Core manufacturing capabilities and their links to product differentiation

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Introduction

Academics have asserted for a long time that business and manufacturing strategies should be "linked" (Corbett and Van Wassenhove, 1993; Garvin, 1993; Hill, 1983; Schendel and Hofer, 1979; Skinner, 1969; Wheelwright, 1984). Researchers have empirically verified positive effects on performance resulting from consistency in operations and marketing strategies (Swamidass and Newell, 1987; Deane *et al*., 1991). However, substantive relationships between dimensions of manufacturing strategy and marketing strategy have not been clearly established. According to Skinner (1996, p. 12), this lack of linkage continues to be "the first and most serious problem, and … the main weakness in MCS" (MCS stands for manufacturing in the corporate strategy).

We suggest that the lack of linkage in strategic models is due in large part to the ambiguity surrounding the essence of manufacturing strategy. The elements of manufacturing strategy have been characterized in many different ways, including manufacturing tasks, competitive priorities, order winners and qualifiers, and components of production competence, to name a few. These concepts have forwarded the cause of manufacturing in important ways. At the same time, they are ill-defined and subject to limitations (to be discussed later).

Recently, researchers have argued that "capabilities" form the primary basis for competition between firms. It has been said that in the current business environment, the essence of strategy is to develop "...hard-to-imitate organizational capabilities that distinguish a company from its competitors in the eyes of its customers" (Stalk *et al*., 1992). Core capabilities contained within a firm's manufacturing processes enable it to differentiate its products from competitors' products.

Like other elements of manufacturing strategy, core capabilities have not been well-defined. Hayes and Pisano (1996) suggest that capabilities are activities that a firm can do better than its competitors. Further, a capability is not something a firm can buy. Capabilities are organizationally specific; they must be developed internally. The fact that they are difficult to imitate or transfer is what makes them valuable. Thus, capabilities derive less from specific technologies or manufacturing facilities and more from manufacturing infrastructure: people, management and information systems, learning, and organizational focus.

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Core manufacturing capabilities are distinct from the notion of manufacturing competence, as defined by Vickery *et al.* (1993, 1994). From the prior discussion, we can see that manufacturing capability refers to a fundamental proficiency in manufacturing, whereas Vickery *et al.* describe manufacturing competence as the degree to which manufacturing performance supports the strategic objectives of the firm. Manufacturing competence therefore provides a measure, albeit an indirect one, of the extent of alignment between manufacturing capabilities and the competitive needs of the firm.

In this article we clarify some of the concepts in manufacturing strategy by identifying core manufacturing capabilities and primary dimensions of product differentiation. We do this by modifying and extending existing models of SBU strategy and manufacturing strategy. Our objectives are to more precisely delineate dimensions of product differentiation and to describe a new, generic set of core manufacturing capabilities. As a second contribution of the research, we seek to remedy part of the "lack of linkage" problem by proposing which manufacturing capabilities are most important for each dimension of product differentiation. Evidence from related survey and case study research provides the logic and basis for the propositions. In essence, the propositions suggest those capabilities expected to produce a high degree of manufacturing competence (in the sense of the term used by Vickery *et al.*, 1993, 1994) for different competitive environments. It is our hope that the propositions stimulate testable hypotheses in future research. We conclude the article with suggestions toward this end.

Strategy planning and content models

Extensive research has specified typical strategic business unit (SBU) approaches to competition, known as "generic strategies." Many researchers have identified generic types using theoretical or empirical bases (Buzzell *et al.*, 1975; Galbraith and Schendel, 1983; Hofer and Schendel, 1978; Miles and Snow, 1978; Mintzberg, 1988; Porter, 1980; Utterback and Abernathy, 1975). Others have tested the descriptive powers of types in different environmental and corporate contexts (Dess and Davis, 1984; Hambrick, 1983a, 1983b; Hrebiniak and Joyce, 1985; Kotha and Vadlamani, 1995; White, 1986; Miller, 1987, 1988).

Porter (1980) developed a well-known model consisting of two generic strategies, "cost leadership" and "differentiation." These strategies can target an entire industry (i.e. a "breadth" strategy) or a market segment (i.e. a "focus" strategy). Although many other business strategy typologies have been developed, Porter's model has arguably had the greatest influence on manufacturing strategy models. Product differentiation concepts provide implications for supportive operational characteristics since they directly address core dimensions of competition. Other business strategy typologies focus more on environment or process variables. Dimensions of product differentiation are typically aggregated or are only implicit in these models (e.g. "harvest" or "build" strategies of Miles and Snow, 1978).

The development of manufacturing strategy has been meager in comparison to SBU strategy research. Extant models include manufacturing strategy planning frameworks and high-level content models which associate manufacturing structural characteristics to SBU strategies. These models contain some inherent limitations.

Limitations of manufacturing strategy models

Manufacturing strategic planning frameworks identify key manufacturing decision areas and stress the need for consistency among decisions affecting SBU strategy, competitive priorities, and manufacturing structure and infrastructure. The top portion of Figure 1 provides a highly summarized schematic of frameworks advanced by Skinner (1969), Fine and Hax (1985), Schroeder *et al.* (1986), Wheelwright (1978), and Hill (1983). These frameworks provide a powerful message, elevating manufacturing decisions to the realm of strategy and highlighting the potential of manufacturing as a competitive weapon. However, these models are also subject to two primary limitations: they lack specificity, and they do not directly address manufacturing capabilities.

Decision-making in manufacturing strategy planning frameworks typically centers around "competitive priorities" (Skinner, 1969; Wheelwright, 1978), including cost, quality, dependability, flexibility, and service. These priorities have frequently been used to characterize the content of manufacturing strategy (Fine and Hax, 1985; Schroeder *et al.*, 1986; Swamidass and Newell,

