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Testing the precepts of operations strategy

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TESTING THE PRECEPTS OF OPERATIONS STRATEGY

by

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TESTING THE PRECEPTS OF OPERATIONS STRATEGY

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ABSTRACT

Operations strategy has received much attention in the production/operations management literature. While numerous conceptual articles have been written, empirical research on operations strategy theory has been neglected.

This dissertation has empirically tested important precepts inherent in operations strategy theory. A causal model of operations strategy, one incorporating these principles, is defined, empirically tested, and redefined in accordance with operations strategy theory, path analytic techniques, and data gathered from 27 strategic business units drawn from several major electronics manufacturers. Model building followed a review of operations strategy literature from the fields of operations management and strategic management. The final model derived represents the precise set of interrelationships discovered among five key operations strategy variables: strategic consensus, manufacturing task consensus, product-process alignment, advanced systems use, and operational performance.

Seven results have been supported by this research:

1. There is no direct relationship between strategic consensus and operational performance; rather the relationship is indirect, primarily through manufacturing task consensus.
2. There is no direct relationship between product process alignment and operational performance; the

relationship is indirect, through advanced systems use.

3. There is a direct positive relationship between strategic consensus and product process alignment.
4. There is a direct positive relationship between advanced systems use and product process alignment.
5. There is a direct positive relationship between advanced systems use and operational performance.
6. There is a direct positive relationship between manufacturing task consensus and operational performance.
7. There is a direct positive relationship between strategic consensus and manufacturing task consensus.

The research has demonstrated the validation and application of various measurement scales for immediate empirical testing of many of the theoretical precepts of operations strategy. Specifically, the research has clarified the distinction between strategic consensus and manufacturing task consensus. Research results have demonstrated the strong influences of both manufacturing task consensus and advanced systems use on operational performance and additionally have challenged product-process matrix orthodoxy.

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CHAPTER 1

Introduction to the Research

Statement of the Problem

Operations strategy is a topic that has received much attention in the production/operations management literature over the past decade. Numerous conceptual articles and books have been written on this subject since 1969, the year that Harvard's Wickham Skinner wrote the landmark article "Manufacturing -- Missing Link In Corporate Strategy", demonstrating a strong consensus among scholars in the field on the essential importance of a coherent operations strategy for competitive success of the manufacturing organization within its industry. This strong and prolific output of conceptual writings on operations strategy theory continues to this day.

Despite general agreement among scholars on many of the major precepts of operations strategy theory, unfortunately little in the way of empirical research toward verification and refinement of these general principles has been forthcoming. With a few recent exceptions, nearly all published works on this subject have taken the form of either a theoretical treatise or an individual case study. Empirical research in the area of operations strategy is at best at an embryonic stage. An important goal of this research is to provide theory testing of several major precepts of operations strategy theory and, by so doing, to help fill the empirical research vacuum which presently exists in the field.

In this dissertation, following a review of the conceptual literature on operations strategy theory, a causal model of operations strategy is presented, empirically tested, and subsequently refined. Path analytic causal modeling is performed on data derived from twenty-seven strategic business units of several major manufacturing firms operating in the electronics industry. The final model evolved through path analytic procedures (Model 3) is seen to provide the best fit of theoretical operations strategy principles and the empirically ascertained relationships and interrelationships of key operations strategy constructs (variables), including their direct and indirect influences on manufacturing/ operational performance.

Operations Strategy Construct Definition

The following operations strategy constructs are used in this research: strategic consensus (managerial consensus within business units on business strategy), manufacturing task consensus (managerial consensus within business units on manufacturing strategy), product-process alignment (the "correct" alignment of product life cycle stage and production process type), the use of advanced manufacturing systems and technologies, and manufacturing/operational performance. Each of these research constructs is discussed below.

Managerial Consensus: Strategic and Manufacturing Task Consensus

A major theme of the literature on operations strategy is that consensus on general strategic direction and on manufacturing task emphasis must exist between business-level strategic planners and functional-level manufacturing managers for effective business unit performance to consistently occur. A well-developed manufacturing strategy is defined as an operational strategy (pursuit of manufacturing task objectives) that is consistent with the business unit's general strategic direction for the focal product (Schroeder et al., 1986). It is the responsibility of the manufacturing manager to develop a manufacturing strategy (manufacturing performance or task emphasis) that supports the business unit strategy. An effective manufacturing strategy is not necessarily one that promises maximum operating efficiency. Rather, it is an operational strategy designed to fit the specific needs of the strategic business unit, i.e. a functional plan that seeks consistency between manufacturing task emphasis and the type of competitive advantage being sought by the strategic business unit (Buffa, 1984). Operations strategy scholars postulate that effective business unit performance results in no small part from a coordinated and consistent manufacturing strategy that effects a close match between production system objectives (manufacturing task performance objectives) and capabilities and the demands of the market place, as reflected in the business unit strategy. Thus, the manufacturing function should be viewed as a powerful competitive weapon or strategic tool. Ideally, the manufacturing function will properly support the business-level strategy and avoid a mismatch between general strategic objectives and manufacturing task objectives for the focal product. Scholars such as Buffa (1984), Hayes and Wheelwright (1984), and Hill (1985) warn that a manufacturing business unit will have a decreased competitive advantage within its industry if it fails to develop a coordinated and supportive operations strategy.

Such an ideal synchronization of manufacturing strategy and business strategy, however, may not be the norm among business units engaged in manufacturing. Importantly, for this state to occur, a common understanding of purpose and task direction must exist among business-level strategic planners and manufacturing managers. A unifying strategy is required (Schonberger, 1986), a vision that manufacturing managers clearly understand and implement (Chase and Aquilano, 1989). All too often this shared understanding or consensus does not occur. Hambrick (1981), for example, found evidence of rapid hierarchial decline in strategic awareness within organizations. Significant declines in strategic awareness were exhibited by second-level executives. Schroeder et al. (1986) sampled manufacturing firms and found that only one-third of the firms had formulated a clear and well-developed manufacturing strategy, i.e. one consistent with the firm's business strategy. Swamidass (1986), too, in a subsequent study of manufacturing firms, found evidence of a general mismatch in strategic emphasis between chief executive officers and their respective manufacturing managers concerning the appropriate role and performance objectives of the manufacturing function.

Business unit strategy formulation traditionally has been viewed as a top-down process. The chief executive officer has the responsibility for formulating the business strategy, while responsibility for formulating the supportive functional-level strategies is delegated to second-level executives such as the manufacturing manager. A unifying strategic consensus, however, might more readily develop in a bidirectional fashion. Rather than following either a strictly top-down or bottom-up communication process, the successful manufacturing business unit might actually use a type of blend management (Chase and Aquilano, 1989). Hayes and Wheelwright (1985) strongly recommend a high level of involvement by manufacturing managers in the strategic planning process. Swamidass and Newell (1987) report finding evidence of a direct positive relationship between the level of involvement of manufacturing managers in the strategic planning process and the level of economic performance of the manufacturing firm.

While Skinner (1978), Wheelwright (1978), Buffa (1984), Hill (1985, 1989) and numerous other scholars have stressed the importance of achieving strategic consensus, no research study to date has empirically tested either of the presumed linkages of business unit-manufacturing function strategic consensus and operational (manufacturing) performance or business unit-manufacturing function consensus on manufacturing strategy and operational performance. Dess (1987), while not directly focusing on operations strategy issues per se, did examine the relationship between the degree of consensus within top management teams (chief executive officer and representatives of all functional areas) on business objectives and competitive methods and firm financial performance. Using data derived from a sample of manufacturing firms competing in the paint and allied products industry, the researcher found general top managerial consensus on either competitive objectives or competitive methods to be positively related to firm financial performance. This finding was consistent with that of results obtained by Bourgeois (1980), who found consensus on competitive methods to be related to firm financial performance. Since the relationship between managerial strategic consensus and manufacturing/operational performance has not been investigated, this relationship is a primary focus of this research.

The relationship between managerial consensus on manufacturing task emphasis (manufacturing strategy) and business unit operations performance also has required empirical testing and validation. Richardson et al. (1985) in a study of Canadian electronics firms did find a significant positive relationship between corporate mission/manufacturing task congruence and firm profitability. The study, however, did not employ a true consensus measure since only the views of the chief executive officer and not those of the manufacturing manager were solicited. Realizing this deficiency, the researchers have recommended that future studies consider both business-level perceptions of manufacturing task goals and the perceptions of manufacturing managers when investigating the linkage of manufacturing task congruence and business unit performance. In a later study, Swamidass (1986) did survey both chief executive officers and their respective manufacturing managers concerning their individual perceptions of manufacturing performance goals. Unfortunately, this research reported only descriptive statistics (relative rankings of manufacturing performance criteria). No performance measure was employed.

Hayes and Wheelwright (1985) strongly recommend a high level of manufacturing involvement in the strategic planning process of business units for the attainment of superior competitive performance. Swamidass and Newell (1987) report finding evidence of a positive relationship between the level of involvement of manufacturing managers in the strategic planning process and the level of economic performance of the manufacturing firm. This research employed a process variable rather than content variable and did not attempt to measure managerial consensus.

An assessment of the level of consensus among strategic planners and manufacturing managers on manufacturing task emphasis provides a measure of the degree of common understanding of the manufacturing or operations strategy of the business unit. In the same way, an assessment of the level of strategic consensus among managers provides a measure of the degree of common understanding of the business strategy of the strategic business unit. In addition to the relationship between strategic consensus and operational performance, the relationship between manufacturing task consensus and operational performance requires investigation. So too, the relationship between strategic consensus and manufacturing task emphasis consensus requires empirical investigation, theoretical definition and clarification.

Product-Process Alignment

Another fundamental tenet of operations strategy is that manufacturing's choice of production process interacts with marketing's product goals and that this interaction effects the business unit's competitiveness within its industry. Hayes and Wheelwright (1979a) first proposed linking product and production process life cycles. Their theory holds that as a product evolves through a series of major life cycle stages (introduction, growth, maturation, continuance or decline), ideally the production process used to manufacture the product should evolve through a series of related configurations. As a prescription for effective business unit performance, Hayes and Wheelwright (1979a, b) recommend a specific alignment of product life cycle stages and process designs. This correspondence of product and process stages can be visualized by means of a product-process matrix. The product-process matrix (Figure 1) links product life cycle stages with theoretically correct general types of production processes. Diagonal positions on the matrix represent "correct" mappings of product life cycle and production process characteristics. These prescribed product-process matchings are listed below:

Product PLC Stage 1 (Introduction) -- Job Shop Process
Product PLC Stage 2 (Growth stage) -- Batch Process
Product PLC Stage 3 (Maturation) -- Assembly Line Process
Product PLC Stage 4 (Continuance) -- Continuous Process

Since operations strategy theory maintains that as the product evolves through its life cycle and corresponding changes in business strategy, the production process should also evolve to conform to the product-process pairings delineated above. Positioning/repositioning the production system in light of the product's current life cycle stage and marketing strategy, is a paramount responsibility of manufacturing managers (Buffa, 1984). In one of the few empirical tests to date of the product-process matrix, however, Wharton (1987) found no association between diagonal process positioning and financial performance among a sample of manufacturing firms. The relationship between product-process alignment and manufacturing/operational performance requires more empirical examination and precise specification. This relationship is a subject of this research.

Production Process	PLC Stage			
	Introduction	Growth	Maturation	Continuance
Job Shop	x			
Batch		x		
Assembly Line			x	
Continuous Process				x
	(Low)<---------------VOLUME--------------->(High)			

Figure 1. Product process matrix

Note. Simplified Hayes and Wheelwright (1979 a,b) product-process matrix

Advanced Systems Use

A number of advanced systems and new technologies are presently available to the manufacturing function of the business unit to improve manufacturing performance and competitive effectiveness. State-of-the-art computer-based systems (OPT, FMS, MRP) as well as manual systems (JIT) are available to manufacturing for production planning and/or inventory control. These new technologies offer the promise of changing the ways business units compete and of helping business units to be more competitive in world markets (Voss, 1986). Properly implemented, each of these systems offers potentially high levels of operational performance improvement along several of the key strategic dimensions of cost, flexibility, quality, and dependability (Wheelwright, 1978). Each of these major systems is discussed below:

OPT. OPT (Optimize Production Technology) is a state-of-the-art proprietary computer program designed primarily for job shop scheduling. The objective of scheduling in a job shop is to route jobs through the production system to maximize the total output of the system, while minimizing work-in-process inventory and meeting due dates. OPT identifies bottlenecks (limited or finite capacity work centers) in the production system and develops a schedule to maximize their output. A proprietary computer program, OPT calculates a near-optimum schedule and sequence of operations for all work centers, taking into account priorities and capacities. Producing benefits through the maximization of output, efficient utilization of critical resources, and the minimization of work-in-process inventories and production times, OPT can provide strategic benefits to business units (especially PLC Stage 1 product groups) in terms of the performance dimensions of cost and dependability.

FMS. FMS (Flexible Manufacturing System) is a manufacturing system designed to bring economies of scale to batch processing. With FMS, numerically controlled machines at work centers are controlled by a central computer with automatic tool changing for product changeover incorporated within the computer program; robots handle all parts, with automatically controlled carts transporting finished components to their next destinations. Based on the concept of group technology, the system offers competitive advantages over traditional batch production. Reduced set-up and queuing times allow higher aggregate production volumes when product variety is high and individual batch sizes are low. With a wide product range and high aggregate volumes, FMS enables the business unit to more efficiently compete on the basis of product differentiation. With FMS, the operational performance benefits of increased flexibility and lower cost production are achievable for PLC Stage 2 business units engaged in batch processing. The system is designed to increase both the variety and the productivity of the unit's manufacturing operations.

MRP. MRP (Materials Requirements Planning) is a computerized production planning and inventory management system. The MRP program computes the quantities and timing of material flows throughout the production process in order to minimize inventories and associated costs while meeting the master production schedule. The result of a properly implemented MRP system is not only an improvement in the timing and flow of materials into the manufacturing process but the consequent reduction in inventory investment. Researchers have reported typical gains in inventory reduction of between 25% - 40% for manufacturing firms successfully implementing MRP (Schroeder et al., 1981). In addition to reduced inventory, the system permits a better response to market demands, bringing increased sales and better customer service. MRP is a valuable tool for business units engaged in complex, non-repetitive, medium volume production with its capability to rather quickly adapt to changing market demands. Materials Requirements Planning systems can provide the strategic benefits of greater flexibility and lower cost production for business units involved in medium to high volume manufacture (PLC Stage 2-3) of products subject to variable demand.

JIT/Kanban. JIT/Kanban (Just-In-Time Manufacturing) has been called an attempt to change batch flow into a facsimile of a continuous flow. The objective of JIT is to have as little inventory in the production system as possible (ideally zero) while achieving a smooth process flow. The system uses a manual communication trigger and a set of production improvement measures, notably the attainment of low set-up times leading to the use of small lot sizes (with an ideal lot size equal to one unit). A small lot size permits a more immediate discovery of product defects. JIT/Kanban is a manufacturing system designed primarily for high volume, product-focused, repetitive manufacturing under conditions of relatively stable market demand or of a stabilized master production schedule. The goal of JIT is to obtain low-cost, high quality, on-time production. The system has been highly successful in Japan in the manufacture of high volume standardized products. JIT/Kanban can provide the dual competitive benefits of low cost production and high quality products. The system is most appropriate for business units engaged in high volume assembly line production (PLC Stage 3) under relatively stable market demand conditions.

Table 1

Advanced Systems and Technologies

Definitions
OPT (Optimized Production Technology): A state-of-the-art computer program designed for job shop scheduling. The objective of scheduling in a job shop is to route jobs through the system to maximize the total output of the system, while minimizing work-in-process inventory and meeting due dates. OPT identifies bottlenecks (limited or finite capacity workcenters) and develops a schedule to maximize their output.
FMS (Flexible Manufacturing System): A manufacturing system designed to bring economies of scale to batch processing. With FMS, numerically controlled machines on the production line are controlled by a central computer with automatic tool changing for product changeover incorporated within the computer program; robots handle all parts, with automatically controlled carts transporting finished components to their next destinations. Based on the concept of group technology, the system has competitive advantages over traditional batch production. Reduced set-up and queuing times allow high aggregate production volumes when product variety is high and individual batch sizes are low. A wider product range permits the manufacturing firm to more efficiently compete on the basis of product differentiation.
MRP (Materials Requirements Planning): A computerized production planning and inventory management system. The MRP program computes the timing of material flows in order to minimize inventories and costs while meeting the Master Production Schedule. It is a valuable tool for firms engaged in complex, non-repetitive, medium volume production with its capability to rather quickly adapt to changing product market demands.
JIT/Kanban (Just-In-Time Manufacturing): Attempt to change batch flow into a facsimile of continuous flow. The objective of JIT is to have as little inventory in the production system as possible (ideally zero) while achieving a smooth process flow. The system uses a manual trigger and a set of production improvement measures, notably the attainment of low set-up times leading to small lot sizes (ideal lot size equal to one unit). A small lot size provides a more immediate discovery of product defects. JIT is a manufacturing system designed primarily for high volume, product-focused, repetitive manufacturing under conditions of relatively stable market demand or a stabilized master production schedule.

Operational Performance

As noted by White and Hammermesh (1981, p. 221), business research must ultimately address the question of effectiveness:

> While it is useful to conceptualize, measure, and correlate a range of organizational and environmental variables, the research is of limited prescriptive value until a link with performance is forged.

Financial performance has been the dominant measure of effectiveness in empirical strategy and business research.

Kaplan (1983) has recommended that accounting researchers attempt to develop non-financial measures of manufacturing performance, measures of efficiency, quality, manufacturing flexibility, and delivery performance (dependability) (Wheelwright, 1978). The author proposed field research as a means of developing such measures. Ideally, a closer coordination between operating data (non-financial) and financial measures could be attained via research at the plant level.

Venkatraman and Ramanujam (1986) have echoed the Kaplan (1983) idea. The authors note that the narrowest conception of business performance centers on the use of outcome-based financial indicators, while a broader conception would additionally include indicators of operational performance. The inclusion of operational performance measures takes us beyond the black box called technology and focuses on the operational factors that lead to financial performance.

The use of a performance variable of any kind in operations strategy research is rare. Strategic management research, on the other hand, often includes performance measurement. Performance measurement should be an objective of operations strategy empirical research, particularly the measurement of business unit manufacturing operational performance. Operational performance measurement has been incorporated into this research.

Research Questions and Initial Research Model

This dissertation is guided by five initial research questions:

1. Is there a relationship between strategic consensus and manufacturing/operational performance within strategic business units? If a relationship exists, what is the precise nature of this relationship?

2. Is there a relationship between product-process alignment and manufacturing/operational performance within strategic business units? If a relationship exists, what is the precise nature of this relationship?

3. Is there a relationship between the use of advanced systems and manufacturing/operational performance within strategic business units? If a relationship

exists, what is the precise nature of this relationship?

4. Is there a relationship between the use of advanced systems and the degree of product-process alignment within strategic business units? If a relationship exists, what is the precise nature of the relationship?

5. Is there a relationship between strategic consensus and the degree of product-process alignment within strategic business units? If a relationship exists, what is the precise nature of this relationship?

Examination of the above research questions was begun through an investigation of an initial Causal Model of Operations Strategy (Figure 2). Subsequent refinement of this initial research model through path analytic procedures has permitted the investigation of the following two additional research questions:

6. Is there a relationship between manufacturing task consensus and manufacturing/operational performance within strategic business units? If a relationship

exists, what is the precise nature of this relationship?

7. Is there a relationship between strategic consensus and manufacturing task consensus within strategic business units? If a relationship exists, what is the precise nature of this relationship?

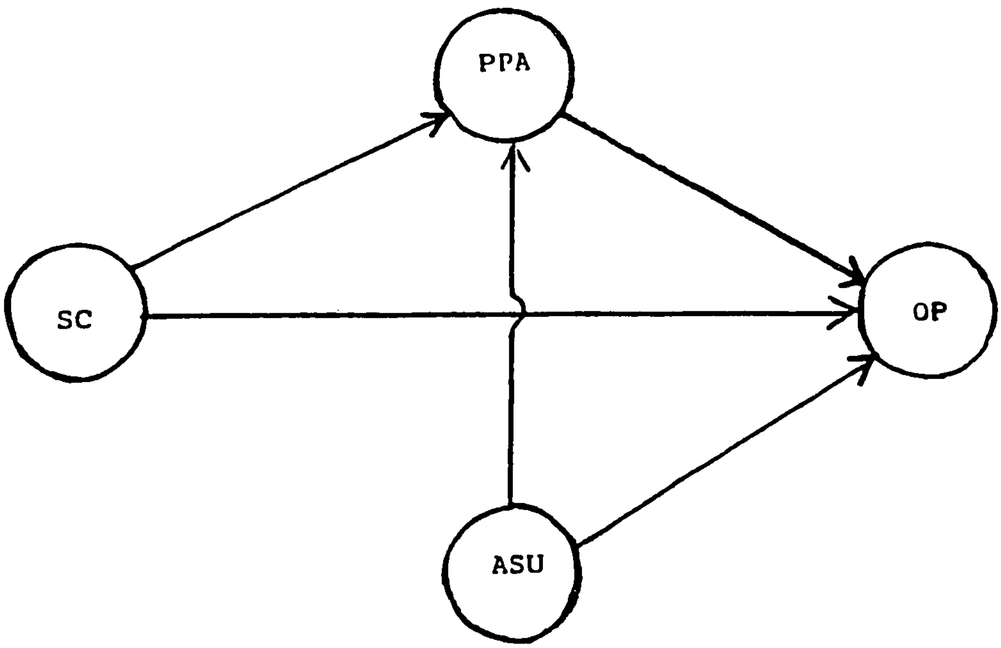


Figure 2. Initial operations strategy research model

Notes. SC: SBU-Manufacturing Strategic Consensus
OP: Operational (Manufacturing) Performance
PPA: Product Life Cycle/ Process Alignment
ASU: Advanced Systems Use

Plan of the Research

In Chapter 1, an introduction to the dissertation research is provided. The theoretical constructs employed in the research study are defined and discussed. The general research questions investigated and answered through this empirical study are delineated.

