Geographic markets served [Port]
5. Service Priorities	- Ancillary services [Port] - Short delivery cycles; dependable delivery promises [MfLit]
6. Price Policy	- Price Policy [Port]
7. Operating Efficiency	- Low cost [MfLit] - Low cost position through cost minimizing equipment [Port]
8. Low Overhead	- Low investment [MfLit] - Low cost position through cost minimizing facilities [Port]
9. Value Stage Participation	- Resource commitments to key functional areas [C&S] - Vertical Integration [Port]
10. Output Variability	- Flexibility to adjust to volume fluctuations [MfLit]
11. Distribution	- Choice of distribution channels [Port]

*[C&S] = Cool & Schendel (1987); [Port] = Porter (1980); [MfLit] = Manufacturing strategy literature (i.e. Skinner, 1974; Hayes & Schmenner, 1978; Stobaugh & Telesio, 1983; Swamidass, 1987; Wheelwright, 1984).

(although the nature of either are quite interrelated) as this appears to be usage of process technology in most of the manufacturing strategy literature. It is also much more easily documented from a research perspective.

Given the importance of analyzing competitive strategy at the intra-industry level (Porter, 1980), differentiation of processes technologies within industries is needed. Yet characterization of process technology has not moved beyond the categories of job shop, batch, assembly line, and continuous flow (found in the works of Hayes & Wheelwright, 1979a; Abernathy and Townsend, 1975; Woodward, 1965). These types are too broad for meaningful use within industries. For example, the processes of all firms within a given industry might be "assembly lines" in a broad sense. Assumedly assembly lines vary on degree of flexibility, yet these typologies do not permit such differentiation.

Even such a differentiation is still fairly general. Many adjectives such as flexible, general purpose, uncoordinated, segmental, dedicated, complex, systemic, integrated, rigid, capital intensive, etc., are used to describe technology, but usage has stressed the unidimensional and unidirectional nature of technology (e.g., Abernathy, 1976; Abernathy & Townsend, 1975; Abernathy & Utterback, 1978; Hayes & Wheelwright, 1979a). Kotha and Orne (1989) do propose three underlying dimensions of mechanization, systemization, and interconnectedness, but see them as covarying such that a unidimensional typology based on "system complexity" results, the same dimension underlying Woodward (1965) and others' scales (Fry, 1982). Perhaps the apparent unidirectionality of these underlying dimensions results from efforts to generalize across industries.

Although these broad technology typologies are too generalized for use within an industry, there may be important conceptual dimensions that can be gleaned from them. Kotha and Orne's (1989) approach of characterizing process technologies by a number of underlying dimensions offers promise in establishing finer linkages. Perhaps their dimensions can be refined and added to such that most process technologies can be characterized by a combination of scores on these dimensions.

To begin examining such a course, it is useful to review the usage of the term "technology" by literature espousing the strategic importance of process technology. Much of this literature focuses only on computer controlled manufacturing technologies, although fit is conceivably relevant to a myriad of different process technologies. The distinctions range from "new versus old" (Blois, 1985; Meredith, 1987; Adler, 1988; Voss, 1986; Skinner, 1984), to "advanced versus conventional" (Dodgson, 1985), to "computerized versus non-computerized (Jelinek & Goldhar, 1983; Majchrzak et al., 1986), and even "post industrial, information intensive" (Jaikumar, 1986). Striking strategic implications (see Jelinek & Goldhar, 1983) might make this a worthy central focus of study.

However, despite this attention to computerized versus conventional process technologies, a more generalized and timeless approach would be to assess technologies along establish dimensions that can be combined to characterize these technologies. Even though dimensions such as "automation" have typically been applied on a cross industry basis as discussed above, one would expect that technology options within an industry can be differentiated on the same dimension, albeit a finer scale. The following subheadings relate to discussion of important underlying conceptual dimensions of process technology to be captured by this study. The chosen dimensions are also summarized in Figure 3.2.

3.2.1 Automation and Integration

A number of dimensions for assessment of technology are possible. The study of organization structure in relation to technology beginning with Woodward (1965) has resulted in measures such as automation and integration (Hickson et al., 1969; Child & Mansfield, 1972), changeability (Aiken & Hage, 1971), and scale (Blau, 1972; Collins & Hull, 1986). Automation and integration appear most relevant for this research.

Increased automation and integration is traditionally associated with process complexity, and less flexibility to produce a variety of products (Abernathy & Townsend, 1975; Hayes & Wheelwright, 1979a,b). However, computer controlled technologies disrupt this co-variation, and confound what is meant by automation and integration (Gerwin, 1981). Research has generally tended to use variations on Amber & Amber's (1962) scale of automation (e.g., Hickson et al., 1969; Collins, Hage, & Hull, 1988; Kotha & Orne, 1989) in which automation progresses from hand tools, to powered machines, to self-feeding, single cycle automatics, to automatics which repeat cycle (usually by mechanical or pneumatic devices), to self-measuring and adjustment, which these authors use to mean computer programmable technologies. But with programmable processes, automation no longer clearly inversely co-varies with flexibility. Jelinek & Goldhar's (1983) typology of independent tools and methods, programmable systems, flexible systems, and dedicated systems reflects decreasing flexibility, and thus places computer controlled systems before dedicated systems. Spur & Mertins (1981) present the same scale but in hardware terminology: stand alone NC machine tools, flexible manufacturing cell, flexible manufacturing systems, flexible transfer lines, and fixed transfer lines. Fixed transfer line corresponds to Jelinek & Goldhar's dedicated systems in that it consists of special purpose machines for a specific product, changeable only after considerable set up time (which by default seems to be mechanical, electro-mechanical, or pneumatic control automation).

In these last two scales, increasing integration results in decreasing flexibility. High automation (more computer control) together with high integration results in high process complexity which is less flexible (Kotha & Orne, 1989). However, Kotha & Orne (1989) also assert (as does Farley et al., 1987) that increased integration may make computer controlled technologies more flexible.

Perhaps this apparent dilemma is due to imprecise use of the term "flexibility." One possible type of flexibility is the ability to continuously take on the production of new products. Another is the ability to switch production back and forth between existing products. This second flexibility comes from low set up times, and is the hallmark of JIT (see Ohno, 1982). This distinction is not clearly made in most uses of 'flexibility' (e.g "variety of parts to made by the production system" - Jelinek & Goldhar, 1983; "number of different variants" - Spur & Mertins, 1981).

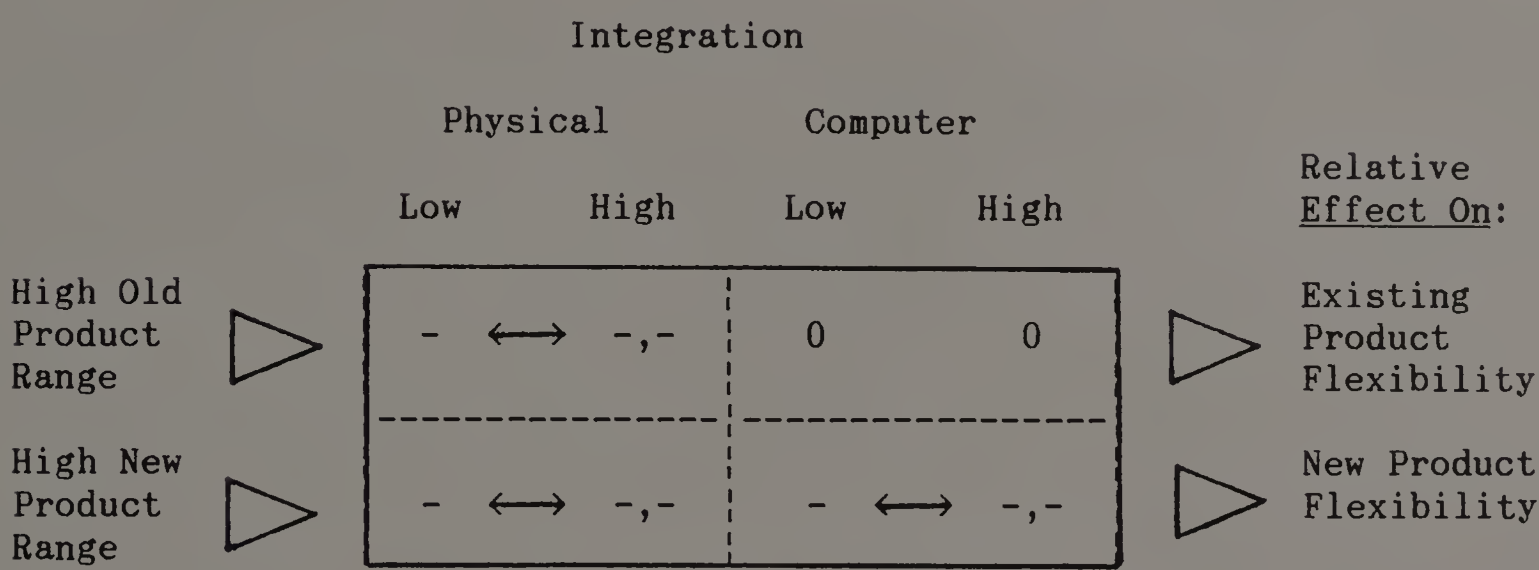
A case can be made for two types of integration which relate differently to these two types of flexibility: physical versus computer integration. Physical integration in pure form would be physical links such as materials handling equipment and work cells (physical grouping of different machines for specific products). This is the fixed transferline or rigid, systematic production system of Abernathy & Townsend (1975). Computer integration might also be termed electronic integration, and would refer to the electronic linking of different computer processing units or controls. Physical integration would likely inhibit the introduction of new products <u>and</u> the switching of existing products. Different jigs or machine arrangements might conceivably be needed for either type of product. Computer integration may also inhibit new product flexibility due to the cost of more complex programming of a larger network of computer controls to handle the processing and sequencing of a new part. Once programmed however, (i.e. now an existing product) switching back and forth between different products can be done quite quickly, with the touch of an electronic button.

A confounding factor is the "differentness" or "range" (size and processing requirements) of the variety of products to be produced. Outside the designed product range, computer integrated manufacturing systems are very inflexible (Blois, 1985). Unfortunately many works on computer controlled flexibility (e.g. Farley et al., 1987; Spur & Mertins, 1981; Jelinek & Goldhar, 1983; Kotha & Orne, 1989) do not discuss the nature of the different parts to be produced.

Conceptually sorting out the interaction of physical and computer integration, range of products, and new and existing product flexibility is difficult. Perhaps physical integration and the physical range of machines would be better labeled degree of "general purposeness." One can perhaps hypothesize that high new or existing product range (differences in processing requirements) has less negative impact on flexibility if process equipment is general purpose as opposed to dedicated. Dedicated, highly specific processes are either unable to handle very different new products and/or lots of adjustments and special tooling will be needed to switch production to very different existing products. Stated another way, new and existing product flexibility will be more adversely affected by high product range when processes are highly specific.

High existing product range should have little impact on flexibility for either low or high computer integration. Once programmed, it is just as easy to switch back and forth between highly different programs. High range in new products would have more of an impact (negative) on flexibility for high computer integration as opposed to low computer integration. Initial programming for a complex, integrated system would likely be more difficult and/or time consuming if the parameters of the new product were quite different from other products due to less learning curve benefits and/or sharing of program sub-routines.

The relative effects of product range and integration on flexibility just described are summarized below in Figure 3.1 below:



* Note: The double arrows indicates that comparison of impact magnitude is only relevant within a pair. The relative impact magnitude across the chart is uncertain.

Figure 3.1

Effects of High Product Range on Product Flexibility Under Conditions of Physical and Computer Integration

In these tentative relationships, high product range is seen as differentially moderating the impact of integration (physical or computer) on flexibility (new or existing product). In most situations, physical and computer aspects are mixed making the prediction of outcomes very difficult. In addition, these constructs are tentative. It may turn out that physical and computer integration almost always strongly co-vary. However, work cells is physical integration that seems to have little to do with computer integration. A DNC network (downloading programs to individual machine tools via a centralized computer network) is at least one case of computer integration that seems unrelated to physical integration.

Given the uncertainty surrounding the constructs just discussed, and the ambiguity of the literature treatment of flexibility, integration, and computer and mechanical automation, it may be difficult to extract these constructs in isolation. However, this discussion has shown that measures of computer and mechanical integration, product range, and new versus existing (repeat) products, may be important in relating technology to strategy. Factor analysis may reveal empirical overlap. This is consistent with the objective of examining the nature of fit.

3.2.2 Range of Capabilities

Not every process technology has the same breadth of capabilities. Capability to handle a variety of part sizes was alluded to above. This "general purposeness" in physical range applies to major process equipment (such as machine tools) as well as connecting equipment. It is conceptually different from integration although usually negatively related in practice. For example, the integration of Abernathy & Townsend (1975) is associated with dedicated systems with less range for new products. Integration in a pure sense restricts flexibility because of process flow patterns that are difficult to adjust or change for different products. However, within a particular integration pattern, connecting conveyors, pallet changers, or robots themselves have a physical range or degree of specificity for the parts they can handle.

Range of capabilities can also include things other than physical range such as range of precision and range of movement. CNC machine tools vary in number of axes (direction) of machining movement. Some parts cannot be made without the complex shaping movements allowed by greater number of axes.

Greater range allows firms to produce products of a broader size or configuration range. A firm in the machining and tooling industry reported that it used machines just adequate for the job rather than more costly "cadillac models" with many extra features which just add to the cost (Schroeder et al., 1988). This dimension should capture some of the cost/benefit tradeoff given the higher cost of multi-capability manufacturing technologies.

3.3 The Concept of Fit

Venkatramen & Camillus (1984) have described the concept of "fit" in strategic management as essentially specifying contingency relationships in matching various components related to strategy. However, the usages of fit can vary depending on whether a content or a process conceptualization is used, and on whether the external and/or internal domain is addressed (Venkatramen & Camillus, 1984). In such a framework, this dissertation research belongs to what Venkatramen & Camillus call the "Strategy Implementation School" because it focuses on the content issues of the alignment of internal factors. In this study, the alignment is between strategy and process technology.

In a later work, Venkatramen (1989) reviews various theoretical usages of fit and discusses analytical issues appropriate to each. He sees six types of fit, varying in degree to which the relationship's functional form is specified, and whether fit is anchored to a particular criterion such as performance. This study will conceptualize fit in two of these ways.

First, fit will be conceptualized as "gestalts" (Venkatramen, 1989), a limited set of viable combinations of strategy and technology dimensions. If "fit" between process technology and strategy is important, variations in technology within an industry should coalesce around different strategic positions, each of which maximizes the advantages of its particular process technology. Over time, firms which least take strategic advantage of their process technology either fail, change strategies, or change process technology. An interpretable pattern of significant technology differences between groups would be evidence of such a process. This conception of fit is not directly linked to a criterion such as firm performance, although performance in the broad sense of survival is assumed to be manifest in current strategy-technology patterns.

Second, fit will also be conceptualized as "moderation" (Venkatramen, 1989), in which process technology moderates the relationship between strategy and performance. Accumulated technology which is less appropriate for a particular strategy or strategic group should result in higher risk and poorer performance. This is conceptually consistent with work by Cool & Schendel (1988) and Lawless et al. (1988) in which appropriateness of accumulated assets or capabilities, respectively, moderate (at the firm level) the relationship between strategic group membership and financial performance.

This study will examine both conceptions of fit. Fit as a gestalt gives us a basic indication of alignment between strategy and technology. Fit as moderation is what Venkatramen calls "criterion-specific" because fit is manifested as correlation between the criterion (performance) and the interaction of moderator (technology) and predictor (strategy) variables. As such, this conception of fit is perhaps the more powerful by requiring that fit be related to the bottom line of firm performance.

3.4 Performance

As the time test any strategy, performance is an issue that strategy researchers cannot avoid. (Schendel & Hofer, 1979). Cameron (1980) identifies four broad conceptualizations: (1) Goals - attainment of explicit organizational goals (e.g. Etzioni, 1964), (2) Systems - organizations as natural systems, ability to obtain resources, survive, grow (e.g. Yuchtman & Seashore, 1967), (3) Internal Processes - smooth, integrated, controlled, harmonious, internal processes (e.g., Steers, 1977), and (4) Constituents - satisfaction of stakeholders, internal and external (e.g., Thompson, 1967). Cameron notes that all have flaws, and appropriateness depends on the situation.

Strategic management research appears to prefer quantitative measures, such as financial and operational data. A survey of performance measures in strategic management research found fourteen quantitative measures typically used (Woo & Willard, 1983). Factor analysis revealed four underlying factors: profitability (highest factor magnitude), relative market position, change in profitability and cash flow, and growth in sales and market share. Chakravarthy (1986) used Peters & Waterman's (1982) and Fortune rankings of computer firms to test accounting measures, financial market indicators, and composites such as Z factors (Altman, 1971; Argenti, 1976). He concluded they were inadequate.

He derived his own discriminant function from measures (financial and operational, - much the same as those identified by Woo & Willard) of "adaptive specialization" (exploiting current environment) and "adaptive generalization" (improving or investing to meet uncertain environments). He concludes that his function measures ability to generate slack resources (e.g. profitability), and investing this slack in the future (e.g. R&D). In Chakravarthy's work, one sees elements of the constituent conceptualization (profitability for stockholders) and the systems conceptualization (slack resources, ability to survive).

Our proposed model will use a systems conceptualization, which includes the ability to generate slack resources (profitability) and the ability to grow (sales growth). This conceptualization is chosen because most of the literature which suggests performance implications for technology-strategy fit refers to or implies profit performance (Kotha & Orne, 1989). In addition to theory and/or precedent, there are certainly pragmatic reasons to chose a particular conceptualization, which depend on the industries studied or the nature of the study.

3.5 The Strategy-Process Technology Model

The Strategy-Process Technology Model presented in Figure 3.2 visually summarizes the underlying dimensions discussed in this chapter and chosen for this study, as well as the hypothesized relationships between the constructs. Process technology consists of the underlying dimensions of automation, physical integration, computer integration, and range of capabilities. Strategy consists of groups of firms which have relatively similar product characteristics and product variability, similar target markets within a similar geographic range, similar service priorities and price policies, and similar positions on strategic dimensions of operating efficiency, overhead, value stage participation, output variability, and distribution. Different dimensions might be relatively more important depending on the industry context. Performance is primarily a combination of profitability and growth.

In this model, the interaction or "fit" (as moderation) between process technology has an impact on firm financial performance beyond or in addition to that of strategy and process technology by themselves. Another way of stating this is that process technology moderates the relationship between strategic group membership and performance. Being in a strong, high performing strategic group may not automatically provide high returns for a firm in that group if its technology does not provide necessary capabilities with reasonable cost effectiveness.