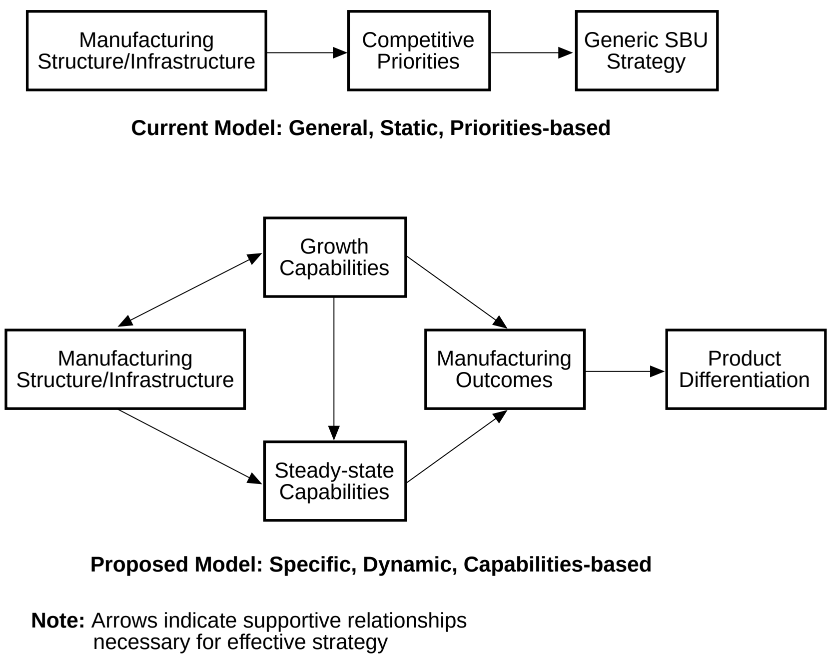

Figure 1.
Current and proposed manufacturing strategy linkage models

1987). A problem with competitive priorities is that they are too conceptually aggregated to clearly direct the proper uses of manufacturing resources. Each of the priorities is multi-faceted and complex, making its interpretation very much dependent on the biases of the researcher, strategy-maker, etc. Many different meanings and interpretations can be (and have been) attached to each term. Witness, for example, the numerous aspects of flexibility discussed by researchers (Gerwin, 1993; Upton, 1994). Precise, disaggregated versions of competitive priorities are needed to direct manufacturing planning and decision-making.

Recognizing this need, researchers have identified finer distinctions of competitive priorities (Garvin, 1993; Skinner, 1992). A complicating factor, however, lies in the perspective one employs when defining competitive priorities. An internal, manufacturing-based perspective might consider priorities in terms of cost, product conformance, and through-put lead time. An external, customer-based perspective might define priorities in terms of price, product performance, and delivery speed. While these two sets of priorities are related, there are frequently distinct differences between manufacturing outcomes and the product attributes which differentiate a product in the marketplace. For example, product pricing is almost certainly influenced by manufacturing costs, but other issues such as promotion and competition may exert even greater influences. Delivery speed may depend largely on manufacturing through-put time. Then again, delivery speed may be quite independent of through-put time, as is the case where large finished goods inventories are held. Since most manufacturing operations are functionally buffered from customers, it is important to distinguish priories related to manufacturing outcomes from priorities related to product differentiation. Making these distinctions enables manufacturing to more clearly define its strategic role in differentiating products.

Another important limitation of current conceptualizations of competitive priorities is that they do not discriminate between manufacturing capabilities and manufacturing outcomes (Corbett and Van Wassenhove, 1993). The ubiquitous list of manufacturing priorities: cost, quality, dependability, and flexibility, contains both attributes. Cost is a manufacturing outcome; flexibility is a manufacturing capability. The former construct refers to an end; the latter construct refers to a means to an end. Recent studies continue to mix means with ends (Vickery *et al.*, 1994; White, 1996). An external, customer-oriented perspective suggests the need to make clear distinctions between customer desires, manufacturing outcomes, and manufacturing capabilities. As Penrose (1959) and McGrath *et al.* (1996) point out, customers do not desire or purchase a firm's capabilities, *per se* (e.g. flexibility). Customers desire and purchase product and service attributes (e.g. delivery speed) a firm creates by deploying its capabilities.

Models of manufacturing structure and infrastructure are subject to the same limitations as competitive priority models. A number of manufacturing strategy models relate process forms (e.g. job shop, batch shop, assembly line) or technologies (e.g. FMS, transfer lines) to product and market characteristics (e.g. product life cycle stages) or to generic strategies (see Kim and Lee, 1993, for a review of this research). For example, a high-level model developed by Kotha and Orne (1989) relates process complexity, product complexity, and organizational scope to cost leadership, differentiation, and market scope strategies. The constructs employed in these models are too aggregated to identify salient relationships between manufacturing decisions and dimensions of competition. As a case in point, Kotha and Orne (1989) essentially adopt "differentiation" as a generic manufacturing strategy *per se*, when in fact numerous dimensions of product differentiation exist (Mintzberg, 1988), each requiring its own, potentially unique, set of supportive manufacturing structures.

Manufacturing structure/infrastructure models also do not explicitly address relationships between manufacturing forms and manufacturing capabilities. For example, Kim and Lee (1993) specify desirable "fits" between production system types and Porter's generic strategies. However, their model does not clearly identify manufacturing capabilities which are related to the production system types, nor do they explain how these capabilities support the competitive needs of the various strategies. Manufacturing structure/ infrastructure models need to explicitly relate core manufacturing capabilities to competitive priorities and to manufacturing structural forms.

The need to identify core manufacturing capabilities

Numerous researchers have lamented the ambiguity in manufacturing strategy constructs (Gerwin, 1993; Skinner, 1992; Swink and Way, 1995). The foregoing discussion suggests that a more specific and distinct terminology is required to resolve these ambiguities. Explicitly defining manufacturing capabilities will provide a step in this direction. In addition, a clear understanding of capabilities should improve the implementation of manufacturing strategy models. We see three key roles that manufacturing capabilities play in the formulation of strategy.

(1) Identifying important capabilities clarifies differences between manufacturing outcomes and manufacturing means. Discussing capabilities completes strategy formulation by leading from addressing what is needed to addressing how it is delivered.

(2) An understanding of needed capabilities clarifies the manufacturing objectives that undergird strategic manufacturing initiatives. A vision of needed capabilities provides a dynamic basis for improvement which goes beyond simple strategic alignment and beyond static improvement goals. Extant manufacturing strategy planning frameworks do not address capabilities directly. They are therefore static in nature, offering little incentive for manufacturing improvement once immediate manufacturing goals have been reached. A clear view of needed manufacturing capabilities is important for maintaining strategic directions over time (Garvin, 1993; Hayes and Pisano, 1994).

(3) Understanding manufacturing capabilities provides deeper insights for translating manufacturing policies and hardware into product attributes that produce competitive advantages. Strategic manufacturing initiatives should seek to gain leverage from existing manufacturing capabilities or to develop needed capabilities that are currently lacking.