In Chapter 2, a review of important literature on operations strategy theory is presented. This literature is drawn from two sources, the field strategic management and the field of operations management. The literature review demonstrates an acute need for empirical analysis of the areas of inquiry addressed by this research.

In Chapter 3, a path analytic causal model of operations strategy (Model 1) is developed and presented together with associated research hypotheses. Specific details of the research design and methodology used in this empirical investigation are outlined.

In Chapter 4, the results of the research are reported. Empirical results have been obtained using path analytic techniques for each of three causal models of operations strategy, the initially proposed framework (Model 1) as well as two subsequently evolved and refined reformulations of the initial model, Model 2 and Model 3. The results of empirical Model 3 represent the culmination of this research.

In Chapter 5, conclusions drawn from the results of this research are presented, together with an examination of the implications of these results for executive decision making. Recommendations for future academic research in the area of operations strategy are outlined.

CHAPTER 2

Review of the Literature

History

Since the late 1960's, when Harvard University's Wickham Skinner first wrote his landmark article "Manufacturing -- Missing Link in Corporate Strategy," there have been numerous articles and books written by production/operations scholars describing how the operations function can be used as a powerful force by the manufacturing firm to attain competitive advantage within its industry (Skinner, 1969; Wheelwright, 1978; Hayes and Wheelwright, 1984; Buffa, 1984). The employment of a coordinated operations strategy in support of the business unit's marketing strategy and the strategic use of process and new technologies have been popular operations strategy themes throughout the 1970's and 1980's.

Although strategy researchers have not intentionally focused on operations strategy issues, per se, strategic management scholars have been concurrently investigating topics which have direct application to the study of operations strategy. Relevant areas studied include the strategy-performance linkage, typologies of generic business strategies, managerial consensus, and the measurement of business unit performance.

Historical Perspective on Strategic Management

Strategic management is a process that deals with the entrepreneurial work of the organization, with organizational renewal and growth, and more particularly, with the development and utilization of the strategy or plan which is to guide the organization's general operations (Schendel and Hofer, 1979). The concept of strategy involves a firm's striving to attain a competitive advantage within its industry. It includes such factors as the appropriate choice of products and markets, the development of distinctive competencies, effective resource deployments, and the attainment of potential synergies.

Strategy exists at four distinct levels of the organization, at enterprise, corporate, business (SBU), and functional levels:

> Enterprise Strategy is concerned with the organization's general relationship to society, i.e. organization - society relations.
>
> Corporate Strategy involves the selection of appropriate businesses for the corporate firm. It is essentially a portfolio decision defining the business(es) and industry(ies) within which the corporation desires to compete.

Business Strategy involves the issue of how the organization will compete in a given industry, i.e. how the given strategic business unit (SBU) might allocate its resources to achieve a competitive advantage over its competitors in a given industry. The business-level strategy must integrate the various functional areas of the business to be effective.

Functional Strategies (ideally) provide congruent support for the strategy of the strategic business unit. The operations function and its use in support of the business-level strategy is a central topic of this dissertation.

Business level strategy. Strategic management includes making such major organizational choices as the choice of environments in which to compete (corporate-level strategies) and how to compete within those environments (business-level strategies). These strategic choices may either diminish or enhance the probability of the development of specific types of management actions and plans, thereby influencing business performance outcomes (Child, 1972; Pfeffer and Salancik, 1978).

Hambrick (1984) pointed out that some classification system is necessary for studying organizational strategies, a means by which a large number of potential variables is reduced to a manageable (yet powerful) few. A general strategy is a broad categorization of strategic choice which would apply generally regardless of industry, organization type or size, etc. At the business level such categorization reduces the myriad variables that demand managerial art to a manageable set of factors with high communality. General patterns of managerial strategic behavior may then be discovered, yielding a model of the situation and broad guidelines for action. Generic strategies provide an important basis for research through which to develop contingency theories of business-level strategy.

Fredrickson (1983) has noted that the organization's strategy has been all too often limited during planning-performance research to comparisons between "formal" and "informal" planners. Such an approach relegates the strategic process to the role of a "black box" which ignores critical questions of strategy content and process. Typologies are useful in bringing definition to the black box called formal planning.

Porter (1980, 1985) has developed a useful business-level strategy typology. The author has defined three potentially successful generic strategies for the strategic business unit to create a defensible position and to out perform its competitors in a given industry. Dess and Davis (1984) have noted that the first of Porter's generic strategies, overall cost leadership, although not neglecting quality, service, and other areas, emphasizes low cost relative to competitors; the second of Porter's generic strategies, <u>product differentiation</u>, requires that the firm create a product or service that is recognized industrywide as being unique, thus permitting the firm to command higher-than-average prices; the third generic strategy is a <u>focus</u> (market segmentation) strategy, a strategy where the firm concentrates or focuses on a particular group of customers, geographic markets, or product lines. The focus strategy is normally found in combination with one of the other two aforementioned strategies.

Porter (1980, 1985) has stated that firms that develop strategies within the framework of one of the three strategies will earn higher-than-average returns in their industries. Porter (1980, p. 35) has noted that "effectively implementing any of these generic strategies requires total commitment and supporting organization arrangements that are diluted if there is more than one primary target." Porter (1980, p. 35) has explained that the generic strategies are approaches for the strategic business unit to out perform its competitors in its industry; in some industries, structure will mean that all firms can earn high returns, whereas in others, success with one of the generic strategies may be necessary just to obtain acceptable returns in an absolute sense."

According to Porter (1980, p. 41), "the three generic strategies are alternative, viable approaches to dealing with the competitive forces" within an industry. The author contends that the firm failing to develop its strategy in at least one of the three directions is "stuck in the middle" and in an extremely poor strategic situation. Such a firm "lacks the market share, capital investment, and resolve to take a low-cost position, the industrywide differentiation necessary to obviate the need for a low-cost position, or the focus necessary to create differentiation or a low-cost position in a more limited sphere" (Porter 1980, p. 41).

Weick (1979) observed that there are inevitable tradeoffs in scientific inquiry and research studies. One type of tradeoff is found in Thorngate's postulate of commensurate complexity. This postulate states that it is impossible for a theory of social behavior to be simultaneously general, accurate, and simple. The more general a simple theory is, for example, the less accurate it will be in predicting specifics.

The researcher, then, who desires simplicity and accuracy must generally forego generalizability, and the researcher who desires generalizability and accuracy must sacrifice simplicity. The Porter strategic typology has some important strengths. While parsimonious, it can account for variations across organizations and industries. It allows strategy to be operationalized in other than unique terms. This typology also has a limitation; specifically, its parsimony can be argued to be incomplete (and hence somewhat inaccurate) view of strategy.

Dess and Davis (1984) have noted that Porter's framework of generic strategies and competitive dimensions provides a potentially valuable research tool for classifying the strategies of all competitors within an industry. A major difference in potential generalizability from other strategic formulations is that Porter allows for variation in industry environment to account for the relative value of a particular generic strategy. Beard and Dess (1979) found the firm's industry to be a primary determinant of its absolute performance. The Porter (1980, 1985) typology is simple to operationalize yet gives broad definition to the strategic emphasis of the entire organization. It has been found to be particularly useful in content based strategy research (Dess and Davis, 1984; Prescott, 1986; Dess, 1987).

Dess and Davis (1984) have performed a multimethod multivariate analysis of "intended" business strategies. These researchers found empirical support for the presence of strategic groups based upon Porter's (1980) generic strategies. Variations in intraindustry profitability and growth were found to be related to strategic group membership. Firms identified with at least one generic strategy outperformed firms identified as "stuck in the middle." The generalizability of this study is limited, because the firms used in the study represented only one of Porter's (1980) five generic industrial environments. The relative importance of competitive methods may vary across as well as within industry environments. Whenever possible, further testing both within other industries and across industries would be particularly useful.

The Dess and Davis (1984) assessment instrument is composed of a set of competitive methods inductively derived from the Porter (1980) framework. The instrument's competitive methods include marketing and as well as some manufacturing criteria. The instrument appears to be fully applicable at the functional level as well as at the business level and provides a ready means of assessing strategic consensus. Dess (1987) employed the instrument to measure consensus among top-level managers of manufacturing firms in the paint and allied products industry.

Historical Perspectives on Operations Management

Operations management has been defined as "managing the direct resources required to produce the products or services provided by an organization" (Chase and Acquilano, 1989, p. 7). The operations function -- a functional area of the business enterprise -- is fundamentally concerned with the production of goods and/or services.

Schroeder (1981) has noted that operations managers are responsible for managing productive systems or transformation processes. A productive system can be thought of as a set of components whose function is to transform a set of inputs (energy, materials, labor, capital) into some desired output product or service. The components of such productive systems include people, tools, machines, process technologies, and management systems. Operations managers manage the transformation process and are directly responsible for coordinating those areas within the organization that produce the firm's products or services.

Schroeder (1981) has noted that operations managers make decisions involving all aspects of the operations function and the type of transformation systems used. Decisions related to the design of the physical productive process include the selection of process type and choice of appropriate technology. Process design is related to marketing strategy and product design and requires close coordination between the functional areas of marketing and operations.

Functional level strategy (operations strategy). Skinner (1969) has defined an operations or manufacturing strategy as a set of manufacturing plans and policies by which a manufacturing firm seeks to gain advantage over its competition within its industry. Hill (1989) has noted that the objective of the manufacturing function is to provide coordinated manufacturing support for those fundamental ways by which the firm's products win orders in the market place. Ideally, the manufacturing function will develop a set of operational plans, systems, and infrastructure to support and improve order-winning performance. An effective operations or manufacturing strategy is one that specifically supports the firm's business strategy for the focal product.

Identification of manufacturing task priorities often center on the operational performance dimensions of low cost, flexibility, quality, and/or dependability (Wheelwright, 1978).

Swamidass (1986) has addressed the need for practical methods of assessing the manufacturing strategy of a business. The author developed and presented a method (two structured questionnaires) which could be used by a chief executive and a manufacturing manager to identify the implied manufacturing strategy of each and to detect agreement/disagreement between the two. As part of this procedure, both the CEO and manufacturing manager respond to a question on manufacturing performance criteria (Wheelwright, 1978). The procedure provides an example of an indirect, multirespondent approach for assessing different aspects of manufacturing strategy and for detecting any mismatch between chief executive officer and manufacturing manager in their perceptions of the firm's manufacturing strategy.

Operations strategy theory. As previously mentioned, Porter (1980, p. 34) delineated three potentially successful generic strategies for the strategic business unit "to create a defensible position and outperform competitors in a given industry." The first generic strategy, overall cost leadership, although not neglecting quality, service, and other areas, emphasizes low cost relative to competitors; the second of Porter's generic strategies, product differentiation, requires that the firm create a product or service that is recognized industrywide as being unique, thus permitting the firm to command higher-than-average prices; the third generic strategy is a focus (market segmentation) strategy, where the firm concentrates or focuses on a particular group of customers, geographic markets, or product lines (Dess and Davis, 1984). The focus strategy is normally found in combination with one of the other two aforementioned strategies.

Porter (1980, 1985) has stated that firms that develop strategies within the framework of one of the three strategies will earn higher-than-average returns in their industries. Porter (1980, p. 35) has emphasized that "effectively implementing any of these generic strategies requires total commitment and supporting organization arrangements that are diluted if there is more than one primary target strategy."

Wheelwright (1978) has noted that the key dimensions of these three basic strategies as far as production is concerned are cost, quality, dependability, and flexibility. (Seldom if ever can all of these dimensions be maximized simultaneously.) Overall cost leadership is a business strategy that necessitates production cost minimization. It is a competitive strategy associated with low cost, high volume, make-to-stock manufacturing. This generic strategy requires a concentration of production process design on those elements that will bring about low cost and economies of scale.

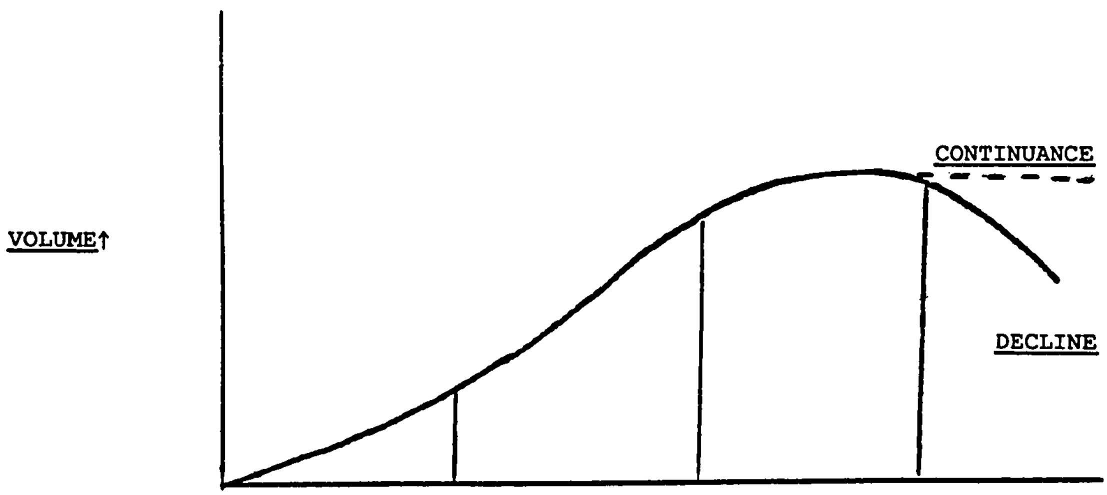
Efficiency is a primary objective. Product differentiation, on the other hand, is a strategy that will normally involve higher quality products, flexibility of production process design, and lower-to-moderate volume manufacturing. The major requirement of the production system is flexibility in order for it to have the capability to quickly adapt to changing market requirements.

Several scholars in the area of operations strategy (Hayes and Wheelwright, 1979a, b, 1985; Buffa, 1984; Hill, 1985) have emphasized that the manufacturing business unit will have a decreased competitive advantage within its industry when it fails to utilize competitive production processes and/or fails to develop a coordinated and integrated operations strategy, i.e. one that brings about a match between production system capability and the marketing strategy of the business unit.

The manufacturing firm's choice of process technology interacts with its product line structure and its general marketing strategy; this interaction will lead the business unit either to a competitive advantage or to a competitive vulnerability within its industry (Buffa, 1984).

Silver and Peterson (1985) have pointed out that products require a different marketing, production planning, and inventory management strategy at each stage of their product life cycle (Hofer, 1975). As the product evolves through its life cycle (in conjunction with appropriate marketing strategies) the production system itself should develop through an evolution of its own. Positioning and repositioning the production system in relation to a changing market environment (and consequent changing marketing strategy) is a critical function of operations management (Buffa, 1984). The product life cycle and the process life should not be considered separately from one another (Hayes and Wheelwright, 1979a, b, 1984). Hayes and Wheelwright (1984) have developed a product/process life cycle chart (Figure 3) that incorporates and delineates typical strategy/product/process matches. Hill (1989) has extended this analysis further specified characteristics of process choice. For additional organizational factors and structures, matched by state of product life cycle, the reader is directed to Schmenner (1985).

PRODUCT	HIGH VARIETY CUSTOM PRODUCTS (LOW-VOLUME)	--------------> TIME ->	LOW VARIETY STANDARDIZED PRODUCTS (HIGH-VOLUME)



PLC Stage	I. Market Development	II. Rapid Growth	III. Maturation	IV. Continuance
Process	Job Shop	Batch/Line-Flow	Assembly Line	Continuous Process
Industry Environment	Many Small Competitors	Shakeout	A Few Large Companies (Oligopoly)	Survivors
Competitive Strategy (Porter)	Product Differentiation (Innovation)	Product Differentiation (Availability)	Low Cost (Dependabilty)	Low Cost (Price)

Figure 3. The product-process life cycle diagram

Note. Source: Hayes and Wheelwright (1984)

Table 2

Product Life Cycle Characteristics

Aspects	Job Shop	Batch	Assembly Line	Continuous Process
PRODUCTS AND MARKETS				
Type of product	Special	----->	Standard	Standard
Product range	Wide	----->	Narrow: standard products	Very narrow: standard products
Customer order size	Small	----->	Large	Very Large
Level of product	High	----->	Low and within agreed options	None
Rate of new product introductions	High	----->	Low	Very low
What does the company sell?	Capability	----->	Products	Products
How are orders won?				
Order-winning criteria	Delivery/quality/ design capability	----->	Price	Price
Qualifying criteria	Price	----->	Quality/design	Quality/design
MANUFACTURING				
Nature of the process technology	Universal	----->	Dedicated	High dedicated
Process flexibility	High	----->	Low	Inflexible
Production volumes	Low	----->	High	Very high
Dominant utilization	Labor	----->	Plant	Plant
Changes in capacity	Incremental	----->	Stepped change	New facility
Key manufacturing task	To meet specification/ delivery dates	----->	Low-cost production	Lost-cost production
INVESTMENT AND COST				
Level of capital investment	Low	----->	High	Very high
Level of inventory				
Components/raw material	As required	----->	Planned with buffer stocks	Planned with buffer stocks
Work-in-process	High	Very high	Low	Low
Finished goods	Low	----->	High	High
Percent of total costs				
Direct labor	High	----->	Low	Very Low
Direct materials	Low	----->	High	Very high
Site/plant overheads	Low	----->	High	High
INFRASTRUCTURE				
Appropriate organizational				
Control	Decentralized	----->	Centralized	Centralized
Style	Entrepreneurial	----->	Bureaucratic	Bureaucratic
Most important production management perspective	Technology	----->	Business/people	Technology
Level of specialist support to manufacturing	Low	----->	High	Very high

Note. Source: Hill (1989)

The generalized PLC stages demonstrate product introduction (stage 1) with basically custom designs and low volume production. This stage is followed by sales growth (stage 2) during which time variety becomes more limited, then maturity (stage 3) when variety becomes even more limited as the product becomes standardized, and finally the continuation stage (stage 4) as the product becomes basically a commodity. Of course, stage 4 may also be one of decline as substitute products become available, superior to the focal product in either function, quality, cost, or other important characteristic.

The manufacturing firm's operations strategy for production planning, production scheduling, and inventory management depends on how easily management can relate raw material and parts requirements with the firm's master schedule of finished end items (Schonberger, 1983). This relationship becomes more direct as one reads across (left to right) the PLC diagram. State of the art production systems (OPT, FMS, MRP, JIT, etc) are available for production planning, production scheduling, and/or inventory control and are appropriate at specific stages of the product life cycle.

Figure 4 summarizes the most effective competitive tools for manufacturing by PLC stage. This diagram represents a contingency approach to the selection of an appropriate operations strategy in pursuit of the firm's competitive strategy.

Production Process	PLC Stage			
	Introduction	Growth	Maturation	Continuance
Job Shop	OPT			
Batch		FMS		
		MRP		
Assembly Line			JIT	
Continuous Process				Dedicated Automation

(High)------------VARIETY---------->(Low)

(Low)-------------VOLUME----------->(High)

Figure 4. Advanced system use by process stage

Note. Extension of Silver and Peterson (1985) chart.

Categories of the Literature and Categorical Literature Review

In the following sections, a classification system recommended by Heyl (1985) is used to summarize operations strategy literature as well as related strategic management literature. This procedure is employed in order to identify gaps and weaknesses within this research area. It is demonstrated that the development and testing of empirical models in pursuit of statistical verification of the major hypotheses of operations strategy is at an embryonic stage.

Categories of Literature

Three basic dimensions have been used in order to appropriately classify operations strategy literature and related strategic management literature (see Table 3). The first dimension is one defining the general focus of the article. Two primary areas of focus of operations strategy scholars are: strategic consensus and the strategic use of technology. The strategic consensus designation refers to articles which focus on the degree of agreement, common understanding, and consistency within a manufacturing firm on the firm's business strategy and/or operations strategy. Often this concept is operationalized as the degree of agreement on ends and/or means between a chief executive officer and a key functional subordinate, for example the vice president of manufacturing. The alignment of business level and operations strategies is a major premise of operations strategy theory. The second focal area designation -- technology -- refers to the strategic use of processes and new technologies toward the attainment of competitive advantages. Given a specific strategic mission, a firm has a great deal of choice in how it manages its production function. One major area of choice is the firm's choice of production process: type, technology, and degree of product specificity. The strategic linking of manufacturing technologies with product characteristics is an important area of inquiry for production/operations theorists. Both operations strategy literature and relevant strategic management literature are reviewed and classified by these two categories.

Table 3

Dimensions of the Literature Review

Focus	Approach	Methodology
Consensus Technology	Case Field Theory Opinion	Qualitative Descriptive Inferential

The second dimension of the classification system is the approach that an author takes toward the study and presentation of the subject. Under this dimension, four categories are delineated. The first category is the case approach. In the case study approach, an article is presented as a discussion of the actual experiences of the author within the organization under study. The second category is the field approach. Field studies reviewed herein are the result of a program of field research to investigate some aspect of operations strategy theory. This would include any type of survey research or controlled experiment (Kerlinger, 1973). The third category is the theory approach. An article that attempts to provide a conceptual framework or model of the organizational processes under study is classified as having a theory approach. In this approach, the underlying rationale for the relationships among variables is explicitly defined and discussed in detail, often building upon earlier works. Finally, there is the opinion approach. In the opinion approach, the author conjectures or states his/her opinion on an issue. Anedoctal histories and conjectural writings fall within this classification.

The last dimension is methodology. Here, one is concerned with the techniques used to develop, analyze, and present the results of an article. The three categories of methodology are qualitative, descriptive, and inferential. Articles that employ a qualitative methodology present no quantitative or statistical analysis of the results of the study. Quantitative data is absent. In descriptive articles, empirical results are reported but such reporting is limited to descriptive statistics -- data lists, percentages, ranks, means, etc. The last methodological category, inferential statistical methodology, describes research articles in which sophisticated, statistical, inferential hypothesis testing is performed to determine the results of the research study.

It is believed that the three dimensions of this classification system and their related categories provide an effective means of classification of the operations strategy literature and related strategic management literature, one that will highlight both the strengths and the weaknesses (including gaps) in these literature streams.