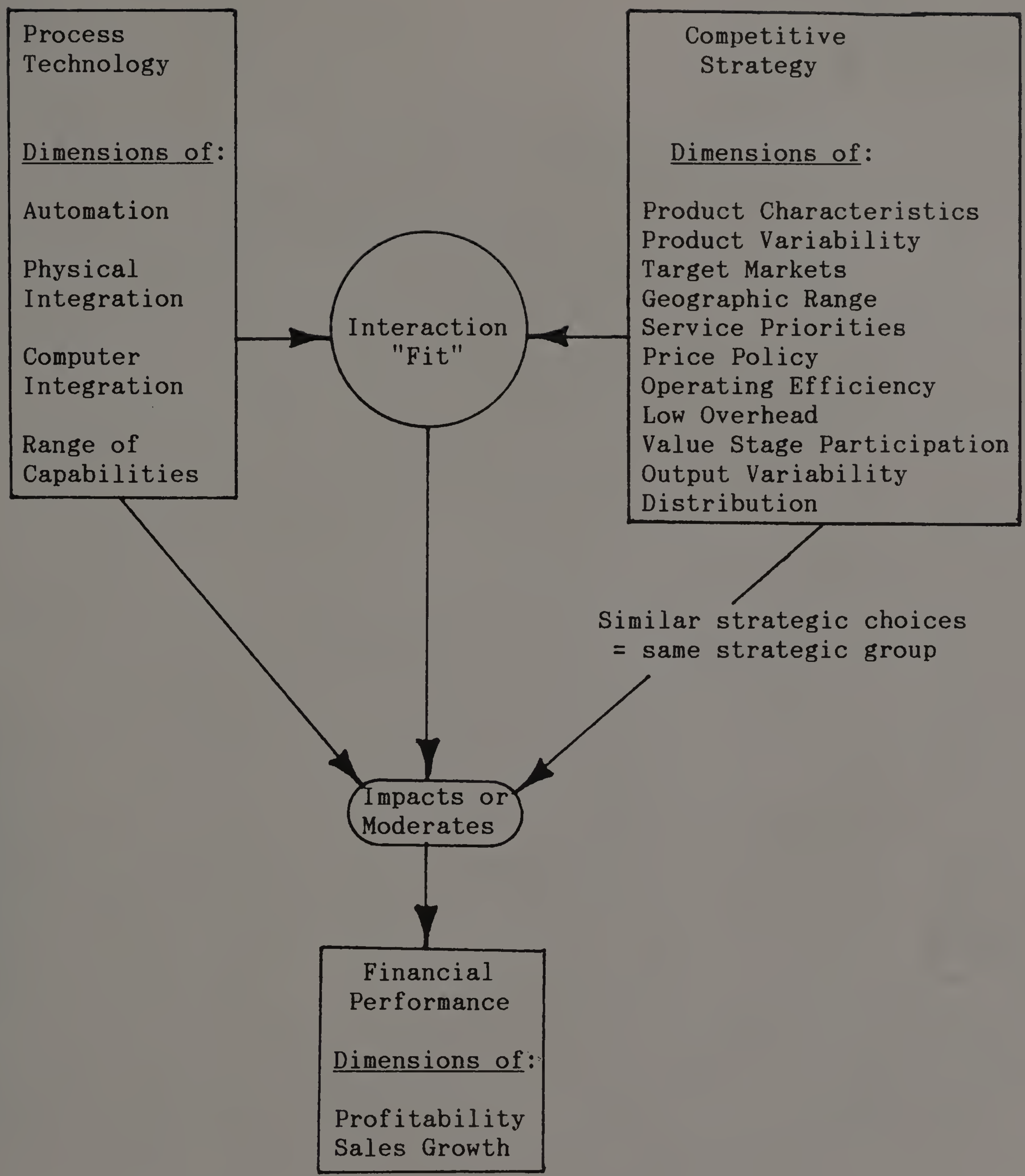


Figure 3.2

Strategy-Process Technology Model

CHAPTER 4

METHODS

This chapter presents the methods used to test the model of strategy-process technology fit presented at the end of Chapter 3. The U.S. tooling and machining industry was selected as a test environment for reasons discussed later.

This chapter starts by presenting four hypotheses used to test the model. Following the hypotheses are details on the sample, instrument, data collection, and data analysis.

4.1 Hypotheses

The hypotheses tested are detailed below. Following each hypothesis is text explaining its underlying rationale. The first two hypotheses (H1 & H2) examine relationships between specific dimensions of technology and strategy that are expected to provide insights into the nature of fit. H3 and H4 are the main focus of the model. They deal with the existence of significant technology differences between strategic groups (H3), and whether fit positively relates to performance (H4).

H1) Use of more automated, integrated process technologies will be positively associated with strategies which minimize new product introductions and/or variations in existing products.

Product-process life cycle research (e.g., Abernathy, 1975: Hayes & Wheelwright, 1979a,b) concludes that progression toward automated, integrated process technologies is related to product standardization and high product volume. For the machining and tooling industry, the equivalent to standardization is repeat orders while the equivalent to high volume is the pursuit of large batch sizes. Batch size and repeat orders are expected to be positively correlated with degree of automation and degree of integration of process technology.

This hypothesis extends the work of Abernathy and Townsend (1975) in a key way. The Abernathy tradition views the complexity, systemization, automation, etc., of processes in an absolute sense. This perspective is revealed, for example, in Hayes & Wheelwright's (1979b) discussion of industries which have stalled in the evolution toward assembly line and continuous flow processes. This perspective emphasizes the physical characteristics of the process technology rather than its relation to a particular competitive arena. It is probably from this same perspective that computer controlled processes are often hailed as the "flexible," nearly as efficient, alternative. Inherent in H1 is the idea that the concepts of automation, integration, systemization, and product standardization are also relevant within a specific competitive context, such as an industry. For this industry, computer controlled machine tools are not the flexible alternative, rather they represent automated efficiency.

Support for this relationship has been found in the tooling and machining industry. An exploratory study (Schroeder et al., 1988, 1989) found the overhead costs of programming CNC machine tools, computerized materials handling systems, CNC inspection devices, etc., makes very small batches prohibitive. Less directly related, a study of CNC usage by metalworking firms in the U.K. found that firms with smaller batch sizes and more unpredictable production had more versatile, multi-tasked operator job arrangements (Dodgson, 1987). The study speculates that more flexible work organization was needed to deal with more "exceptional cases" (such as more frequent programming and set-up changes). Unfortunately, this evidence is more related to procedures aspects of process technology than machine aspects as is our study.

H2) Firms will use a technology if it provides special capabilities for a key strategy dimension, despite possible negative consequences with regard to less critical strategic dimensions.

Firms will use given process technologies despite unfavorable trade-offs such as low efficiency if the technology provides capabilities key to their strategy or for serving their market segments. This is not to say that negative trade-offs will be overlooked, but that such firms will tolerate greater negative impact on a particular strategic dimension than firms whose strategies do not benefit from offsetting capabilities afforded by a particular process technology. This assumes that various capabilities are often bundled in one process technology, and that there are increased costs for the more capable technology.

In this industry, even though process automation is expected to correlate positively with pursuit of large batch sizes, process automation should also correlate positively with firms producing small batch sizes if they also pursue high precision (consistency and close tolerances). CNC machine tools, which represent automation for this industry, are said to yield higher tolerances and consistency (Jelinek & Goldhar, 1983; Voss, 1986), and thus should provide an important capability to firms targeting such market segments.

H3) Process technology (levels of automation, physical integration, computer integration, and range of capabilities) will differ significantly between strategic groups.

This hypothesis tests the proposition that, within an industry, a given process technology will be differentially appropriate for different strategies. The general validity of this hypothesis will be inferred from theory as discussed earlier combined with the assumption that strategic groups have survived to a degree based on the viability of their structural whole. If process technologies are closely linked to strategy, as the literature suggests, variations in technology within an industry should coalesce around different strategic positions, each of which maximizes the advantages of its particular process technology. This assumes that significantly different technologies are available and that some kind of price/performance tradeoff exists between them (e.g., capital costs, or the frequently noted efficiency versus flexibility). Over time, firms which least take strategic advantage of their process technology either accept lower returns, fail, change strategies, or change process technology. A pattern of significant technology differences between groups is evidence of this process, and demonstrates the existence of fit as a "gestalt."

H4) Interaction between process technology and strategic group membership has a significant impact on firm financial performance beyond that of process technology and strategic group membership alone.

This hypothesis goes beyond H3 by looking more directly at the manifestations of lack of fit. Rather than failing, some firms with poor fit may continue operations indefinitely by accepting low returns. H4 tests for the existence of fit (as moderation) which is directly linked to firm performance, in essence, whether the relationship between strategy and technology is strong enough to result in current performance differences between firms. This is the primary research question with respect to competitive strategy and manufacturing technology (Kotha & Orne, 1989).

If a lack of "fit" between current strategy and accumulated process technology moderates the relationship between strategy and performance as our model suggests, a poor match should result in lower profitability and/or sales growth. Firms which have inappropriate process technology (levels of automation, physical integration, computer integration, and range of capabilities) are expected to be suffering relative to competitors due to excessive capital costs, poor production efficiency, lack of capabilities important to customers, etc.

4.2 Sample

The industry studied is the contract tooling & machining industry. This industry was chosen for its (1) highly competitive nature, (2) the recent introduction of new process technologies, (3) relatively clear cut distinctions in manufacturing technologies, (4) a background understanding by the author from previous research, and (5) opportunity for field survey and research.

The tooling and machining industry is composed of approximately 11,000* small firms producing a near infinite variety of machined parts, machining services, tooling, dies, molds, jigs, fixtures, etc., for a variety of customer industries such as automotive, computers, and aerospace. Most firms are "job shops" in that they produce parts to customers' specifications on a bid/contract basis. Most firms fall under SIC codes 3544 (special dies, tools, jigs, and fixtures) and 35595 (machine shop jobwork).

These firms are predominately privately owned and small to medium in size. The National Tooling and Machining Association (NTMA), the primary trade association for the industry, reports the following size distribution (Table 4.1) for the entire machining and tooling industry and average sales per firm for NTMA members. All figures are for 1979:

Table 4.1

Size Distribution Data for Tooling and Machining Firms

Employees per Firm	% of Total	Ave # of Emply/Firm	Ave Sales per Firm
1-19	48%	10	$ 494,800
20-49	32%	30	1,332,400
50-99	14%	68	3,541,700
100-249	5%	144	7,562,300
250-499	1%	332	19,576,700
500+	0%	-	-

*"Industry Census of the Contract Tooling and Machining Industry, 1979-1980," by the National Tooling and Machining Association, 9300 Livingston Road, Washington, DC, 20022; published January 1981.

Customers of contract machining and tooling shops are quite diverse. Almost any firm that uses some kind of metal parts are potential customers. Table 4.2 shows that the Automobile and Aerospace industries are by far the largest customer types. The large share of "All Other Customers" (13.4%) is indicative of the diversity of the markets served by this industry.

Table 4.2

Tooling and Machining Customers

Customer Industries	Percent Total Sales (1979)	(1980 est.)
Automotive	20.9	17.9
Aerospace	14.6	16.8
Fabricated Metal Products	10.1	9.6
Electronics	9.5	10.1
Machinery, Parts & Acces.	8.0	8.0
Appliances	4.8	4.7
Mining, Construction & Oil Field Equipment	4.7	4.9
Ordnance	3.2	3.7
Food Processing & Packaging	2.8	2.7
Chemical and Petroleum	2.5	2.8
Electrical Machinery	2.3	2.2
Agricultural Equipment	2.3	2.2
Pharmaceutical	0.8	1.0
All Other Customers	13.5	13.4

The sample population for this study is drawn from the 3,180 member firms of the National Tooling and Machining Association (NTMA). The NTMA provides services such as lobbying, seminars and workshops, training assistance, and group insurance. A 1980 survey by the NTMA (footnoted above) of the tooling & machining industry concludes that non-members are not significantly different from members on a variety of characteristics such as size, geographical dispersion, sales, and market segments served.

This study did not survey firms under 15 employees because the construct of competitive strategy becomes more tenuous, and the impact of individual machine tools becomes too preponderate in very small firms. Such a segmentation reduced the relevant sample population to 1577 firms, all of whom were sent surveys.

4.3 Instrument

This study used a mail survey questionnaire to assess strategy, technology, and performance of NTMA member firms. Survey analysis offers the potential to capture more of current or intended strategy (Dess & Davis, 1984) than would data base studies typical of most strategic group research.

4.3.1 Development

The survey instrument was developed jointly with Dr. Dean M. Schroeder who, along with the author, has extensive background knowledge of the industry from prior research. Expert feedback regarding format, wording, and variables missed, was received from industry experts at the NTMA and the Massachusetts Small Business Development Center Manufacturing Assistance Program. A copy of the questionnaire is contained in Appendix A.

4.3.2 Measures

Measures were developed for the three major constructs of strategy, technology, and performance. Most measures were either ratio, or interval, such as Likert scales. Objective measures were used as much as possible. Where subjective Likert scales were used, the instructions clearly related the question to the total sample to preclude responses based on the more limited reference frame of direct competitors, such as those of the same strategic group.

4.3.2.1 Strategy Measures

Table 4.3 relates theoretical dimensions from the model (Figure 3.2 and Table 3.1) to corresponding survey measures. Measures are briefly described, and are referenced to specific questions from a copy of the questionnaire provided in Appendix A. The actual dimensions used in the analysis will be determined by principal factor analysis of the strategy measures. The degree to which the strategy factors correspond to the theoretical dimensions of Tables 3.1 and 4.3 will demonstrate the validity of the factors.

Table 4.3

<u>Strategic Grouping Measures</u>

Dimensions	[Quest #]	- Survey Measures
1. Product Characteristics	[1]	- Categories - jigs, molds, dies, etc.
	[2abc]	- Complexity, size, precision
	[3]	- Tolerance ranges sought
	[19bc]	- Close tolerances and consistency
2. Product Variability	[2d,5]	- New vs. repeat products
	[2f]	- Similar vs. different products
	[2d,4]	- Batch sizes sought
	[19h]	- Importance of ability to make a wide variety of different products
3. Target Markets	[2h,7a]	- Growing vs. declining markets
	[7b]	- High vs. low tech industry
	[7c]	- New vs. repeat customers
	[7d]	- Government related
	[9]	- Customer industry categories
	[10]	- Contract vs. proprietary products
	[15]	- Actively seek new customers
4. Geographic Scope	[8]	- Sales locally, regionally, nationally, internationally
5. Service Priorities	[6]	- JIT deliveries, SPC for customers
	[19d]	- Verifiable quality assurance
	[19ef]	- Quick turnaround from order to delivery; dependable delivery dates
	[19k]	- Frequent contact and close customer relations
6. Price Policy	[14]	- Lowest bidder vs. cost plus
7. Operating Efficiency	[11]	- Low cost vs. differentiation
	[19a]	- Importance of competitive pricing
8. Low Overhead	[17]	- Low capital cost vs. state-of-art efficient technology
9. Value Stage Participation	[12]	- Design function - strictly customer blue print vs. design participation
	[19ij]	- Value added from engineering & design; extra processing (assembly)
10. Output Variability	[19g]	- Importance of being able to accommodate fluctuations in orders
11. Distribution	N/A	

4.3.2.2 Process Technology Measures

Research on this industry indicates that because of the wide variety of products made in relatively small batches, few dedicated, integrated, electro-mechanical-pneumatic controlled systems are used (see Schroeder et al., 1988, 1989). The range of technologies used results in a truncated Jelinek & Goldhar (1983) scale of independent tools and methods (stand alone, manual machine tools) to programmable systems (CNC machine tool groups). This represents a progression of increasing automation and decreasing flexibility due the overhead costs of programming each new part. Firms in this industry typically report it quicker to just start manually machining a single part from blue print than to take the time to program all the machine moves. Automatic tool changers, multiple spindles, and automatic monitoring devices are features that further automate CNC machine tools. Automatic tool changers may increase flexibility for products within a range handled by the various tools.

For this industry, physical integration comes in the form of machine tool groupings (work cells), robotic parts handling between machines, connections with other work cells and/or inventories via material handling systems. Computer integration takes the form of DNC networks (centralized, electronic program loading of machines) and integrated CAD/CAM systems.

Two important capability ranges are multi-axis machines machine tools, and the size range accommodated by machine tools. Multi-axis machines allow a wider range of movement and more complex shaping. Sizes accommodated by machine tools is important in determining what type of products can be made.

These technology attribute measures have been grouped below in Table 4.4 for conceptual purposes, but one can see that they overlap. Materials handling systems as well as CAD/CAM also represent automation. Factor analysis will help determine overlap and arrive at factors meaningful for comparison with strategy. The ultimate test of how these variables fall within our technology construct will be determine by factor loadings.

4.3.2.3 <u>Performance Measures</u>

Objective measures of performance are sometimes difficult to obtain from owners of privately held firms typical of this industry. For this reason, this study asked for subjective measures in addition to objective measures. Dess & Robinson (1984) first demonstrated the viability of subjective measures of financial performance by finding that, within industries, subjective ratings of performance

Table 4.4

Technology Measures

[Quest #]	Survey Measures
1. Automation	
[20]	- % sales on CNC, NC, & Conventional machine tools
[27a]	- Multi-spindle machine tools
[27b]	- Automatic tool changers
[27cde]	- Automatic monitoring devices
[27f]	- CNCs set up to run unattended
[27h]	- Automatic parts changing
2. Physical Integration	
[21]	- Percent machine tools arranged by machine process, in work cells, line fashion, or no arrangement
[27i]	- Material handling equipment
3. Computer Integration	
[27abc]	- CAD/CAM systems
[27d]	- DNC networks
4. Range of Capabilities	
[22]	- Size ranges accommodated by machine tools
[23c,25c,27g]	- Secondary or extra capabilities on machine tools
[25f,26]	- Axis range of CNC machine tools

by top managers correlated highly with objective measures such as return on assets and growth in sales. They suggest that researchers consider using subjective measures where accurate objective measures are unavailable, and the only alternative is to remove performance from the research design. This study represented such a situation.

4.3.2.3.1 Profitability

Deficiencies of accounting measures of profit performance are well documented (Chakravarthy, 1986; Fisher & McGowan, 1983; Salamon, 1985; Schwartzman, 1975; Stauffer, 1975). This is especially true in small firms, where variations in owners' compensation can cause relatively greater distortions of profit measures. Reliance on accounting measures of assets also causes problems in profit measures. A major machine tool can be a relatively significant asset for a small firm. Return on assets or investment (and return on sales to a lesser degree) can be distorted by differences in depreciation schedules and the size of the asset bases. A firm with new equipment may be well positioned for the future, but show lower profitability than a firm with old, fully depreciated equipment. This distortion is somewhat offset by a phenomena where new technology has a relatively greater positive impact on performance in firms with newer productive asset bases (Dertouzos et al., 1989). If new technology generally results in higher "real" performance, the favorable performance distortions of firms with older, more fully depreciated asset bases will be somewhat offset by their relatively lower real gains from new technology.