The framework pictured in the lower portion of Figure 1 illustrates links among manufacturing structure/infrastructure, manufacturing capabilities, manufacturing outcomes, and product differentiation attributes. The model is specific in that it delineates the relationships between disparate constructs that were formally subsumed by "competitive priorities." Further, manufacturing outcomes are linked to specific dimensions of product differentiation in lieu of broad, generic strategies. The model is dynamic in that manufacturing capabilities are explicitly addressed. Growth capabilities enable a manufacturing operation to change over time. Steady state capabilities represent the proficiencies of a manufacturing operation at a given point in time. The model indicates that capabilities stem from decisions affecting the manufacturing structure and infrastructure.

Specifying dimensions of product differentiation, manufacturing outcomes, and manufacturing capability

We now turn to the task of specifying the capabilities-based model in more detail. Foregoing research provides the raw material for a model of linkages between product differentiation, manufacturing outcomes, and manufacturing capabilities. Mintzberg (1988) and others (Porter, 1980; Hambrick, 1983b; Miller, 1986) have identified specific dimensions of product differentiation. Other works specify disaggregated dimensions of manufacturing competitive priorities (Chase *et al*., 1992; Garvin, 1993; Gerwin, 1993; Miller and Roth, 1994; Skinner, 1992; Vickery *et al*., 1993). We built our linkage model by refining this inventory of theoretical constructs. The refining process included three stages. First, we distinguished constructs describing outcomes from those describing capabilities. Second, we grouped related manufacturing capability constructs and attempted to identify a core manufacturing capability construct for each group. Definitions for the constructs are provided in Tables I-III. Third, we formulated propositions which describe supportive linkages between dimensions of product differentiation, manufacturing outcomes, and manufacturing capabilities.

Bases for product differentiation

The bases for product differentiation provided in Table I have been discussed in other works, most notably, by Mintzberg (1988). He defined the bases for differentiation using a customer's perspective. For example, Mintzberg argued that competition on the basis of cost leadership (a generic strategy proposed by Porter, 1980) is really price differentiation, since it is a low price offering that is of value to the customer. Mintzberg also distinguished three dimensions of

Differentiation	Definition
Purchase price	The expenditure of resources required of the customer to acquire the product, including costs of return or replacement
Performance/uniqueness	Product attributes which exceed comparable attributes in competitors' products or are unique in terms of greater reliability, greater durability, and/or superior performance. These include relative measures of the product's fitness for customer use
Product image	Perceived differences for products which in fact do not differ in dimensions of performance. Image, a measure of the impact of a product or company name, reputation, advertising, etc. on the customer's evaluation of the product
Product information	Instruction or data which accompany the sale, delivery, or use of the product and which augment the customer's value satisfaction
Delivery speed	The expenditure of time required of the customer to acquire the product or to receive replacement of defective product or replenishment of stocks
Delivery reliability	The customer's level of confidence that delivery will occur on an agreed date

Note: [a] There are certainly other possible bases of product differentiation. This list is limited to only those dimensions which are potentially influenced by manufacturing

Table I.
Bases for product differentiation [a]

Manufacturing outcome	Definition
Development cost	The cost to the manufacturer to design, test and develop production processes for a new product
Production/transfer cost	The cost to the manufacturer to make and deliver the product, including the cost to return or replace the item if necessary
Superior manufacturing technology	Levels of operating characteristics by manufacturing processes which are unique or superior to competitors' manufacturing processes
Order status information	The availability and accuracy of data regarding manufacturing performance or process parameters
Manufacturing process information	The availability and accuracy of data regarding manufacturing performance or process parameters
Order processing time	The time required for the customer and the supplier to communicate and agree on the order specifications and to place the order (i.e. ease of ordering)
Development time	The time required to create, design and introduce a new product into manufacturing, including the time to develop and ramp-up needed manufacturing processes
Production/transfer time	The time required to produce and transfer the complete contents of the customer's order, including the time to return or replace defective products (i.e. the availability of the product as a function of time)
Lean time variance	The variance between the scheduled delivery date and the actual, agreed on, date

Table II.
Manufacturing outcomes

Capability	Definition
Improvement	*The ability to incrementally increase manufacturing performance using exisitng resources*
Motivation	The ability to impel human resource to higher levels of effort and effectiveness
Learning	The ability to increase and apply process understanding
Waste reduction	The ability to identify and remove non-value-adding activities
Innovation	*The ability to create and implement unique manufacturing processes that radically improve manufacturing performance*
Scanning	The ability to identify problems, process needs, or useful technological developments inside and outside the manufacturing organization
Creativity	The ability to generate and evaluate new ideas which meet organizational objectives
Ingenuity	The ability to apply new technologies or methods to solve problems
Integration	*The ability to incorporate new products or processes into the operation*
Product intro. flexibility	The ability to introduce and manufacture new products quickly
Process ramp-up flexibility	The ability to quickly learn new skills and adopt new processes
Modification flexibility	The ability to easily adjust processes to incorporate product design changes or special needs
Aggregate change flexibility	The ability to adjust smoothly to changes in product mix over the long term
Acuity	*The ability to understand customers' needs and to acquire, develop and convey valuable information and insights regarding products or processes*
Consulting	The ability to assist both internal groups and customers in problem solving (e.g. in new product development, design for manufacturability, quality improvement, etc.)
Information sharing	The ability to furnish critical data on product performance, process parameters, and cost to internal groups and to external customers
Showcasing	The ability to enhance sales and marketing by exhibiting technology, equipment, or production systems in a way that conveys the value or quality of manufacturing capabilities
Control	*The ability to direct and regulate operating processes*
Process understanding	The ability to understand manufacturing process capability limits and sources of variation
Feedback	The ability to monitor process outputs and to compare them with desired outputs
Adjustment	The ability to determine the causes of adverse effects and remedy undesired variations in manufacturing outcomes
Agility:	*The ability to easily move from one manufacturing state to another*
Volume flexibility	The ability of efficiently produce wide ranges in the demanded volumes of products
Mix flexibility	The ability to manufacture a variety of products, over a short time span, without modifying facilities

(*Continued*)

Table III.
Core manufacturing capabilities

Table III.