Using the above classification system, the reviewer or researcher is able to identify and categorize articles on and/or related to operations strategy. Such an undertaking requires a search of the literature within both the fields of production/operations management and strategic management. The academic journals of both fields are primary sources of investigation. This includes major journals such as the Academy of Management Review, Academy of Management Journal, Management Science, Decision Sciences, and Interfaces. Production/operations specific journals include the Journal of Operations Management, International Journal of Production Research, and AIIE Transactions. Strategic management specific journals include the Strategic Management Journal, Journal of Business Strategy, California Management Review, and Long Range Planning. Also sources of investigation are the more sophisticated general management information journals such as the Harvard Business Review and the Sloan Management

Review which often present articles on operations strategy topics. Additionally, recent proceedings papers from APICS, Decision Science Institute, and Academy of Management annual conferences are reviewed for the most current work in the area of operations strategy. Operations strategy articles published in less common journals also have been included in this analysis along with a number of full texts written specifically on the subject of operations strategy. By this endeavor, articles or books have been classified according to the classification methodology previously described. Table 4 contains a summary of this literature review analysis.

Table 4

Summary of the Literature Review

Focus		Approach		Methodology	
Operations Management Literature					
Consensus	23	Case	11	Qualitative	43
Technology	28	Field	8	Descriptive	5
		Theory	20	Inferential	3
		Opinion	12		
Strategic Management Literature					
Consensus	14	Case	0	Qualitative	1
Technology	3	Field	16	Descriptive	0
		Theory	1	Inferential	16
		Opinion	0		

Basic weaknesses. Two issues are quite apparent from an analysis of the literature count in Table 4. First, the overwhelming majority of the operations strategy literature reviewed has been of a conceptual nature. Empirical work in this area is limited. In general, production/operations management scholars have applied little quantitative rigor to the study of operations strategy. The vast majority of the POM articles published on this topic have been case histories, anecdotal experiences, and conjectural writings. Inferential statistical research is lacking. Although much of the operations strategy literature does have a great deal of intuitive appeal and face validity, it does not have a foundation in true descriptive research (St. John, 1986) or inferential research. Since little empirical work exists to substantiate these highly appealing conceptual formulations, empirical analysis is now essential for the continued growth and development of operations strategy theory.

Swamidass and Newell (1987, p. 511) have commented on this issue:

> Manufacturing strategy literature lacks some of the essential ingredients that can stimulate empirical research. It lacks the benefits of an accumulation of empirical findings over a period of time. Consequently, although many concepts have been identified, it lacks the scientific development of these concepts, integration of relevant literature from several disciplines, operationalization of manufacturing strategy variables for empirical analysis, empirically validated models of manufacturing strategy, and empirical findings relating to manufacturing strategy which can sprout new hypotheses for investigation.

Clearly, the time has come for production/operations management researchers to begin the necessary empirical testing of the paradigms and hypotheses of operations strategy theory.

A second important conclusion that can be drawn from the literature summary count is that strategic management researchers have readily used empirical testing in their studies which have often included a performance or outcome variable. While most of the rigorous inferential research has come from the strategic management side, it is unfortunate that this research stream has not given enough specific attention to many of the variables at the core of operations strategy theory. Operations strategy research per se has not been the intention of strategic management research (Scheela, 1986). Noticeably absent from most of strategic management research is the operations function. Technology is seldom a key variable in this research. The literature summary chart above reveals only a single strategic management study related to the strategic importance of technology.

Literature Review

Voss (1986) has noted that there are two well established frameworks for the development and analysis of manufacturing strategies. The first, developed by Skinner (1978) and Wheelwright (1978) links manufacturing and engineering priorities with the firm's business strategy and the market. The second, developed by Hayes and Wheelwright (1979a, b) links technology (process and systems) with product characteristics. These frameworks form two focal points for the classification and detailed review of representative key works in the area of operations strategy.

Literature on managerial consensus: strategic consensus and manufacturing task consensus. Skinner (1978), in his text Manufacturing in the Corporate Strategy, wrote of the importance of manufacturing to the business firm and its potential use as a formidable competitive weapon. The author defined manufacturing strategy as essentially a statement of how manufacturing will support the business level strategy of the firm. It defines how manufacturing will assist in the accomplishment of organizational objectives through the appropriate design and utilization of manufacturing resources. The author noted that the manufacturing function must be treated strategically and coordinated with the business level strategy to avoid a mismatch between marketing objectives and manufacturing structure.

Wheelwright (1978) reported on a procedure designed to help achieve consensus among company vice presidents and manufacturing managers. The initial step in the procedure was to have the firm's vice presidents individually assess current manufacturing priorities (degree of emphasis on cost, quality, dependability, flexibility). Upon discussion a consensus was reached as to past priorities and required priorities for each of the firm's product lines. Through this procedure, a number of performance priority areas in need of change in emphasis were identified, so that manufacturing and it performance priorities (operations strategy) could better support the firm's business level strategies. The vice president of manufacturing next used this same approach with the manufacturing managers who reported to him. In this way, consensus and common purpose were thought to be achieved. A significant reduction in conflict was reported between manufacturing and marketing since both areas had agreed on a common direction. Wheelwright uses the above case as an illustration of the attainment of strategic consensus.

In a strategic management piece, Hambrick (1981) found evidence of hierarchial decline of strategic awareness within organizations. Significant declines in strategic awareness were exhibited by second-level executives and by third-level executives. The author concluded that strategic awareness (consensus) cannot be assumed to exist at even high levels within an organization. This investigation was an exploratory field research effort employing inferential statistical testing (nonparametric) of specific hypotheses. In addition to small sample sizes, a limitation of this study is that the industries studied (college, hospital, insurance) are not involved in sophisticated strategic planning or manufacturing.

Ebert, Rude, and Cecil (1985) designed a judgement-capturing process called Pro Pol (Production Policy) to reveal and help clarify managerial judgmental processes. The procedure uses correlation methods to identify where and how managers diverge from a common focus. In one application, manufacturing executives competed in week-long simulation games where Pro Pol was introduced to assist the executives in clarifying their production policies and strategies. Five policy areas -- marketing effort, cost efficiency of production, R & D effort, product pricing, and service flexibility -- were used as key variables in the simulation, an exercise which sought to reveal a manager's subjective views among these variables. The manufacturing manager's judgmental processes were compared in terms of judgmental consistency, complexity, and espoused versus in-use importance of the policy variables. Group/team discussion and feedback helped the executives clarify specific directions for the production function and provide a more focused strategic thrust, i.e., to gain consensus.

Using data gathered from field research, Richardson, Taylor, and Gordon (1985) studied sixty-four Canadian firms in the electronics industry, in order to measure the potential impact of increased corporate focus and mission congruence on performance. Using a regression model, the investigators found a significant positive relationship between corporate mission/manufacturing task congruence and profitability. Unfortunately, the study considered only the views of the chief executive officer. The authors recommended that future studies examine the degree of congruence between business-level perceptions of manufacturing task (perceptions of the CEO) and the perceptions of manufacturing executives.

Schroeder, Anderson, and Cleveland (1986) reported on a study of manufacturing strategy based on questionnaire responses received from the manufacturing managers from thirty-nine firms. These investigators found that only about one-third of the manufacturing firms sampled had a well developed manufacturing strategy, i.e., one consistent with the business unit strategy. A POM study, the study was intended as exploratory field research. Descriptive statistics were used to report results. No inferential hypothesis testing was performed.

Swamidass (1986), in a study of thirty-five manufacturing firms, employed an assessment technique that could be used with both chief executive officers (CEOs) and manufacturing managers to identify their implied manufacturing strategy as well as to detect strategic agreement/disagreement between the two. The author discovered that, in general, chief executives stressed criteria such as quality, technology, etc., which would reflect a business level strategy based on product differentiation, while manufacturing managers stressed cost and the keeping of delivery promises (dependability). This result echoes the finding of Schroeder et al. (1986). The author conjectured that the mismatch of emphasis between the two executives could be a sign of problems in the effective use of the operations function. Procedurally, five manufacturing criteria were assessed and ranked by pairs of chief executive officers and manufacturing managers and the results compared. Only descriptive data (criteria rankings) were reported by the author. No other statistical treatment of the data was performed. No measure of performance was used in this study, a near universal phenomenon to date in operations strategy studies.

Swamidass and Newell (1987) employed a path-analytic model to determine the relationship among four operations strategy variables: role of manufacturing managers in strategic decision making, (manufacturing) flexibility, environmental uncertainty, and business economic performance. These researchers reported a significant positive relationship between the role of the manufacturing manager in strategic decision making and performance. The conclusion was drawn that, regardless of environmental conditions, efforts should be made to maintain the involvement of manufacturing managers in strategic decision making (thus building SBU-operations strategic agreement and consistency). It is important to note that this is the first published operations strategy study known to this writer to have used a performance variable. The study used statistical testing (path analysis) and controlled for both industry and technological process. Process effects were filtered out and were not part of this study.

In a strategic management article, a replication of an earlier study by Bourgeois (1980), Dess (1987) examined the relationship between organizational performance and the degree of consensus within top management teams on company objectives and competitive methods. The study used a sample of nineteen manufacturing firms competing within a highly fragmented industry. The author's findings indicated that consensus on either objectives or methods is positively related to organizational performance. This result is consistent with previous work (Bourgeois, 1980) that found that consensus on competitive methods has an important relationship to performance. The earlier study concluded that while agreement on both objectives (ends) and means is positively associated with economic performance, agreement on means is significantly more important. "Consensus on means always yields higher performance," reported Bourgeois (1980, p. 243), "...disagreement on the choice of competitive weapons may hurt performance as the domain navigation strategies of different functional areas clash, constrained by muddled and internally inconsistent or incomplete strategies." It is important to note that in both works consensus was defined as agreement among members of the top management team. It is assumed by this writer that this designation would include a vice president for manufacturing. Dess (1987) recommended that future research provide comparisons across other industries to determine if the association between consensus and performance are industry-specific or rather applicable to a wide variety of competitive environments. The Dess (1987) study is an empirical piece of research, one with inferential statistical analysis. Although this article was not specifically intended to study operations strategy concepts, it's subject (top management consensus) is conceptually closely related to the topic of business unit/manufacturing function strategic agreement. An extension of the Dess (1987) review listing of consensus literature is presented in Table 5.

Table 5

Extension of Dess (1987) Review of Consensus Literature

Study	Subjects and research method	Consensus type	Dependent variables	Key findings
Stagner (1979)	217 Vice President and top executives from Fortune 500 companies; mailed questionnaire	'managerial cohesiveness' --amount of agreement on responses to questionnaire items by executives	profitability: (not used examining relationships with managerial cohesiveness)	positive correlation between executive executive satisfaction on decision-making process and profitability; supported view of corporation as a coalition; found three important dimensions of decision making managerial cohesiveness, formality, and centralization.
Whitney and Smith (1983)	88 U.S. graduate and undergraduate students assuming roles of product managers of strategic planners; laboratory study; evaluated two marketing case studies; one to facilitate role induction and the second to develop a strategic plan	'cohesiveness'--a group characteristic which is inferred from the number and strength of mutual positive attitudes among the members of a group'	attitude polarization and knowledge about the strategic plan	increased polarization between strategic planners and product managers under emphasized group cohesiveness condition; persuasive arguments and social comparison theories do not lead to contradictory predictions of the effect on attitude of interaction between two groups holding initially opposing positions; high cohesiveness within groups leads to reduced receptivity to information; cohesiveness may interfere with the ability to utilize information fully
Grinyer and Norburn (1977-78)	91 subjects of which two-thirds were CEOs or Executive Vice Presidents and one-third were senior managers reporting to a top executive; subjects drawn from 21 publicly held UK firms in 13 industries; field study using questionnaire	consensus on: objectives; role perception--responsibility for decision-making; degree of perceived formality of planning systems; information monitoring--number of items received and number of items used	return on net assets	higher financial performance is associated with use of more information processes (channels of information); use of informal channels is associated with high performance; agreement on desirable changes may not be high when a high percentage of companies suggest a change in the status quo; no evidence to support common perception of of objectives with financial performance; when performance is good, there is little desire for change--struggling companies are the ones anxious to change.

Table 5 (continued)

Study	Subjects and research method	Consensus type	Dependent variables	Key findings
DeWoot, Heyvaert, and Martou (1977-78)	original study based on 168 firms--analysis based on 123 firms followed by series of in-depth studies to document conclusions; extensive details not provided on the research method or interviewees	agreement on means for innovation activities	long term profitability--15-year trend (profit/owners' equity)	more 'efficient' groups making decisions on change are characterized by: heterogeneity of orientation (functional); frequent disagreement on means of innovation; low concentration of influence among decision-makers; problem-centered conflict-solving; no irrelevant disagreement; communication difficult but faster implementation (Major conclusion: economic development of a company is not explained by the number of innovations made but by its capacity for combining technical progress with corporate strategy.)
Bourgeois (1980)	on-site interviews with 12 CEOs; field study with questionnaire completed by 67 top managers	consensus on goals, means	factor scores of performance index combining five-year growth in: return on total assets; capital; net earnings, EPS; and return on sales	consensus on means always leads to higher performance than disagreement on means; disagreement on less tangible goals tends to be associated with better performance; worst performance occurs with goals agreement--means disagreement combination
Bourgeois and Singh (1983)	on-site interviews with 24 CEOs and completion of questionnaires by 4-10 managers in each firm; total sample size not provided	'strategic discord'--disagreement among TMT on environment; goals; strategies	organizational slack--consisting of available slack (e.g. dividends/net worth); recoverable slack (e.g. inventory/sales); potential slack (e.g. price/earnings)	infusions of slack seems to promote goal consensus and reduce strategic discord; slack resources provide the wherewithal and opportunity for policy conflicts and coalition formation necessary to achieve goal consensus.
Hrebiniak and Snow (1982)	247 top-level managers from 88 firms within four industries; plastics/resins; automotive; semiconductor; and air transportation questionnaire	agreement on firm's strengths and weaknesses with respect to environmental context	return on assets	positive relationship between top management agreement on firm's strengths and weaknesses and return on assets; interaction among top managers and commitment to action plans and objectives have positive implications for strategy implementation

Table 5 (continued)

Study	Subjects and research method	Consensus type	Dependent variables	Key findings
Richardson, Taylor, and Gordon (1985)	Study based on sample of 64 Canadian electronics firms; Questionnaire on corporate mission and manufacturing task completed by CEOs (only); Regression analysis.	Congruency of CEO goals and CEO perception of manufacturing task.	Corporate profit as a percent of sales over five years.	Congruence between corporate mission and manufacturing task has a significant positive relation to profit.
Schroeder, Anderson and Cleveland (1986)	Questionnaire administered to 39 high level manufacturing managers enrolled in a university executive program on manufacturing Exploratory research rather than a rigorous statistical study with specific hypotheses.	Consistency (match) of business strategy and manufacturing strategy elements chosen by manufacturing manager.	None.	A close match found between rank-ordered elements of business strategy and elements of manufacturing mission in terms of consistency, contrary to literature.
Swamidass (1986)	Survey of 33 Pacific manufacturing firms in the machine tools industry. Two distinct structured questionnaires used--one to CEO and one to MM of each firm.	Comparison (match) of areas of agreement on manufacturing performance goals.	None.	A general mismatch of business and manufacturing goals. Need for greater communication between CEOs and their respective MM to resolve manufacturing related strategic bias.
Swamidass and Newell (1988)	Same sample as above. Investigation, in part, of the "Role of manufacturing managers in decision making" and its effect on firm economic performance. Causal, path-analytic model employed.	Not a 'consensus' (content variable) per se. RMMSDM is a process variable.	Growth in ROA, Sales, and Return on Sales over five years.	Significant positive relation found between RMMSDM and economic performance.

Table 5 (continued)

Study	Subjects and research method	Consensus type	Dependent variables	Key findings
Dess (1987)	Surveyed 19 privately-held manufacturing firms in the paint and allied products industry. Questionnaire on competitive objectives and competitive methods given to members of the top management team on each firm. Correlation analysis and ANOVA. Designed as replication study of Bourgeois (1980) with control for industry and competitive methods instrument based on Porter (1980).	Consensus on competitive objectives and consensus on competitive methods.	Average firm sales and after-tax ROA over five years.	Consensus on either objective methods is positively related to organization performance.

Literature on the strategic use of process and systems technology. In his book Manufacturing in the Corporate Strategy, Skinner (1978, p. 81) lectured on the importance of technology to organizations:

> The importance of technology to corporations is evident. Corporations producing products or services must make decisions on their technology when they design products, plan services, choose equipment and processes, and devise operating facilities, distribution, and information systems. Because these decisions involve large blocks of irreplaceable time, they are some of the most vital and critical decisions top management makes. Once made, their reversal or even a major shift is apt to be difficult or even impossible. Unwise decisions on technological issues are frequently fatal in small businesses.

Hill (1985, p. 44) echoed these remarks as he emphasized the strategic importance of technology and process choice to the manufacturing firm:

> Manufacturing can choose from a number of alternative processes in order to make the products involved. The key to this choice is volume and the order-winning criteria involved. Each choice needs to reflect the set of trade-offs involved for the various products in both current and future terms. The issues embodied in these trade-offs are both extensive and important.

The management of technology, particularly of change in the production process and its relationship to productivity, flexibility, and product change is thought by operations strategy theorists to be a major determinant of a firm's competitiveness (Hayes and Wheelwright, 1979a). For this reason a detailed review of representative works on the strategic use of technology is now presented.

The first article of this review is a theoretical work by Utterback (1978). Building on earlier works by Abernathy and Utterback (1975) and Abernathy and Townsend (1975), Utterback (1978) argued that design choices made in organizing a firm's production process both stimulate the firm to make certain changes in its products and constrain its ability to introduce and profit from other changes. According to the author, from a strategic point of view, management may want a degree of "inefficiency" in the design of its physical facilities, process integration, materials standardization, and labor specialization in order to have greater flexibility in product design and to meet changing competitive conditions within the industry. Thus, demands for standardization and productivity must be balanced against needs for flexibility and product innovation in long term manufacturing decisions. A model of process development was proposed. As a production process develops toward higher levels of output and productivity, it does so with a characteristic pattern: it becomes more capital intensive, direct labor productivity improves through greater division of labor and specialization, the flow of materials within the process takes on a straight line flow quality and becomes more rationalized, the product becomes more standardized, and the production process scale becomes larger. This theoretical piece presented a plausible explanation of production process evolution.

In another conceptual piece of rather profound theoretical influence, Hayes and Wheelwright (1979a) noted that the life cycle concept provides a useful framework for thinking about the growth and development of a new product, a company, or an entire industry. The authors proposed extending this concept to production process evolution. The product life cycle was distinguished from a new related concept, the process life cycle. As the product and market pass through a series of major stages, ideally so does the production process used in the manufacture of that product. The authors conceptualized a product-process matrix, a method by which the interaction of both product and process life cycle stages could be represented. The rows of the matrix represent the major stages through which a production process tends to pass in going from a fluid form (top row) to a systematic form (bottom row). The columns of the matrix represent the product life cycle phases, ranging from a great variety of custom products (left-hand side) to standardized commodities (right-hand side). Using this system, a business unit can be characterized as occupying a particular region on the matrix according to the stage of a product's life cycle and its choice of production process for this specific product. The authors proposed diagonal positions (upper left-hand side to lower right-hand side) as preferred positions for matching marketing needs and manufacturing capabilities. Hayes and Wheelwright (1979a) noted that while it is occasionally possible to operate off-diagonal and be successful, moving away from a diagonal position on the matrix is risky. Problems can exist coordinating marketing and manufacturing needs. Schmmener (1985, p. 393) observed:

> A strategy that consistently positions a company above the diagonal is a conservative one. The company risks loss of dollars that could have been made (opportunity cost) rather than the loss of dollars already earned. The conservative firm would rather lose potential profits by lagging behind in technology than incur certain out-of-pocket expenses for advances in process.

Operating below the diagonal too is a risky proposition. Such a positioning risks unnecessary investment costs (capital intensity), underutilization of equipment, and reduced process flexibility. By moving away from a diagonal position on the product-process matrix, the firm becomes dissimilar to its competitors and, depending on its success in capturing a unique market niche, potentially vulnerable. A first rate conceptual piece building on the work of Utterback (1978) and others, the Hayes and Wheelwright (1979a) article provided a base for theory building in operations strategy. Empirical testing of this concept, however, has been limited.

In his book, Meeting the Competitive Challenge -- Manufacturing Strategy for U.S. Companies, Buffa (1984) emphasized that as the company's product evolves through its life cycle (in conjunction with appropriate marketing strategies) the production system should develop through an evolution of its own (Hayes and Wheelwright, 1979a, b). According to the author, positioning and repositioning the production system in relation to a changing market environment (and potential changing marketing strategy) is a critical function of operations management. The manufacturing firm's choice of process technology thus interacts with its product line structure and its general marketing strategy, and this interaction will give the business unit either a competitive advantage or a competitive disadvantage within its industry. Positioning the production system, process technology, and the strategic use of operating systems represent three of Buffa's (1984) six "basics" of operations strategy. A fine review of the precepts of operations strategy, the author nevertheless presented little or no empirical support for the correctness of his propositions. The text is a classic opinion piece on operation strategy theory.

In conjunction with the 1984 North American Manufacturing Futures Project, Huete and Roth (1987) surveyed 213 manufacturing managers on the manufacturing capabilities and strategic directions of their business units. Using factor analysis and a regression model, the authors determined several significant relationships. Specifically, the performance criterion "flexibility" appeared as an important manufacturing capability associated with product innovation and market selection. In contrast, the manufacturing capability "low cost" (efficiency) was negatively associated with product innovation. The low cost criterion appeared incompatible with a strategic direction toward developing new products for new markets, one that involves a strong commitment to innovation. This empirical operations strategy study provided some evidence toward establishing the validity of the precepts expressed by Utterback (1978) and Hayes and Wheelwright (1979a).

In a strategic management piece, Anderson and Zeithaml (1984) empirically tested the product life cycle concept by examining differences among the determinates of high organizational performance across the various stages of the PLC. The results obtained by these researchers supported the use of the product life cycle as a contingency variable important to strategy research. Consistent with operations strategy theory, the link between performance and efficiency was found to be strongest at the maturity stage of the PLC.