Consequently, subjective measures of profitability were obtained in addition to objective measures. For an objective measure, firms were asked to categorically indicate average return on sales over the past three years [Q39]. Subjective measures were obtained by asking firms to rate themselves, relative to competitors over a three year period, on return on investment [Q35], return on sales [Q36], and overall performance [Q39]. Subjective measures of return on sales should suffer less from asset distortions than return on assets. Average return over a three year period should also smooth distortions from asset lumpiness.

4.3.2.3.2 Growth

Growth should provide a good complement to profitability given the measurement problems discussed above. Growth has its own problems for this industry as many owner/managers may not want employee growth beyond their ability to manage. Sales growth should suffer less from this limitation than a measure of employee growth. Sales growth over three years was assessed subjectively, relative to competitors [Q37], and objectively by asking for annual sales volume from 1986 to 1989 [Q40].

4.3.2.3.3 Controls

To control for spurious effects on performance, data was collected on firm size [Q34], region [Q33], and customer industries [Q9].

4.4 Data Collection

4.4.1 Mailing and Response Rate

A computer mailing list was provided by the NTMA. This was reduced to 1577 firms by eliminating firms of under 15 employees (as noted previously). The mailing followed much of Dillman's (1978) "total design method" for achieving high response rate, such as envelopes with first class postage and typed addresses, self-addressed, postage-paid, return envelopes, individually addressed cover letters, different type styles for questions and answers, etc. The NTMA logo was also included on the questionnaire cover. Each questionnaire included a cover letter to stimulate interest, and explain the NTMA's support of the survey (sample cover letter in Appendix B).

In December 1989, local NTMA chapters were instructed by the national NTMA to notify members to expect the questionnaire and request their assistance. The first mailing was sent in December, resulting in 468 responses.

The second mailing in January 1990 drew 208 responses, for a total of 676 responses and a 43 percent response rate. This is a high response rate for this industry, comparing favorably with a rate of twenty percent typically achieved by the NTMA with its annual questionnaire.

4.4.2 Data Coding

Data coding included judgments concerning missing data, apparently errant data, and combining responses to form composite variables.

Non responses were, for the most part, coded as missing values. Only for questions 27 and 28 were non-responses coded as not having the technologies in question. Most surveys gave partial responses indicating that the questions had been read. It was assumed that a non-response probably indicated non-familiarity with the term, most likely the result of not having the technology.

Questions 27 and 28 were part of a group of questions that were segregated as not applicable to firms without CNC equipment. A few firms which had 100 percent conventional technologies answered these questions anyhow, and indicated that they did have things like CAD systems and automatic gaging. Segregation may have distorted the results on these particular measures, but not too severely as few firms were

100 percent conventional. Any firms with even a little NC or CNC had been instructed to answer this section.

A fairly significant amount of non-response was seen for the subjective measures of performance [Q35-38]. Many respondents noted on the instrument that they did not know other firms' performance. Apparently, this industry is too fragmented for firms to have a good sense of overall industry performance. Lower than expected correlations between subjective and objective measures of return on sales [Q39] and sales growth [Q40] (0.57 and 0.30 respectively), along with the comments of respondents, lead to the conclusion that the subjective measures should not be used. Fortunately, excellent response rates were obtained on the objective measures.

Apparently errant results were seen on the contract and proprietary questions [Q10], which were expected to be mutually exclusive, and together, totally inclusive (sum to 100 percent). Yet approximately twenty-nine percent of the responses did not sum to 100 percent. The NTMA agreed with our suspicion that the "term" contract had been misunderstood. Telephone calls to six firms of this response type confirmed our interpretation. Most said that to them, "contract" has a more narrow usage as a one time contract agreement. They use "purchase order" to refer to ongoing contracts. The calls also indicated that the expression "proprietary products" was clearly understood. Accordingly, contract responses were changed so that a total with the proprietary product question would equal one hundred percent. The two questions were then combined into one variable called "contract" with a value of 100 percent for purely contract firms.

Like the contract variable, other measures were combined to form new variables. For the tolerances [Q3], batch size [Q4], and machine axis [Q26] questions, the category means were weighted by corresponding response percentages and summed to result in mean scores for each variable. For customer location [Q8], category weights of one through four were multiplied by response percentages and summed to form a variable reflecting increasing geographic dispersion of customers. Questions 20 and 21 were treated similarly to form variables reflecting increasing automation (essentially more CNC), and increasing integration (essentially more dedicated machine arrangements). The return on sales categories [Q39] were weighted on scale of 1-9 to reflect increasing profitability. A variable for sales growth (referred to above) was formed calculating the average annual sales growth from the sales volume figures [Q40]. Figures were calculated even if one end value was missing, resulting in a two year average for 30 cases. This resulted in a 93 percent response rate on the performance questions (Q39 and Q40) for the questionnaires returned.

Two measures, batch size [Q4] and firm employment [Q34b] were adjusted with log transformations to more accurately reflect their theoretical content. For example, the difference between 1 part and 50 parts is generally much more important than the difference between 500 and 600 parts, although the later is greater in absolute terms. The log transformation puts less emphasis on the higher end of the scale, more accurately reflecting the meaningfulness of the differences. Evidence of this is seen in the product-moment correlations between the subjective [Q2e] and the objective [Q4] measures of batch size. One would expect the subjective measure to better reflect the importance of batch size differences. With the log transformation, the correlation between the subjective and objective measures increased from 0.56 to 0.65. Similar logic was used for the log transformation of firm size.

The overall result of the coding process was a data base with essentially interval scale ratings (1-7), or ratio scale responses and indexes.

4.4.3 Sample Refinement

Because the survey instrument was designed to assess metal cutting technologies, refinement of the sample was needed to focus on firms with such operations. Although metalcutting processes are the mainstay of the industry, firms of quite different nature often seek membership in the NTMA for a variety of reasons. This nature was judged by the products firms produce [Q1]. Products such as metal stamping, jigs, fixtures, gages, special dedicated machines, involve numerous technologies such as stamping presses, welding, handtools, etc., which are neither conventional nor computerized metal cutting technologies, and are too varied to assess. Screw machine products are metal cutting in a technical sense but the ultra-high volume, dedicated nature of these technologies set them apart from most metal cutting processes.

To focus the sample, only firms for which at least 80 percent of their output is derived from metal cutting processes were retained. Products judged to be derived from metal cutting processes are dies, molds, machined parts, and machining services. Written responses to the "other" category were distributed to the metal cutting categories where judged appropriate. This refinement in sample focus reduced the relevant sample from 676 to 399 firms.

4.5 Data Analysis

While figure 4.1 presents the general data analysis framework for the Strategy-Process Technology model which relates primarily to Hypothesis 4, the other three hypotheses draw on the preliminary steps of this framework as well.

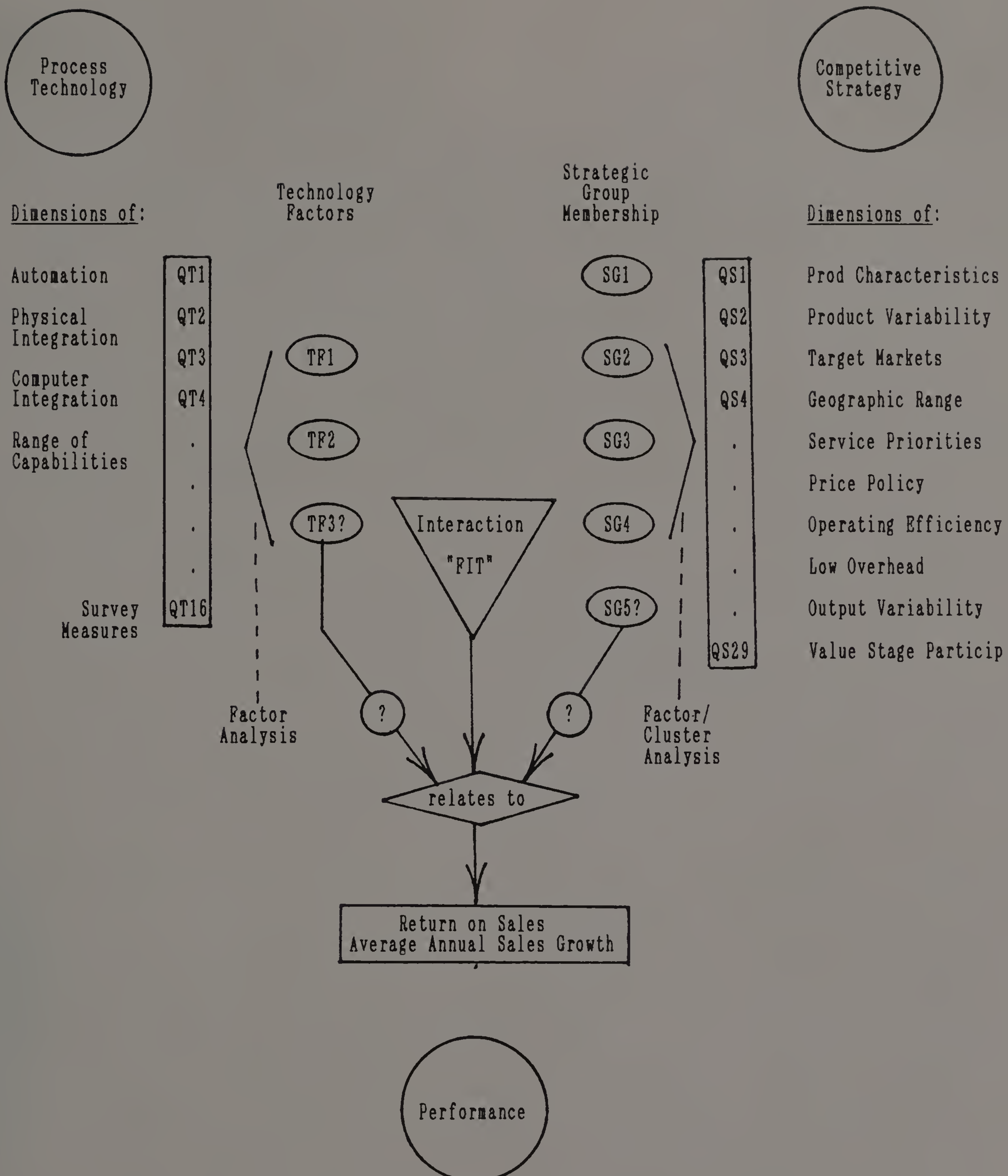


Figure 4.1

Analysis for the Strategy-Process Technology Model

Technology and strategy measures were factor analyzed to reduce measurement overlap, and reveal major underlying dimensions. Cluster analysis on the resulting strategy factors grouped firms with like strategies. This last section of the methods chapter discusses the factor and cluster analyses. Models drawing on the resulting factors and strategic groupings to test specific hypotheses are outlined in the following chapter on results.

4.5.1 Technology Factor Analysis

To assess a firm's "technology," it was necessary to reduce the dimensionality of the measures to some workable number, as well as see if they naturally grouped around underlying dimensions. From a theoretical standpoint, it seemed reasonable to expect that firms' process technologies would vary on more than one underlying dimension. Such factors could be compared to the underlying theoretical dimensions proposed earlier.

First, the relevant technology measures were identified. Because this study retained a hardware focus, questionnaire items that dealt with usage issues were not included (i.e., Q24, Q27f, Q28e, Q29-Q32). These measures were included in this survey instrument as part of another study. In addition, questions 25b,d,e were not included because they deal with cost and depreciation rather than the technologies used. Questionnaire items 27c,d,e deal with hardware, but were judged as not on the same level of relevance as the other items. The remaining sixteen technology items yielded a score of 0.63 for Kaiser's measure of sampling adequacy (for factor analysis). This is considered "mediocre," but adequate for factor analysis (Kaiser & Rice, 1974).

The principal factor method was used to extract the factors. Six of sixteen potential factors had eigenvalues above one, but a scree plot did not indicate a definitive cut-off point. Rotations were then run on the 3,4,5, & 6 factor solutions. Although explaining only 44.3 percent of the total variance, a four factor solution was chosen for interpretability, parsimony, and for best aligning with the theoretical underlying dimensions proposed earlier. Five and six factor solutions did not relate well to theory, and were not as readily interpretable. In addition, subsequent analysis would have been rendered very cumbersome. Factors of the three factor solution were not interpretable, and explained even less variance than the four factor solution.

Promax oblique rotations were used. It was felt that interpretability would be enhanced, and that the factors would better reflect reality. As discussed earlier in chapter 3, the theoretical dimensions of technology are expected to be somewhat interrelated. However, one can see from the inter-factor correlation matrix below (Table 4.5) that overlap is not consequential:

Table 4.5

Technology Factor Inter-Correlations

	Factor1	Factor2	Factor3	Factor4
Factor 1	1.00	-.01	.19	.12
Factor 2	-.01	1.00	.09	.10
Factor 3	.19	.09	1.00	.07
Factor 4	.12	.10	.07	1.00

The resulting factor loadings are displayed below in Table 4.6. The major contributing measures to each factor are grouped together along with the name ascribed. Cronbach Alpha coefficients were calculated within each group to provide reliability estimates for each factor. These estimates essentially hover around the .50 level which is considered at least adequate (Nunnally, 1967).

Table 4.6

Technology Factors

	Factor 1	Factor 2	Factor 3	Factor 4
F1 "Computer Aided Design"				
Stand alone CAD	.66*			
Integrated CAD/CAM	.65			
DNC Network	.58			
F2 "Dedicated Automation"				
Dedicated Material Handling		.66		
Automatic Parts Changing		.58		
Secondary Capabilities		.49		
Product Specific Machine Layouts		.45	-.32	
Custom Machine Tools		.43	.40	
Multi-Spindle Machine Tools	.32	.40		
F3 "Range of Capabilities"				
Machine Tools w/ Extra Capabilities			.71	
Broad Size Range Capabilities			.55	
Multi-Axis Machine Tools	.45		.53	
Average Axis of CNC Machine Tools	.48		.41	
F4 "Non-Dedicated Automation"				
CNC Machine Tools				.77
Automatic Tool Changers on CNC				.66
CNC-Code Programming Computer	.39			.51
Percent of Total (44.3) Variance:	12.5	11.1	10.8	10.0
Cronbach Alpha Reliability within factors:	.54	.58	.48	.48

* Factor loadings less than .25 are not shown.

The four factors correspond fairly well to the theoretical dimensions proposed earlier. Factors two and four parallel the integration and automation dimensions respectively. As expected from earlier discussion, these dimensions show some overlap. Factor two encompasses items such as automatic parts changing and material handling systems which automate, but which also integrate by linking different tasks together. Perhaps the factor should be call "dedicated automation" as most of the items are either automating technologies, technologies or arrangements that are dedicated and restrict flexibility to some degree, or most often a combination of both. All the items generally result in less flexibility to produce a wide variety of products.

Factor 4 generally reflects the degree to which CNC machine tools are used versus conventional. It logically includes the machine coding or programming technologies which are necessary for CNC. It also includes automatic tool changers which further automate CNC machine tools while maintaining flexibility. Non-dedicated automation seems to be the common thread. One might be tempted to call this factor "flexible automation" relative to factor two, but this term has specific meaning in production technologies, and also confuses the idea that stand alone, conventional machine tools on the other end of this factor are thought to be more flexible. "Non-dedicated automation" conveys the idea that it is more flexible than dedicated automation, but perhaps less flexible than non-dedicated, general purpose conventional machine tools.

Factor 3 parallels the range of capabilities dimension proposed earlier. Both machine tool axis measures contribute as expected from earlier discussion. Broad size range directly indicates broad capability range. Machine tools with "extra capabilities" (beyond what is necessary for most situations) were most highly loaded. These extra capabilities allow a broader range of products to be made.

Factor 1 represents computer aided design. Individual correlations reveal that DNC networks are probably most used in firms which have strong designing and programming functions such as integrated CAD/CAM. No association is found between DNC and stand alone programming technologies.

4.5.2 Strategy Factor Analysis

Like technology, assessment of strategy began with factor analysis to reduce measures to a manageable number of underlying factors on which to group firms. Theoretical factors were proposed earlier in Table 3.1.

First, the relevant strategy measures were identified. Questions 6a and 6b on JIT and SPC were not included because some firms might not have properly understood the jargon and its fairly specific meaning. The broader issues behind both questions should be captured in the more generically worded questions 19d,e,f on delivery, leadtimes, and verifiable quality assurance. Questions 17 and 18 were not included because they had the lowest communality estimates (.32 & .23), their inclusion hampered factor interpretation, and their content was more in the realm of technology assessment and usage than in the realm of product market strategy. Questions 2h and 7a, on whether firm's customer industries were growing rapidly or declining, were also not included. Question 7a was reserved as a control variable for the testing of Hypothesis 4 rather than as a strategic grouping dimension. The remaining twenty-nine strategy items yielded a score of 0.70 for Kaiser's measure of sampling adequacy. Kaiser & Rice (1974) characterize this as "middling," and thus acceptable for factor analysis.

Again principal factor analysis was used to extract the factors. A scree plot of factor eigenvalues did not reveal a clear cut-off point. Nine factors had eigenvalues above one. Promax oblique rotations were run on the 7,8,& 9 factor solutions to aid selection. The eight factor solution, which explained 58.3 percent of the total variance, was chosen for interpretability. The inter-factor correlation matrix is displayed below in Table 4.7

Table 4.7

Strategy Factor Inter-Correlations

	F1	F2	F3	F4	F5	F6	F7	F8
Factor 1	1.00	.05	.02	-.04	-.08	-.07	-.13	-.12
Factor 2	.05	1.00	.12	-.01	-.06	-.04	-.03	-.06
Factor 3	.02	.12	1.00	.10	.14	-.14	-.05	.02
Factor 4	-.04	-.01	.10	1.00	.13	-.23	.05	.04
Factor 5	-.08	.06	.14	.13	1.00	.04	.09	.26
Factor 6	-.07	.04	-.14	-.23	.04	1.00	.17	.05
Factor 7	-.13	.03	-.05	.05	.09	.17	1.00	.04
Factor 8	-.12	-.06	.02	.04	.26	.05	.04	1.00

The resulting factor loadings are displayed below in Table 4.8. The major contributing measures to each factor are grouped together along with the name ascribed. Cronbach alpha coefficients were calculated within each group to provide reliability estimates for each factor. Most estimates are above the .50 level, which is considered at least adequate (Nunnally, 1967). As could be expected, the later factors are less reliable.