Capability	Definition
Responsiveness	*The ability to react to changes in inputs or output requirements in a timely manner*
Material flexibility	The ability to accomodate raw material substitutions or variations
Rerouting flexibility	The ability to change product sequencing/loading in response to machine/equipment problems
Sequencing flexibility	The ability to rearrange the order in whcih parts are fed into the manufacturing process, because of changes in parts and raw material deliveries or changes in customer delivery requirements
Shipment flexibility	The ability to expedite or reroute shipments to accommodate special circumstances without loss of time

product quality-based differentiation: performance, uniqueness, and image. Product conformance is conspicuously absent from the list. While a customer's expectations of product conformance may clearly be related to his choice, conformance itself is rarely a basis for differentiation. Using Hill's terminology (1983), conformance is almost always an order-qualifier; rarely an order-winner. We include conformance as a manufacturing outcome that forms a prerequisite for product performance, uniqueness, and image.

We derived the dimensions of product delivery and support shown in Table I from more aggregated concepts discussed by business strategy researchers (Miller, 1986; Mintzberg, 1988). Business strategy research has rarely made distinctions between types of product support that are information-oriented and those that are tangible, dealing with product delivery. However, these distinctions are necessary in order to establish clear linkages with related manufacturing outcomes.

Non-manufacturing functions in the firm may have the largest share of responsibility for certain bases of differentiation. For example, marketing frequently has more impact on product image than manufacturing. For the sake of comprehensiveness, however, we adopt a large view of the realm of manufacturing and include any bases of differentiation for which manufacturing might play a role.

Manufacturing product outcomes

Manufacturing product outcomes are product attributes that reflect the cost, quality, and timing of production as well as the additional service provided by the operation (Chase *et al*., 1992; Corbett and Van Wassenhove, 1993). These dimensions of manufacturing performance are corollaries to the familiar marketing dimensions of price, product, place, and promotion. As such, manufacturing outcomes serve as conceptual lynch pins connecting manufacturing capabilities to bases for product differentiation.

The manufacturing outcomes defined in Table II are commonly found in manufacturing research. One of the outcomes which bears additional explanation is superior manufacturing technology. This construct refers not only to the characteristics of the technology itself, but rather to the levels of operating performance resulting from superior uses of technology. An example of superior uses of manufacturing technology is provided by R&R Engineering, a small manufacturer of bent bolts and custom wire forms. This firm has perfected its use of various planetary thread rolling machines to make products at faster rates and with higher conformance quality than any of its competitors, who continue to use circular die rollers and flat die rollers. The complexity of the planetary threaders makes it very difficult to calibrate and adjust the machines for peak performance. Realizing this, the firm's managers invested a great deal of time and effort into experimenting with the equipment and understanding its capabilities. Competitors have also purchased planetary threaders, but have been unable to use them as effectively. Because R&R managers have a unique understanding of the equipment's capabilities and have successfully integrated them into their operations, they have distinct quality advantages and can deliver products in half the time required by competitors.

Manufacturing capabilities

While manufacturing capabilities span a wide range of attributes, we propose that seven core capabilities address steady state and growth aspects of manufacturing performance. Steady state capabilities can be measured at any given point in time and are indicated by superior manufacturing outcomes. Growth capabilities are indicated by changes in manufacturing outcomes over time or by the development of new steady state capabilities. The components of each of these multi-dimensional capabilities are described in Table III.

The framework suggests that growth in manufacturing effectiveness stems from three core capabilities for change: improvement, innovation, and integration. Improvement relates to the ability to steadily increase the efficiency and productivity of existing manufacturing resources over time. The NUMMI plant, established as a joint venture between General Motors and Toyota, provides an example of superlative improvement capabilities. Adler (1993) documents the steady performance improvement which resulted at the plant as a result of increased worker motivation, learning and problem solving, waste reduction, and work standardization.

Innovation refers to the ability to radically improve manufacturing performance through the creation and implementation of new resources, methods, or technologies (Schroeder *et al*., 1989). Innovation stems from awareness of technological developments, plus the abilities to adapt and apply technology in ways that meet needs or create opportunities. Innovation capabilities are vividly illustrated in the early development of flexible manufacturing systems by Hitachi Seiki (Hayes, 1990). The company cultivated the intellectual assets and organizational skills it needed to successfully apply a burgeoning micro-processor technology to machine tool systems. Technical and R&D expertise were important to the success of these developments. However, equally crucial were the contributions of manufacturing experts who understood the myriad production issues that needed to be addressed (e.g. scheduling, materials handling, etc.). Numerous other stories in the popular press tell of the advantages manufacturing firms enjoy due to innovative developments of superior, often proprietary, processing capabilities.

Integration is the ability to easily expand an operation to incorporate a wider range of products or process technologies. Upton (1994) discussed the ability to quickly manufacture new product designs at John Crane Limited. The company's proficiency at introducing custom mechanical seal designs into an existing mix of manufactured components greatly enhanced its ability to meet unique customer needs. Related abilities to quickly introduce and utilize new processes or equipment are also important, especially for firms that compete in dynamic environments involving rapidly changing process technologies.

Core steady state capabilities include acuity, control, agility, and responsiveness. Acuity refers to the insights of operations managers regarding process capabilities and performance. These insights derive from high quality operations data and from abilities to translate internal or external customer needs into manufacturing specifications. Allegheny Ludlum Corporation, a speciality steel manufacturer, provides an example of superior acuity in manufacturing (March, 1985). The company has developed acuity through extensive process modeling and experimentation. Information systems rapidly and frequently provide in-depth data regarding productivity, utilization, yields, rejects, and operating variances. In addition, manufacturing personnel have close ties to key customers. Allegheny Ludlum uses its extensive process information coupled with a keen understanding of customer needs as a basis for evaluating strategic alternatives. In doing so, the company has achieved a high level of financial success, even during periods of industry-wide recession.

Control is the ability to direct and regulate operating processes. A necessary requirement for control is feedback, a property which permits comparisons of actual output values to desired output values. An illustration of control capabilities is found in statistical process control techniques. Statistical process control tools are used to analyze and understand process variables, to determine a process's capability to perform with respect to those variables, and to monitor the effect of those variables on the difference between customer needs and process performance (Gitlow *et al.*, 1989). In a larger sense, control refers to management's ability to understand and reduce sources of unwanted variation in a process.