Fine and Hax (1985) provided a conceptual framework and a set of guidelines with which a manufacturing firm could design a congruent operations strategy. The authors employed the product/process life cycle matrix (Hayes and Wheelwright, 1979a) as a strategic tool to capture the interaction of product and process life cycles. Here, the matrix was used to determine which of a manufacturing firm's product lines were similarly positioned within their product-process cycles and were therefore candidates for homogeneous grouping. The matrix was also used to detect the degree of congruency between product structure and its natural (or diagonal) process structure. A product line falling outside the diagonal could be explained by either inadequate managerial attention or by concerted strategic actions designed to depart from conventional competitive moves. Finally, to detect the degree of focus at each plant, the product-process matrix was again used, with one matrix prepared for each plant, positioning within the matrix every product line manufactured at that plant. This procedure permitted management to judge each plant's degree of focus and to consider the possible reallocation of products to plants. This case study assumed the appropriateness of the product-process matrix as a correct methodological tool. No empirical testing was offered as evidence of the validity of the matrix.

Wharton (1987) sought an empirical investigation of the Hayes and Wheelwright (1979a) product-process matrix and the assumption that a diagonal position is the normal "correct" position for product/process alignment and performance. Using data relating to product and process dimensions and organizational performance from 169 manufacturing firms, no evidence was found that manufacturing firms operating along the matrix diagonal showed higher performance than non-diagonally operating firms. The author conjectured that technological characteristics appeared to have had a higher degree of influence on a firm's positioning and performance than the matrix format. Movement toward the use of new, flexible, automated process technologies to produce a larger variety of products in lower volumes might have distorted the classical matrix diagonal positioning assumption. The question is thus raised -- do the new technologies (OPT, FMS, MRP, JIT) distort or accentuate the assumed correctness of product-process positioning along the matrix diagonal? The author noted that this empirical work may suffer from definitional problems.

Sharma (1987) tested numerous manufacturing strategy principles using a rigorous statistical technique (LISREL). Unfortunately, many of the hypothesized relationships could not be substantiated due to a lack of statistical significance found in the fit of the causal models tested. Some directional evidence, was discovered, however, on the relationship between product diversity and positioning strategy and the relationship among positioning strategy, demand volume, and demand uncertainty. Both sets of relationships provided a degree of support for the structure of the Hayes and Wheelwright (1979a, b) product-process matrix.

Meredith (1987b) observed that previously manufacturing firms were generally limited to strategies that lay on the product-process matrix diagonal. The author proposed that new technologies are allowing smaller manufacturing firms, less inhibited by structure, to move off the diagonal and attain success within their industries. No empirical evidence was provided.

In an oft quoted strategic management work, Hitt, Ireland, and Palia (1982) investigated the impact of four grand (corporate) strategies on the relative importance of organizational functions (including the production function) and the moderating effect of type of production system on this relationship. The researchers defined type of production system using the Woodward (1965) classification scheme: unit and small batch, large batch and mass production, and continuous process. Type of production system was found to have only a weak moderating effect on the strategy-functional importance relationship. Problems in this empirical study appear to exist due to the researchers' mixing of levels of analysis and from an aggregation of data. The focus of the study was on corporate rather than business-level strategy. Since each strategic business unit within a corporation might rely on various types of processes, it is difficult to imagine how a correct process classification was derived for the corporation as a whole. Hitt et al. (1982) recommended that the study's conceptual framework be applied to the business level and conjectured that the moderating impact of technology might increase when business-level strategies are considered. The authors also recommended that performance be used as a dependent variable in future research. This article is an example of the more complete empirical testing of relationships common to strategic management research. However, operations strategy research was not the intent of the authors. Methodological precision is needed in future study of the SBU strategy--process choice--performance relationship.

Summary and Direction

A review of the literature on operations strategy theory has demonstrated that while production/operations management theorist have done an admirable job of conceptualizing operations strategy principles, in general, these scholars have avoided the empirical research necessary for validation of these principles. Theory testing must follow theory building. The research process is an iterative one, with theory testing providing hard evidence for subsequent theory building and refinement. This operation strategy dissertation research was undertaken to answer this research need. Specifically, this research provides theory testing of both the relationship of the influence of managerial consensus (both strategic consensus and manufacturing task consensus) on operational performance and the relationship of the influence of strategic use of process and technology (product-process alignment and advanced systems use) on operational performance.

Strategic management research provides various concepts and methodological tools which can increase the potential success of empirical research in the area of operations strategy. In addition to their own literature base, production/operations management researchers can make ready use of strategic management conceptual and methodological studies, work covering such topics as strategic typologies, managerial consensus, and the strategy-performance linkage.

An integrative approach to such empirical research should be beneficial to researchers. Jemison (1981, p. 607) has commented:

> The challenge to strategic management researchers and educators is clear. We can continue to work in relative conceptual isolation by drawing on limited disciplinary bases for research purposes, and expect our results to be correspondingly limited in their usefulness and generalizability. Or, we can take steps to implement a multidisciplinary approach that reflects and richness and complexity of strategic management. The more we are able to integrate the ideas and findings from a variety of disciplines, the greater will be our understanding of the phenomena involved and the more rapidly will this understanding be achieved.

This integrative approach was undertaken in this research. It is the belief of this author that drawing from the literature streams of both operations management and strategic management has enriched this research.

In Chapter 3, the research plan used for the empirical testing of important dimensions of operations strategy theory is presented. The research process was initiated with the creation of a performance model, one that incorporates dimensions of strategic consensus and the strategic use of process and technology.

CHAPTER 3

Research Design and Methodology

Introduction

A set of research questions for this dissertation was proposed and presented in Chapter 1. Four of these research questions focus on the separate direct influences of strategic consensus, managerial task consensus, product-process alignment, and advanced systems use on manufacturing operational performance. The rich conceptual literature base of operations strategy theory (Chapter 2) predicts profound causal influences of these variables on the operational performance of the manufacturing business unit. In order to empirically test these relationships, as well as to assess the interrelationships of these operations strategy variables with one another and the combined and indirect influences of these variables on performance, this dissertation research was undertaken. The research design for this project is presented in this chapter.

Development of Hypotheses

According to the tenets of operations strategy theory, a consensus on both general strategic direction and manufacturing task emphasis must exist between business-level strategic planners and functional-level manufacturing managers for effective business unit performance to occur. Effective business unit performance results from a coordinated and consistent manufacturing strategy that effects a close match between manufacturing task performance objectives and the type of competitive advantage being sought by the strategic business unit (Skinner, 1978; Wheelwright, 1978; Buffa, 1984; Hill, 1985, 1989).

Accurate knowledge of the business unit's strategy (high strategic consensus or level of common understanding of strategic direction and task emphasis) can be translated by manufacturing managers into appropriate manufacturing performance goals, processes, systems, and infrastructure that can adequately support the strategic direction of the business unit. Since it is the responsibility of manufacturing managers to develop a manufacturing strategy which supports the business unit strategy, the assumption is made that consensus on competitive priorities and methods will normally lead to the creation of consistent cross-level strategies between the strategic business unit and its manufacturing function. Importantly, the manufacturing manager's beliefs as to the strategic direction and importance of various competitive methods will form the basis for manufacturing strategy development and execution. Since the design and implementation of the specific manufacturing systems necessary to effect the goals of the business unit result from important functional-level strategic choices made by manufacturing, cross-level managerial consensus on competitive direction and methods will be crucial to the success of the strategic business unit. A high degree of consensus among strategic planners and manufacturing managers on competitive methods within the strategic business unit should be associated with high levels of business unit performance.

As Venkatraman and Ramanujam (1986) have pointed out, the narrowest conception of business unit performance centers on the use of outcome based financial indicators, while a broader conception of performance would ideally first focus on indicators of operational performance. Kaplan (1983), too, has strongly recommended that researchers begin to employ nonfinancial measures of manufacturing performance and focus on the operational outcomes that lead to increased financial performance. If high levels of strategic consensus among strategic planners and manufacturing managers lead to increased levels of business unit performance, then such an effect must occur through the influence of manufacturing operational performance. Ceteris paribus, a strategic business unit's operational performance (and subsequent financial performance) should increase with increased levels of strategic consensus among the business unit's strategic planners and its manufacturing managers. Therefore, the first hypothesis tested in this research is as follows:

H1: There is a direct positive relationship between SBU-Manufacturing Strategic Consensus and manufacturing Operational Performance.

A second major principle of operations strategy theory involves the linkage of manufacturing processes and product characteristics (Voss, 1986). Hayes and Wheelwright

(1979a, b) have posited that a product's life cycle and its process life cycle should not be considered separately from each other. The theory holds that as a product evolves through its life cycle with corresponding adaptations in business strategy, the production process design used to manufacture the product must also evolve to conform to current strategic and product requirements. Positioning and repositioning the production system in light of the product's life cycle stage and current marketing strategy is a primary responsibility of the manufacturing function (Buffa, 1984). This orthodox view of operations strategy holds to a specific correspondence of product life cycle stages and manufacturing process systems. This matching of product life cycle stage and production process is represented by the Hayes and Wheelwright (1979a, b, 1984) product-process matrix. Employing the product-process matrix, a business unit's product can be characterized as occupying a particular region of the matrix according to the stage of the product's life cycle and manufacturing's choice of production process used to produce the product. Diagonal positioning on the matrix is strongly recommended (Hayes and Wheelwright, 1979a, b, 1984; Schmenner, 1985; Fine and Hax, 1985). Diagonal positioning represents the following product-process matchings: introduction stage - job shop, growth stage - batch process, maturity stage - assembly line, continuance stage - continuous process. In addition to reflecting higher volume manufacturing, movement down the diagonal trades off decreased process flexibility and product range variety for lower per unit manufacturing (and higher process investment costs). Diagonal positions are thought to represent ideal matchings of product strategy and production process requirements. The authors cited above have noted that while it is occasionally possible for a business unit to operate off-diagonal, such positioning on the product-process matrix is risky. Operating above the diagonal the strategic business unit risks opportunity costs by lagging behind in technology. Operating below the diagonal the strategic business unit risks the incurrence of unnecessary investment costs. Fine and Hax (1985) have strongly recommended the use of the product-process matrix as a diagnostic strategic tool for assessing the congruence between product structures and their "natural" (diagonal) process structures.

Since the traditional view of operations strategy theory is that manufacturing managers should seek to align product and process characteristics via the product-process matrix, the following hypothesis has been put forth:

H2: There is a direct positive relationship between the degree of "correct" Product-Process Alignment and manufacturing Operational Performance.

While Wharton (1987) studied a similar premise, his dependent measure was strategic business unit financial performance. This research is the first study designed to test the effect of product-process alignment on manufacturing operational performance.

It is assumed that strategic consensus among business-level strategic planners and manufacturing managers would be a logical precondition for a business unit to effect "correct" product-process alignment. Since the design and implementation of specific manufacturing systems necessary to effect the goals of the business unit result from functional-level strategic choices made by manufacturing, cross-level managerial consensus on competitive methods (strategic consensus) would be necessary requirement if manufacturing is to choose the "correct" (diagonally positioned) production process for a given product or product line. Stage of product life cycle, marketing goals, performance criteria, etc. must be adequately communicated to, and understood by, the manufacturing function if "correct" production processes are to be chosen, processes which properly support the business unit's strategy for the product. Since a high level of strategic consensus would be a necessary condition for manufacturing's ability to choose a correctly aligned production process (other than by chance), the following hypothesis has been proposed and tested in this research:

> H3: There is a direct positive relationship between the level of SBU-Manufacturing Strategic Consensus and the degree of "correct" Product-Process Alignment.

This proposition has not been tested by either strategic management or operations management researchers.

Several operations strategy scholars, however, have begun to question the general prescription of the Hayes and Wheelwright (1979a) product-process matrix for on-diagonal production process positioning. Jelinek and Goldhar (1984), Wharton (1987), and Meredith (1987b) argue that the use of new manufacturing technologies and advanced systems may now permit manufacturing organizations to operate off-diagonal and yet attain superior operational and business unit performance. The use of the new technologies may distort the traditional trade-off of flexibility for lower unit cost production that the matrix diagonal represents by providing such operational benefits as greater flexibility, improved quality, and lower unit costs. To test the influence of new technologies on diagonal positioning, the following hypothesis has been proposed and examined in this research:

H4: There is an inverse (negative) relationship between Advanced Systems Use and the degree of "correct" Product-Process Alignment.

The potential benefits of such advanced systems as OPT, FMS, MRP, JIT (Aggarwal, 1985) and other new technologies toward the production of superior operational performance have been highly touted in recent years in both trade and academic journals. "A deluge of material has hit the American public concerning the 'factory of the future', high technology, and computerized automation", Meredith (1987b, p. 249) has noted. The adoption of new manufacturing technologies can potentially enable the strategic business unit to compete in new ways by providing such competitive opportunities as faster new product introductions and product modifications, higher product quality, a broader variety of products and/or product features at the same cost, reduced order to delivery time, and reduced unit manufacturing costs (Voss, 1986). Properly implemented, appropriately chosen advanced systems can provide these competitive opportunities by impacting one or more of the operational performance criteria as defined by Wheelwright (1978), i.e. cost, flexibility, dependability, and quality. Since past research on the potential benefits of advanced systems and new technologies has been limited to case study reports and opinions, the following hypothesis has been put forth:

H5: There is a direct positive relationship between Advanced Systems Use and Manufacturing Operational Performance.

The above proposition is the last of five initial hypotheses tested in this dissertation. In summary, the following five initial hypotheses have been proposed and tested in this research:

H1: There is a direct positive relationship between SBU-Manufacturing Strategic Consensus and manufacturing Operational Performance.

H2: There is a direct positive relationship between the degree of "correct" Product-Process Alignment and manufacturing Operational Performance.

H3: There is a direct positive relationship between the level of SBU-Manufacturing Strategic Consensus and the degree of "correct" Product-Process Alignment.

H4: There is an inverse (negative) relationship between Advance Systems Use and the degree of "correct" Product-Process Alignment.

H5: There is a direct positive relationship between Advanced Systems Use and manufacturing Operational Performance.

These five initial hypotheses have provided the theoretical basis for the development of an initial causal research model (Figure 5). The arrows drawn between the nodes (variables) of this structural model, a causal model of operations strategy, demonstrate each of the hypothesized relationships and, taken together, demonstrate the interrelationships of the four variables defined for initial study (Strategic Consensus, Operational Performance, Product-Process Alignment, and Advanced Systems Use). Note that each of the five hypotheses mentioned above is denoted along specific causal arrows of the research model.

Analysis of this initial research model has lead to a subsequent refinement of its structure and has permitted the statistical testing of two additional research hypotheses. These additional hypotheses, which are not part of the structure of the initial research model, have been incorporated into this study as part of the necessary revision of the initial causal model. This subsequent development and testing of the refined research model (Model 2) has permitted the examination of the following two additional propositions:

H6: There is a direct positive relationship between SBU-Manufacturing Task Consensus and manufacturing Operational Performance.

H7: There is a direct positive relationship between SBU-Manufacturing Strategic Consensus and SBU-Manufacturing Task Consensus.

In total, seven hypotheses have been investigated in this dissertation research.

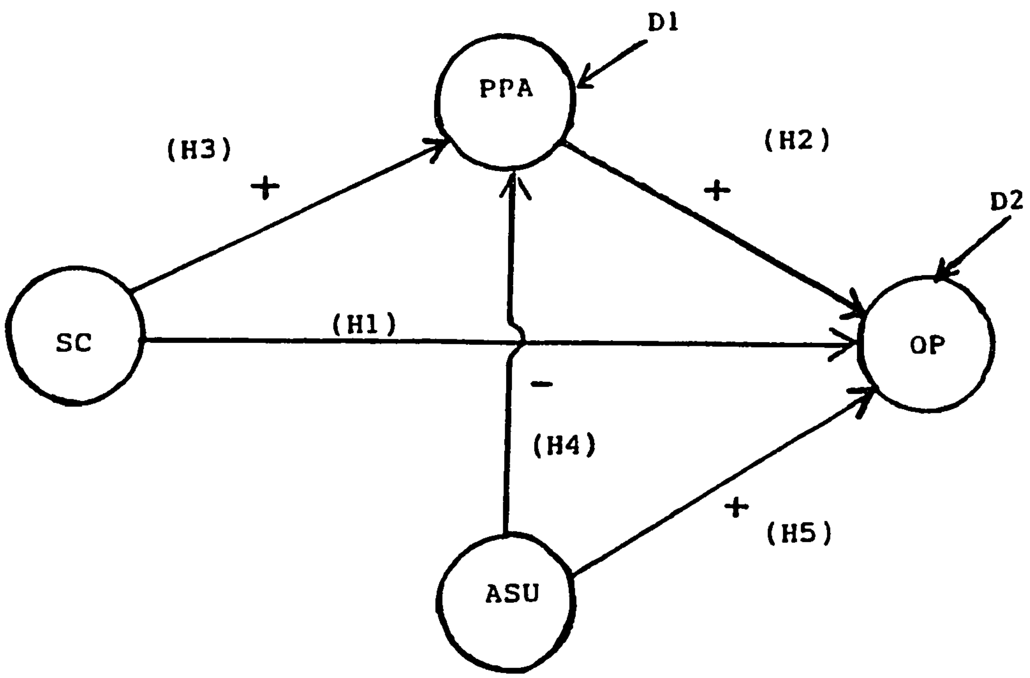


Figure 5. Operations strategy research model

Note. SC: SBU-Manufacturing Strategic Consensus
OP: Operational (Manufacturing) Performance
PPA: Product Life Cycle/Process Alignment
ASU: Advanced Systems Use

Research Sample Characteristics

The level or unit of analysis for this research is the "strategic business unit", defined for purposes of this analysis as a product group, i.e. a major product line or group of smaller similar products sharing a common marketing strategy, product life cycle stage, production process and production volume level. The use of this unit of analysis has permits the specificity and precision required (although often lacking in such research studies) to adequately test operational influences and effects. Twenty-seven such product groups, chosen from several major U.S.-based electronics manufacturers, have been included in the research sample. Multiple business units (product groups) within individual electronics manufacturing firms will be sampled. Examples of products manufactured by the business units surveyed in this research include such electronics products as pagers, electronic automotive components, and computer interface modules. A listing of sample characteristics is presented in Table 6.

Table 6

Research Sample Characteristics

Industry: Electronics
Corporations: Major U.S.-Based Electronics Manufacturers
Level of Analysis: SBU
Definition of "SBU": Product group
Sample size: 27

Individuals surveyed within each SBU:

(VI) Strategic Consensus
Variables Measurement:

Strategic Planners:
1. General Manager (Product Group Manager)
2. Business Planner
3. Marketing Manager

Operations Manager:
1. Manufacturing Manager
2. Production Control Manager
3. Quality Assurance Manager

(V2) Product-Process Alignment Assessment:
PLC Stage Process Type
1. General Manager
2. Manufacturing Manager

(V3) Advanced Systems Use
Variable Measurement:
Manufacturing Manager

(V4) Operational Performance
Variable Measurement:
General Manager

(V5) Manufacturing Task Consensus
Variable Measurement:

Strategic Planners:
1. General Manager
2. Business Planner
3. Marketing Manger

Operations Managers:
4. Manufacturing Manager
5. Production Control Manager
6. Quality Assurance Manager

Measurement Instruments

Kerlinger (1973) has noted that poor measurement can invalidate any scientific investigation or research study. Measurement instruments employed in research must be designed and examined for their reliability and validity. If the researcher does not have confidence the measurement scales used in his/her research actually and adequately measure what they purport to measure, then he/she will be unable to determine the existence of relationships among particular constructs. The design characteristics of each measurement scale employed in this research study is reviewed below:

Strategic Consensus Measurement

Bourgeois (1980) inductively derived a competitive strategies (means) scale as a method of defining the competitive emphasis of a given single-mission firm within its industry. From a set of strategies or 'competitive methods' recommended by Uyterhoeven, Ackerman, and Rosenblum (1977), Bourgeois (1980) developed a set of competitive methods which he operationalized into a 23-item questionnaire scale. This competitive methods scale consists of such items as 'cost reduction', 'product range', 'brand image', etc. which are rated by members of the firm's top management team on a Likert-type scale (1-5). The standard deviation of the scores on each competitive method item serves as a basis for computing an aggregate firm level measure of top management team consensus on the means for competitive emphasis.

Following the lead of Bourgeois (1980) and upon a review of the theoretical work of Porter (1980), Dess and Davis (1984) inductively derived a questionnaire scale designed to evaluate the various competitive methods that might be used to characterize a particular firm's generic competitive strategy (product differentiation, low cost, focus). Porter (1980) had proposed a number of strategic dimensions that were designed to capture the possible differences among strategic options available to firms competing within a given industry. Factor analysis of the questionnaire on competitive methods was employed to develop the competitive methods dimensions associated with each of Porter's generic strategies. A panel of experts was employed to help clarify the relationships between competitive methods and generic strategies and to aid the interpretation of the factor analysis. The results of this factor analysis are reported in Table 7. The competitive methods instrument derived by Dess and Davis (1984) consists of 21 items on a 5-point Likert scale. [An augmented version of the Dess and Davis (1984) scale, one including these original 21 items, was employed in this dissertation research. Factor analytic results are reported in Chapter 4.] Dess (1987) employed the competitive methods instrument to determine the degree of consensus among members of a firm's top management team regarding their individual perceptions on the relative importance of different aspects of the firm's actual strategic emphasis. As Dess (1987) has pointed out, the purpose of the instrument is to measure consensus. It is not intended to obtain the process by which consensus is obtained nor the preference orderings among the members of the top management team as to what strategic direction should be.