Table 4.8

Strategy Factors

	Factor 1	Factor 2	Factor 3	Factor 4
F1 "Product Stability"				
% Sales which are repeat orders	.81			
Average batch/lot size (log of)	.81			
Products are large batch/lot size	.77			
Products are repeat, routine	.69			
Customer does design	.61			
F2 "Product Precision"				
Products are high precision		.84		
Customers are "high tech"		.71		
Products are complex		.71		
Close tolerances important		.56		
Average tolerances held		-.49		
F3 "Service"				
Delivery			.75	
Dimensional consistency		.26	.67	
Close customer relations			.53	
Short lead times	-.32		.51	
Verifiable quality assurance	.34		.44	
Accommodate fluctuations in orders			.37	
F4 "Price Premium"				
Competitive pricing				-.81
Differentiation (vs. low cost)				.71
Cost plus pricing				.61
Value added from design	-.36			
Many Customers in number				.31
Percent of Total (58.3) Variance:	11.6	9.0	8.0	6.4
Cronbach Alpha Reliability within factors:	.83	.74	.59	.56

Continued, next page.

Table 4.8 Continued

	Factor 5	Factor 6	Factor 7	Factor 8
F5 "Value Added"				
Value added from design	.65			
Value added from assembly	.87			
F6 "Customer Stability"				
Customers are repeat		.76		
Actively seek new customers		-.71		
F7 "Geographic Scope/ Proprietary Product"				
Wide geographic range			.76	
Percent products contract		.33	-.55	
F8 "Product Range"				
Products broad in range, different			-.25	.71
Products large in size				.68
Wide variety of products important			-.46	.46
Many Customers in number			-.38	.42
Products are repeat, routine			.27	
Customer does design	-.33		-.38	
Average tolerances held		.37		
Accommodate fluctuations in orders	.35		-.35	
Close customer relations important	.35			
Percent of Total Variance (58.3):	6.1	5.9	5.9	5.5
Cronbach Alpha Reliability within factors:	.55	.45	.37	.49

* For clarity, factor loadings less than .25 are not shown.
** The standardized form of variables with negative factor loadings were reversed in polarity for the reliability calculations. Although high negative loadings contribute significantly and reliably to factor scores via regression coefficients, reliability calculations interpret the negative correlations as unreliable. The transformation of the following four variables overcame this problem: contract, importance of competitive pricing, average tolerances held, and actively seek new customers.

As can be seen below in Table 4.9, the strategy factors correspond quite well to the theoretical grouping dimensions proposed earlier in Table 3.1

Table 4.9

Strategy Factors and Theoretical Dimensions

	Factor Name	Theoretical Dimension
Factor 1,	"Product Stability	"Product Variability"
Factor 2,	"Precision"	"Product Characteristics"
Factor 3,	"Service	"Service Priorities"
Factor 4,	"Price Premium"	"Price Policy" "Operating Efficiency"
Factor 5,	"Value Added"	"Value Stage Participation"
Factor 6,	"Customer Stability	"Target Markets"
Factor 7,	"Geographic Scope/ Proprietary Product	"Geographic Scope"
Factor 8,	"Product Range	"Product Variability"

Factors 1 and 8, product stability and product range, raise an important distinction within the theoretical dimension "product variability." Product stability refers to long or repeat production runs which mean relatively less new products to be made. This results in stable production with a minimum of change-over. Product range on the other hand gets at the idea that given a particular level of product stability, a firm's products might be very different from each other in size, complexity, fragility, configuration, processing requirements, etc., or very similar to each other.

Factor 7 loads most heavily on wide geographic scope, but also appears to have a facet that could be called "proprietary products." Even though firms in this sample do mostly contract work, they appear to have proprietary product lines which are sold over a wide geographic scope through distributors. Factor 7 also has negative loadings on contract, wide variety of products, customer does design, and fluctuations in orders, much as one would expect for proprietary products. However, because many firms are purely contract, but score high on this factor because of a high geographic scope, using "proprietary product" as the only label for this factor could be misleading. Thus a two part factor name was chosen.

4.5.3 Strategy Clustering

Clustering of the eight strategy factors was used to group firms with like strategies. The term "strategic groups" will be used to describe the clusters of like product-market strategies although for some it has a narrower meaning as noted in Chapter 3. Like other works in strategic management (e.g., Cool & Schendel, 1987,1988; Harrigan, 1985; Hambrick, 1983b,c), this study used a hierarchical, euclidean distance, clustering algorithm. Following the lead of Cool & Schendel (1987), the Ward's method, which minimizes the within cluster or "error" sum of squares, was the specific algorithm employed. Because this method is sensitive to outliers (Milligan, 1980), ten percent of data points which had the lowest estimated probability densities* were removed prior to clustering.

Selection of the level or number of clusters to use was primarily based on interpretability. As Harrigan (1985, p61) notes, "the appropriate number of clusters will be a trade-off between parsimony and one's need for detail." Cluster centroids were examined in detail for 4,5,6,7, and 8 cluster solutions. A six cluster solution was judged to correspond to meaningful differences observed by the author in this industry. Case studies from previous research (see Schroeder et al., 1988, 1989) provided good reference points to aid in interpreting individual clusters. The four cluster solution had reasonable overall interpretability for which one could see parallels with the Porter (1980) and Miles & Snow (1978) typologies; however, meaningful distinc-

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*The Kth-nearest-neighbor density estimation was used with k=5. For further information, see Silverman (1986).

The outliers trimmed by the clustering algorithm appear to be firms that have a higher than average amount of proprietary products (see table 4.8 for the mean values of the strategy factors). High geographic scope, lower percentage contract, slight price premium, low service, and low precision, are all characteristics that point to firms which tend to market their own products. Designing and marketing one's own products has major ramifications on the way firms do business in ways that are different not only from contracting firms, but also from other proprietary product firms which might have totally different products, and marketing and distribution processes. This is reflected in significantly higher factor standard deviations for the outlier group than for each of the clusters.

tions found in the six cluster solution were lost. The seven and eight cluster solutions resulted in two very small clusters (17 and 13 firms) with questionable interpretability.

Statistical indicators were also examined to see if a particular stopping point appeared optimal. Tests of optimality and statistical significance have been slow to develop around cluster analysis (Everitt, 1979; Hartigan, 1975). Two key reasons for lack of progress are the lack of a workable null hypothesis, and that most real data sets do not conform to the standards of multivariate normal distributions (Aldenderfer & Blashfield, 1984).

Nonetheless, scholars in strategic management suggest using some kind of indicators to complement interpretability and parsimony as criteria in selecting the number of clusters. Some have suggested looking for "pronounced" increases in cluster tightness as measured by the mean squared error (Hambrick & Schecter, 1983; Harrigan, 1985). For this study, the steepest changes result from the 7 to 6 and 6 to 5 cluster joinings. However, no real criteria exists by which to judge whether these changes are "pronounced." A scree plot revealed no significant visual discontinuity.

Cool & Schendel (1987) compare the differences between cluster centroids using MANOVA for clues that the clusters are significantly different from each other. Such analysis for the 3 through 9 cluster solutions resulted in very significant (prob=.0001 for Hotelling-Lawley trace and Wilk's Lambda) results for all the cluster solutions. However, the 5 and 6 cluster solutions were the only that resulted in significant differences across clusters for each of the clustering variables (eight strategy factors). Overall, one concludes that interpretability and relevance to the questions under study are most important in deciding on cluster level.

To judge the character of each cluster, the mean values of the strategy dimensions in each cluster (Table 4.10) were examined.

Table 4.10

Mean Values of Cluster Centroids

		Cluster Number					
Strategic Factor	Trim*	1	2	3	4	5	6
1. Product Stability	-.07	-1.21	1.05	-.13	.33	.31	-.04
2. Precision	-.76	.33	.41	.42	.30	-.15	-.79
3. Service	-.20	.19	.14	-.19	.71	-.75	.00
4. Price Premium	.26	-.16	-.65	.03	.97	-.56	.27
5. Value Added	-.14	.37	-.08	.23	-.02	-.62	.37
6. Customer Stability	-.14	.58	.44	-1.12	-.25	.18	-.41
7. Geographic Scope/ Proprietary Product	.91	.31	.27	-.10	-.07	-.50	-.61
8. Product Range	-.09	.43	.31	-.09	-.57	-.70	.86
Number of firms	34	65	47	29	55	61	44
Average Employment	63	43	71	45	53	34	42
Percent Contract	73	100	100	87	90	99	99

*The "trim" firms are those outliers trimmed in the clustering process as described in an earlier footnote. The mean values of the trimmed firms are displayed here to allow comparison with the final clusters.

By comparing the strategy factor means of one cluster to those of the other clusters, one can obtain a sense of the nature of each cluster. Keep in mind that across the whole sample (including the 34 outliers trimmed), the mean value for each factor is zero with a standard deviation of one. What follows are the qualitative descriptions of each cluster based on the results displayed in Table 4.10, and on the author's knowledge of the industry based on previous research (see Schroeder et al., 1988 1989). A cluster name precedes each description.

Cluster 1: "One-of-a-Kind"

Cluster 1 represents primarily die and mold makers or firms that machine one-of-a-kind products (mean percentage of products which are dies and molds = 85.7). What most characterizes this cluster is low product stability because of the lowest batch sizes, and the lowest amount of jobs which are repeat. Customer stability is high but each mold or die is different, thus the higher than average score on product range. Firms in this cluster are among the highest in value added, mostly in the form of design. In the larger scheme of things, the firms in this cluster could be said to have a "one-of-a-kind" strategy.

Cluster 2: "Hi-Volume Parts"

Unlike Cluster 1, Cluster 2 is distinguished by the highest batch sizes and repeat orders. This cluster is highest in government work and highest in percent products which are machined parts. Their customer base is fairly stable, precision is very high, service is slightly above average, value added is average, but price competition is intense. Firms in this group are generally larger than firms in the other groups. Perhaps these large, high volume firms are very efficient and can afford smaller margins across a high volume of output.

Cluster 3: "Hi-Precision Prospector"

This cluster is most distinguished by very low customer stability. Firms in this group produce less than average batch sizes at levels of precision higher than any of the other clusters. Their products are often prototype parts, small batches of high precision parts, or special assemblies (firms in this cluster score highest on value added from assembly). The special nature of such products leads these firms to search quite widely for customers requiring such services.

Cluster 4: "Service Volume"

Firms in this cluster provide significantly higher service than any other cluster. They provide the shortest lead times, dependable deliveries (almost half on a "Just-in-time" basis), verifiable quality assurance ("ship-to-stock"), and accommodate fluctuations in orders second only to Cluster 6. For this high level of service and moderately high precision, these firms command significantly higher price premiums. This cluster is second highest in product stability, very similar to Cluster 5, but not really close to Cluster 2

<u>Cluster 5: "No Frills Volume</u>"

Relative to most clusters, this cluster produces moderately high and repeatable batches. Although lower in production stability, firms in this cluster are comparable to the "High Volume Parts" strategy (Cluster 2) in that they produce mostly machined parts (83 percent), many for the government, under conditions of intense price competition. Where they differ is that they provide absolutely no services, no value added, and they stick to a very narrow range of product types at lower than average precision. In essence, no frills.

<u>Cluster 6: "Opportunist</u>"

The salient characteristic of this cluster is the very wide product range. As one might expect, this is somewhat reflected in the highest percentage of machining services (11.3). This cluster is strictly contract oriented like most of the clusters, but is different in that it is the most local in geographic scope. These firms produce the lowest precision and, next to Cluster 3, highest value added from assembly. Customer stability is low, apparently from doing a wide variety of jobs for a wide variety of customers, where ever opportunities arise. For their trouble, these firms command a slight price premium.

In sum, the clusters appear to represent meaningfully different strategic groups. Each cluster corresponds very well to firms in this industry studied previously by the author in great detail. The relationships of the factor means to one another within each cluster seem to result in meaningful wholes. From this point, the clusters will be referred to as "strategic groups."

CHAPTER 5

RESULTS

The organization of this chapter consists of a section for each of the four hypotheses to be tested. Each section begins by restating the hypothesis for the reader's convenience, followed by discussion leading to a model of the hypothesis and the statistical analysis used to test it, and ending with the results of the statistical tests. Elaboration of the results will be mostly limited to discussion about the support found for the hypotheses. Further interpretation, probing, and linking with other works will take place in the following chapter.

5.1 Hypothesis 1

"Use of more automated, integrated process technologies will be positively associated with strategies which minimize new product introductions and/or variations in existing products."

This hypothesis examines the nature of fit by relating particular dimensions of strategy and technology. Factor analysis of strategy and technology variables provides measures of the hypothesized dimensions.* New product introductions (wording used by the hypothesis) inversely corresponds to the factor "Product Stability," while variations in existing products corresponds to product range. Level of automated technologies corresponds to both Dedicated and Non-Dedicated Automation while integration corresponds mostly with Dedicated Automation.

5.1.1 Model for H1

Simple Pearson correlation coefficients will tell us about the strength, direction, and significance of relationships amongst these factors.

5.1.2 Results for H1

Results are displayed below in Table 5.1. Three of the four correlations are of the expected sign and significant at the .05 level or better, thus supporting H1. One might expect Dedicated Automation to be more strongly related to product stability than Non-Dedicated Automation, but the

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*Canonical correlation analysis was also tried using survey measures that correspond to the wording of H2. Highly significant results (.0001) were obtained for the first canonical correlation as well as the overall results. However, the new factors or "canons" did not add significant insight beyond analysis with the original strategy factors. The canonical correlation analysis is therefore not reported, as it would be redundant if not confusing.

Table 5.1

Results of Hypothesis One

Pearson Correlation Coefficients
(Significance Probabilities in Parentheses)
306 Observations

	Product Stability	Product Range
Dedicated Automation	.27716 (.0001)	-.12132 (.0339)
Non-Dedicated Automation	.35685 (.0001)	-.05547 (.3335)

later, which is primarily CNC, is probably a cleaner relationship. Product specific machine layouts (part of Dedicated Automation) may not be as strong of a technological imperative as CNC machine tools.

The relationship between Product Range and Non-Dedicated Automation is not significant, but this is really to be expected. CNC is typically very general purpose and therefore not adversely affected by wide product range. Because the alternative to CNC for this sample is conventional machine tools which are also general purpose and thus not adverse to wide product range, one would not expect the correlation to be significant in either direction. Overall, H1 is strongly supported.

The results of Hypothesis One tell us something about the nature of fit, the specific linkages between process technologies and strategic dimensions. However, more can be learned by looking at the other correlations between strategy and technology factors. Although examination of these correlations is not based on a priori hypotheses, patterns that make sense may suggest something about the general nature of fit between process technology and strategy. Table 5.2 presents these correlations.

Examination of the correlations reveals many relationships that make sense. Product stability is strongly related to Dedicated and Non-Dedicated Automation as predicted by H1. In addition, Computer Aided Design (CAD) is negatively related to product stability as automation of the design process makes less sense when new products are few. Range of capabilities should have little to do with new or existing product stability if their processing requirements match the range of the production equipment. As could be expected, no relationship is found.

Precision relates to technology pretty much as one might expect. CNC is positively related, and one can reason that parts designed by CAD would be high precision if only because the use of CAD indicates a technologically advanced firm. The same reasoning could be extended to automatic pallet changers, but very little else would seem to make Dedicated Automation related to Precision, thus the weaker correlation ($p=.067$). Range of capabilities is probably

Table 5.2

Strategy-Technology Factor Correlations

(Significance Probabilities in Parentheses)
306 Observations

Strategic Dimension	Computer Aided Design	Dedicated Automation	Range of Capabil.	Non-Dedicated Automation
1. Product Stability	-.295 * (.0001)	.277 * (.0001)	-.042 (.4640)	.357 * (.0001)
2. Precision	.207 * (.0003)	.105 (.0673)	.164 * (.0040)	.244 * (.0001)
3. Service	.024 (.6781)	.083 (.1491)	.066 (.2526)	.108 (.0588)
4. Price Premium	.023 (.6902)	.033 (.5602)	.090 (.1178)	-.087 (.1267)
5. Value Added	.252 * (.0001)	.178 * (.0018)	.239 * (.0001)	.104 (.0690)
6. Customer Stability	.107 (.0620)	-.146 * (.0104)	-.131 * (.0221)	.031 (.5867)
7. Geographic Scope/ Proprietary Product	.132 * (.0207)	.131 * (.0218)	.027 (.6420)	-.160 * (.0049)
8. Product Range	.138 * (.0156)	-.121 * (.0339)	.309 * (.0001	-.055 (.3335)

* Probabilities below the .05 significance level are marked for the reader's convenience.

highly significant because of the complex shaping abilities of multi-axis machine tools.

The relationships with Value Added make more sense when one looks at correlations with the design and assembly value added measures directly. As one might expect, CAD is related to value added from design (p=.0001), while Dedicated Automation is related to value added from assembly (p=.0001). Range of capabilities is positively related to both types of value added (.0001, .0012), although a physical cause and effect is not apparent. CNC is strongly related to value added from assembly (.0003), but negatively related to value added from design (.0159). This last relationship is negative probably because mold makers, which do more designing than other strategic groups, do not use CNC for their one-of-a-kind products.

Customer Stability is related negatively to both Range of Capabilities and Dedicated Automation. As one might expect, more customer turnover could result in a greater product range, and the need for equipment with greater range. Although one might expect customer stability to carryover into product stability, in this sample it does not. The "One-of-a-Kind" strategic group has the highest customer stability of any group but, gets many one-of-a-kind orders from their "regular" customers, and thus do not use dedicated automation.

Given the relatively greater stability of proprietary products over contract products, one would expect proprietary products to be correlated with technology in much the same way as the product stability dimension. This is the case for Dedicated Automation, but not for CAD and Non-Dedicated Automation. CAD correlates positively, as one might expect, simply because proprietary products entail the design function. Why proprietary product firms would be less likely to use CNC is not so obvious, but has been previously observed in metalworking firms (Schroeder, et al., 1989). The explanation given is that, although it might make more sense for proprietary product firms to use CNC, contract firms might adopt sooner because of (1) greater competitive rivalry, (2) the image that CNC affords (also Dodgson, 1987) is more important for a service (contract machining) than a physical product, and (3) because greater management attention is directed to manufacturing equipment because it is the often the only value stage addressed by a contract firm as opposed to design, marketing, and distribution of proprietary product firms. Our observation is further evidence for such a possibility.

Product Range correlates as expected. A greater Range of Capabilities is needed to handle products of wide range. If a firm designed a wide range of products, it might use CAD to automate the process. However, unlike CAD, Dedicated Automation is not flexible enough for wide product variety, and thus is negatively correlated as noted also in H1.

Finally, discussion of Service and Price Premium has been saved for last because neither are significantly (less than .05) correlated with any of the technologies. Why might this be so?