Agility is the ability to move from one manufacturing state to another with very little cost or penalty. Manufacturing may be required to produce a wide range of products using a fixed set of resources. Agile processes are able to switch process set-ups quickly and efficiently, so that non-value-added time is minimized and so that smaller production runs are economical. Referring once again to John Crane Limited, Upton (1994) relates agility (which he names "mobility") to the need for the company to maintain a wide offering of products without having to maintain a large finished goods inventory. Agility also involves the ability to produce wide ranges of individual product quantities and aggregate volumes with equal efficiency. Flexible resources compensate for varying demand volumes by shifting work loads or by accelerating or slowing down operations.

Responsiveness refers to the ability to quickly adjust manufacturing processes to deal with changes in inputs, changes in resources, or changes in output requirements. For example, a responsive process can accommodate variations in the quality of raw materials or the uptime availability of equipment. Similarly, responsive processes can shift work schedules, job sequences, or physical routings to deal with unexpected changes in customer needs. In these ways, responsive processes are robust to input or demand variations.

Linking capabilities to product differentiation

Our objective is to suggest manufacturing capabilities which support each dimension of product differentiation. The proposed relationships are depicted in Figure 2. While many manufacturing outcomes and capabilities may be important for a given product, we focus on those manufacturing attributes that provide competitive advantage via differentiation. Product cost, for example, is almost always an important product attribute. However, we only examine cases in which lower product cost is a primary determinant of price, and price is a primary source of product differentiation.

Since manufacturing capabilities as we define them have not been empirically studied, we must propose linkages by relying on examples, logic, and related theory. However, we can also draw on prior research that has associated a

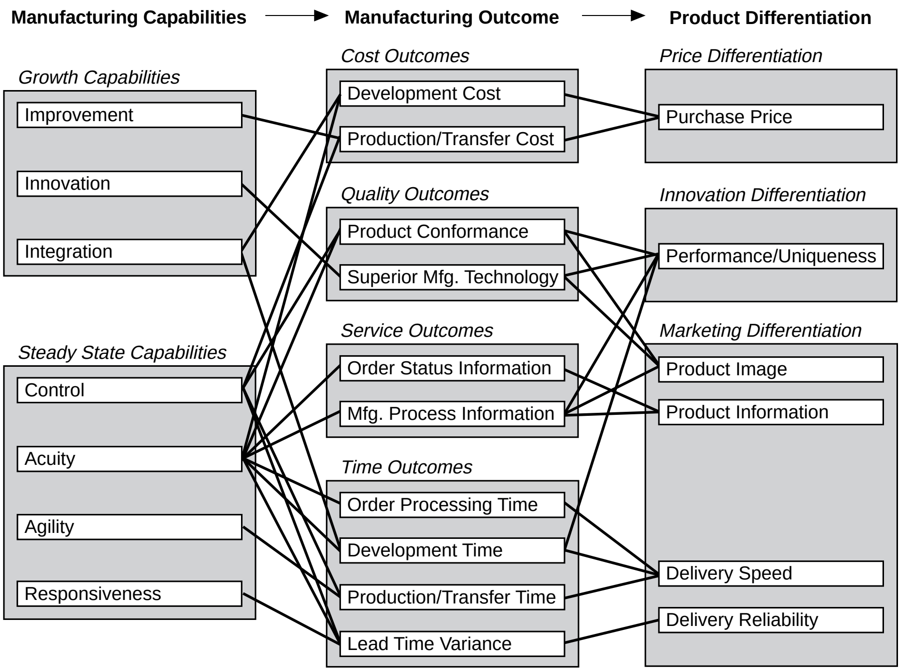

Figure 2. Supportive manufacturing capabilities for product differentiation

number of environmental and structural variables to different types of product differentiation. Table IV provides a summary of these research findings. These environmental and structural relationships provide a context for proposing relationships between manufacturing capabilities and product differentiation.

Price differentiation

Product cost is often a highly prioritized manufacturing outcome when purchase price is a primary source of competitive differentiation. The total cost to produce and deliver the product to the customer provides a lower bound on profitable pricing, and in this way limits pricing discretion.

Price differentiation correlates negatively with attributes related to environmental hostility, uncertainty, dynamism and heterogeneity. It is likely to be found in predictable, stable markets. Consequently, growth in manufacturing effectiveness is likely to result primarily from continuous improvement on the status quo. Mature process technologies and stable product designs reduce the possibilities of growth through innovation or integration, making improvement an important source of performance growth.

Cost-oriented outcomes have been associated with operations designed to increase efficiencies in production, delivery, and service through greater automation, utilization, learning, and scale or scope economies (Goldhar and Jelinek, 1983; Hill, 1988). The findings in Table IV suggest that formal procedures and controls are prevalent in firms which differentiate products on the basis of price. Standards and measures are based on historical values and are employed to reduce uncertainty. The lack of delegation of authority, the lack of organizational differentiation, and the existence of a small number of departments imply centralization and variance reduction tendencies.

These structural correlates are consistent with operations which prioritize control and improvement capabilities. Stable markets and technologies allow firms to establish well-designed organizational hierarchies and measurement systems. Operations managers can establish efficient routines and performance standards, providing greater abilities to analyze and reduce variances and waste. Suggestions for job design, standards, and improvements can be generated by line workers who become experts as they execute cumulative production in a stable environment. This enhances the likelihood that improved performance and control measures will be embraced by the system. Repeated production of standardized products enables operations personnel to concentrate on process refinements that produce steady performance improvement over time.

Based on these arguments, we propose the following:

> *P1*: When product pricing is largely a function of production and delivery costs, price differentiation is more successful when the manufacturing strategy emphasizes improvement and control.

As the degree of product customization increases, product design costs comprise a larger share of total product cost. This is especially true for low volume orders.