The Dess and Davis (1984) competitive methods instrument was chosen for use in this research for several important reasons: The scale is built upon the theoretical work of Porter (1980). Porter's system of generic strategies is the most often cited typology of business unit strategic direction cited in the operations strategy literature. Factor analytic results have been published showing the general agreement of the scale items with specific generic strategies. The competitive method items consist of both marketing-related and operations-related competitive dimensions. It was designed to be an improved version of a similar scale used by Bourgeois (1980). The instrument has been successfully employed in a previous study (Dess, 1987) as a measure of consensus on competitive methods among members of top management teams of manufacturing firms. Since such business unit means or competitive methods serve as functional-level goals for the manufacturing area, the instrument provides the necessary bridge for measuring the degree of strategic consensus between strategic planners and manufacturing managers. It provides a common instrument that can be completed by both strategic planners and manufacturing managers.

The assessment of the level of strategic consensus within business units (product groups) concerning the competitive direction for the focal product and consequent measurement of the general strategic consensus variable (SC) has been determined by means of the following procedure: Each of the six members of the product group team (general manager, marketing manager, business planner, manufacturing manager, quality assurance manager, and production control manager) were asked to complete an augmented version of the Dess and Davis (1984) competitive methods scale. To measure "consensus", the measurement instrument was employed as recommended by Dess (1987). Specifically, strategic consensus measurement entailed: 1) the calculation of the standard deviation of the responses per item from the six product group team members and 2) the summation of the item standard deviations to yield a total strategic consensus score for the manufacturing business unit (product group). Since the standard deviation statistic measures the dispersion or differences in perception on product strategy by the

Table 7

Factor Analysis of Dess and Davis (1984) Measurement Scale

		Factor One Differentiation		Factor Two Low Cost		Factor Three Focus		Communalities
	Competitive Methods	Factor (a_{j1})	Squared Factor (a_{j1})	Factor (a_{j2})	Squared Factor (a_{j2}^{2})	Factor (a_{j3})	Squared Factor (a_{j3}^{2})	(n_j2)
VI.	New product development	.19858	.03943	.15352	.02357	.62736	.39358	.45658
V2.	Customer service	-.26645	.07100	.48492	.23515	.41641	.17340	.47955
V3.	Operating efficiency	.49412	.08659	.51166	.26180	-.14168	.02007	.36837
V4.	Product quality control	.16526	.02731	.80309	.64495	.02370	.00056	.67281
V5.	Experienced/trained personnel	.05293	.00280	.80309	.64495	.02370	.00056	.34994
V6.	Maintain high inventory levels	.02485	.06118	.07925	.00618	-.05166	.00270	.07016
V7.	Competitive pricing	.04730	.00223	-.01997	.00040	-.26566	.07058	.07321
V8.	Broad range of products	.02949	.00087	-.11203	.01255	.26821	.07194	.08536
V9.	Developing/refining existing products	.19764	.03906	.61536	.37867	.34666	.12017	.53790
V10.	Brand identification	.82943	.68795	.12707	.01615	.03331	.00111	.80263
V11.	Innovation in marketing techniques and methods	.85953	.73879	.20290	.02117	.15055	.02267	.80263
V12.	Control of channels of distribution	.70853	.50201	.29166	.08596	.07323	.00536	.59244
V13.	Procurement of raw materials	.50326	.25327	.61069	.37294	-.15426	.02380	.65001
V14.	Minimizing use of outside financing	.23042	.05309	.30128	.09077	-.11744	.01379	.15765
V15.	Serving special geographic markets	.17321	.03000	.10626	.01129	.25196	.06348	.10477
V16.	Capability to manufacture specialty products	-.08241	.00679	.16097	.02591	.76621	.58708	.61978
V17.	Products in high price market segments	.22651	.05131	.00842	.00070	.69132	.47792	.52993
V18.	Advertising	.83112	.69076	.01627	.00026	.06969	.00486	.69588
V19.	Reputation within industry	.04930	.00243	.78639	.61841	.25484	.06464	.73265
V20.	Forecasting market growth	.55085	.34034	.51302	.26319	.17149	.02949	.63293
V21.	Innovation in manufacturing processes	.44429	.19739	.61579	.37920	.11464	.01314	.58973
	Eligen value	6.7871		2.2416		1.8101		10.8388
	Percent of common variance	62.60		20.74		16.66		100.00
	Percent of total variance	32.3		10.7		8.6		51.6

individual product group team members, the lower the dispersion of responses of team members to the items composing the competitive methods instrument, the higher the level of strategic consensus. The augmented Dess and David (1984) measurement scale, employed in this research to measure strategic consensus, is presented in Table 8.

Manufacturing Task Consensus Assessment

In addition to the measure of strategic consensus, a second "consensus" measure, one more manufacturing function specific, was measured in this research. A twelve item manufacturing task consensus measurement scale, one composed on scale items corresponding to the four manufacturing strategic dimensions defined by Wheelwright (1978) (low cost, flexibility, quality, and dependability), was used to assess the level of agreement within business units (product groups) on manufacturing strategy. This supplemental manufacturing task consensus (MTC) measurement scale is presented in Table 9. The quantification of the MTC consensus score was accomplished in the same manner as the determination of the strategic consensus measure, i.e. by summing the standard deviations of scale item responses of the six product group team members.

Table 8

Strategic Consensus Measurement Scale

Competitive Methods

Listed below are various items which might be used as methods for competing in your industry. Please indicate how IMPORTANT you feel each item is to your business unit's (product group's) overall competitive strategy.

1 = NOT AT ALL IMPORTANT
2 = NOT VERY IMPORTANT
3 = SOMEWHAT IMPORTANT
4 = VERY IMPORTANT
5 = EXTREMELY IMPORTANT

1.	Developing New Products..........	1	2	3	4	5
2.	Customer Service Capabilities....	1	2	3	4	5
3.	Operating Efficiency............	1	2	3	4	5
4.	Quality Control.................	1	2	3	4	5
5.	Experienced/Trained Personnel....	1	2	3	4	5
6.	Maintaining High Inventory Levels	1	2	3	4	5
7.	Competitive Pricing.............	1	2	3	4	5
8.	Broad Product Range.............	1	2	3	4	5
9.	Developing/Refining Existing Products......................	1	2	3	4	5
10.	Building brand Identification....	1	2	3	4	5
11.	Innovation In Marketing Techniques and Methods...........	1	2	3	4	5
12.	Control of Distribution System...	1	2	3	4	5
13.	Procurement of Raw Materials.....	1	2	3	4	5
14.	Conservative Use of Outside Funding (Debt)	1	2	3	4	5
15.	Serving Special Geographical Markets........................	1	2	3	4	5
16.	Capability to Manufacture Specialty Products...............	1	2	3	4	5
17.	High Priced Products Designed For Affluent Market.................	1	2	3	4	5
18.	Advertising.....................	1	2	3	4	5
19.	Effort To Build Industry Reputation......................	1	2	3	4	5
20.	Forecasting Market Growth........	1	2	3	4	5
21.	Innovation In Manufacturing Processes/Technologies...........	1	2	3	4	5
22.	Ability To Meet Due Dates........	1	2	3	4	5
23.	Frequent Product Innovations.....	1	2	3	4	5
24.	Flexibility Of Manufacturing Process For Design changes.......	1	2	3	4	5
25.	Custom Manufacture..............	1	2	3	4	5

Note. Augmented Dess and Davis (1984) Competitive Methods Scale

Table 9
Manufacturing Task Emphasis Consensus Scale

Manufacturing Task Items

Please indicate how IMPORTANT you feel each manufacturing task item is to the overall competitive strategy chosen by your business unit's general manager. (Circle only one number per item.)

1 = NOT AT ALL IMPORTANT
2 = NOT VERY IMPORTANT
3 = SOMEWHAT IMPORTANT
4 = VERY IMPORTANT
5 = EXTREMELY IMPORTANT

1.	Manufacturing Costs................	1	2	3	4	5
2.	Productivity of Labor..............	1	2	3	4	5
3.	High Production Volume.............	1	2	3	4	5
4.	Product Variety and Features.......	1	2	3	4	5
5.	New Product Introductions..........	1	2	3	4	5
6.	Design Change Incorporation........	1	2	3	4	5
7.	Quality of Product in terms Conformance and Consistency........	1	2	3	4	5
8.	Product Reliability................	1	2	3	4	5
9.	Product Price......................	1	2	3	4	5
10.	Meeting Customer Due Dates.........	1	2	3	4	5
11.	Speed of Delivery..................	1	2	3	4	5
12.	Speed in Accommodating Customer Changes............................	1	2	3	4	5

Product-Process Alignment Assessment

The assessment of the degree of product-process alignment within a manufacturing business unit (product group) and consequent measurement of a product-process alignment variable (PPA) was accomplished by way of the following procedure: The business unit general manager (product group manager) was asked to state the current life cycle stage (introduction, growth, maturity, continuance, or decline) for the focal product. Definitional criteria was provided the general manager to assist him/her in an appropriate designation of product life cycle stage. Independent of this event, the manufacturing manager within the same business unit (product group) was asked to designate the dominant type of operational process (job shop, batch process, assembly line, or continuous process) used for the manufacture of the focal product. A subsequent comparison of the resulting two pieces of information provided a means with which to assess whether or not a specific product-process match conformed to the prescriptive "correct" diagonal placement recommendations of Hayes and Wheelwright (1978a, b). A 4-point Likert-type measurement system was employed to measure the degree of product-process alignment/misalignment. This product-process positioning measurement system is illustrated in Table 10.

Table 10

Production Process Positioning Procedure

PLC Stage:	Introduction	Growth	Maturity	Continuance
Job Shop Process	4	3	2	1
Batch Process	3	4	3	2
Assembly Line Process	2	3	4	3
Continuous Process	1	2	3	4

Note. Aligned Product - Process Matchings:

Introduction PLC Stage	--	Job Shop Process
Growth PLC Stage	--	Batch Process
Maturity PLC Stage	--	Assembly Line Process
Continuance PLC Stage	--	Continuous Process

Advanced Systems Use Assessment. The extent of use of advanced systems and technologies (OPT, FMS, MRP, JIT and Robotics) within individual manufacturing business units (product groups) and the consequent measurement of an advanced systems use variable (ASU) was determined via the following assessment procedure: The manufacturing manager for each product group was asked to supply a specific designation as to the extent of use of each of the five advanced systems in the manufacture of the focal product. A 5-point Likert-type scale was employed for each of the five items (advanced systems). Scores were summed creating a total measure of the degree of advanced systems use. The advanced systems use measurement scale is presented in Table 11. The scale is similar in general design to that employed by Sharma (1987).

Table 11

Advanced Systems Use Measurement Scale

	Extent of Advanced Systems Use				
	None		Moderate		Extensive
OPT	1	2	3	4	5
FMS	1	2	3	4	5
MRP	1	2	3	4	5
JIT	1	2	3	4	5
Robotics	1	2	3	4	5

Operational Performance Measurement. An operational performance measurement scale was designed to assess the level of manufacturing performance within business units (product groups). The instrument provides a non-financial manufacturing-specific measure of manufacturing function performance. The twelve item seven-point Likert scale reflects an equal balance of the manufacturing performance criteria recommended by Wheelwright (1978). Measurement scale items employed include many of the items empirically tested by Heute and Roth (1987) and demonstrated by these researchers to correspond to the operational performance criteria of low cost (prices), flexibility, quality, and dependability (delivery). The results of the Heute and Roth (1987) factor analysis of eight manufacturing performance items, as derived from 1984 Manufacturing Futures Project data, are reported in Table 12.

The procedure used for the assessment of business unit (product group) operational performance is as follows: The general manager (product group manager) was asked to assess the level of focal product manufacturing performance for each performance criterion specified on the operational performance scale. Each response item was weighted by the degree of importance attached to each performance dimension, as separately and independently designated by the general manager. Weighted responses were summed producing a total measure of an individual manufacturing business unit's (product group's) operational performance.

The operational performance variable (OP) was measured by means of the above process. The operational performance measurement scale is presented in Table 13. The measurement scale is similar in format to the scale of manufacturing goals of Swamidass (1986) and incorporates six items used by Swamidass (1986), five items used by Huete and Roth (1987), and six items used by Sharma (1987). The 12-item performance scale contains three cost items, three flexibility items, three quality items, and three dependability items.

Table 12

Huete and Roth (1987) Manufacturing Task Items Factor Analysis

	Factor Loadings				
Variables	Factor 1 (Quality)	Factor 2 (Delivery)	Factor 3 (Flexibility)	Factor 4 (Cost)	Commu- nalities
High Performance Products	.82	.02	.06	.18	.70
Consistent Quality	.77	.16	.08	.32	.72
After Sales Service	.57	.30	.31	.19	.56
Dependable Deliveries	.23	.83	.12	.02	.75
Fast Deliveries	.01	.77	.27	.14	.69
Rapid Design Changes	.04	.01	.87	.01	.77
Rapid Volume Changes	.11	.18	.61	.47	.64
Low Prices	.08	.08	.02	.87	.77
Percent of Variance Explained	.27	.18	.14	.11	
Cumulative Variance Explained	.27	.45	.59	.70	

Note. Source: Huete and Roth (1987)

Table 13

Operational Performance Measurement Scale

Operational Performance Criteria							
The statements below indicate various ways in which your manufacturing unit can contribute to business unit performance. Please state your evaluation of the SBUs (product group's) current level of performance for each categorical item. Please focus on your dominant product.							
	Highest in industry					Lowest in industry	
1. Manufacturing Costs	1	2	3	4	5	6	7
	Lowest in industry					Highest in industry	
2. Labor Productivity	1	2	3	4	5	6	7
3. Volume of Production	1	2	3	4	5	6	7
	Narrowest range in industry					Widest range in industry	
4. Product Varieties And Features	1	2	3	4	5	6	7
	Least Frequent in industry					Most Frequent in industry	
5. New product Introductions	1	2	3	4	5	6	7
6. Design Changes Incorporation	1	2	3	4	5	6	7
	Worst In Industry				Best in Industry		
7. Quality of Conformance And Consistency	1	2	3	4	5	6	7
8. Product Reliability	1	2	3	4	5	6	7
	Lowest in industry					Highest in industry	
9. Product Price	1	2	3	4	5	6	7
	Worst in industry					Best in industry	
10. Meeting Customer Due Dates	1	2	3	4	5	6	7
11. Speed Of Delivery	1	2	3	4	5	6	7
12. Speed In Accommodating Customer Changes	1	2	3	4	5	6	7

Methodology

Measurement Instrument Validation

Kerlinger (1973) has mentioned that poor measurement scales can invalidate any research study. Measurement instruments used for inferential research must be carefully examined for reliability and validity.

The reliability of a measurement instrument refers to its stability and consistency in repeated measurement of an object. Investigating the reliability of a measuring instrument requires estimating its consistency in repeated measurements of the same object. Cronbach's Coefficient Alpha (Cronbach, 1951) is a frequently used measure of the internal consistency of a measurement scale. Coefficient Alpha provides a conservative estimate of the reliability of a Likert-type interval scale using scores derived from a single sampling. In order for a measurement instrument to be valid, it is necessary for the instrument to have relatively high reliability. High reliability is a necessary, although not a sufficient, condition for high validity. If the reliability of a measurement scale is low, it must be raised to an adequate level before the instrument can achieve a desired validity.

Measurement scales must be both reliable and valid. In a general sense, a measurement instrument is valid if it does what it is intended to do (if it measures what it is intended to measure). Validation requires empirical investigations. The researcher must validate the use to which the measurement instrument or score is put. The type of validity important to this research effort is content validity, the representation of the specified universe of content associated with each operations strategy variable. The American Psychological Association has specified that content validation is demonstrated by reflecting on how well the content of a measurement scale samples the class of situations or subject matter about which inferences are to be drawn. Thus, content validation consists essentially in judgement: Is the substance or content of the measurement scale representative of the property being measured? Along with the experience of others, the researcher evaluates the representativeness of the measurement scale items. In developing a sample of items which capture the content domain of the construct under study, previous attempts at measurement (similar measurement scales) are examined. Valid and reliable measurement scales are considered for use and/or modification. Additionally, confirmatory factor analysis can be employed to compare a measurements scale's item structure and factor loadings with both theoretical prescriptions and factor loadings known from previous work in the literature (both strategic management and operations management literature).

The reliability and validity of the measurement scales employed in this research study have been assessed. The results of this assessment are reported in Chapter 4.

Statistical Treatment

Path analytic causal modeling and multiple regression. Statisticians tell us that confirmatory analysis including such techniques as path analysis and structural equation is designed to evaluate questions of causal influence in research studies using nonexperimental and quasiexperimental data. Path analysis is designed to test the correctness of causal hypotheses by testing the fit between a theoretical causal model and empirical data. A confirmatory approach has been taken in this research effort in an evaluation of the initially proposed causal model of operations strategy and subsequent specifications.

The causal modeling process was begun with the specification of the hypothesized relationships of the causal connections among the theoretical operations strategy variables in the form of an initial causal model. This initial causal model of operations strategy was designed following a thorough review of the operations strategy literature and in accordance with the advice of experts on the causal modeling process that "the smallest number of variables connected by the smallest number of arrows that can do the job is the path diagram to be sought, one representing the most parsimonious explanation of the phenomenon under study." The causal model indicates the functional relationships among variables that relate effects to causes and specifies the form of functional or structural equations that are to be used to represent these relationships. The initially formulated causal model of operations strategy permitted a simultaneous examination of the first five hypotheses proposed in this chapter for research study.

Path analysis was employed in this study to empirically ascertain the direction and magnitude of the causal relationships between the operations strategy variables hypothesized to be related. In the initial research model developed in Chapter 3, both the Strategic Consensus variable (SC) and the Advanced Systems Use variable (ASU) are defined as manifest, exogenous (independent) variables. Both the Product-Process Alignment variable (PPA) and the Operational Performance variable (OP) are defined as manifest, endogenous variables. An endogenous variable is a dependent variable whose occurrence is to be explained by the causal model. D1 and D2 represent disturbance terms associated with each of the two endogenous variables. Theoretically, disturbance terms are latent variables. These disturbance terms account for variation in an endogenous variable attributable to causal influences other than the variables explicitly included in the causal model.

Asher (1983) has noted that path analysis is essentially concerned with estimating the linkages between variables and using the estimates to provide information about underlying causal processes. One way to obtain these estimates or path coefficients is to employ ordinary regression techniques. The process requires that all the assumptions of regression analysis are met, particularly the assumption that the residual variable in the regression equation be uncorrelated with explanatory variables. A regression approach has been used to test the proposed model of operations strategy and subsequent formulations. Regression analyses of standardized antecedent and dependent variables have been performed at the nodes of the causal models. Path coefficients have been determined. Each path coefficient defines the extent to which a change in the variable at the tail of an arrow of the model is transmitted to the variable at the head of the arrow. A path coefficient is a partial regression coefficient, measuring the change that occurs when the other causal variables of the model are held constant. Thus utilizing empirical research data, the investigator can solve for a numerical value of each arrow of the causal model and by so doing estimate the relative strength of the causal influence.

With a path analytic approach, all variables of the model are required to be measured manifest variables. Path analysis permits the use of a much smaller sample size than such latent variable statistical techniques as LISREL or EQS. Thus, because of the sample size (n = 27) employed in this research and the fact that the initially proposed model is strictly a manifest variables model (as opposed to a latent variable model) path analysis using least squares multiple regression was the statistical method of choice for use in this research.

Nonparametric regression. Statisticians recommend the use of nonparametric statistical procedures in situations where the assumption of a normal distribution of variable measurements is not warranted. Nonparametric statistical tests are distribution-free tests that do not require restrictive assumptions about the shape of population and/or sample distributions. Nonparametric methods do not require that variables be normally distributed or for that matter, distributed in any other specific manner.

Conover (1978) has noted that a difficult statistical situation also exists for a researcher when sample sizes are small. Due to the somewhat small size of the research sample (n = 27) and the nonnormality of the sampled values of at least one of the measured variables in this research, a nonparametric multiple regression approach has been employed as an appropriate statistical method with which to empirically estimate and test the causal linkages and associated structural equations of the initially hypothesized causal model of operations strategy and subsequent models.

Conover (1978) has outlined the basic rationale behind this use of nonparametric regression: The approach is recommended when sample sizes are low and a researcher needs to estimate the regression of y on x; with a nonparametric approach no assumptions regarding the distribution of (x, y) are made, so that the least square method is distribution free; the method is valid even when the values of x are nonrandom as long as the values of y are independent. Additionally, the regression of the rank of y on the rank of x will be linear if y and x are monotonically related.

Conover (1978, p. 39) has described a simple procedure for the extension of nonparametric regression methodology to multiple regression analysis:

> Suppose n observations Y_1, Y_2,...Y_n of a dependent are combined with corresponding n measurements on a set of k independent variables X_1, X_2,...X_k. The Y values, and the values for each X_i are separately ranked from 1 to n. Any usual multiple regression method is used on ranks to obtain a regression equation.

All causal modeling in this research has been carried out using a combination of path analytic and nonparametric multiple regression procedures. The results of the statistical research are reported in Chapter 4.

CHAPTER 4

Results

Introduction

Six executives from each of twenty-seven individual business units, product groups drawn from several major U.S. electronics manufacturers, participated in this research study. This chapter contains the results derived through this research. The analysis of these results begins with an inspection of both the reliability level and factor structure of each of the five measurement instruments used. Next, with confidence gained in the reliability and content validity of the measurement instruments, descriptive statistics for the five primary operations strategy variables measured are provided. Statistics on both unranked and ranked data are presented. This procedure is followed by the presentation of the results of the statistical testing of the initial path analytic research model (Model 1). The results of Model 1 provide specific answers to research questions one through five, questions proposed in Chapter 1. Upon appraisal of Model 1, two additional structurally refined causal models are subsequently developed. The results obtained through the statistical testing of operations strategy Model 2 provide specific answers to research questions six and seven. Finally, the empirical results of causal Model 3, a framework further evolved from Model 2 are presented and analyzed. As demonstrated through the process of decomposition of correlation of variables, causal Model 3 is found to represent the best fit of research data and operations strategy theory.

Measurement Scale Reliabilities

The reliability and validity of the measurement scales employed in this research study have been assessed. The results of these analyses are now reported.

Strategic Consensus Scale

The measurement scale used to assess the level of strategic consensus (SC) among product group managers is an augmented version of the Dess and Davis (1984) of strategic or competitive methods. Dess and Davis (1984) factor analyzed this scale to demonstrate its congruence with (and use as a measure of) Porter's (1980, 1985) generic strategies. The Dess and Davis (1984) measurement scale was further employed by Dess (1987) to assess the degree of strategic consensus within the top management teams of manufacturing firms operating in the paint and allied products industry.