Looking at correlations with individual measures of service and price premium provides little clue. Non-Dedicated Automation (CNC) is positively correlated with consistency (but consistency is more a quality than service measure), verifiable quality assurance, close customer relations/frequent contact, and accommodating fluctuations in orders. These combine to form a weak (p=.059) Non-Dedicated Automation-Service relationship. No other service measures are correlated significantly (less than .05) with the other technologies. For the price premium measures, no correlations are significant except for two relationships between CAD and Range of Capabilities and a measure of low cost versus differentiation.

Overall, it appears that service and price premium are have no direct links with process technology. No direct impact seems plausible for the few service measures which are correlated with CNC. For example, defense contractors, which typically do verifiable quality assurance, are CNC users because defense parts orders are usually large. CNC is not needed to do verifiable quality assurance. CAD and Range of Capabilities probably do provide a way to differentiate, but the results suggest a price premium is not earned for this differentiation.

5.2 Hypothesis 2

"Firms will use a technology if it provides special capabilities for a key strategy dimension, despite possible negative consequences with regard to less critical strategic dimensions."

Hypothesis Two also predicts the nature of strategy-technology fit. The main issue is that more than one capability often comes bundled in a particular technology. Because these capabilities cannot be practically separated, a particular strategy may have strategic dimensions which relate both negatively and positively to the technology with respect to a particular firm. If the positive benefits to a firm's strategy outweigh the negative tradeoffs, a firm will use the technology anyway. An instance of this for our sample is that CNC is best suited for both new product stability and precision. A firm might use CNC despite low product stability if it provided much needed high precision.

5.2.1 Model for H2

To get at the essence of accepting negative trade-off on one dimension for positive benefits on the other, two sub-samples were created: The 20 percent of total firms with the lowest scores on product stability, and the 20 percent with the lowest scores on precision. The lowest "pentiles" of these dimensions were used because CNC correlates positively with product stability and precision. One would not expect firms in the lowest pentile to use seemingly inappropriate CNC machine tools unless the firm needed some positive benefit on another dimension.

Linear regression is use to test these two possibilities. Strategy factors one and two correspond directly with the example which supports H2. Survey Question 20 provides a direct measure of CNC. Each sub-sample contains 67 firms.

(1) <u>Low product stability sub-sample</u>:

CNC = f (PRODUCT STABILITY, PRECISION)

(2) <u>Low precision sub-sample</u>:

CNC = f (PRODUCT STABILITY, PRECISION)

5.2.2 <u>Results for H2</u>

The regression results for sub-samples one and two are displayed below in Table 5.3.

Table 5.3

Results of Hypothesis Two

(1) Low Product Stability Sub-sample:

n=67 Variable	T for HO: Regression Coefficient=0	Probability* > ¦T¦
Product Stability	.124	.9015
Precision	2.431	.0179

R-square = .0948
Overall F = 3.350
Probability = .0413

(2) Low Precision Sub-sample:

n=67 Variable	T for HO: Regression Coefficient=0	Probability* > ¦T¦
Product Stability	2.631	.0107
Precision	1.798	.0769

R-square = .1210
Overall F = 4.405
Probability = .0161

*The significance level, Probability > ¦T¦, is the probability of getting a larger value of T if the regression coefficient is truly equal to zero. A very small Probability value leads to the conclusion that the independent variable contributes significantly to the model.

The results are highly significant for both possibilities. Among firms with very low product stability, firms which have high precision needs use CNC (p=.0179) despite the programming costs involved. Within this group, product stability is so low that it does not even relate to CNC usage (p=.9015). Among firms with very low precision needs, firms with higher product stability use CNC (p=.0107) despite its higher capital costs. CNC somewhat relates to precision even within the low precision sub-sample, but the relationship is not significant (p=.0769).

If one example is enough to confirm the hypothesis, H2 is strongly support. Stronger support would come from similar findings for other technologies in other samples.

5.3 Hypothesis 3

"Process technology (levels of automation, physical integration, computer integration, and range of capabilities) will differ significantly between strategic groups."

5.3.1 Model for H3

Hypothesis 3 essentially says that technology will be a function of the strategy one has, in this case the strategic group a firm has been classified into. Because this study finds four underlying process technologies, an overall linear model using MANOVA looks at the four technology factors together:

(TECHNOLOGY FACTORS 1-4) = f (STRATEGIC GROUP MEMBERSHIP)

However, one can also look at each technology factor individually with a model using ANOVA to determine whether a particular technology factor varies significantly from group to group:

(TECHNOLOGY FACTOR) = f (STRATEGIC GROUP MEMBERSHIP)

5.3.2 Results for H3

First it is insightful to examine the technology means and standard deviations within strategic groups. These results are tabulated below in Table 5.4. Keep in mind that for each technology factor, the total sample mean equals zero and the standard deviation equals one:

Table 5.4

Technology Factor Means within Strategic Groups

(Standard Deviations in Parentheses)

Strategic Group	Computer Aided Design	Dedicated Automation	Range of Capabil.	Non-Dedicated Automation
1. One-of-a-Kind	.64 (.80)	-.21 (1.05)	.07 (.90)	-.21 (.83)
2. Hi-Volume Parts	.08 (1.01)	.29 (1.14)	.05 (1.13)	.37 (.93)
3. Hi-Precision Prosp	-.08 (1.08)	-.01 (1.01)	.30 (.81)	.02 (.92)
4. Service Volume	.05 (1.08)	.12 (.85)	-.23 (.95)	.15 (1.06)
5. No Frills Volume	-.28 (.81)	-.03 (.85)	-.33 (.91)	.23 (.97)
6. Opportunist	-.15 (.96)	-.20 (.85)	.38 (.98)	-.16 (.96)

Within these scores, one finds patterns that make sense for each strategy. The "One-of-a-Kind" strategy has significantly higher than average CAD capabilities given the preponderance of mold makers which do design work. Both kinds of automation are lower than average because of extremely low batch sizes. On the other hand, a "Hi-Volume Parts" strategy has the highest levels of both kinds of automation because of its very large and repeat batches. The "Hi-Precision Prospector" strategy has an above average range of capabilities to deal with the many customer needs that it seeks to fulfill. The "Service" strategy has a narrower range of capabilities to match its narrow product range. The "No Frills Volume" strategy has high non-dedicated automation like the "Hi-Volume Parts" strategy, but has only average dedicated automation as its batches are not quite as high or repeatable. These firms also score negative on CAD and Range of Capabilities as they have no intention of performing value added or accommodating a wide range of products. The "Opportunists" have the widest range of capabilities of any strategy. This provides them the means to take on a variety of jobs as opportunities arise. These firms score negative in all the other technologies as they do not design, have very low precision needs, and have no need of automation given the unpredictability of their product mix.

The patterns described above make sense but the question remains as to whether the technology means are significantly different from each other. Does variance within strategic groups overshadow the apparent variance between groups? For the answer to this question, we turn to the results of the MANOVA and ANOVA for the models described above.

The overall MANOVA model results in highly significant positive results at the .0001 level (Table 5.5).

Table 5.5

Results of Hypothesis Three: MANOVA

Statistic	Value	F	Num DF	Den DF	Pr > F
Wilks' Lambda	.754	4.00	20	900	.0001
Hotelling-Lawley Trace	.302	4.07	20	1078	.0001

The ANOVA results are displayed below in Table 5.6. Three of four technology factors taken individually were also highly significantly different across strategic groups. The other, "Dedicated Automation" is only significant to a .0975 level.

Table 5.6

Results of Hypothesis Three: ANOVA

Tech Factor	Num DF	Den DF	F Value	Pr > F
Computer Aided Design	5	274	6.45	.0001
Dedicated Automation	5	274	1.88	.0975
Range of Capabilities	5	274	3.97	.0017
Non-Dedicated Automation	5	274	2.85	.0158

Overall, one concludes that H3 is strongly supported. It appears that process technology does vary significantly between strategic groups.

5.4 Hypothesis 4

"Interaction between process technology and strategic group membership has a significant impact on firm financial performance beyond that of process technology and strategic group membership alone."

Like H3, there are a few different ways to interpret this hypothesis. One way, as outlined below in Model 1, is to look within each strategic group for significant relationships between a technology factor and each of the two kinds of performance, return on sales (ROS) and average annual growth (GROW). The "vitality" of customer markets as indicated by their industry growth may also have a direct bearing on the performance of firms serving those markets.

Accordingly, market growth (MARKET) as measured by survey question 7a is included in most models*.

5.4.1 Model I for H4

ROS = f (MARKET, TECHNOLOGY FACTOR)

GROW = f (MARKET, TECHNOLOGY FACTOR) *

* Within each strategic group, for each technology factor.

Model I was tested using least-squares linear regression. To make sure a linear model was appropriate, scatterplots of each technology-performance relationship within each strategic group were examined for evidence of curvilinear relationships. No clear patterns other than linear were found.

Another way to consider within strategic groups relationships is to view process technology as a whole and test the model with all technology factors together.

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*Firm size might also have an impact on profitability and growth. Firm size (total employment and log of total employment) was tried in the model initially, but did not show any evidence of a relationship with either growth or return on sales. It was not included in the final models reported.

5.4.2. <u>Model II for H4</u>

ROS = f (TECHNOLOGY FACTORS 1-4)

GROW = f (TECHNOLOGY FACTORS 1-4) *

* Within each strategic group.

Liner regression was also used to test this model. Unlike Model I, MARKET was not included so that the overall regression result would represent the significance of the combined effect of the four technology factors.

The first two models look only at performance differences within strategic groups. However, before one can really conclude that strategic group membership makes a difference in technology-performance relationships, one needs to look at these relationships across strategic groups. This is necessary to determine whether relationships within individual groups are different enough from other within groups relationships. If the relationship between technology and performance was roughly the same for every strategic group, one could say that technology made a difference in performance but would have to conclude that fit with strategy did not make a difference.

Across group examination in this case is what Venkatramen (1989) labels the "moderation" form of fit, which he asserts is most typical in strategy research. In this model of fit, if the interaction coefficient of technology and strategic group membership is significant, while accounting for the main effects of strategic group membership and technology by themselves, one can conclude that fit exists relative to the particular criterion variable used (in this case, two types of performance). Like Model I, technology factors can be examined individually:

5.4.3 Model III for H4

ROS = f (MARKET, STRATEGIC GROUP MEMBERSHIP, TECHNOLOGY FACTOR, STRATEGIC GROUP MEMBERSHIP*TECHNOLOGY FACTOR) *

GROW = f (MARKET, STRATEGIC GROUP MEMBERSHIP, TECHNOLOGY FACTOR, STRATEGIC GROUP MEMBERSHIP*TECHNOLOGY FACTOR) *

* For each technology factor.

This linear model is typically tested with "moderated regression analysis" (Venkatramen, 1989), which signifies the inclusion of an interaction term. In this study, generalized linear regression (including the appropriate interaction terms) is used because strategy is a categorical variable.

The technology-strategy interaction model can also examine all technology variables together as did Model II.

5.4.4 Model IV for H4

ROS = f (MARKET, STRATEGIC GROUP MEMBERSHIP, TECHNOLOGY FACTORS 1-4, STRATEGIC GROUP MEMBERSHIP*TECHNOLOGY FACTORS 1-4) *

GROW = f (MARKET, STRATEGIC GROUP MEMBERSHIP, TECHNOLOGY FACTORS 1-4, STRATEGIC GROUP MEMBERSHIP*TECHNOLOGY FACTORS 1-4) *

5.4.5 Results of Model I for H4

The regression results for the test of Model I are shown below in Table 5.7. For clarity, only the probability values are shown for T tests of each variable's regression coefficient. Only those below a .05 significance level are shown. For all of the probabilities shown, the corresponding regression coefficients are all positive. Of the technology relationships shown as significant, in all cases (except technology factor 4 (TF4)-GROW in Group 1) the overall regression equations are significant to at least the .05 level.

Table 5.7

<u>Results of Hypothesis Four: Model I</u>

Individual Technologies within Strategic Groups

(Probabilities for T test of each variable's regression coefficient)

		Strategic Group #					
		1	2	3	4	5	6
	n =	(65)	(47)	(29)	(55)	(61)	(44)
Tech Fac 1							
ROS =	MARKET					.0344	
	TECH FAC			.0126			
GROW =	MARKET					.0008	
	TECH FAC			.0159			
Tech Fac 2							
ROS =	MARKET					.0239	
	TECH FAC				.0004		
GROW =	MARKET					.0003	
	TECH FAC						
Tech Fac 3							
ROS =	MARKET					.0328	
	TECH FAC	.0029					
GROW =	MARKET					.0014	
	TECH FAC						
Tech Fac 4							
ROS =	MARKET					.0294	
	TECH FAC						
GROW =	MARKET					.0017	
	TECH FAC		.0468			.0035	

There appears to be little support for H4 in these results. Although highly significant, evidence for a relationship between technology and performance is found in only six of forty-eight regressions. Growth of customer markets does not explain performance much better, with significance below the .05 level in only eight of forty-eight regressions.

5.4.6 Results of Model II for H4

The results of Model II are displayed below in Table 5.8 similarly to those of Model I. Probabilities of T tests for all the regression coefficients are displayed along with their sign. Overall regression R-squares and probabilities are also shown. Probabilities below the .05 significance level are underlined for the reader's convenience.

Table 5.8

Results of Hypothesis Four: Model II

Overall Technology with Strategic Groups

(Probabilities for T test of each variable's regression coefficient)

		Strategic Group #					
		1	2	3	4	5	6
# Firms in group:		(65)	(47)	(29)	(55)	(61)	(44)
ROS =	TECH FAC 1	(-).7207	.8670	.0158	(-).4923	.9849	(-).6098
	TECH FAC 2	.2460	.0991	.5298	.0002	(-).7514	.2044
	TECH FAC 3	.0068	.9396	.4289	(-).2501	(-).9106	(-).5573
	TECH FAC 4	.8833	.3194	.5834	.9460	(-).5349	.7081
	R-Square	.1866	.0997	.2941	.2895	.0112	.0610
	Overall P	.0250	.3796	.1211	.0054	.9622	.6871
GROW=	TECH FAC 1	(-).9327	(-).3094	.0366	(-).6046	.1508	.2704
	TECH FAC 2	(-).3244	.3781	(-).7387	.1377	(-).6883	(-).4786
	TECH FAC 3	.7928	.9653	(-).9215	(-).9364	(-).1282	.7530
	TECH FAC 4	(-).6567	.0428	(-).5741	.2168	.0057	.9086
	R-Square	.0276	.1360	.2322	.0815	.2580	.0553
	Overall P	.8296	.2112	.2366	.4677	.0056	.7269

The perspective of Model II is more encouraging, but the results are similar to those of Model I. The significance of individual regression coefficients match the results of Model I in every case. This is to be expected given the relative independence of the technology factors. Where the individual technology-performance relationships within in a group are very strong (i.e., TF3-ROS in Group1;

TF2-ROS in Group4; TF4-GROW in Group5), they render the overall regression significant.

If one underlying technology dimension can be considered adequate to distinguish the "process technology" of one firm from another, Model II yields more encouraging results, with significance in three of twelve cases. Perhaps it is unrealistic to expect each of the four technologies to be equally important to every strategic group, just as it is unrealistic to expect every strategic group to be different from other strategic groups on every strategic dimension. Additionally, if one believes "firm performance" to be sufficiently characterized by only one kind of performance (either ROS or Growth), then significance is found in three of six cases. This perspective seems to offer partial support for H4.

5.4.7 <u>Results of Model III for H4</u>

The results of testing Model III are displayed in Table 5.9. Generalized linear regression (including appropriate interaction terms) is used because strategy is a categorical variable. Accordingly, the significance of individual variables is assessed with an F test for Type III sum of squares (incremental sum of squares as if each variable was added to the model last). Probabilities below a .05 significance level are marked with an asterisk for convenience.

Table 5.9

Results of Hypothesis Four: Model III

Individual Technologies Across Strategic Groups

Tech Fac 1 (CAD)		F-Value	Prob > F	
ROS =	MARKET	5.17	.0238 *	Overall F = 1.83
	STRATEGY	1.35	.2434	Prob > F = .0438
	TECH FAC 1	0.74	.3902	
	STRATEGY * TECH FAC 1	1.62	.1560	R-Square = .0787
GROW =	MARKET	8.00	.0051 *	Overall F = 2.11
	STRATEGY	0.43	.8298	Prob > F = .0171
	TECH FAC 1	3.95	.0480 *	
	STRATEGY * TECH FAC 1	1.31	.2608	R-Square = .0918

Tech Fac 2 (Dedicated Automat)		F-Value	Prob	
ROS =	MARKET	5.26	.0226 *	Overall F = 2.92
	STRATEGY	1.30	.2626	Prob > F = .0008
	TECH FAC 2	7.77	.0057 *	
	STRATEGY * TECH FAC 2	2.31	.0449 *	R-Square = .1198
GROW =	MARKET	9.53	.0023 *	Overall F = 1.86
	STRATEGY	0.51	.7698	Prob > F = .0394
	TECH FAC 2	0.65	.4219	
	STRATEGY * TECH FAC 2	1.28	.2743	R-Square = .0820

Tech Fac 3 (Range of Capabl)		F-Value	Prob	
ROS =	MARKET	4.76	.0300 *	Overall F = 2.17
	STRATEGY	1.70	.1352	Prob > F = .0134
	TECH FAC 3	2.86	.0920	
	STRATEGY * TECH FAC 3	1.94	.0874	R-Square = .0921
GROW =	MARKET	7.75	.0058 *	Overall F = 1.51
	STRATEGY	0.99	.4248	Prob > F = .1207
	TECH FAC 3	0.00	.9789	
	STRATEGY * TECH FAC 3	0.51	.7662	R-Square = .0676

Continued, next page.

Table 5.9 Continued

Tech Fac 4 (Non-Dedic. Automat)	F-Value	Prob	
ROS = MARKET	5.23	.0231 *	Overall F = 1.48
STRATEGY	1.57	.1690	Prob > F = .1335
TECH FAC 4	0.70	.4035	
STRATEGY * TECH FAC 4	0.79	.5543	R-Square = .0644
GROW = MARKET	6.56	.0110 *	Overall F = 2.51
STRATEGY	1.00	.4181	Prob > F = .0039
TECH FAC 4	3.47	.0635	
STRATEGY * TECH FAC 4	1.79	.1157	R-Square = .1075

*Probabilities below a .05 significance level are marked with asterisks.

The results of Model I are again evident in the results of Model III. In this case, the strong individual factor, within groups relationships (i.e., TF3-ROS in Group1; TF2-ROS in Group4; TF4-GROW in Group5) are spread out over all the strategic groups. All three relationships appear to be strong enough to render significant (to the .10 level) main effect relationships between technology and performance (.0057, .0920, .0635). Unfortunately, this strength is dissipated over more degrees of freedom for strategy-technology interaction. Only Tech Fac 2 (Dedicated Automation) shows evidence (prob = .0449) of an interaction effect below the .05 level. Tech Fac 3 (Range of Capabilities) shows interaction at a probability of .0874.