Correlates	Price	Basis for differentiation Marketing	Innovation
Environmental variables			
Uncertainty	–	+	+
Unpredictability	–	+	+
Dynamism	–	+	+
Technological change	+	ns	ns
Growth	ns	ns	+
Innovation and R&D	ns	ns	+
Technical stability	+	ns	ns
Hostility	–	+	+
Number of competitive dimensions	ns	ns	+
Bargaining power	+	+	ns
Entry threat	ns	–	ns
Heterogeneity	–	+	+
Production/marketing diversity	ns	ns	+
Structural variables			
Formal rules/procedures	+	+	–
Formal authority	ns	+	–
Precedents/traditions	+	+	–
Scanning	–	+	+
Analysis of key decisions	+	+	+
Field briefings	ns	ns	+
Group decisions	ns	ns	+
Number of profit/cost centers	–	ns	+
Middle management size	–	+	+
Support staff size	–	+	+
Authority delegation	–	ns	+
Organization differentiation	–	+	+
Technocrat influence	–	ns	+
Support staff power	–	+	+
Formal cost controls	+	+	ns
Decision integration	+	+	ns
Use of task forces	–	+	+
Communication (vertical and horizontal)	–	+	+
Multiplexity	ns	+	+
Co-ordinative committees	ns	+	ns
Liaison devices	–	ns	+

Notes:
"+" means a positive correlation; "–" means a negative correlation, "ns" means data were not statistically significant. Findings come from Hambrick (1983b), Dess and Davis (1984), Miller and Friesen (1984), Miller (1987, 1988), and Kim and Lim (1988). Only statistically significant ($p < 0.1$) correlations are reported. In cases where distinction was made between high and low performance firms, the high performance correlates are reported. The studies by Miller all used a common set of strategy identification variables developed by a panel of experts and tested in Hambrick (1983b) and Dess and Davis (1984)

Table IV.
Correlations from empirical studies

Many activities outside the realm of manufacturing contribute to product design costs. At the same time, manufacturing resources are often heavily involved in product design and development. Additionally, supportive manufacturing characteristics can contribute to more efficient product customization processes. Consider the example of a supplier firm that designs and produces metal castings which are used in low volume products such as medical equipment or weapon systems. The potential of the firm to differentiate itself on the basis of price is related to manufacturing's abilities to clearly communicate casting feasibility and constraints to product designers early during development activities. High quality communications serve to reduce product design and tool rework in latter development stages. In addition, manufacturing's capability to efficiently integrate new products, tools, and processing requirements into the existing production environment reduces process development costs.

P2: When product pricing is largely a function of product design costs, price differentiation is more successful when the manufacturing strategy emphasizes integration and acuity.

Innovation differentiation

Innovation differentiation is based on superior or unique product performance, features, reliability, durability, serviceability, or aesthetics (Garvin, 1987). For example, McDougall *et al.* (1992) found that new venture firms typically offer a narrower range of products which have superior performance characteristics or unique product features and patented technologies. Businesses often exploit market niches by tailoring products and processes to their unique needs.

In order to deem a product superior or unique, customers must implicitly or explicitly compare product attributes to competing product attributes or to their own expectations. In the case of competing products that have similar features, product conformance to design specifications is a necessity, since customer comparisons are preempted by defects. In addition, the degree of conformance to specifications may greatly influence the reliable performance of the product. High conformance quality stems from the coherence of process capabilities and design specifications. Conformance can be improved through greater process controls. However, greater conformance also results from more effective allocation of design tolerances and specifications. If manufacturing personnel are able to relate process capability information to the needs of product designers, this improves the designers' abilities to specify design requirements in ways which meet product performance requirements and are at the same time producible. In this way, manufacturing acuity leads to greater product conformance.

Many unique or superior products find their source in process and customer acuity and process innovation. For example, Allegheny Ludlum Steel (mentioned earlier) provides unique product solutions to its customers by leveraging its ability to translate customer needs into process refinements.

From Table IV, a number of environmental and structural characteristics of innovation differentiation suggest the importance of high acuity and process innovation capabilities. Environments of high growth, research, and a large number of competitive dimensions provide a fertile ground for process innovation. The changing, dynamic nature of the environment described by these variables requires that operations personnel be acutely aware of changes in customer needs, competitors' products, and processing technologies. Further, operations personnel need to be able to distill and translate this information in ways that guide manufacturing innovations and improvement initiatives. Table IV implies that scanning activities, in-depth analysis, frequent communications via liaison devices, field briefings, and group decision making are prevalent in firms pursuing innovation differentiation. These are all means for improving acuity and for identify opportunities for new products or processes. In addition, reduced formality, increased delegation, and increased technocrat influence free-up creative talents to generate and evaluate new ideas.

The ability to innovate a valuable new manufacturing technology or to use technology in a unique way, coupled with abilities to communicate an understanding of the technology's superior or unique capabilities, makes manufacturing more supportive of innovation differentiation.

P3: Product innovation differentiation is more successful when the manufacturing strategy emphasizes process innovation, control, and acuity.

Drastically reduced product life cycles in many industries testify to the fleeting nature of competitive advantages provided by innovation differentiation. In environments of dynamic product change, rapid and accurate input from manufacturing is important for reducing product development time. The results in Table IV show that formal procedures and controls are negatively associated with innovation, suggesting that these mechanisms are ineffective in dealing with unanticipated expenses and interruptions associated with product development processes. When many new or revised products are introduced to a manufacturing plant, product prototyping, testing, and production ramp-up activities compete with existing production activities for uses of manufacturing resources. Manufacturing managers must be able to quickly adjust operating resources to integrate these activities while maintaining acceptable levels of cost and efficiency.

P4: In environments of dynamic product change, product innovation differentiation is more successful when the manufacturing strategy emphasizes integration in addition to process innovation, control, and acuity.

Marketing differentiation

Business strategy research identifies marketing differentiation as a unique strategy (Miller, 1986). However, few studies have distinguished its different forms. Discussions of marketing differentiation address ancillary product aspects such as superior product promotion, service, delivery speed and reliability, packaging, installation, maintenance, etc. Marketing differentiation concepts therefore encompass the intangible, informational aspects of selling and servicing a product as well as the tangible, procedural aspects of product delivery and replenishment (Mintzberg, 1988).

The associations shown in Table IV suggest that marketing differentiation is built on formalized controls and procedures linked with high degrees of internal coordination, support, and communication. These characteristics are consistent with the proposition that superior customer service in the forms of information or product delivery requires a keen understanding of customer needs coupled with the corporate infrastructure required to meet those needs, including support staff, coordinating units, communication systems, policies, and procedures. We discuss the roles of these infrastructural components in following paragraphs.