An augmented Dess and Davis (1984) measurement scale was completed by the 162 (27 x 6) respondents participating in the current study. The strategic consensus measurement scale consists of 25 items which provided a ratio of 6.5 to 1 respondents to scale items. Importantly, the assessed reliability of the measurement scale was high, with Chronbach's Alpha equaling .86. (A reliability measure was not reported by Dess and Davis (1984).)

Factor analysis of the augmented Dess and Davis (1984) measurement scale produced seven factors. Factor analysis of the original 21 items of the Dess and Davis (1984) scale also produced seven factors. Cronbach's Alpha equaled .83. As previously mentioned, in addition to being a measure of strategic dimensions, the Dess and Davis (1984) scale has been designed as a measure of Porter's (1980, 1985) three generic strategies (low cost, product differentiation, and focus). Limiting the measurement scale's items to three factors, a subsequent factor analysis of the data produced factor loadings of individual scale items, results similar to those obtained by Dess and Davis (1984). The results of this second (forced three factor) analysis are reported in Table 15. Items 3, 4, 5, 13, 20, 21, 22 strongly loaded to a common factor best described as a "low cost" factor; items 8, 11, 12, 15, 18 strongly loaded to a common factor best termed a "product differentiation" factor; items 16, 17, 24, 25 strongly loaded to a third common factor, one best described as a "focus" factor. The content validity of these scale items, items appropriate for the measure of strategic direction, has been substantiated through the work of Bourgeois (1980) and Dess and Davis (1984).

Manufacturing Task Consensus Scale

A supplemental manufacturing task emphasis scale, one used to assess the degree of manufacturing task consensus (MTC) among product group managers, was also completed by the same 162 respondents who completed the strategic consensus (SC) measurement scale. The manufacturing task emphasis scale contains twelve manufacturing - specific task items. Thus, the ratio of respondents to scale items in the current sample was 13.5 to 1. Cronbach's Coefficient Alpha was computed to be .76, demonstrating a relatively high degree of measurement reliability. Factor analysis of the MTC scale produced the expected four factors, representing each of the manufacturing task dimensions of Wheelwright (1978). The results of this factor analysis are thus consistent with expectations for content criteria. These results are presented in Table 16.

Advanced Systems Use Scales

An advanced systems use (ASU) scale, one similar in design to that employed by Sharma (1987), was completed by 54 (2 x 27) managers. A designation of the extent of advanced systems was provided by both the manufacturing manager and the production control manager within each product group. Unfortunately, a very low Coefficient Alpha measure (.30) was obtained. Such a low level of reliability was deemed unacceptable for adequate statistical measurement of, and inferential statistical testing with, the advanced systems use variable. A subsequent factor analysis of the five ASU scale items (OPT, FMS, MRP, JIT, and Robotics) produced two factors, with two items of the original five item measurement scale loading highly (.80 level) on a single common factor. These two scale items, FMS (flexible manufacturing systems) and

Robotics, were used to define a new and reduced advanced systems measurement scale (FMS/RB). Cronbach's Alpha computed for the new two-item FMS/RB scale rose to an acceptable level of .65, providing a sufficient degree of reliability for subsequent statistical analysis. With only two items comprising the new scale, 54 respondents provided a ratio of 27 to 1 individuals to FMS/RB scale items. Thus, the originally designed advanced systems use (ASU) scale by necessity was reduced to a FMS - Robotics or flexible automation measurement scale. The results of the factor analysis of the original ASU scale are contained in Table 17. Scale items FMS and Robotics each load to factor 1 at the .80 level. No combination of measurement scale items other than FMS and Robotics produced a sufficiently high reliability level for inferential research. (For example, while the MRP item and the JIT item each loaded on a common factor (factor 2) at the .60 level, Cronbach's Coefficient Alpha computed for a two-item MRP/JIT scale was only .09.) As a simple Likert-type scale, measuring the extent of use of each of five major advanced systems for production improvement, the content validity of the scale items had appeared appropriate for the measurement of advanced systems application. A measurement scale similar to the original advanced systems use (ASU) scale was used by Sharma (1987) for empirical research. The content validity of the reduced two item (one factor) scale was empirically substantiated through factor analysis and the obvious close connection of the FMS and robotics constructs.

Operational Performance Scale

The operational performance (OP) scale used in this research contains twelve items, chosen to appropriately represent the manufacturing performance criteria of cost flexibility, quality, and dependability (Wheelwright, 1978). Each general manager assessed the level of focal product manufacturing performance for each performance item of the 12-item, 7-point, Likert-type operational performance measurement scale. Each item response score was then weighted (multiplied) by the level of importance (1 to 5) independently designated for each performance item by the general manager on the manufacturing task emphasis scale. The twelve products of performance item scores and corresponding importance levels were summed to produce a total score of the product group's operational performance.

Since only the general manager assessed the level of operational performance within each product group, only twenty-seven individuals in total completed the operational performance scale. However, even with a low ratio of respondents to scale items (just over 2.25 to 1), a Coefficient Alpha level of .65 was obtained.

A somewhat similar manufacturing performance measurement scale was defined and factor analyzed by Heute and Roth (1987) and shown to yield four factors corresponding to the

Wheelwright (1978) manufacturing performance criteria of cost, flexibility, quality, and dependability. A factor analysis of the current operational performance scale also yielded four factors. The results of this factor analysis are presented in Table 18. Factor loadings for this scale demonstrate factor 1 as a "quality" factor and factor 2 as a "flexibility" factor. Interpretations of factor 3 and factor 4 are more difficult. Although factor 3 is predominately a "dependability" factor, surprisingly item 1 (manufacturing costs) strongly loads to this factor and not to factor 4. Factor 4, to which the remaining two cost items (labor productivity and volume of production) load, appears hybrid and indeterminate in nature, with item 1 (manufacturing costs) having nearly no association with this factor, and with flexibility item 6 (design change incorporation) strongly associated with this factor. The low sample size of respondents (27), however, may be somewhat insufficient for a complete and exact interpretation of factor loadings.

Product-process Alignment Procedure

Finally, the degree of product-process alignment (PPA) within each product group was determined by means of a comparison of the focal product's current life cycle stage (introductory, growth, maturity, continuation, or decline), as designated by the product group general manager, with the dominant manufacturing process used for the manufacture of the product (job shop, batch process, assembly line, or continuous process), as designated by the product group manufacturing manager. Originally designed to accommodate a wide range of potential product-process misalignment, the measurement scale was designed as an Likert-type interval scale with measures of 1 to 4. The data obtained from the current sample of twenty-seven product groups, however, showed the maximum level of product-process misalignment limited to one interval of misalignment. Thus, the sample data produced only two values related to product-process alignment, "aligned" (on diagonal) and "nonaligned" (one stage off diagonal), with product groups nearly equally represented between the two designations.

The above measurement instruments, designed to measure the key operations strategy variables defined in this research, produced sufficient estimates of internal reliability and evidence of appropriate content validity for the empirical testing of the hypothesized causal research model.

Table 14

Measurement Scale Reliabilities

Construct	Variable	Cronbach's Alpha
Strategic Consensus	SC	.8559
Manufacturing Task Consensus	MTC	.7617
Operational Performance	OP	.6386
Advanced Systems Use	ASU	.2977
Flexible Manufacturing Systems and Robotics	FMS/RB	.6195

Table 15

Factor Analysis of Strategic Consensus Scale

	Factor Loadings			
ITEM	FACTOR 1 (Low Cost)	FACTOR 2 (Differentiation)	FACTOR 3 (Focus)	COMMUNALITY
Developing New Products	.41960	.34330	.22729	.34558
Customer Service Capabilities	.15680	.46757	.18823	.27863
Operating Efficiency	.68017	.13779	-.22157	.53071
Quality Control	.55096	-.06419	.04224	.30945
Experienced/Trained Personnel	.62155	-.00152	.08955	.39434
High Inventory Levels	-.20523	.43623	.09779	.24198
Competitive Pricing	.39311	.23526	.16765	.23799
Broad Product Range	-.03848	.63092	.32635	.50604
Developing Existing Products	.38166	.18229	.35365	.30396
Brand Identification	.26052	.40700	.08225	.24029
Innovation in Marketing	.29256	.64714	.04217	.50616
Control of Distribution	.21436	.71716	-.16701	.58817
Procurement of Raw Materials	.66465	.06363	-.03395	.44696
Conservative Use of Funding	.32116	.33191	.05903	.21679
Service Special Geo. Markets	.17622	.59839	-.01431	.38933
Manufacture of Specialty Products	.01074	-.00029	.84290	.71060
High Priced Products	-.25003	.39104	.51757	.48330
Advertising	.04933	.67178	-.11201	.46627
Building Industry Reputation	.27883	.39245	.10577	.24295
Forecasting Market Growth	.62349	.18513	.05534	.42608
Innovation in Manufacturing	.66757	.24824	-.00284	.50729
Ability to Meet Due Dates	.627093	.20567	.10298	.44607
Frequent Product Innovations	.30697	.43466	.43550	.47282
Flexibility of Process	.44196	.16787	.58502	.56576
Custom Manufacture	.01054	-.11292	.82275	.68977
Eigen Value	5.94627	2.51309	2.08794	
Percent of Variance	23.8	10.1	8.4	
Cumulative Percent	23.8	33.8	42.2	

Notes. Varimax Rotation 1, Extraction 1, Analysis 1 - Kaiser Normalization. Varimax converged in 5 iterations.

Table 16

Factor Analysis of Manufacturing Task Emphasis Scale

Factor Loadings

ITEM	FACTOR 1 (Cost)	FACTOR 2 (Dependability)	FACTOR 3 (Quality)	FACTOR 4 (Flexibility)	COMMUNALITY
Manufacturing Costs	.84146	.06103	.16500	.00788	.73907
Labor Productivity	.73614	-.01458	.12377	-.01992	.55783
Volume of Production	.69342	.02074	-.10413	.23034	.54516
Product Variety/Features	.03564	.12442	.12282	.84473	.74540
New Product Introductions	.02072	.17969	.08471	.83522	.73748
Design Change Incorp.	-.08912	.58600	.38070	.11905	.51044
Product Quality	.07469	.07936	.84254	.07100	.72679
Product Reliability	.15446	.18096	.80718	.10892	.72001
Product Price	.62972	.31210	.06153	-.10560	.50957
Meeting Due Dates	.33334	.62125	.06815	-.02909	.50256
Speed of Delivery	.25607	.66815	-.13013	.31622	.62892
Speed in Accommodating Customer Changes	-.08495	.80968	.22370	.18448	.74686
Eigen Value	3.34948	1.9438	1.30992	1.06834	
Percent of Variance	27.9	16.2	10.9	8.9	
Cumulative Percent	27.9	44.1	55.0	63.9	

Notes. Varimax Rotation 1, Extraction 1, Analysis 1 - Kaiser Normalization. Varimax converged in 6 iterations.

Table 17

Factor Analysis of Advanced Systems Use Scale

	Factor Loadings		
ITEMS	FACTOR 1	FACTOR 2	COMMUNALITIES
OPT	.35297	-.70064	.61548
FMS	.80794	-.09411	.66162
MRP	.00516	.60499	.36604
JIT	.30422	.60346	.45671
ROB	.83045	.10396	.70045
Eigen Value	1.5673	1.23298	
Percent of Variance	31.3	24.7	
Cumulative Percent	31.3	56.0	

Note: Varimax Rotation 1, Extraction 1, Analysis 1 - Kaiser Normalization. Varimax converged in 3 iterations

Table 18

Factor Analysis of Operational Performance Scale

	Factor Loadings				
ITEMS	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4	CUMULATIVE
Manufacturing Costs	-.21959	-.18083	.73862	-.02985	.62737
Labor Productivity	.14808	-.25283	.17012	.80761	.76702
Volume of Production	.57396	-.06887	.02874	.54783	.63512
Product Variety/Features	.11890	.67242	-.17585	-.16075	.52305
New Product Introductions	.09009	.75251	.02716	-.02048	.57554
Design Change Incorp.	.02847	.50625	-.13272	.76461	.85934
Product Quality	.79869	.11222	.08319	.17853	.68929
Product Reliability	.73857	.15005	.06245	.04473	.57391
Product Price	.71515	-.03446	-.42754	.01832	.69575
Meeting Due Dates	.57703	-.06915	.59318	-.03966	.69117
Speed of Delivery	.18273	.23369	.73873	.15013	.65625
Speed in Accommodating Customer Changes	-.08797	.61539	.34313	.25073	.56705
Eigen Value	2.96844	1.84055	1.76658	1.28529	
Percent of Variance	24.7	15.3	14.7	10.7	
Cumulative Percent	24.7	40.1	54.8	65.5	

Notes. Varimax Rotation 1, Extraction 1, Analysis 1 - Kaiser Normalization. Varimax converged in 6 iterations.

Descriptive Statistics

Descriptive statistics related to each original variable of the study (SC, MTC, FMS/RB, PPA, OP) are provided in Table 19. The table lists means, variances, and sample sizes. A correlation matrix derived from the original data of the sample is shown in Table 20. Additionally, the distribution characteristics of the five operations strategy variables are examined and are reported herein. Specifically, the Kolmogorov-Smirnov test for distribution normality is performed to examine whether or not the sampled values of each variable approximate a normal distribution, a criterion necessary for the proper use of least squares regression and the evaluation of the hypothesized path analytic causal model. The results of the K-S analysis (Table 21) indicate that the sampled distributions of four variables (SC, MTC, FMS/RB, OP) appear to be approximately normal, while the distribution of one variable (PPA) appears to be non-normal. The non-normal nature of the sampled distribution of the PPA variable is particularly relevant for subsequent statistical analysis of the research data, since the manifest variable path analytic operations strategy model requires the use of least squares regression and its normality assumption. The result of the K-S analysis of the product-process alignment variable is not surprising due to the bivariate nature of the PPA values of the research sample.

Table 19

Descriptive Statistics of Original Research Data

Variable	Mean	Std Dev	Minimum	Maximum	N
SC	19.25	3.08	13.36797	25.39936	27
MTC	7.71	1.14	5.311530	10.270190	27
OP	242.04	34.60	161	315	27
PPA	.44	.51	0	1	27
FMSRB	2.39	2.13	.00	6.00	27

Table 20

Correlation Matrix of Original Research Data

Correlations:	SC	MTC	OP	PPA	FMSRB
SC	1.0000 P= .000	.3987 P= .020	.1050 P= .301	.1930 P= .167	.2160 P= .140
MTC	.3987 P= .020	1.0000 P= .000	.4254 P= .013	.2487 P= .105	.2244 P= .130
OP	.1050 P= .301	.4254 P= .013	1.0000 P= .000	.2054 P= .152	.5116 P= .003
PPA	.1930 P= .167	.2487 P= .105	.2054 P= .152	1.0000 P= .000	.3147 P= .055
FMSRB	.2160 P= .140	.2244 P= .130	.5116 P= .003	.3147 P= .005	1.0000 P= .000

Note. 1-tailed significance

Table 21

Results of Kolmogorov-Smirnov Goodness of Fit Test

Test for Normality

Test Distribution - Normal — Mean: 19.2470989
SC Variable — Standard Deviation: 3.0764987

Most Extreme Differences Absolute	Positive	Negative	K-S Z	2-tailed P
.10974	.08469	-.10974	.570	.901

Test Distribution - Normal — Mean: 7.70727539
MTC Variable — Standard Deviation: 1.14208007

Most Extreme Differences Absolute	Positive	Negative	K-S Z	2-tailed P
.11728	.10931	-.11728	.609	.852

Test Distribution - Normal — Mean: 242.04
OP Variable — Standard Deviation: 34.60

Most Extreme Differences Absolute	Positive	Negative	K-S Z	2-tailed P
.09039	.09039	-.07514	.470	.980

Test Distribution - Normal — Mean: 2.3889
FMSRB Variable — Standard Deviation: 2.1319

Most Extreme Differences Absolute	Positive	Negative	K-S Z	2-tailed P
.16506	.16506	-.13124	.858	.454

Test Distribution - Normal — Mean: .44
PPA Variable — Standard Deviation: .51

Most Extreme Differences Absolute	Positive	Negative	K-S Z	2-tailed P
.36550	.36550	-.30815	1.899	.001

Note. N = 27 for all variables tested.

Table 22

Descriptive Statistics of Ranked Data

Variable	Mean	Std Dev	Minimum	Maximum	N
SCR	14.00	7.94	1.00	27.0	27
MTCR	14.00	7.94	1.00	27.0	27
OPR	14.00	7.93	1.00	27.00	27
PPAR	14.00	6.87	7.00	20.50	27
FMSRBR	14.00	7.80	2.0	23.5	27

Table 23

Correlation Matrix of Ranked Data

Correlations:	SCR	MTCR	OPR	PPAR	FMSRBR
SCR	1.0000 P=.000	.4768 P=.006	.0580 P=.387	.2570 P=.098	-.1093 P=.294
MTCR	.4768 P=.006	1.0000 P=.000	.4714 P=.007	.2474 P=.107	.2870 P=.073
OPR	.0580 P=.387	.4714 P=.007	1.0000 P=.000	.1476 P=.231	.4882 P=.005
PPAR	.2570 P=.098	.2474 P=.107	.1476 P=.231	1.0000 P=.000	.3873 P=.023
FMSRBR	-.1093 P=.294	.2870 P=.073	.4882 P=.005	.3873 P=.023	1.0000 P=.000

Note. 1-tailed significance

Causal Model 1

Research Model 1 is presented in Figure 6. This initial research model, a causal model of operations strategy, has been empirically tested using nonparametric multiple regression procedures. Estimated regression equations, structural equations associated with this path analytic causal model, are reported in this section. The paths or causal linkages between variables, each corresponding to the five initial hypotheses proposed in Chapter 3, have been statistically tested by means of multiple regression analysis on ranked data.

Empirical Results of Model 1

The hypothesized causal model has produced three multiple regression structural equations. These equations are listed in Table 24. Equation 1 was formed by regressing PPA (product-process alignment) on SC (strategic consensus) and FMS/RB (flexible manufacturing systems/robotics). Equation 1 is statistically significant at the .05 level. (The analysis of variance test of equation 1 is significant to $p = .032$). The estimated coefficient of the SC variable is statistically significant at the .10 level ($p = .0964$).

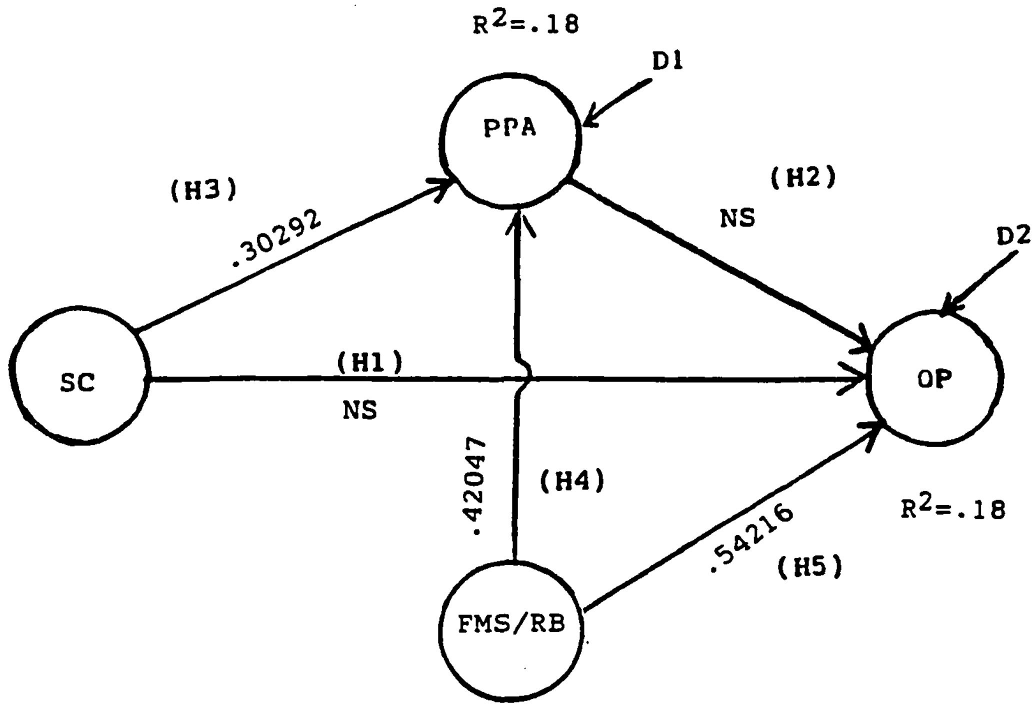


Figure 6. Operations Strategy Causal Model 1

Notes. SC: SBU-Manufacturing Strategic Consensus
OP: Operational Performance
PPA: Product Life Cycle/Process Alignment
FMS/RB: Flexible Manufacturing Systems/Robotics

The estimated coefficient of the FMS/RB variable is statistically significant at the .05 level (P = .0243). The adjusted coefficient of determination associated with equation 1 is .18. Thus, approximately 18% of the variation of the product-process alignment variable is explained by the two independent variables, strategic consensus and flexible manufacturing systems/robotics.

Equation 2 was determined by regressing OP (operational performance) on SC (strategic consensus), FMS/RB (flexible manufacturing systems/robotics), and PPA (product-process alignment). The F-test of equation 2 is significant at the .10 level (p = .0625). Only one coefficient of the regression equation's three variables is statistically significant. The coefficient of the FMS/RB variable is significant at the .05 level (p = .0108). Neither the SC variable nor the PPA variable is statistically significant. (Multicollinearity can be ruled out as a cause of this situation. Testing for potential multicollinearity among independent variables by regressing each variable of the model separately on all other variables collectively produced low R^2 values and thus indicated an absence of multicollinearity). The adjusted R^2 value of equation 2 is .16563, indicating that approximately 17% of the variation of operational performance is explained by the independent variables of equation 2. A deletion of the nonsignificant independent variables (SC and PPA) from this regression equation increased the adjusted R^2 value to .20902.