Vitality of customer industries (MARKET) is strongly related to performance in all cases. The strength of this relationship is apparently strong enough to render most of the overall regressions significant. No significance is found for the main effect of strategic group membership.

5.4.8 Results of Model IV for H4

Model IV looks at the technology factors taken together across strategic groups. The results are displayed in Table 5.10. Probabilities below the .05 significance level are marked with an asterisk.

Table 5.10

Results of Hypothesis Four: Model IV

Overall Technology, Across Strategic Groups

		F-Value	Prob > F	
ROS =	MARKET	5.56	.0192 *	
	STRATEGY	1.18	.3176	
	TECH FAC 1	0.94	.3341	
	TECH FAC 2	9.07	.0029 *	Overall F = 1.95
	TECH FAC 3	0.96	.3292	Prob > F = .0033
	TECH FAC 4	0.50	.4800	
	STRATEGY * TECH FAC 1	1.61	.1590	
	STRATEGY * TECH FAC 2	2.29	.0467 *	R-Square = .1966
	STRATEGY * TECH FAC 3	1.72	.1316	
	STRATEGY * TECH FAC 4	0.41	.8393	
GROW =	MARKET	6.06	.0146 *	
	STRATEGY	0.61	.6917	
	TECH FAC 1	1.93	.1666	
	TECH FAC 2	0.33	.5673	Overall F = 1.53
	TECH FAC 3	0.01	.9078	Prob > F = .0434
	TECH FAC 4	2.32	.1288	
	STRATEGY * TECH FAC 1	1.44	.2102	
	STRATEGY * TECH FAC 2	1.03	.4010	R-Square = .1655
	STRATEGY * TECH FAC 3	0.30	.9149	
	STRATEGY * TECH FAC 4	1.54	.1795	

*Probabilities below a .05 significance level are marked with asterisks.

In these results, one sees the last vestiges of the individual factors, within groups relationships. However, only Dedicated Automation's positive impact on ROS remains significant as a main effect (p=.0029), and contributes significantly to an interaction effect with strategy (p=.0467). Only a trace of the Range of Capabilities-ROS relationship (p=.1316), and the Non-Dedicated Automation-GROW relationship (p=.1795), are found as interaction effects.

The overall models are significant (p=.0033, p=.0434), apparently aided by the strong contribution of market vitality. The performance variance explained by these models (20 and 17 percent) is not trivial given the myriad of things that impact performance. The main and interaction effects of Dedicated Automation explain approximately three and four percent of the total ROS variance respectively (not displayed in table).

5.4.9 Overall Results for H4

Given the results of the four models, H4 does not appear to be sufficiently supported. Only about 13 percent (6 of 48) of the individual factors, within groups relationships are significant (Model I). A quarter of (3 of 12) the relationships are significant if one considers the technology factors taken together (Model II). Half (3 of 6) are significant for one or the other types of performance. These relationships basically hold, but are diluted within the interaction models (III & IV), so that in the overall model (IV), only a Dedicated Automation-Strategy interaction relationship with ROS remains significant.

Even though the cross-strategy interaction models (III & IV) are considered by the literature to be the appropriate tests for "fit as moderation" (Venkatramen, 1989) between two variables (strategy and technology), Model I appears to be the most instructive. If one had a mixture of significant within groups relationships of varying strength and sign, then a cross-strategy model would indicate whether these relationships are different enough from each other to conclude that strategy really makes a difference. But significant results from such a model by itself could be misleading if within groups relationships were not examined. In our case, for a particular technology factor, only one within groups relationship with performance is ever significant. In the case of Dedicated Automation within Strategic Group 4 ("Service Volume"), the positive relationship with ROS is strong and different enough from the other five non-significant within groups relationships to render a cross-groups test significant (as in Model III). This is not necessarily the conceptually "ideal" between-groups contrast that one hopes to find in support H4.

Whatever the model, the important elements of structure that appear throughout the four models are three very strong, positive within groups relationships:

1. Dedicated Automation-ROS within the "Service Volume" group
2. Range of Capabilities-ROS within the "One-of-a-Kind" group
3. Non-Dedicated Automation-GROW within the "No Frills Volume" group

Three less strong, but significant, within groups relationships also merit discussion:

4. CAD-ROS within the "Hi-Precision Prospector" group
5. CAD-GROW within the "Hi-Precision Prospector" group
6. Non-Dedicated Automation-GROW within the "Hi-Volume Parts" group

Further examination and discussion of these relationships will be presented in the next chapter.

5.5 Summary of Results

Three of four hypotheses received strong support. With strong, interpretable technology differences between strategic groups (H3), this study's main question of a relationship between technology and strategy appears to be supported. Fit anchored to performance (H4), was not supported. Discussion of these results, and further probing into the nature of the within-groups performance relationships uncovered in H4 follow in the next chapter.

CHAPTER 6

DISCUSSION

This chapter is organized around six topics. The first three address the results of the hypotheses testing. H1 and H2 are discussed for what they tell us about the "Nature of Fit." H3 is speaks to the "Existence of Fit," while the results of H4 are probed for the existence of "Fit Anchored to Performance." After discussion of the results, the question of "Generalizability of the Findings" is addressed. The chapter finishes with this study's "Contribution to Current Research," and "Implications and Suggestions for Future Research."

6.1 The Nature of Fit

As determined in Chapter 2, details on the nature of fit between process technologies and competitive priorities are so far conspicuously missing from the manufacturing strategy literature. This section tries to shed some light on these alleged but undisclosed linkages by discussing the results of H1, H2, and the pattern of relationships found between the other strategy and technology dimensions.

H1 showed that dedicated and non-dedicated automation are most appropriate under conditions of new and existing product stability. These results are consistent with thinking about conventional automation and integration (e.g., Abernathy & Townsend, 1975; Hayes & Wheelwright, 1979a,b), but not for the case of Non-Dedicated Automation. These "programable technologies" (comprised mostly of CNC machine tools) are reported to have the flexibility to switch product runs with little loss of efficiency (Adler, 1988; Wheelwright, 1984; Jelinek & Goldhar, 1983; Thompson & Paris, 1982; Voss, 1986). This study's finding is congruent with previous research in this industry in which CNC was found to be inappropriate for small batch sizes and non-repeat products (Schroeder et al., 1988, 1989).

The explanation of this finding lies with the difference between new and existing product stability as discussed in Chapter 3. The literature generally does not make this distinction explicit, but is implicitly referring to existing product stability. While product switches may be inconsequential to CNC technologies, programming new products is not.

Ideally, the two types of product stability should be treated separately. In theory, each would probably relate differently to CNC. In our sample, new product stability (repeat orders) and existing product stability (batch size) were strongly correlated and formed one strategy factor. In a mostly contracting industry, a small order size often equals batch size (a firm runs the whole order in one batch). For a given capacity or firm size, small batches therefore reflect many new products. On the other end, it is the larger volume parts makers who also get repeat orders. In other sample industries, batch sizes may have less or little to do with how often a product is redesigned.

H1 also found that Dedicated Automation was inappropriate in conditions of high Product Range, while Non-Dedicated Automation was unrelated to Product Range. While the literature is typically not explicit about the idea of wide product range, the finding on Dedicated Automation makes sense, and is congruent with past research (e.g. Abernathy & Townsend, 1975). Although the literature (Adler, 1988; Wheelwright, 1984; Jelinek & Goldhar, 1983; Thompson & Paris, 1982; Voss, 1986) implies that CNC is typically very general purpose, and therefore not adversely affected by wide product range, Blois (1985) notes that flexible manufacturing systems (perhaps semi-dedicated automation) are very inflexible outside of their designed product range. Likewise, CNC surely has some limits such as size or complexity. However, because the alternative to CNC for this sample is conventional machine tools which are also general purpose, and probably subject to similar limits, one would not expect the correlation to be significant in either direction.

Hypothesis Two tells us that we cannot expect one-to-one correspondence between strategic needs and particular process technologies. Although strategic dimensions may be conceptually independent from each other, in practice, supporting capabilities often come bundled in one technology offering. In this study, among firms with very low product stability, firms with higher precision needs used more CNC despite the programming costs involved. Likewise, among very low precision firms, firms with higher product stability used more CNC despite higher equipment cost. The more complex correspondence found in this hypothesis makes relationships between process technology less clean and any technology imperative less obvious.

Examination of the correlation matrix between technology and strategy factors (Table 5.2) also tells us something about the nature of strategy-technology fit. Although this examination is post hoc, many of the relationships make sense as discussed earlier, and provide ideas for further testing. In addition, the overall character of the correlations is meaningful for what it tells us about the nature of fit.

What can be concluded from the strategic dimensions which appear to be related to process technology? Most represent physical product characteristics such as quality (precision and consistency), the stability of new and existing products, differentness or range of products made, or extra processing of the products (value stages). These product attributes are primarily consequences of particular market segments. In essence, this study finds a link between what products to make for what markets (product-market strategy), and how to make those products (process technology).

6.2 The Existence of Fit

Hypothesis Three demonstrates that strategy-technology linkages do add up to the existence of fit as a gestalt. The significant differences in technology between the strategic groups suggest that over a period of time, variations in technology have coalesced around different strategic positions as firms with inappropriate technology have either vanished or changed strategic positions. The logic and interpretability of the technology differences as discussed earlier are key in demonstrating the existence of fit. Although conceptually simple, this kind of statistical demonstration of significant difference in technology between strategies in an industry has not been done before.

6.3 Fit Anchored to Performance

Hypothesis Four attempts to assess the existence of fit anchored to firm performance. In this somewhat stronger (than H3) conceptualization, the relationship between strategy and technology should be manifest by its impact on firm performance. The results of testing H4 show little support for the idea that fit between process technology and strategy will be reflected in higher performance.

One response to these results is that a clear, strong relationship was a lot to expect. The results of H2 show that relationships between strategy and technology dimensions are often not a clean, one-to-one correspondence. Discussion in Chapter 3 pointed out that, not only is performance hard to measure, but so many factors converge to impact performance that our relationship might be difficult to perceive through the noise. However, even despite the difficulties of performance measurement, one might expect at least one or the other performance measures (ROS or Growth) to be meaningfully measured because the drawbacks for each counteract the other to some degree (e.g., a firm reporting low profit due to high investment would likely report high growth). In addition, despite the noise surrounding a multi-faceted construct like performance, one might expect that our hypothesized relationship would show through given our relatively large sample size.

Another response is that there might be more here than meets the eye. After all, one would not expect every strategic group to have significantly different technology-performance relationships with respect to each of the other groups for each of the technologies. Similarly, strategic groups are not different from every other group on every dimension. While the results of this study are still not strong enough to support H4, it might be instructive with respect to theory building to examine the traces of technology-performance relationships found in Model I.

6.4 Exploration of Individual Technology-Performance Relationships

If such a thing as technology-strategy-performance fit exists, one might expect every strategic group to have at least one technology imperative. When one considers the within group relationships identified previously, this study does find a technology imperative for all but the "Opportunists" strategic group (see Table 6.1).

Table 6.1

Significant Within Groups Technology-Performance Relationships

1. Range of Capabilities-ROS within "One-of-a-Kind"	(.0068)*
2. Dedicated Automation-ROS within "Service Volume"	(.0002)
3. Non-Dedicated Automation-GROW within "No Frills Volume"	(.0057)
4. Non-Dedicated Automation-GROW within "Hi-Volume Parts"	(.0428)
5. CAD-ROS within "Hi-Precision Prospector"	(.0158)
6. CAD-GROW within "Hi-Precision Prospector"	(.0366)

* Probabilities are from Model II, Table 5.8, for the individual technology while taking into account the other three technologies.

The next question is whether these technology-performance relationships make sense within their context and what does this tell us about the performance impact of fit?

To search for the answer, each relationship is examined for underlying strategic dimensions that are most important in the technology-performance relationship within the corresponding strategic group. In these discussions, correlations referred to are between strategy and technology factors unless otherwise noted (e.g., a correlation involving a survey measure). The term "interaction" is used to refer to the significance of strategy-technology interaction terms in liner regression models. Such interactions are taken from within a strategic group to try and isolate which strategic dimensions underlie the technology-performance relationship within that group. For example, if Technology Factor One (TF1) was related to ROS within a group, an interaction term of TF1 and the each of the eight strategy factors would be examined in relation to ROS within that strategic group (ROS=TF1*SF1, ROS=TF1*SF2, ROS=TF1*SF3, ... SF8). This essentially tells us whether, within a group, firms which score high on TF1 <u>and</u> on SF1 (or other factors) also score higher on ROS.

Range of Capabilities appears to relate logically to ROS within the "One-of-a-Kind" strategic group. One might expect that a wide capability range would allow firms to command higher margins by being able to do a wider range of products or more complex products (with multi-axis capabilities). Significant interaction between Range of Capabilities and Product Range (.0106), and between Range of

Capabilities and Precision (.0040), with ROS, support this expectation. Interestingly, interaction with Product Stability was also significant (.0029) but negative. Examination of individual technology measures revealed that the underlying influence came from Product Specific Layouts (Survey Question #21), which interacted positively (.0073) with Product Stability as one might suspect. This measure loads negatively in the Range of Capabilities Factor (see Table 4.6), thus causing the negative interaction relationship. In sum, all the linkages make sense, although this last linkage hints of larger than expected product stability for some firms than one would expect to find in this group, stable enough to warrant product specific machine layouts.

Because "Service" is the salient characteristic of the "Service Volume" strategic group, one might expect higher ROS to be related to service, and whatever technology supported that extra service. However, while related to ROS, dedicated automation is not related to service, nor is it apparent how it would be related. The linkages that are significant in this group are interactions between Dedicated Automation, and the strategy factors Product Stability, Precision, and Price Premium. Dedicated Automation makes sense for Product Stability, and Price Premium is probably significant as proxy for ROS. It is not clear why Dedicated Automation would be needed for precision, but perhaps things like automatic parts changers reflect technologically sophisticated firms which tend to deal in high precision products, especially defense aerospace.

The two positive relationships (within "No-Frills Volume" and "Hi-Volume Parts" groups) between Non-Dedicated Automation (CNC) and Growth appear very similar. In both groups, CNC interacts negatively with Price Premium and Product Range in relation to Growth. For Price Premium, it may be that firms are growing faster because they are pricing aggressively. In this case, CNC may have nothing to do with growth, but may indicate that it is the higher volume firms which need aggressive pricing. Firms with wide product ranges show some signs of slower growth, but those with CNC even slower growth. The CNC equipment may be limiting growth by not being able to accommodate a wide product range (such as size). Perhaps these firms have not yet adjusted their customer base to grow with CNC.

In the case of the "No-Frills Volume" group, CNC interacts negatively with Value Added (primarily from design) with respect to Growth. In this case, a firm probably finds it easier to grow without having to expand a design function. It would purchase CNC equipment rather than conventional machine tools because of higher volume. This is perhaps a pure example of "No Frills" which characterizes this group.

Within the "Hi-Volume Parts" group, Customer Stability interacts positively with CNC in relation to growth.

Customer Stability is high in this group compared to other groups, but is not significantly related to growth. Only in interaction with CNC does Customer Stability result in growth. The reason behind this relationship is not clear, but perhaps the firms which are growing the fastest have some stable relationships with growing customers, and are buying CNC machine tools rather than conventional.

In the last two relationships to be discussed, within the "Hi-Precision Prospector" group, CAD is positively related to both ROS and Growth. Perhaps because value added through assembly is more prevalent than design within this group, firms which do design are more differentiated. Within this group, CAD interacts negatively with Customer Stability in relation to both ROS and Growth. With a wide number of customers (customer instability), perhaps CAD is needed to design efficiently. The automation of design may allow even more customer prospecting and further growth.

The six relationships just discussed appear reasonable for the most part. The explanations need to be viewed with caution as cause and effect are impossible to discover from this data even if it does exist. However, many of the relationships, especially the first two, make sense because of physical linkages similar to those discussed in the previous section on the nature of fit.

One conspicuous pattern in these observations is that the technology-performance relationships do not take place within the strategic groups that one might expect would most benefit from the technologies. While wide Range of Capabilities makes sense for firms in the "One-of-a-Kind" group, it is the "Opportunists" which have the higher levels of this technology, and for which "Range of Capabilities" would seem to fit with the strategy of the group. Dedicated Automation is more a part of "Hi-Volume Parts" than "Service Volume," yet it is the later where a performance impact is seen. CNC does relate to performance for "Hi-Volume Parts," but one would think such a relationship would also occur in the "Service Volume" group before it did in the "No-Frills Volume" group, given the higher product stability of the former. CAD should be more important to the "One-of-a-Kind" group which does the most designing than it is for the "Hi-Precision Prospector" group.

It might be that such technologies are more of a given in the seemingly more relevant groups, and as such do not provide strategic advantage. First mover advantages of early adoption of new technologies has been noted by other scholars (e.g., Porter, 1983, 1985; Schroeder, 1990). These technologies (most of which are new, e.g., CAD, CNC, Multi-Axis CNC, Automatic Parts Changing) may have more of an advantage in groups where the technologies are "newer" so to speak, and provide a source of differentiation. On the other hand, "new" may have less to do with it than being in a viable but minority position within the group, itself a source of differentiation. Schroeder (1990) found evidence of this in the foundry industry, where some firms formed a very profitable niche with the unique capabilities of the older process technologies discarded by the majority of firms.

Questions remain as to why firms which do not use a technology which seems most appropriate for their strategy are not suffering negative performance. Again we can refer back to the uncertainties of performance assessment, or the complexity of factors that impact performance. Perhaps these firms compensate in subtler ways than can be picked up by strategic grouping, or the methods of this study in general. Issues of firms surviving or benefiting from the temporary advantage of new technologies are not fully serve by the cross-sectional nature of this study.

6.5 Generalizability of Findings

Given the results of this study, the next important question is to assess to what degree these findings are generalizable to other settings. A large part of whether these findings can be projected to other industries involves the two major constructs of this study, process technology and competitive strategy. The generalizability of this study's process technology construct derives primarily from the dimensions used to characterize technology. The generalizability of the strategy construct depends not only on whether the strategy dimensions make sense in other industries, but also on whether the groupings or gestalts of these dimensions have any meaning in other industries.

This section first examines the generalizability of the technology and strategy dimensions. The strategic groups derived from the dimensions are then examined against other strategic group research, and against generic strategy typologies. Finally, the overall generalizability of the industry will be touched on.

6.5.1 Strategy and Process Technology Dimensions

The main question concerning the strategy and technology factor analyses is whether the dimensions found are merely unique to the industry studied, or are to some degree fundamental, and thus generalizable to other industries. Part of the answer lies in the intent of the measures gathered. The measures were gathered to reflect generalized, theoretical strategy dimensions as identified by other works, so it is not too surprising that the resulting factors correspond quite closely with the literature as demonstrated earlier. However, measures could conceivably have been related and grouped any number of ways other than as predicted. Thus comparability between the factors and the theoretical dimensions support to some extent the generalizability of this study's factors.