Chase and Garvin (1989) and Chase *et al*. (1992) identified the service roles manufacturing can play in improving the information and image characteristics of product differentiation. To enhance external customer satisfaction, "service factories" seek to make their products more attractive by offering customers easy access to manufacturing information and consultation, and by making inputs into the design or sales of the product or accompanying service. For example, manufacturing functions at Hewlett-Packard and Digital Equipment Corporation provide quality data sheets, video tapes, and equipment demonstrations for potential customers. Manufacturing's ability to share useful information with customers increases their total satisfaction and loyalty, thereby increasing repeat business. Numerous other examples exist of suppliers who provide greater access to product ordering and replenishment information by electronically linking their scheduling systems to those of their customers. As more and more firms employ these types of media to convey manufacturing information, the relative quality of service performance will be determined by the acuity with which manufacturing consults, communicates, and exhibits.

P5: Product information differentiation is more successful when the manufacturing strategy emphasizes acuity.

Image differentiation is produced by addressing customers' expectations via promotions or other communications (Davidow and Uttal, 1989). Manufacturing contributes to a product's positive image by providing product or processing information which presents the firms' capabilities as unique or superior to competitor's manufacturing capabilities. Manufacturing's showcasing abilities make customers aware of product differences and process superiorities. To be successful there needs to exist an in-depth understanding of customer's desires and values.

The value of manufacturing's showcasing abilities is closely tied to the customer's perception of uniqueness or superiority of manufacturing processes. General Motors' Saturn plant provides a widely visible example. General Motors has promoted the plant to customers as a highly innovative operation. Its work systems and technologies are advertised in the media, public tours are frequently conducted, and Saturn owners are regularly invited to visit the plant. This marketing differentiation approach leverages manufacturing's abilities to successfully innovate superlative processing technologies and infrastructures (e.g. work environment, planning and control procedures, etc.). Customers' perceptions of these manufacturing superiorities influence their perceptions of product image.

P6: When customers' perceptions of product quality are greatly influenced by manufacturing, product image differentiation is more successful when the manufacturing strategy emphasizes innovation and acuity.

Product delivery timing has recently been highlighted as an important element of competition. Suppliers are increasingly asked to support just-in-time production requirements. In addition, customers buying finished goods are continually pressing for faster product delivery. Time-oriented manufacturing outcomes include product lead time and the variance in lead times. Three components of lead time are:

(1) the time required to place the order;

(2) the time required to develop the product and associated processes; and

(3) the time required to produce and deliver the product.

For non-customized products, the time required to produce and deliver the items constitutes the majority of lead time, since a new product design is not required and order placement is routine. Control has been identified as the basis for process reliability, which in turn is an essential capability for delivery speed (Ferdows and De Meyer, 1990). Reductions in production/delivery lead time can also result from advances in technological capabilities which increase processing speed (e.g. some machines run faster than others, some transport modes are faster than others). However, many products spend a majority of lead time waiting for processing due to needed process changeovers or as a result of competing needs for resources by different products. Consequently, manufacturing's abilities to efficiently produce wide ranges in product volume and variety provide a great potential for improved production/delivery time. Increased agility reduces the non-value-added proportion of total lead time. An example of agility is provided by Allen-Bradley's World Contactor Facility. The plant has been touted for its ability to produce up to seven varieties of contactors and relays, with more than 1,000 different customer specifications, in small or large lot sizes, within a lead time of 24 hours.

P7: For existing standard product designs, delivery speed differentiation is more successful when the manufacturing strategy emphasizes control and agility.

By definition, new or customized products require product design and development. Since product specifications are not pre-existing, order time and development time make up larger proportions of total lead time for customized products. Manufacturing's contribution to reduced order processing time lies in its ability to retrieve and communicate information needed to define and schedule the order. Product development lead time may be mostly due to activities which occur outside the manufacturing function. However, development lead time is improved by manufacturing's abilities to understand product performance requirements, to communicate process design information, to participate in design activities, and to quickly integrate new products or processes into the existing manufacturing structure.

P8: When development time makes up a large proportion of lead time, delivery speed differentiation is more successful when the manufacturing strategy emphasizes integration and acuity.

Lead time variance results from unplanned events, from customer-initiated changes, or from inaccurate requirement forecasts. Unexpected downtime, late supplier deliveries, changes in customers' due dates, variations in processing times, and changes in demand loads all contribute to lead time variance. Consequently, delivery reliability is largely a function of manufacturing's abilities to predict, to control, and to respond. These attributes stem from many of the structural variables which are positively correlated with marketing differentiation (see Table IV).

Better ability to predict resource capacities and competing resource requirements provides more accurate forecasts of production lead time. This ability comes from the acuity gained through improved communication, scanning, and analysis. Each of these activities is positively associated with marketing differentiation in Table IV.

Greater control reduces process and schedule variations that contribute to lead time variance. Several of the structural correlates of marketing differentiation are recognized means for gaining greater organizational control. Formal procedures, formal authority, and organizational differentiation are structural approaches aimed at reducing variation in processes and in decision making.

Greater responsiveness provides flexibility to react to schedule variations and changes. Four structural correlates of marketing differentiation suggesting greater emphasis on responsiveness are support staff size and power, coordination mechanisms, and task forces. Greater support staff resources provide greater capabilities to devise work-arounds and alternatives for meeting schedule requirements. In addition, a larger, more powerful support staff makes a firm more likely to be able to dedicate resources and focused attention to production problems that threaten on-time delivery. Coordination committees and task forces facilitate this type of problem solving.

The foregoing discussion suggests the following proposition regarding manufacturing capabilities and superior delivery reliability.

P9: Delivery reliability differentiation is more successful when the manufacturing strategy emphasizes acuity, control, and responsiveness.

The foregoing propositions address "pure" dimensions of product differentiation independently in order to establish theoretical relationships with manufacturing outcomes and capabilities. Much of the foregoing research has addressed generic strategies in this way. However, product differentiation strategies are rarely unidimensional. Innovation differentiation strategies are often linked with efforts to elevate product image. Marketing differentiation strategies often emphasize a combined package of superior delivery speed, dependability, and information. Value-based strategies seek to provide superior product performance at competitive prices. The recent move by many manufacturers toward mass-customization may reflect the ultimate in combination strategies, linking low prices with high product uniqueness (customization) and quick and reliable delivery.

We suggest that the proposed model can be used to identify supportive capability bundles for combination differentiation strategies. For example, a service-based differentiation strategy for standard products may attempt to maximize the ratio of delivery speed to product price. The model predicts that businesses pursuing this strategy are best served by operations which emphasize improvement, control, and agility.