The resulting regression of OP on FMS/RB is statistically significant at the .01 level ($p = .0084$).

Evaluation of Hypotheses 1 - 5

Equation 1 and equation 2 are the structural equations of the originally proposed causal model of operations strategy (Model 1). These regression equations provided a means with which to test the hypothesized relationships defined in Chapter 3. The initial five hypotheses of Chapter 3 are individually examined below. Each hypothesis is presented as the alternative hypothesis of a pair of stated hypotheses. Rejection of the null hypothesis provides statistical justification for the acceptance of the alternative hypothesis.

Hypothesis number one is presented and evaluated:

$H1_0$ There is no direct positive relationship between SBU - Manufacturing Strategic Consensus (SC) and manufacturing Operational Performance (OP).

$H1_A$ There is a direct positive relationship between SBU - Manufacturing Strategic Consensus (SC) and manufacturing Operational Performance (OP).

The multiple regression of OP on SC, PPA and FMS/RB produced a statistically significant regression equation at the .10 level ($p = .0625$) one which contained a statistically nonsignificant coefficient on the SC variable ($p = .4529$). A simple regression of OP on SC also produced a nonsignificant coefficient on the SC variable (as well as a nonsignificant regression equation). Based on this evidence, the null hypothesis $H1_0$ cannot be rejected. Thus strategic consensus

(SC) has not been shown to be directly related to operational performance (OP).

Hypothesis number two is now stated and tested:

$H2_0$: There is no direct positive relationship between the degree of "correct" Product-Process Alignment (PPA) and manufacturing Operational performance (OP).

$H2_A$: There is a direct positive relationship between the degree of "correct" Product-Process Alignment (PPA) and manufacturing Operational Performance (OP).

The regression of OP on SC, PPA, and FMS/RB produced a statistically nonsignificant coefficient of the PPA variable ($p = .6278$) within a statistically significant regression equation at the .10 level ($p = .0625$). A simple regression of OP on PPA also produced a statistically nonsignificant PPA regression coefficient ($p = .4535$) and a statistically nonsignificant regression equation. Thus, the null hypothesis $H2_0$ cannot be rejected. It has not been established herein that there is a direct positive relationship between the degree of "correct" product-process alignment (PPA) and manufacturing operational performance (OP).

Hypothesis number three is presented and evaluated:

$H3_0$: There is not direct positive relationship between the level of SBU - Manufacturing Strategic Consensus (SC) and the degree of "correct" Product-Process Alignment (PPA).

$H3_A$: There is a direct positive relationship between the level of SBU - Manufacturing Strategic Consensus (SC) and the degree of "correct" Product-Process Alignment (PPA).

The regression of PPA on SC and FMS/RB produced a statistically significant regression equation at a .05 alpha level (p = .032), one containing a statistically significant coefficient of the SC variable at the .10 level (P = .0964). Based on this finding, the null hypothesis is rejected at an alpha level of .10. Therefore, it is concluded that there is a direct positive relationship between the level of SBU-Manufacturing strategic consensus (SC) and the degree of "correct" product-process alignment (PPA).

Hypothesis four is presented and tested:

$H4_0$: There is no inverse (negative) relationship between advanced systems use (FMS/RB) and the degree of "correct" Product-Process Alignment (PPA).

$H4_A$: There is an inverse (negative) relationship between advanced systems use (FMS/RB) and the degree of "correct" Product-Process Alignment (PPA).

In the process of attaining an acceptable level of reliability for the advanced systems use scale, the construct "advanced systems" was narrowed and redefined as flexible manufacturing systems and robotics (FMS/RB). The regression of PPA on both SC and FMS/RB produced a statistically significant multiple regression equation (p = .032) and a statistically significant FMS/RB variable coefficient (p = .0243), both significant at the .05 level. A simple regression of PPA on FMS/RB produced a highly significant regression equation and coefficient of FMS/RB variable (p = .0084). However, this significant regression coefficient was <u>positive</u> in sign, not <u>negative</u> in sign as proposed. While significant results were obtained, the results do not correspond to the hypothesized relationship. Thus, the null hypothesis $H4_0$ cannot be rejected. (It is important to note that hypotheses defined in terms of positive relationship between PPA and FMS/RB would have lead to a confirmation of such a relationship.)

Hypothesis five is presented and evaluated:

$H5_0$: There is no direct positive relationship between advanced systems use (FMS/RB) and manufacturing Operational Performance (OP).

$H5_A$: There is a direct positive relationship between advanced systems use (FMS/RB) and manufacturing Operational Performance (OP).

"Advanced systems use" is again defined as the use of flexible manufacturing systems and robotics. The regression of OP on SC, PPA, and FMS/RB produced a statistically significant regression equation ($\alpha = .10$; $p = .0625$) with a statistically significant FMS/RB coefficient ($\alpha = .05$; $p = .0108$). A simple regression of OP on FMS/RB produced a highly significant regression coefficient and related regression equation ($\alpha = .01$; $p = .0084$). $H5_0$ is therefore rejected. Based on evidence obtained from the sampled data, it is concluded that there exists a positive relationship between advanced systems use (FMS/RB) and manufacturing operational performance (OP).

Table 24

Causal Model 1 Structural Equations

EQ 1 (M1):	PPA = .30292 SC + .42047 FMS/RB
EQ 2 (M1):	OP = .14278 SC + .54216 FMS/RB - .09907 PPA

Table 25

Regression of PPA on SC and FMS/RB

Multiple Regression Through The Origin

Equation 1 (M1) Dependent Variable ZPPAR ZSCORE(PPAR)

Variable(s) Entered on Step Number

1	ZFMSRBR	ZSCORE(FMSRBR)
2	ZSCR	ZSCORE(SCR)

Multiple R	.49062
R Square	.24071
Adjusted R Square	.17996
Standard Error	.88863

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	2	6.25834	3.12917
Residual	25	19.74166	.78967

F = 3.96265 Signif F = .0320

Variables in the Equation

Variable	B	SE B	Beta	T	Sig T
ZFMSRBR	.42047	.17533	.42047	2.398	.0243
ZSCR	.30292	.17533	.30292	1.728	.0964

Table 26

Regression of OP on SC, FMS/RB, and PPA

Multiple Regression Through The Origin

Equation 2 (M1) Dependent Variable ZROPR ZSCORE(ROPR)

Variable(s) Entered on Step Number

1	ZFMSRBR	ZSCORE(FMSRBR)
2	ZSCR	ZSCORE(SCR)
3	ZPPAR	ZSCORE(PPAR)

Multiple R	.50827
R Square	.25834
Adjusted R Square	.16563
Standard Error	.89636

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	3	6.71672	2.23891
Residual	24	19.28328	.80347

F = 2.78655 Signif F = .0625

Variables in the Equation

Variable	B	SE B	Beta	T	Sig T
ZFMSRBR	.54216	.19614	.54216	2.764	.0108
ZSCR	.14278	.18711	.14278	.763	.4529
ZPPAR	-.09907	.20174	-.09907	-.491	.6278

Model Revision: Causal Model 2

Causal modeling is an iterative process, one incorporating an interaction between theory building and empirical theory testing. Asher (1983, p. 23) states the "decisions about model construction must involve an interplay of theory and data." The author also notes that when the predictions inherent in a model do not hold, the model is in need of some form of revision. The revision process can take the form of adding and/or dropping linkages. Model revision might also require the addition or deletion of variables to or from the model. The revised model is then statistically tested for adequacy.

Empirical testing of the originally proposed model of operations strategy (Model 1) and its associated hypotheses produced mixed results. The results derived from this empirical testing of the causal model, however, provided valuable data from which to revise and to "fine-tune" its structure. It is a goal of this research to go beyond the simple testing of the originally specified model, and to revise and improve the model, as necessary, in conformance with both operations strategy theory (Chapter 2) and the empirical evidence derived through this exploratory research. The mixed results found in the empirical testing of Model 1 indicated the possibility of some misspecification of the original causal model. The empirical results of Model 1 provide valuable information for deriving better specification of the relationships among the measured variables.

Empirical Results of Causal Model 2

In testing Model 1, strategic consensus (SC) was not found to be directly related to manufacturing operational performance (OP). It is possible, however, that the relationship between strategic consensus and operational performance is indirect. To assess this possibility, an additional variable (a second "consensus" variable) was incorporated into the causal model. This second consensus variable -- manufacturing task consensus (MTC) - was designed to measure the degree of consensus among product group teams on specific manufacturing tasks and goals. The MTC variable was measured as part of this research. A second revised research model (Model 2), a causal model incorporating the MTC variable, was created and tested. Model 2 is presented in Figure 7. Importantly, Model 2 is consistent with Model 1. The revised causal model includes all former linkages contained in Model 1 with the exception of the addition of an indirect linkage between strategic consensus (SC) and operational performance (OP) [through manufacturing task consensus (MTC)] and the necessary deletion of the direct linkages between strategic consensus (SC) and operational performance (OP) and between product-process alignment (PPA) and operational performance (OP). The omission of linkages occurred as a result of the previous hypothesis testing procedures.

Three structural equations are associated with this second causal model. These regression equations are presented in Table 27.

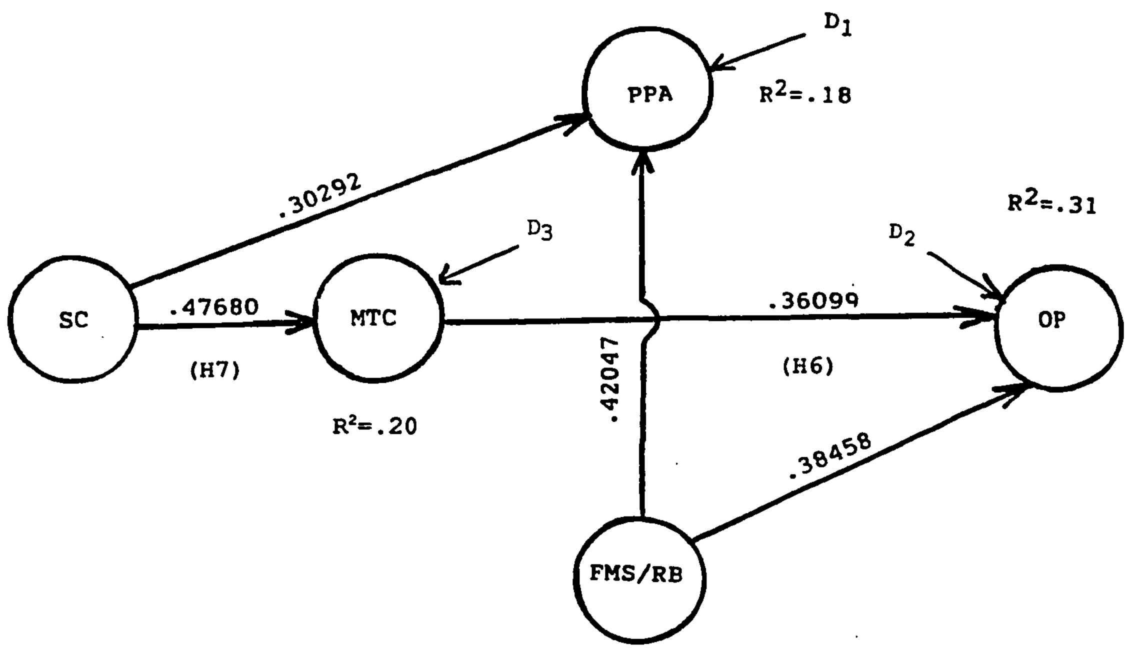


Figure 7. Operations Strategy Causal Model 2

Notes.

SC:	SBU-Manufacturing Strategic Consensus
MTC:	SBU-Manufacturing Task Consensus
OP:	Operational Performance
PPA:	Product Life Cycle/Process Alignment
FMS/RB:	Flexible Manufacturing Systems/Robotics

Equation 1 (M2) and equation 2 (M2) represent new relationships determined by the inclusion of the MTC variable into the initial causal model. Equation 3 (M2) is identical in specification to equation 2 of causal Model 1.

Two additional hypotheses are inherent in the structure of causal Model 2:

H6: There is a direct positive relationship between Manufacturing Task Consensus (MTC) and manufacturing Operational Performance (OP).

H7: There is a direct positive relationship between Strategic Consensus (SC) and Manufacturing Task Consensus (MTC).

Multiple regression estimates of the structural equations of Model 2 provided a means of testing these additional hypotheses.

Hypothesis six is presented and evaluated:

$H6_0$: There is no direct positive relationship between Manufacturing Task Consensus (MTC) and manufacturing Operational Performance (OP).

$H6_A$: There is a direct positive relationship between Manufacturing Task Consensus (MTC) and manufacturing Operational Performance (OP).

The multiple regression estimate of equation 2 (M2) was statistically significant at the .05 level ($p = .032$). Both the manufacturing task consensus (MTC) variable coefficient ($p = .0408$) and the manufacturing systems/robotics (FMS/RB) coefficient ($p = .0302$) were statistically significant at the .05 level. A subsequent simple regression of OP on MTC also produced a statistically significant MTC coefficient and a corresponding statistically significant regression equation (p = .0113). Thus, $H6_0$ is rejected and $H6_A$ is accepted. Based on this research, it is concluded that there is a direct positive relationship between manufacturing task consensus (MTC) and operational performance (OP).

Hypothesis 7, written in the form of an alternative hypothesis, is presented and tested:

$H7_0$: There is no direct positive relationship between Strategic Consensus (SC) and Manufacturing Task Consensus (MTC).

$H7_A$: There is a direct positive relationship between Strategic Consensus (SC) and Manufacturing Task Consensus (MTC).

The multiple regression estimate of equation 1 (M2) is statistically significant at the .05 level (p = .0103). As a simple regression equation, both the equation and the coefficient of its independent variable (MTC) are significant at this level. The adjusted coefficient of multiple determination (R^2) is .20. Thus, the empirical results of this analysis provide statistical evidence of a direct positive relationship between strategic consensus (SC) and manufacturing task consensus (MTC). Hypothesis $H7_0$ is rejected and hypothesis seven ($H7_A$) is accepted.

Table 27

Causal Model 2 Structural Equations

EQ 1 (M2) :	PPA	= .30292 SC + .42047 FMS/RB
EQ 2 (M2) :	OP	= .36099 MTC + .38458 FMS/RB
EQ 3 (M2) :	MTC	= .4768 SC

Table 28

Regression of PPA on SC and FMS/RB

Multiple Regression through the Origin

Equation (M1,M2)   Dependent Variable   ZPPAR ZSCORE(PPAR)

Variable(s) Entered on Step Number

1	ZFMSRBR	ZSCORE(FMSRBR)
2	ZSCR	ZSCORE(SCR)

Multiple R	.49062
R Square	.24071
Adjusted R Square	.17996
Standard Error	.88863

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	2	6.25834	3.12917
Residual	25	19.74166	.78967

F = 3.96265   Signif F = .0320

Variables in the Equation

Variable	B	SE B	Beta	T	Sig T
ZFMSRBR	.42047	.17533	.42047	2.398	.0243
ZSCR	.30292	.17533	.30292	1.728	.0964

Table 29

Regression of OP on MTC and FMS/RB

Multiple Regression through the Origin

Equation 2 (M2)   Dependent Variable   ZOPR   ZSCORE (OPR)

Variable(s) Entered on Step Number

1	ZFMSRBR	ZSCORE (FMSRBR)
2	ZMTCR	ZSCORE (MTCR)

Multiple R	.59825
R Square	.35790
Adjusted R Square	.30653
Standard Error	.81718

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	2	9.30534	4.65267
Residual	25	16.69466	.66779

F = 6.96730   Signif F = .0039

Variables in the Equation

Variable	B	SE B	Beta	T	Sig T
ZFMSRBR	.38458	.16730	.38458	2.299	.0302
ZMTCR	.36099	.16730	.36099	2.158	.0408

Table 30

Regression of MTC on SC

Multiple Regression through the Origin

Equation 3 (M2)   Dependent Variable   ZMTCR   ZSCORE(MTCR)

Variable(s) Entered on Step Number

1   ZSCR   ZSCORE (SCR)

Multiple R	.47680
R Square	.22734
Adjusted R Square	.19762
Standard Error	.87901

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	1	5.91082	5.91082
Residual	26	20.08918	.77266

F = 7.64995   Signif F = .0103

Variables in the Equation

Variable	B	SE B	Beta	T	Sig T
ZSCR	.47680	.17239	.47680	2.766	.0103

Decomposition of Correlations
And Development of Causal Model 3

Incorporation of the manufacturing task emphasis variable (MTC) into the initial research model produced significant improvement in its specification. The final test of correct specification of any path analytic causal model involves a decomposition of the correlations between all pairs of variables of the model. Asher (1983, p. 36) has commented on the decomposition procedure:

> The decomposition of the correlation is extremely important since it yields information about the causal processes... The decomposition also provides a way in which to test the adequacy of a model if some linkages have initially been omitted. If the model was specified correctly, then (except for measurement error and sampling error when relevant) the empirical correlation between any two variables should be numerically equal to the sum of the simple and compound paths linking the two variables. If the equality does not hold, this suggests that the model may be improperly specified and in need of revision.

An evaluation (decomposition of correlations) of Model 2 was performed according to Wright's rules. It is noted that while the empirical correlations between the pairs of variables of Model 2 were approximately equal to the respective sums of the simple and compound paths linking the variables in many cases, such was not the case for all pairs of the operations strategy variables. To account for such inconsistencies and to obtain approximate mathematical equality, an additional linkage, a causal connection from the strategic consensus (SC) variable to the flexible manufacturing systems/robotics (FMS/RB) variable, was required. The resulting model, causal Model 3, is equivalent to Model 2 with the addition of a causal link from the SC variable to the FMS/RB variable. Model 3 is presented in two forms, both without (3A) and with (3B) possible multiple reciprocal linkages. Model 3A is presented in Figure 8 and Model 3B is presented in Figure 9. Tables 31 and 32 contain data on the partitioning of total correlation between pairs of variables into direct and indirect effects (decomposition of correlation). Models 3A and 3B are consistent with all results derived from Model 2 and Model 1. Thus, a complete evolution from Model 1 to Model 3 has occurred correspondence with the empirical data derived through this research. Importantly, these two versions of the final causal model of operations strategy conform to both the theoretical prescriptions of operations strategy and the realities of the sampled real- world manufacturing data. As a result of this research, correct specification of a causal Model of Operations Strategy has been determined, a model whose structure is based in theory and in fact.

Empirical Results of Model 3

The structural equations for Model 3A are presented in Table 31. Equations 1 through 3 of this model are identical to the first three equations of Model 2. Equation 4 demonstrates the regression of FMS/RB on SC, MTC, and PPA. Equation 4 (M3A) is significant at the .05 level. All independent variables are significant at least the .10 level.

The SC variable is significant at the .05 level. P values for the independent variables SC, MTC, and PPA are .0366, .0676 and .0590, respectively.

The structural equations for Model 3B are presented in Table 32. Equations 1 through 4 of this model are identical to the first four equations of Model 3A. Equation 5 demonstrates a regression of MTC on SC and FMS/RB. Equation 5 (M3B) is significant at the .01 level. Each of the independent variables of the equation are significant at least .05 level. P values for the independent variables SC and FMS/RB variables are .0041 and .0454, respectively.

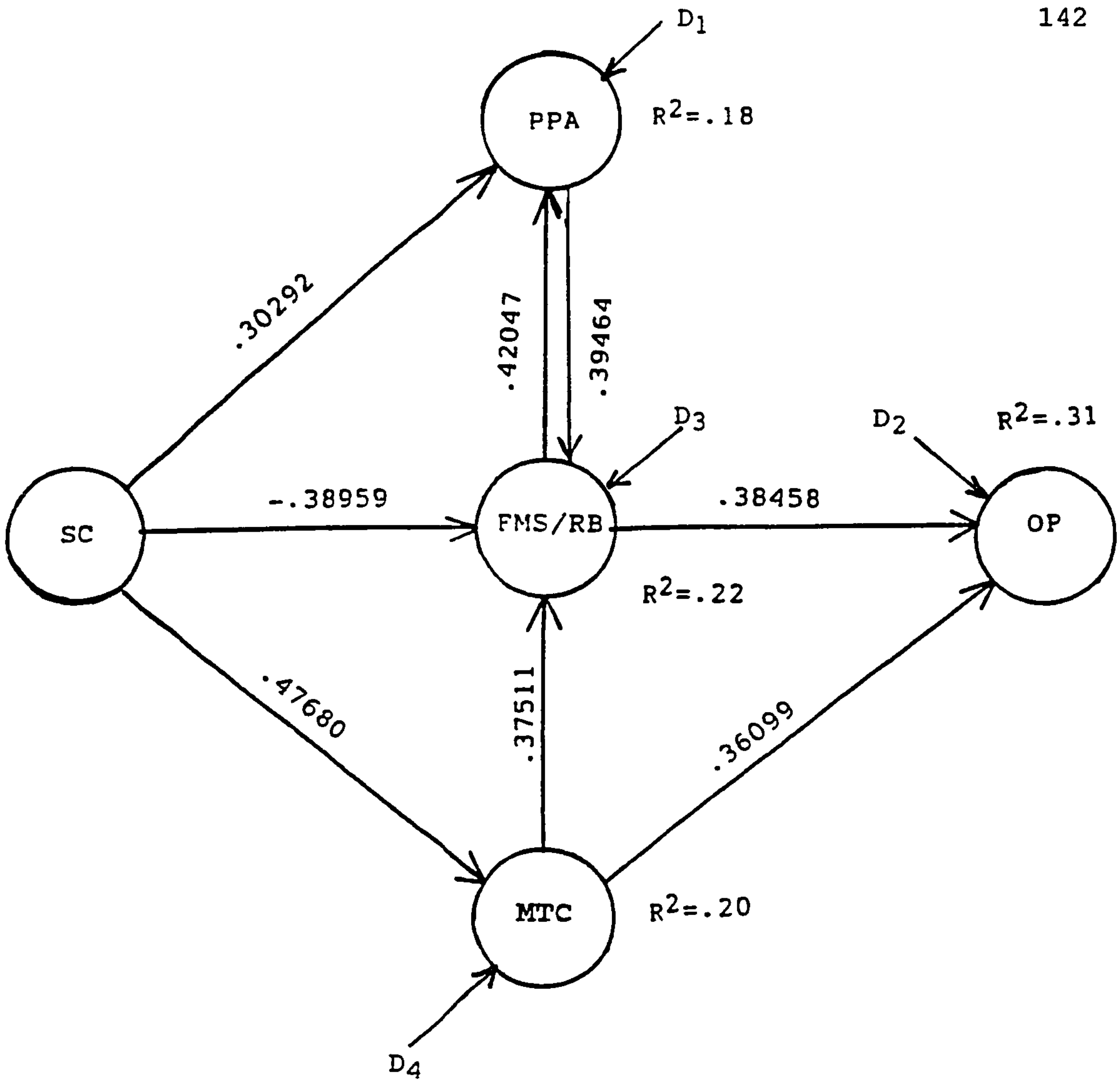


Figure 8. Operations Strategy Causal Model 3A

Notes.