A key aspect to the generalizability of the strategy and technology dimensions is that interpretation of measures should be made relative to the sample context. Among the strategy dimensions, "Product Characteristics" (from Table 3.1) is an important strategy differentiator in any setting, but deciding which product characteristics are key depends on the sample industry. In this study, "precision" was a key characteristic. The degree of "Product Stability" probably differs most widely between industries in an absolute sense, but within one industry, one should find a range of differences which is strategically meaningful. Although the options firms have for "Service" will certainly depend on the industry, the importance of differentiation based on service is relevant to most conceivable industry settings.

On the technology side, the process technology of any firm should have a "Range of Capabilities," but the defining dimensions, and what is considered wide and narrow range, will depend on the industry context. In this sample, range was primarily differentiated on the breadth of part sizes and complexity accommodated.

This study's automation dimensions form a scale that is relevant to most conceivable process technology situations if taken relative to a particular industry context. The scale runs from Non-Dedicated, Non-Automated technologies (conventional machine tools in our sample), to Non-Dedicated Automation (CNC machine tools), to Dedicated Automation. This scale is very similar to Jelinek & Goldhar's (1983) Independent Tools & Methods, Programmable System, Flexible Systems, and Dedicated Systems. While "Non-Dedicated Automation" is perhaps a more generalizable way to characterize the middle of the scale than their "Programmable Systems" and "Flexible Systems" (because of potential confusion between "Flexible Systems" and the hardware specific term "Flexible Manufacturing Systems"), neither scale would be generalizable if fixed in hardware terms. What is considered "Dedicated" or "Automated" hardware surely depends on the industry, but the technology choices of most any industry probably have some meaningful differentiation along the dimensions of automation and dedication.

Given the relative nature of specific measures, scholars need to be careful in discussing the strategic implications of specific hardware technologies. For example, the flexibility of CNC technologies is often extolled without adequate specification of context. CNC is often equated with flexibility, but the results of H1 show that it is a fairly inflexible technology choice within this sample industry.

A few proposed dimensions did not materialize. One was the difference between physical and computer integration.

This is mostly due to the fact that there is very little computer integration in this industry. Studies in other industries such as the Automobile industry would likely pick up this dimension in more highly computerized plants such as General Motor's new Saturn plant with its complex materials requirements planning systems. The systemization dimension proposed by Kotha & Orne (1989) would likely be an important underlying dimension in studies which went beyond the hardware focus of this study to the procedures technologies that surround hardware.

In addition, as noted above in the discussion of H1, a distinction between new and existing product stability did not emerge from this sample. The impact on this study's results is minimal because, as noted above, the two stabilities are very related in this contracting oriented sample. In addition, both new and existing product stability were expected to have roughly the same relationship to physical integration or dedicated automation. In other sample industries, new and existing product stability may be unrelated, resulting in different relationships with regard to non-dedicated automation.

In sum, although additional dimensions may emerge in other studies, the factor analyses of strategy and technology measures result in underlying dimensions which correspond well with those suggested by the literature as important. These dimensions should be generalizable to most industries if measures are applied relative to a specific context.

6.5.2 Generalizability of the Strategic Groups

Given the formation of strategic groups in this study, it is important to reflect on how these groups compare to other methods for assessing strategy. First, how do the strategic groups of this study correspond to the generic or universal typologies of Porter (1980) and Miles & Snow (1978)? Hambrick (1983a) asserts that the Miles & Snow typology cannot be used to compare strategies between industries, only within an industry. Likewise, Porter states that his strategy types are really generic strategic groupings, which only relate firms within an industry. What is generalizable about these typologies is that they are claimed to represent the fundamentally viable strategic positions or types within any industry. Do the types found in our study appear to be generalizable in the same way?

A useful way to investigate this question is to assign this study's groups to the strategy types of Porter and Miles & Snow. While they each found three viable types, this study found six meaningful strategic groups. From the perspective of Porter's strategies, this studies types appear to correspond as follows in Table 6.2.

Table 6.2

Strategic Groups and the Porter Typology

Porter's Types	Strategic Groups	Number
Low Cost:	"Hi-Volume Parts"	(2)
	"No Frills Volume"	(5)
Differentiation:	"Hi-Precision Prospector"	(3)
	"Service Volume"	(4)
Focus:	"One-of-a-Kind"	(1)
	"Opportunist"	(6)

Clearly, groups two and five with their volume and intense price competition can be considered low cost strategies. Groups three and four, with their value added and price premium, appear to be differentiators. Group one focuses on a stable customer base and one-of-a-kind work while group six focuses on opportunities within a very local scope.

Although the distinctions between differentiation and focus may not be clear, the pattern that emerges from this comparison is clear. This study's groups represent different approaches to low cost, different dimensions on which to differentiate, or different things on which to focus. Porter (1980) recognizes that different approaches to the generic strategies are possible, but chooses to emphasize the broader differences. Similar to this study, Schroeder and Congden (1990) found what they considered to be three meaningfully different approaches to differentiation and two approaches to low cost.

An assignment of the strategic groups to the Miles & Snow typology also yields different approaches to their strategy types (see Table 6.3).

Table 6.3

Strategic Groups and the Miles & Snow Typology

Miles & Snow Types	Strategic Groups	Number
Defender:	"One-of-a-Kind"	(1)
	"Hi-Volume Parts"	(2)
	"No Frills Volume"	(5)
Prospector:	"Hi-Precision Prospector"	(3)
	"Opportunist"	(6)
Analyzer:	"Service Volume"	(4)

With high customer and product stability, groups two and five are defender strategies. While group one has very high customer stability and is probably a defender, it could also be thought of as an analyzer for its unstable products. Group four has reasonably high product stability but unstable customer relationships, and thus falls in the middle as an analyzer. Groups three and six have very low customer stability and high product range, and are thus prospector strategies. In essence, there are different approaches to these types depending on whether one emphasizes new product stability, existing product stability, or customer stability as the key dynamic.

Although the Miles & Snow typology assignments may not be perfect, a comparison with the Porter assignments shows that the two typologies result in different groupings. For example, groups three and six are of the same Miles & Snow type whereas they are each grouped with a different Porter strategy type. This results from different conceptual underpinnings. The Miles & Snow typology is base on differences in product-market stability whereas Porter concentrates on whether or not firms differentiate their product offerings enough to command price premiums.

The larger point is that perhaps both of these conceptual underpinnings are important for particular situations, such as linking strategy with process technology. In such situations, strategic groups should not be further clustered together and reduced to a few broad archetypes.

Each of the six groups did result in meaningful process technology differences. This is especially evident if one compares the technology differences (Table 5.4) of the groups that are assigned to the same generic strategy type (Porter, 1980). For the two low cost strategies, Group 5 has significantly less CAD and Range of Capabilities than Group 2, as it is strictly no frills, while Group 2 has high Dedicated Automation for its higher product stability. Because of its prospecting nature, Group 3 has a high "Range of Capabilities" relative to Group 4, while the later has higher automation for its greater product stability. Group 1 has significantly higher CAD than Group 6 because of its value added from design, while the later has a very high Range of Capabilities for its prospecting nature. These technology difference support the arguments in Chapter 3 that further sub-division of the generic strategy types would permit us to see more detailed technology relationships.

In addition to meaningful technology differences, the strategic differences of the six groups appear meaningful. First, based on case studies from prior research in the sample industry which seem to parallel the strategic groups in this study, the groupings are meaningful because their markets really do not overlap very much. Second, each strategic group consists of a different mix of strategic priorities that interact in a way that makes intuitive sense.

With regard to the question of generalizability, from our analysis, the strategic groupings are potentially generalizable if subsumed under one of the generic typologies. However, this would defeat the purpose of the more detailed strategic groupings we have just argued for. The exact six types here are probably not generalizable because different approaches to the generic strategies may hinge on other strategic dimensions in other samples. However, the fact that different approaches to the generic strategies were found to be meaningful is important in itself.

Some generalizability can still be inferred if our grouping process conforms to standards of strategic grouping literature. As noted previously, mobility barriers have been the primary rationale behind strategic grouping. Indeed Mascarenhas & Aaker (1989) assert that mobility barriers are the only meaningful basis for strategic grouping. This study grouped primarily on product-market variables because the strategy-technology literature generally takes a product-market view of strategy and because process technology, although undoubtedly a mobility barrier, needs to be treated separately from strategy if one is to determine whether there is such a thing as fit between the two. Other types of "resource commitments" (Cool & Schendel, 1987) or "industry supply characteristics" (McGee & Thomas, 1986) such as distribution and R&D would have been included in this studies grouping if relevant to the sample industry.

The good news borne by the results of H3 is that because of the fit between process technology and strategy, the more product-market oriented groupings formed in this study effectively do take into account the mobility barriers posed by process technology. The significant differences in technology between the strategic groups of this study undoubtedly hinder movement between the groups.

In addition, the literature focus on tangible assets as mobility barriers overlooks the possibility that product-market strategies are not easily imitated. For example, successful service strategies depend on suitable behavioral patterns and mind-sets, and a service reputation, neither of which is easily established. This may be no less of a barrier than the capital needed to go out and purchase new process technologies. One concludes that the strategic groups of this study are congruent with the mobility barriers rational behind strategic grouping.

The degree to which conforming to the standards of strategic grouping practice affords some generalizability, however, is uncertain because standards are still emerging (McGee & Thomas, 1986; Mascarenhas & Aaker, 1989; Cool & Schendel, 1987). However, most strategic grouping seems to be defined around two broad concepts of product-market choice ("Business scope commitments," Cool & Schendel, 1987; "Market related strategies," McGee & Thomas, 1986) and different deployments of resources to serve those markets ("Resource commitments," Cool & Schendel, 1987; "Industry supply characteristics," McGee & Thomas, 1986). Cool & Schendel (1987) propose that these two dimensions compose the core of strategic grouping. The groups of this study essentially conform to this core. Further strategic groups research is needed to establish these or more specific dimensions as the common core of strategic groups analysis.

6.5.3 Industry Generalizability

A large part of whether results in this industry are generalizable to other industries stems from the generalizability of the technology dimensions and the strategic approach discussed above. Nevertheless, it appears that the results of this study will be least generalizable to service industries for three reasons. First, the tooling and machining industry is a manufacturing industry. Whether manufacturing technologies bear enough resemblance to service industry technologies so that basic relationships (e.g., with respect to automation) hold is uncertain. Second, many of the service priorities in this industry showed little relationship to technology. Third, the hardware focus of this study may be less appropriate. However, with expansion of the definition of process technology to include procedures, and with use of a "systemization" dimension, the approach taken by this study should translate to service industries.

This study's results should relate to other manufacturing industries, but the special contract nature of the sample industry raises some questions. The sample industry is very competitive so that one might expect a closer alignment (stronger relationship) if fit is important. In addition, because other functional areas such as R&D, Marketing, Distribution, play less of a role in this predominately contract industry, one would expect a stronger fit where operations was the primary focus of firms. Nevertheless, both of these concerns deal with the strength of the relationship; there is no reason to suspect that fit does not exist in other manufacturing industry.

6.6 Contribution to Current Research

Like previous studies (Schroeder, 1990; Schroeder et al., 1988, 1989), this study found that manufacturing technologies do differ meaningfully between different strategies within an industry. This work extends the previous observations of the existence of fit by demonstrating statistical significance across a larger sample.

In addition, while this study did not find sufficient evidence of fit related to performance, it is the first study attempting to statistically examine what has recently been described as the primary question facing research attempting to link manufacturing technology to competitive strategy (Anderson et al., 1990; Kotha & Orne, 1989). A viable research approach to this question, upon which future research can build, has been demonstrated

A good deal was learned about the nature of fit. In the past, fit between process technology and strategy was primarily a question of choosing between efficient, automated technologies for a low cost, high volume strategy, or more flexible, but less efficient technologies for a differentiation strategy (e.g., Abernathy & Townsend, 1975; Hayes & Wheelwright, 1979a,b). More recently, manufacturing strategy literature has argued that technology can impact business level strategy at a finer level of strategic priorities (e.g., Hayes & Schmenner, 1978; Skinner, 1984; Stobaugh & Telesio, 1983; Wheelwright, 1984). The advent of computer controlled technologies has prompted speculation that a trade-off between flexibility and efficiency is now greatly diminished (Adler, 1988; Blois, 1985; De Meyer et al., 1989; Jelinek & Goldhar, 1983; Meredith, 1987; Thompson & Paris, 1982; Voss, 1986; Wheelwright, 1984). However, these recent works are conceptually based, providing little detail on specific linkages between manufacturing technology and strategy. An empirical study by Schroeder et al. (1989) reported specific linkages, but did not statistically validate them.

This study found that new and existing product stability is positively related to automation technologies, both dedicated and non-dedicated. This finding is contrary to the idea that CNC is a flexible technology choice. As Schroeder et al. (1989) observed, the programming costs are too great for very small batches. This finding serves to remind us that specific hardware technologies have different strategic relevance in different industries.

This study also demonstrated that a particular technology often comes bundled with capabilities, each of which may be differentially important for various strategies. This makes one-to-one correspondence of particular technologies to particular strategies improbable, and the resulting performance impacts less strong.

One key characteristic of fit is suggested by post hoc examination of correlations between strategy and technology factors. Manufacturing technology appears to relate to strategy primarily through strategic dimensions which are most directly related to physical characteristics of products, much of which derives from choice of market segment. Service and differentiation strategy dimensions appear less related to manufacturing technology.

The approach taken by this study is also a meaningful contribution. The strategic groupings further demonstrate the usefulness of the strategic groups concept for determining the important competitive positions within an industry. The effectiveness of cluster analysis in this grouping process was corroborated (see Harrigan, 1985). With respect to grouping variables, this study finds a difference between product stability (how many times a firm has to change production over for new or other already existing products), and product range (the breadth of how different products of a firm are from one another in size, complexity, fragility, processing requirements, etc.). Product range generally has not been reported in the literature, but appears to be important in linking strategy to process technology. The difference between new and existing product stability has also not been made clear in literature discussion of flexibility. Although a difference was not found in this study, it may be important in other industries.

On characterizing technology, this study demonstrates the viability of Kotha & Orne's (1989) proposal that process technology be assessed along a number of underlying dimensions. They propose dimensions of mechanization (automation), interconnectedness (integration), and systemization. This study contributes an additional dimension of "Range of Capabilities." A distinction between physical and computer integration is also recommended. These additional dimensions provide the means to differentiate technologies on more than just automation-integration, which has resulted in the powerful but not fully satisfying dictum of "flexibility versus efficiency."

Overall, the approach taken by this study retains meaningful detail in the strategy and technology assessment so that the linkages with technology can emerge.

6.7 Implications and Suggestions for Future Research

While the approach taken by this study appears generalizable, more studies are needed to validate and expand its results. The success this study had in finding process technology differences related to competitive strategy bodes well for such findings in other industries. The intra-industry approach ensures that technology differences meaningful within an industry are not obscured by more prominent relationships in more technology ladened industries. The nature of fit as found from H1 and H2 should hold in most settings as the hypotheses were derived from generalized reasoning. Research findings in other industries may allow some cross-industry generalization in the form of strategy sub-typologies consisting of a limited number of meaningful approaches to the generic strategies. Finer linkages between strategy and technology may only hold within a limited number of industries of similar nature.

A challenge to the results of this study might be found in less technologically oriented, service industries. Although Skinner (1984) asserts that manufacturing technology can impact on a number of service related strategic priorities, this study did not find evidence of service linkages. Many service priorities may be related to technologies more peripheral to process technology, such as "delivery technologies." As Porter (1983, 1985) notes, potential for technology based competitive advantage exists at every value stage. Still, it is not clear what the boundaries of "process" technology are. This study took a narrow focus looking only at hardware. A broader focus including Kotha & Orne's (1989) "systemization" might get at some of the less concrete "procedures" technologies. Service industries might be better served by such an approach.

The "Range of Capabilities" dimension raises interesting questions about the idea of "factory focus" (Hill & Duke-Woolley, 1983; Skinner, 1974, 1984). In this study, having a wide range of capabilities seemed to be an integral part of two strategies ("Hi-Precision Prospector" and the "Opportunist" strategy). Should all strategies within an industry work toward factory focus, or can some firms form viable niches by focusing on "non-focus?" As Anderson et al. (1990) conclude, the idea of factory focus has much potential, but needs empirical research.

This study's finding on CNC machine tools' relationship to product stability invites speculation on the impact of computer controlled technologies. While CNC machine tools are generally thought of as a "flexible" technology choice, programming costs make them the inflexible choice for very small batch sizes. As programming technologies develop, programmable technologies will yield increasing flexibility <u>and</u> efficiency for both new and existing product changeovers. On the margins, there should still be trade-off between efficiency and flexibility, especially considering that integration of computer controlled components will still tend toward product dedication and therefore less flexibility. However, the trade off is bound to diminish in magnitude given the intense pursuit of both efficiency and flexibility by Japanese firms (De Meyer et al., 1989).

Will this obscure strategy-technology relationships? Probably not. Jaikumar (1986) asserts that the focus of competitive advantage shifts to the initial design of flexible systems, and to continuous programming improvements. Manufacturing "procedures" technologies will become more important relative to "hardware." The range of capabilities will also become more important. Outside the design range, such systems are very inflexible given high installation time and cost. The importance of individual linkages between process technology dimensions and strategy dimensions may change, but it is difficult to imagine that the processes of all firms in an industry becoming so similar that they bear no relation to strategy. Much future research is needed to establish current technology-strategy linkages and to track their evolution.

CHAPTER 7

CONCLUSION

The concluding chapter consists of three sections. The first summarizes the findings of this study. This is followed by caveats and limitations with respect to the findings. Finally, the significance of the findings to scholars, practitioners, and future research is discussed.

7.1 Summary of Findings

Much has been written in the last decade about the importance of process technology to competitive strategy. Most of these works explicitly or implicitly contend that process or manufacturing technology needs to be congruent with or "fit" a firms' business level strategy. Within an industry, a particular technology may or may not be appropriate for every strategy. Using the wrong technology (poor "fit") is supposed to hurt firm performance.

Except for some exploratory studies, these works are conceptually based, and contain little detail about specific linkages between technology and different dimensions of strategy. Only one empirical study (Schroeder et al., 1989) has addressed the issue of fit and performance, but it was exploratory in nature, with too few sample firms to assess statistical significance. This study is the first to empirically address the issue of fit and performance with a large enough sample to test for statistical significance.