	SC:	SBU-Manufacturing Strategic Consensus
	MTC:	SBU-Manufacturing Task Consensus
	OP:	Operational Performance
	PPA:	Product Life Cycle/Process Alignment
	FMS/RB:	Flexible Manufacturing Systems/Robotics

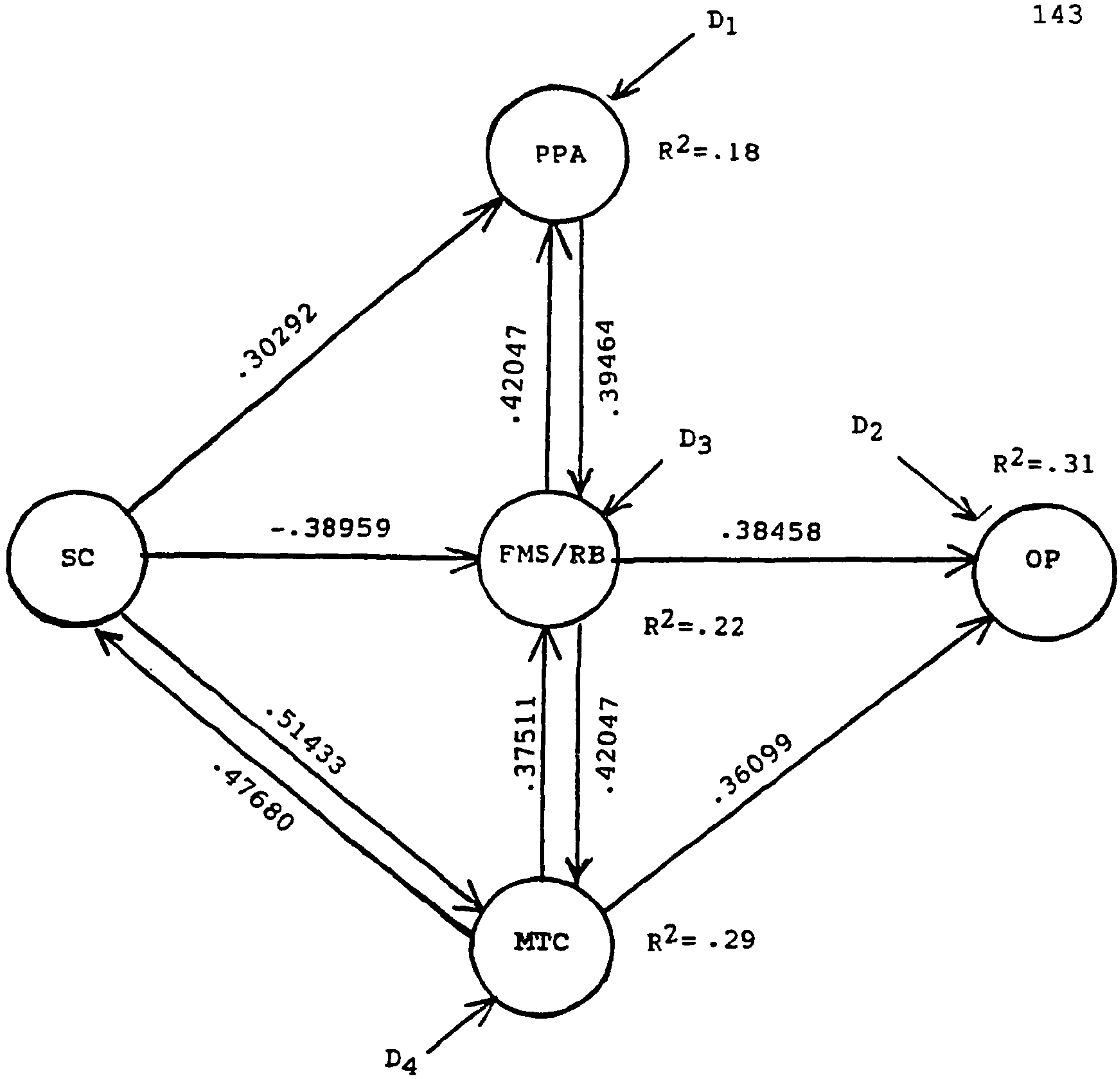


Figure 9. Operations Strategy Causal Model 3B

Notes.

SC:	SBU-Manufacturing Strategic Consensus
MTC:	SBU-Manufacturing Task Consensus
OP:	Operational Performance
PPA:	Product Life Cycle/Process Alignment
FMS/RB:	Flexible Manufacturing Systems/Robotics

Table 31

Causal Model 3A Structural Equations

EQ 1 (M3A)	:	PPA = .30292 SC + .42047 FMS/RB
EQ 2 (M3A)	:	OP = .36099 MTC + .38458 FMS/RB
EQ 3 (M3A)	:	MTC = .4768 SC
EQ 4 (M3A)	:	FMS/RB = -.38959 SC + .37511 MTC + .39464 PPA

Table 32

Causal Model 3B Structural Equations

EQ 1 (M3B)	:	PPA = .30292 SC + .42047 FMS/RB
EQ 2 (M3B)	:	OP = .36099 MTC + .38458 FMS/RB
EQ 3 (M3B)	:	SC = .4768 MTC
EQ 4 (M3B)	:	FMS/RB = -.38959 SC + .37511 MTC + .39464 PPA
EQ 5 (M3B)	:	MTC = .51433 SC + .42047 FMS/RB

Table 33

Regression of PPA on SC and FMS/RB

Multiple Regression through the Origin

Equation 1 (M2,M3A,M3B) Dependent Variable ZPPAR ZSCORE(PPAR)

Variable(s) Entered on Step Number

1	ZFMSRBR	ZSCORE(FMSRBR)
2	ZSCR	ZSCORE(SCR)

Multiple R	.49062
R Square	.24071
Adjusted R Square	.17996
Standard Error	.88863

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	2	6.25834	3.12917
Residual	25	19.74166	.78967

F = 3.96265 Signif F = .0320

Variables in the Equation

Variable	B	SE B	Beta	T	Sig T
ZFMSRBR	.42047	.17533	.42047	2.398	.0243
ZSCR	.30292	.17533	.30292	1.728	.0964

Table 34

Regression of OP on MTC and FMS/RB

Multiple Regression through the Origin

Equation 2 (M2,M3A,M3B) Dependent Variable ZOPR ZSCORE (OPR)

Variable(s) Entered on Step Number

1	ZFMSRBR	ZSCORE (FMSRBR)
2	ZMTCR	ZSCORE (MTCR)

Multiple R	.59825
R Square	.35790
Adjusted R Square	.30653
Standard Error	.81718

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	2	9.30534	4.65267
Residual	25	16.69466	.66779

F = 6.96730 Signif F = .0039

Variables in the Equation

Variable	B	SE B	Beta	T	Sig T
ZFMSRBR	.38458	.16730	.38458	2.299	.0302
ZMTCR	.36099	.16730	.36099	2.158	.0408

Table 35

Regression of MTC on SC

Multiple Regression through the Origin

Equation 3 (M2,3A,3B) Dependent Variable ZMTCR ZSCORE (MTCR)

Variable(s) Entered on Step Number

1 ZSCR ZSCORE (SCR)

Multiple R	.47680
R Square	.22734
Adjusted R Square	.19762
Standard Error	.87901

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	1	5.91082	5.91082
Residual	26	20.08918	.77266

F = 7.64995 Signif F = .0103

Variables in the Equation

Variable	B	SE B	Beta	T	Sig T
ZSCR	.47680	.17239	.47680	2.766	.0103

NOTE: Identical to the regression of SC on MTC.

Table 36

Regression of FMS/RB on SC, MTC, and PPA

Multiple Regression through the Origin

Equation 4 (M2,M3A, M3B) Dependent Variable ZFMSRBR (FMSRBR)

Variable(s) Entered on Step Number

1	ZPPAR	ZSCORE (PPAR)
2	ZMTCR	ZSCORE (MTCR)
3	ZSCR	ZSCORE (SCR)

Multiple R	.55056
R Square	.30311
Adjusted R Square	.21600
Standard Error	.86888

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	3	7.88098	2.62699
Residual	24	18.11902	.75496

F = 3.47965 Signif F = .0315

Variables in the Equation

Variable	B	SE B	Beta	T	Sig T
ZPPAR	.39464	.17826	.39464	2.214	.0366
ZMTCR	.37511	.19599	.37511	1.914	.0676
ZSCR	-.38959	.19649	-.38959	-1.983	.0590

Table 37

Regression of MTC on SC and FMS/RB

Multiple Regression through the Origin

Equation 5 (3B) Dependent Variable ZMTCR ZSCORE(MTCR)

Variable(s) Entered on Step Number

1	ZFMSRBR	ZSCORE(FMSRBR)
2	ZSCR	ZSCORE(SCR)

Multiple R	.58629
R Square	.34374
Adjusted R Square	.29124
Standard Error	.82614

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	2	8.93724	4.46862
Residual	25	17.06276	.68251

F = 6.54732 Signif F = .0052

Variables in the Equation

Variable	B	SE B	Beta	T	Sig T
ZFMSRBR	.42047	.16300	.34323	2.106	.0454
ZSCR	.51433	.16300	.51433	3.155	.0041

Table 38

Decomposition of Correlation of Variables (Model 3A)

Variables	Direct Effect	Indirect Effect	Total Effect	Correlation Coefficient
Effects on Performance				
SC-OP	0	.0910	.0910	.058
MTC-OP	.3609	.0728	.4338	.4714
PPA-OP	0	.1789	.1789	.1476
FMS/RB-OP	.3846	.0683	.4529	.4882
Other Strategic Relationships				
SC-MTC	.4768	0	.4768	.4768
SC-PPA	.3029	-.0886	.2143	.2570
SCC-FMS/RB	-.3896	.1789	-.2107	-.1093
MTC-PPA	0	.1789	.2240	.2474
MTC-FMS/RB	.37511	-.1858	.1894	.147
FMS/RB-PPA	.4205	-.1180	.3025	.3873

Table 39

Decomposition Of Correlation Of Variables (Model 3B)

Variables	Direct Effect	Indirect Effect	Total Effect	Correlation Coefficient
Effects on Performance				
SC-OP	0	.1370	.1370	.0580
MTC-OP	.3609	.0728	.4338	.4714
PPA-OP	0	.1888	.1888	.1476
FMS/RB-OP	.3846	.0683	.4529	.4882
Other Strategic Relationships				
SC-MTC	.4768	0	.4768	.4768
SC-PPA	.3029	-.0886	.2143	.2570
SCC-FMS/RB	-.3896	.2984	-.0912	-.1093
MTC-PPA	0	.2240	.2240	.2474
MTC-FMS/RB	.3751	-.1858	.1894	.1470
FMS/RB-PPA	.4205	-.0638	.3566	.3873

CHAPTER 5

Summary and Recommendations

Research Summary

The evolution to a final model of operations strategy (Model 3) via the causal modeling process and the data derived through this research, has provided important evidence concerning the validation of key precepts of operations strategy theory. The causal modeling process has enabled the analysis of these principles from both a confirmatory research perspective and an exploratory research perspective. This research has been undertaken to help fill the empirical vacuum present in the literature on operations strategy theory, a body of work currently dominated by hypothesis, speculation, opinion, and prescription. A fine-grained field research study, one which focused on the "product group" within the manufacturing organization as an appropriate unit of analysis, was undertaken for this purpose. In total, twenty-seven distinct business units drawn from major U.S.-owned corporations operating in the electronics industry, were included in this research. Using causal modeling, this research has produced empirical evidence for a clarification and verification of several important principles at the core of operations strategy theory. It is hoped that through this research study, new insight has been gained into the specific strategic dimensions and nature of the operations function for the attainment of manufacturing performance success.

Theoretical interpretation of the empirical results of this research, have been reported in Chapter 4. Consequent implications of these findings for the developing field of operations strategy are presented in this chapter.

Managerial Consensus and Performance

For many years, strategic management researchers have sought to relate the constructs of strategic consensus and organizational performance, organizational performance often having been defined as financial performance. Such studies include the work of Bourgeois (1980) and of Dess (1987). The exact nature of the linkage of strategic consensus to organizational performance for the manufacturing firm has not been specified in such "consensus" studies. The empirical results derived through the current research have provided important evidence toward the specification and clarification of the possible nature of this linkage. Specifically, managerial consensus on strategic direction among business unit (product group) managers has been found to have no direct positive influence on manufacturing performance. Rather, the effect of strategic consensus on operational performance has been discovered to be indirect. The results of this research demonstrate that strategic consensus, agreement on the strategic direction for a specific product among product group managers, serves as a stimulus for the occurrence of a more manufacturing-specific, task-oriented form of managerial consensus, i.e. consensus on manufacturing task emphasis. It is this form of consensus, consensus on manufacturing strategy, that is seen to be directly and positively related to operational performance. A significant direct positive relationship has been demonstrated between general strategic consensus and manufacturing task consensus for the business units (product groups) in the research sample. This finding is consistent with the prescriptive writings of Hayes and Wheelwright (1984), who have stressed the critical importance of manufacturing functional involvement in the strategic planning process. In this research, the business unit level strategic consensus measure was not directly related to the functional level measure of operational performance. Thus, based on this evidence, general strategic consensus within business units appears to be a necessary, although by no means a sufficient, condition for increased levels of manufacturing performance. The strategic consensus - operational performance relationship is effected in part through an important intermediate variable -- managerial consensus on the manufacturing function's task requirements for the focal product. This empirical result reinforces the central assumption and belief of operations management scholars of the critical importance of a well understood, coordinated manufacturing strategy in support of the business unit's marketing strategy for gaining competitive advantage within an industry.

Product-Process Alignment, Advanced Systems Use and Operational Performance

The empirical results of this research indicate that general strategic consensus has a direct positive effect on product-process alignment. Manufacturing task consensus, however, has been found to be unrelated to product-process alignment. The data from this research study indicate that the alignment or matching of product life cycle stage and manufacturing process type is an early strategic decision, one ideally set at the time of agreement among product group managers on the general strategic direction and competitive methods to be employed for the focal product.

The use of advanced systems, specifically the use of flexible manufacturing systems and robotics, a manufacturing functional level decision, was found to be statistically related to product-process alignment in the research sample. Much has been written in the operations management literature on the use of flexible manufacturing systems to enable a manufacturing unit to potentially operate off the diagonal of the Hayes and Wheelwright (1979a, b) product-process matrix for strategic advantage. For this reason, product-process alignment was hypothesized in this research to be negatively related to the use of such advanced systems. This hypothesis was presented as an exploratory research premise. An important finding of this research is that while product-process alignment and the use of flexible manufacturing systems and robotics were found to directly related, this association represented a positive rather than a negative relationship. The use of flexible manufacturing systems and robotics by the sampled business units (product groups) was found to be positively related to "correct", on-diagonal product-process matrix placement. Thus, models 3A and 3B illustrate the probable use of flexible manufacturing systems and robotics as a cause (together with general strategic consensus) of "correct" product-process alignment. (Subsequent regression analyses have shown that the direct relationship between product-process alignment and the use of flexible manufacturing systems may in fact be a reciprocal one.)

Importantly, no relationship could be found in this empirical research between product process alignment and operational performance. This result is consistent with the finding of Wharton (1987), who in an empirical test of the relationship of product-process alignment and financial performance, could find no relationship between these variables. The concept of a direct positive association of product-process alignment and performance (Hayes and Wheelwright, 1979a, b), while an intuitively appealing one, could not be substantiated by the research data of this dissertation study. The relationship of product-process alignment and operational performance appears to be much more complex. Models 3A and 3B demonstrate an indirect relationship between these variables, one that operates through the use of advanced systems. This study provides evidence that product-process alignment is directly related to the use of flexible manufacturing systems and robotics, which in turn is directly related to operational performance.

Finally, the use of flexible manufacturing systems and robotics has been found to be directly related to manufacturing operational performance for the strategic business units of the research sample. This result is a key finding of this research. Two critical variables - the Use of Flexible Manufacturing Systems and Robotics (FMS/RB) and Consensus on Manufacturing Task Emphasis (MTC) - accounted for over 30% of the variance in operation performance of the business units sampled in this research. The critical importance of these two powerful influences on operational performance for the manufacturing firm cannot be over emphasized.

Managerial Implications

This dissertation has sought to empirically test important precepts inherent in operations strategy theory. A causal model of operations strategy, one incorporating these principles, was defined, empirically tested, and subsequently redefined in accordance with operations strategy theory, path analytic techniques, and data gathered from strategic business units operating in the electronics industry. The research also has demonstrated the validation and application of various measurement scales for immediate empirical testing of many of the theoretical precepts of operations strategy.

This research has been undertaken to substantiate basic tenets of operations strategy theory. The current study provides hard statistical evidence for reaching several important general conclusions about these principles. Based on the empirical evidence derived through this research, the following conclusions for managerial decision making have been drawn:

1. Managerial consensus on general strategic direction for a manufactured product is a necessary but not sufficient condition for the attainment of high levels of operational performance within business units. Rather, a more manufacturing-detailed form of consensus is required. Strategic consensus operates through manufacturing task consensus to effect operational performance. Manufacturing task consensus, in turn, is directly related to operational performance. The importance of such an operationally - specific sense of strategic direction for the manufacturing firm cannot be over emphasized.

2. Managerial consensus within strategic business units (product groups) on general strategic direction for a manufactured product is directly related to the establishment of product life cycle - production process alignment. The coupling of production process capabilities with product and market

characteristics is a temporally early strategic task, one dependent upon a close understanding of the general strategic direction for the focal product among strategic (business and marketing) planners and operations managers. This fact is highly consistent with the Hayes and Wheelwright (1984) prescription for an early and an extensive degree of manufacturing management involvement in the strategic planning process.

3. The use of such advanced technologies as flexible manufacturing systems and robotics is directly related to the attainment of high levels of operational performance. Such systems enhance manufacturing capability through lower cost production and improved response capability to changes in product market requirements. Advanced systems use can significantly augment and enhance manufacturing competitive performance.

As a means of testing the precepts of operations strategy, this research has brought progress in measurement scale development. A frequently stated reason for the lack of empirical work in the area of operations strategy theory is the problem of the unavailability of measurement instruments necessary to adequately operationalize and measure key operations strategy constructs. While work on measurement scale development and refinement in this field must proceed, the current study has demonstrated that measurement instruments do exist or rather quickly can be constructed to begin immediate empirical testing and validation of the precepts of operations strategy. It is recommended that future operations strategy researchers always explore the empirical measures found in the strategic management literature for supplemental methods of empirical research. The Dess and Davis (1984) measurement scale, employed as a measure of strategic consensus among product group teams in the current study, has been further validated as an appropriate measure of Porter's (1980, 1985) generic strategies through this research. Additionally, a similar manufacturing task emphasis consensus scale, one incorporating manufacturing task dimensions analyzed by Heute and Roth (1987) and recommended by Wheelwright (1978), has been validated herein as a reliable measure of managerial consensus on manufacturing strategy.

Finally, in addition to the empirical test results of operations strategy concepts, this dissertation has included an extensive compilation and review of the literature on operations strategy theory. Importantly, this review has incorporated relevant operations strategy literature from both the field of strategic management and the field of operations management.

Recommendations for Further Research

Models 3A and 3B, causal models of operations strategy, were created after a thorough review of the major precepts of operations strategy and after a subsequent empirical testing of these principles. These versions of the resultant model of operations strategy provide the framework for future empirical testing and validation of operations strategy principles, research which can be undertaken in the electronics industry and importantly in other industries. In this way, the generalizability of the causal model can be tested and further refinement of its structure can be specified, if and when necessary. The objective of such subsequent empirical research would be further clarification, legitimization, and validation of operations strategy theory -- quantitative verification of its central principles and precise specification of the general interrelationships of its theoretical constructs. Ideally, the end result of this research stream would be a universal "scientific model" of the strategic role of the operations function in effecting world-class manufacturing performance and consequent global competitive advantage for a strategic business unit within its industry. While the literature on operations strategy is rich in theoretical prescription and intuition, especially in its assignment of an important role to the operations function in effecting business unit success, precise modeling and quantification of the exact nature of this process is long overdue. It is my hope that this dissertation research will serve as a stimulus toward this eventual end.

Further work in measurement scale development will assist in this endeavor. In particular, further developmental effort should be applied to the creation of an extensive and detailed advanced systems use scale, one that delineates all common and distinct characteristics of such commonly employed systems a OPT, MRP, JIT, and FMS. An important area for future research, the construction and validation of a highly detailed advanced systems use scale would provide a sophisticated means by which to assist the operations strategy researcher in an assessment of the precise nature of influence of specific dimensions of advanced systems and technologies on manufacturing performance.

Finally, the relationship of operational performance to financial performance (business unit return on investment) needs exploration, definition, and empirical assessment. Such specification would create a further expanded causal model of operations strategy, one incorporating both operational and financial measures of performance, i.e. a model of business unit performance that delineates the association of these two performance variables with one another and the association of each of these variables with other relevant strategic variables. This final recommendation is consistent with that of Kaplan (1983), who has advised that both operational and financial measures of business unit performance be employed in assessing the effectiveness of manufacturing organizations.

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