Within the tooling and machining industry, this study confirmed the existence of fit between competitive strategy and process technology. The existence of fit was demonstrated by highly statistically significant differences in technology between strategic groups combined with the qualitative plausibility with which these differences appear to correspond to each strategy. This study did not find sufficient evidence to confirm the existence of fit related to firm performance. However, within five of the six strategic groups, this study found strong, positive relationships between a particular process technology (technology factor or dimension) and either profitability (ROS) or firm growth in sales. While these relationships appear to make sense within the corresponding groups, the strategic group in which one would have expected a particular technology to be most important often did not exhibit a performance relationship with that technology. It may be that technology is more of a given for such groups, and thus provides no real advantage. In other groups where the technology is also appropriate but less widespread, a performance advantage may be gained by firms in which early adoption differentiates them from the other firms.

This study also discovered much about the "nature" of fit or specific linkages between technology and strategy. Dedicated <u>and</u> non-dedicated automation are most appropriate under conditions of new and existing product stability. In this setting, CNC was inflexible with regard to new products, reminding us that what constitutes relatively high stability and dedication depends on the industry context. In addition to new and existing product stability, which the literature often fails to differentiate between, this study finds that product range is an important characteristic of a firm's products with respect to process technology. The range of capabilities of a firm's process technologies, an important technology characteristic found by this study, often relates directly to product range. This study also found that firms with very different strategic needs will use the same technology because of different capabilities bundled in a given technology. This phenomena acts to obscure linkages between strategy and technology. Overall, technology appears to be most linked with strategic dimensions which are concerned with the physical characteristics of products, such as quality, the stability of new and existing products, differentness or range of products made, or extra processing of the products (value stages). These product attributes are primarily consequences of serving particular market segments.

7.2 Caveats and Limitations

Caution needed in projecting these results comes from three sources: (1) the nature of the sample industry, (2) strategic grouping, (3) performance assessment. First, this study's results need to be validated in other industry settings. The terms "manufacturing technology" and "process technology" were used interchangeably because the sample industry is a "manufacturing" industry. The process technologies of service industries may not be considered "manufacturing" technologies. Given the lack of linkages with service measures, the results of this study (the existence of fit) may not hold up in service industries unless a broader definition of technology is used (e.g., to include procedures). The results should translate to other manufacturing industries, although some differences in strategy can be expected due to the special contract nature of the sample industry.

Second, although the detail of strategic grouping is needed to establish finer linkages, strategic group practice is not settled. This makes cross-industry comparisons of strategy difficult. Recent progress has been made with works by Cool & Schendel (1987, 1988), and Mascarenhas & Aaker (1989). Further strategic groups research is needed to make cross-industry generalizations more meaningful. Ultimately, finer grained sub-typologies which complement generic strategy typologies might emerge. This and further research on technology's relationship with strategy may result in a better understanding of which specific linkages are most relevant in which industry types.

Third, performance assessment has to be viewed with caution. The meaning of return on sales is somewhat suspect because technology purchases are relatively significant investments for firms in this industry. Some firms may achieve above average short term profits by neglecting investment in new technologies for the future. Assessment of growth counteracts short term profits to some degree, but many factors impinge on growth. Large sample size and control for growth of customer industries should mitigate these problems.

With respect to issues of performance measurement, because most firms are small and privately owned, self-reported, objective measures are probably more meaningful than accounting measure even if the later could have been obtained. The high response rate on performance measures (93 percent) attests to the explicit anonymity of the survey instrument, and suggests that respondents did not object to answering, and were therefore unlikely to knowingly report invalid performance scores.

7.3 Significance to Scholars, Practitioners and Future Research

To bring closure to this study, reflection on its significance to scholars, practitioners, and future research is needed. For scholars, the importance of this dissertation is its successful intra-industry approach. The actual findings, while new to the field, are of less direct importance than the fact that linkages between strategy and technology can be uncovered with this focused approach. Cross-industry studies must often dismiss detailed linkages as not appropriate for "all" industries before anything can be learned from them. Cross-industry or global research potentially results in problems of comparability among measures of strategy, as strategy is a relative phenomenon (Snow & Hambrick, 1980; Hambrick, 1983a). In the same way, the relationships of manufacturing technology to strategy may be relative. As development of business strategy theory is probably better served through an inductive approach of studying individual industries, (Datta, 1980; Ginsberg & Venkatramen, 1985; Spender, 1983), so to is understanding of the linkages with technology.

This study has implications for strategic group research as well. Successful clustering of dimensions resulting in meaningful strategic groups adds to the success of previous strategic groups research at typing strategy within an industry. This study's linking of process technologies to strategic groups gives some assurance to researchers that groupings with a preponderance of product-market variables inherently reflects the "hard" mobility barrier of process technology. Like much previous strategic groups research (see Cool & Schendel, 1987; or McGee & Thomas, 1986 for a review), this study did not find significant performance differences between strategic groups. Process technology may be an important moderator in the strategic groups-performance model.

For managers, this study has implications for the survival and performance of firms. The realization that strategy and technology are closely related is important to deciding which firms are chosen as frames of reference. This study suggests that performance advantage from a technology may come only to the earlier adopters, but after a point, a technology is necessary despite the fact that it no longer brings a performance advantage.

With respect to future research, the successful results of this study should encourage further research on the linkages between strategy and process technology. Specific issues suggested for inclusion in future research are (1) the difference between new and existing product stability, (2) assessment of relative product range and range of capabilities, (3) the difference between physical and computer integration, and (4) the degree of process systemization. Special topics for research include (1) the implications of range of capabilites for the concept of factory focus, (2) the impact on the relative importance of technology-strategy linkages by evolution of process technologies, and (3) research in service industries. The intra-industry approach appears to be fruitful in discovering linkages while leaving plenty of territory for future research in other industries. Perhaps, in combination with other studies, a more generalized but detailed understanding of fit will emerge.

APPENDIX A

SAMPLE QUESTIONNAIRE

TOOLING AND MACHINING QUESTIONNAIRE

National Tooling & Machining Association

NTMA

PRECISION

UNIVERSITY OF MASSACHUSETTS
SCHOOL OF MANAGEMENT

This survey is being conducted in cooperation with the National Tooling & Machining Association and the University of Massachusetts School of Management

Issues addressed in this survey deal with your markets and products, strategies, equipment technologies, and performance. The questionnaire is being sent to NTMA members with 15 or more employees. Please answer questions relative to all tooling and machining firms of this size or larger, not just a few direct competitors.

Questions either ask you to fill in an approximate percentage or to rank your company on a 7 point scale. For questions with 7 point scales, circle a number closer to the description which better matches your situation. For example, 4 represents an average response appropriate when your situation falls in the middle of the two descriptions or when you do about equal amounts of either description. Circling a 1 or 7 means that your situation strongly matches one description and not the other.

Every shop's experience is unique. Consequently, some questions may not match your experience perfectly. Your best approximations are better than no responses.

MARKETS AND PRODUCTS

1) *What percent of production (sales) falls in each of the following product types?* (Totaling 100%)

- ________ Jigs, Fixtures, & Gages
- ________ Dies (all types)
- ________ Molds - Die Casting
- ________ Molds - For Plastics
- ________ Molds - All Other
- ________ Special (Dedicated) Machines
- ________ Precision Machined Parts
- ________ Metal Stampings
- ________ Screw Machine Products
- ________ Machining Services (other than finished parts)
- ________ All Other Products & Services (please specify: ________________)

2) *Compared to most other tooling and machining firms, how would you describe your products?*

Simple	1	2	3	4	5	6	7	Complex
Small in size	1	2	3	4	5	6	7	Large in size
Low precision	1	2	3	4	5	6	7	High precision
Each job new & different	1	2	3	4	5	6	7	Repeat, routine
Small lots/order quantities	1	2	3	4	5	6	7	Large lots/order quantities
Narrow in range, similar	1	2	3	4	5	6	7	Broad in range, very different
Capital intensive	1	2	3	4	5	6	7	Labor intensive
In growing markets	1	2	3	4	5	6	7	In declining markets

3) *What percent of production (sales) falls in each of the following tolerance ranges?*

greater than .005"	________	
.005 - .003"	________	
.002 - .001"	________	
.0009 - .0006"	________	
.0005 - .0001"	________	Total
less than .0001"	________	= 100%

4) *What percent of production (sales) falls in each of the following order/lot/batch size categories?*

one-of-a-kind	________	parts/pieces
2 - 9	________	
10 - 49	________	
50 - 149	________	
150 - 499	________	
500 - 2500	________	Total
over 2500	________	= 100%

5) *Approximately* _______ *percent of our sales are repeat orders (same exact part).*

6) *Approximately* _______ *percent of our sales are to customers requiring just-in-time (JIT) deliveries.*

Approximately _______ *percent of our sales are to customers requiring Statistical Process Control (SPC) checks on their deliveries.*

7) *Which best describes your customers?*

Declining industry	1	2	3	4	5	6	7	Growing industry
"Low tech"	1	2	3	4	5	6	7	"High tech"
New, first time	1	2	3	4	5	6	7	Repeat, same customers
Non-Government	1	2	3	4	5	6	7	Government related
Few in number	1	2	3	4	5	6	7	Many in number

8) *Percent of sales to customers located:* (Totaling 100%)

________ Locally (within 100 miles or so)
________ Regionally (for example, Southeast, Mid-Atlantic, etc.)
________ Nationally
________ Internationally

9) *Percent of sales to customers in the following industries:* (Totaling 100%)

________ Automotive
________ Aerospace
________ Ordnance
________ Appliances
________ Electrical Machinery
________ Electronics
________ Agricultural Equipment
________ Mining, Construction, & Oil Field Equipment
________ Chemical & Petroleum
________ Food Processing & Packaging
________ Pharmaceuticals
________ Machinery, Parts, & Accessories
________ Fabricated Metal Products (not listed above)
________ Other (please specify): ________________

____

10) *What percent of your sales are done on a contract basis?* __________

What percent of your sales are proprietary (your own products)? __________

STRATEGIES

11) *How would you characterize the way in which you compete?*

Primary emphasis on keeping costs lowest relative to competitors	1	2	3	4	5	6	7	Emphasis on service, quality, value added, special capabilities, etc., to differentiate our firm from competitors.

12) *How is the design of your products accomplished?*

We do all design in house	1	2	3	4	5	6	7	Customer furnishes design with NO input from us

13) *What basis is used for determining costs?*

Fixed shop rates for all work	1	2	3	4	5	6	7	Cost system with different rates for different work centers and/or workers.

14) *How do you price contract work?*

We strive to be the lowest bidder	1	2	3	4	5	6	7	Cost plus (time & material)

15) *Our marketing effort focuses primarily on:*

Working closely with existing customers	1	2	3	4	5	6	7	Actively seeking new customers

16) *What percentage of your sales are made through the following individuals?* (Total = 100%)

__________ Top management
__________ Company sales personnel
__________ Independent agent or representatives
__________ Other (please specify): ______________________________

17) *We keep our production costs low by:*

Investing in the latest production equipment for high efficiency	1	2	3	4	5	6	7	Investing in inexpensive production equipment to keep capital costs down.

18) *Most of our equipment is used:*

Extensively and regularly	1	2	3	4	5	6	7	Only occasionally, for special jobs.

19) *Compared to most tooling & machining firms, please rate the importance of the following to the manner in which you compete for work:*

	Unimportant						Of primary Importance
Competitive pricing	1	2	3	4	5	6	7
Close tolerances	1	2	3	4	5	6	7
Dimensional uniformity or consistency	1	2	3	4	5	6	7
Verifiable quality assurance ("Ship to Stock")	1	2	3	4	5	6	7
Short lead times, quick turnaround from order to delivery	1	2	3	4	5	6	7
Dependability at meeting promised delivery dates	1	2	3	4	5	6	7
Being able to accommodate fluctuations in orders	1	2	3	4	5	6	7
Ability to make a wide variety of different products	1	2	3	4	5	6	7
Value added from engineering & design assistance	1	2	3	4	5	6	7
Value added from extra processing such as assembly	1	2	3	4	5	6	7
Frequent contact and close customer working relations	1	2	3	4	5	6	7

TECHNOLOGY

20) *What percent of your production (sales) is made with?* (Totaling 100%)

__________ Conventional machine tools
__________ NC controlled machine tools
__________ CNC controlled machine tools

21) *What percent of your total machine tools are?* (Totaling 100%)

__________ Arranged by type of machining operation (turning, milling, grinding, etc.)
__________ Arranged in work cells and/or grouped for specific products
__________ Arranged in an assembly line fashion
__________ No particular layout scheme

22) *The range of piece/part sizes our total equipment can do is:*

Narrow 1 2 3 4 5 6 7 Wide

23) *In general, how would you describe your* <u>*conventional*</u> *machine tools?*

Standard, off the shelf	1	2	3	4	5	6	7	Custom, special made
Inexpensive compared to similar equipment	1	2	3	4	5	6	7	Expensive compared to similar equipment
Having only necessary capabilities	1	2	3	4	5	6	7	Having extra capabilities for many possible situations
Purchased used	1	2	3	4	5	6	7	Purchased new
Fully depreciated	1	2	3	4	5	6	7	Newly purchased

If your firm does not have NC or CNC machine tools, skip forward to question 31.

24) *How extensively is your CNC equipment used?*

Seldom in use	1	2	3	4	5	6	7	Always running through full shift

25) *In general, how would you describe your CNC or NC machine tools?*

Standard, off the shelf	1	2	3	4	5	6	7	Custom, special made
Inexpensive compared to similar equipment	1	2	3	4	5	6	7	Expensive compared to similar equipment
Having only necessary capabilities	1	2	3	4	5	6	7	Having extra capabilities for many possible situations
Purchased used	1	2	3	4	5	6	7	Purchased new
Fully depreciated	1	2	3	4	5	6	7	Newly purchased
Mostly 2 axis	1	2	3	4	5	6	7	Multi-axis

26) *What percent of your CNC machine tools are?* (Totaling 100%)

_________ 2 axis
_________ 2.5 axis
_________ 3 axis
_________ 4 axis
_________ 5 or more axis

27) *To what degree does your firm have and use the following?*

	Do not have	Have but do not use		Used moderately, for some of our production			Used extensively, for most of our production	
Multi-spindle CNCs	0	1	2	3	4	5	6	7
CNCs with automatic tool changers	0	1	2	3	4	5	6	7
Automatic monitoring of tool breakage	0	1	2	3	4	5	6	7
Automatic gaging	0	1	2	3	4	5	6	7
CNCs programmable for tool wear	0	1	2	3	4	5	6	7
CNCs set up to run unattended	0	1	2	3	4	5	6	7
Secondary operation capabilities on CNC equipment (for example, a milling spindle on a lathe)	0	1	2	3	4	5	6	7
Automatic parts changing (such as multi-purpose robots or automatic pallet changers)	0	1	2	3	4	5	6	7
Dedicated material handling equipment (such as conveyors, transfer lines)	0	1	2	3	4	5	6	7

28) *Which of the following capabilities do you use?* (Check appropriate response(s)).

	Yes	No
Stand-alone computer aided design system (CAD)	______	______
Stand-alone CNC code programming computer (CAM)	______	______
Integrated CAD/CAM system	______	______
Electronically download to machine tools from programming computer (i.e. DNC network)	______	______
Take machine code programs from customer's CAD/CAM without exchange of blueprints	______	______

29) *What percentage of your CNC programming is done by the following people?* (Totaling 100%)

__________ Machine operators
__________ Assigned or dedicated programmer, technician
__________ Foreman or supervisor
__________ Engineer
__________ Contract programer
__________ Customers

30) *Our CNC machine tool operators have:*

minimal training	1	2	3	4	5	6	7	extensive training, journeyman level
broad skill range	1	2	3	4	5	6	7	narrow range of skills
little experience	1	2	3	4	5	6	7	extensive experience

----

31) *Our conventional machine tool operators have:*

minimal training	1	2	3	4	5	6	7	extensive training, journeyman level
broad skill range	1	2	3	4	5	6	7	narrow range of skills
little experience	1	2	3	4	5	6	7	extensive experience

32) *What percentage of your newly hired shop-floor employees are best described by each of the following categories?* (Totaling 100%)

_____ Unskilled
_____ Fresh from tech schools
_____ Partially skilled, some experience from other firms
_____ Highly experienced, journeyman level from other firms

PERFORMANCE

33) *First three numbers of your firm's postal zip code:* ___ ___ ___ X X (used for regionalizing results)

(Over for last page)

34) *Current number of shop-floor employees:* ________

Current number of total employees: ________

Please rank your firm's performance over the past three years relative to most other tooling and machining firms (as best you can judge). The questionnaires are anonymous. Circle the appropriate number:

	lowest 20%	lower 20%	middle 20%	next 20%	top 20%
35) *After-tax return on investment*	1	2	3	4	5
36) *After-tax return on sales*	1	2	3	4	5
37) *Total sales growth over past 3 years*	1	2	3	4	5
38) *Firm's overall performance*	1	2	3	4	5

39) *Over the past 3 years, what has been your average after tax return on sales?* (check appropriate category)

_____ loss of more than 15%
_____ loss of 11 to 15%
_____ loss of 6 to 10%
_____ loss of 0 to 5%

_____ profit of 0 to 5%
_____ profit of 6 to 10%
_____ profit of 11 to 15%
_____ profit of 16 to 20%
_____ profit of more than 20%

40) *Approximate Sales Volume:* ________ 1986 ________ 1987 ________ 1988 ________ 1989

Thank you for your time and effort in completing this questionnaire. Feel free to write down additional comments. Please return the questionnaire in the enclosed self-addressed, postage-paid envelope to:

Dr. Dean M. Schroeder
School of Management, 340 SOM
University of Massachusetts
Amherst, MA 01003

Additional Comments Welcome:

APPENDIX B

COVER LETTER

UNIVERSITY OF MASSACHUSETTS AT AMHERST
School of Management
Amherst, MA 01003
(413) 549-4930

Department of Management

December 21, 1989

Joseph R Petras
Machine Tooling, Inc.
7507 Exchange Avenue
Cleveland, OH 44125

Dear Mr. Petras:

We need your help in completing and returning the enclosed questionnaire. This should take approximately 15 minutes. Confidentiality is assured because we cannot trace the surveys to respondents.

Determining the appropriate machine tools and equipment a shop requires has been complicated by the introduction of many expensive new computer controlled machining technologies. Our work indicates that there are company and market situations in which these new technologies are absolutely necessary and other situations in which they are an unjustified financial burden. In cooperation with the National Tooling & Machining Association, we are conducting a study to more precisely identify these situations.

The results of our research will be published in the NTMA newspaper (The Record) and made available to both the Association and its members. Our hope is that such information will help tooling and machining shop managers with their equipment decisions. If you have any questions on the study, please write or call (413) 549- 4930. Thank you for your time.

Sincerely,

Dean M. Schroeder, Ph.D.
Professor of Business Strategy

Steven W. Congden, MBA, ABD
Research Associate

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