Conclusion and suggestions for future research

Manufacturing strategy research needs to move away from only studying the relationships of manufacturing structures to performance and toward studying the core capabilities that certain structural and infrastructural forms encourage. In addition to asking what policies and practices improve manufacturing performance, we need to ask why performance improves. Perhaps this research focus will lead practitioners away from a belief in panaceas and toward a deeper understanding of why and under what circumstances certain programmatic initiatives (such as JIT or TQM) are effective. This deeper understanding naturally drives one to consider the strategic implications of such initiatives.

Strategic management research indicates the existence of diverse product differentiation strategies. We suggest that each of these different strategies calls for distinct sets of manufacturing capabilities. Existing conceptualizations of SBU strategies are too broad to provide detailed guidance in specifying linkages to operational priorities. In addition, existing manufacturing strategic constructs are ill-defined and confounded in a number of ways. We have proposed more precise construct distinctions to remedy these problems. Research is needed to confirm that these distinctions are effective in explaining differences in competitive approaches.

This paper also presents an inventory of manufacturing capabilities and proposes their links to manufacturing outcomes and dimensions of product differentiation. It is our hope that the propositions will spur the formulation and testing of detailed hypotheses addressing these linkages. Several important considerations will influence the design of this future research. First, multiple information sources will be required to supply adequate data concerning bases for differentiation, manufacturing outcomes, and manufacturing capabilities. These informants would ideally include sources from marketing who are knowledgeable about each of the product families included in the study, and sources from manufacturing who are knowledgeable about the facilities used to produce them. A less integrated but easier to implement research approach would be to break the research into two streams, the first studying relationships among manufacturing outcomes and bases for product differentiation, the second studying relationships between manufacturing capabilities and manufacturing outcomes.

Measurement of capabilities presents another important consideration. The definitions provided in Table III suggest the salient dimensions for each capability. Operationalizations for some of these dimensions may prove more difficult than others. For the more opaque constructs (e.g. creativity), early research attempts may have to rely on perceptual measures rather than objective statistics that are difficult to define or obtain.

A tangential direction for future research is the study of relationships among manufacturing capabilities. It may be that certain capabilities build on other capabilities. For example, control is a likely prerequisite to improvement. Questions of the compatibility of various competitive priorities have provided a rich source of debate for researchers in recent years. We suggest that elevating this debate to address the compatibilities of underlying capabilities will lead to a clearer understanding of the nature of trade-offs in manufacturing management.

References

Adler, P.S. (1993), "Time-and-motion regained", *Harvard Business Review*, January-February, pp. 97-108.

Buzzell, R.D., Gale, B.T. and Sultan, R.G. (1975), "Market share: a key to profitability", *Harvard Business Review*, Vol. 54 No. 1, pp. 97-106.

Chase, R.B. and Garvin, D.A. (1989), "The service factory", *Harvard Business Review*, Vol. 67 No. 4, pp. 61-9.

Chase, R.B.K., Kumar, R. and Youngdahl, W.E. (1992), "Service-based manufacturing: the service factory", *Production and Operations Management*, Vol. 1 No. 2, pp. 175-84.

Corbett, C. and Van Wassehnove, L. (1993), "Trade-offs? What trade-offs? Competence and competitiveness in manufacturing strategy", *California Management Review*, Summer, pp. 107-22.

Davidow, W.H. and Uttal, B. (1989), "Service companies: focus or falter", *Harvard Business Review*, Vol. 67 No. 4, pp. 77-85.

Deane, R.H., McDougall, P.P. and Gargeya, V.B. (1991), "Manufacturing and marketing interdependence in the new venture firm: an empirical study", *Journal of Operations Management*, Vol. 10 No. 3, pp. 329-43.

Dess, G.G. and Davis, P.S. (1984), "Porter's (1980) generic strategies as determinants of strategic group membership and organizational performance", *Academy of Management Journal*, Vol. 27 No. 3, pp. 467-88.

Ferdows, K. and De Meyer, A. (1990), "Lasting improvements in manufacturing performance: in search of a new theory", *Journal of Operations Management*, Vol. 9 No. 2, pp. 168-84.

Fine, C.H. and Hax, A.C.(1985), "Manufacturing strategy: a methodology and an illustration", *Interfaces*, Vol. 15 No. 6, pp. 28-46.

Galbraith, C. and Schendel, D. (1983), "An empirical analysis of strategy types", *Strategic Management Journal*, Vol. 4 No. 2, pp. 153-73.

Garvin, D.A. (1987), "Competing on the eight dimensions of quality", *Harvard Business Review*, November-December, pp. 101-9.

Garvin, D.A. (1993), "Manufacturing strategic planning", *California Management Review*, Summer, pp. 85-106.

Gerwin, D. (1993), "Manufacturing flexibility: a strategic perspective", *Management Science*, Vol. 39 No. 4, pp. 395-410.

Gitlow, H., Gitlow, S., Oppenheim, A. and Oppenheim, R. (1989), *Tools and Methods for the Improvement of Quality*, Irwin, Homewood, IL.

Goldhar, J.D. and Jelinek, M. (1983), "Plan for economies of scope", *Harvard Business Review*, Vol. 61 No. 6, pp. 141-8.

Hambrick, D.C. (1983a), "An empirical typology of mature industrial-product environments", *Academy of Management Journal*, Vol. 26 No. 2, pp. 213-30.

Hambrick, D.C. (1983b), "High profit strategies in mature capital goods industries: a contingency approach", *Academy of Management Journal*, Vol. 26 No. 4, pp. 687-707.

Hayes, R., (1990), "Hitachi seiki (Abridged)", Case No. 9-690-067, Harvard Business School, Boston, MA.

Hayes, R. and Pisano, G.P. (1994), "Beyond world class: the new manufacturing strategy", *Harvard Business Review*, January-February, pp. 77-86.

Hayes, R. and Pisano, G.P. (1996), "Manufacturing strategy: at the intersection of two paradigm shifts", *Production and Operations Management*, Vol. 5 No. 1, pp. 25-41.

Hill, C. (1988), "Differentiation versus low cost or differentiation and low cost: a contingency framework", *Academy of Management Journal*, Vol. 13 No. 3, pp. 401-12.

Hill, T. (1983), "Manufacturing's strategic role", *Journal of the Operational Research Society*, Vol. 34 No. 9, pp. 853-60.

Hofer, C. and Schendel, D. (1978), *Strategy Formulation: Analytical Concepts*, West, St. Paul, MN.

Hrebiniak, L.G. and Joyce, W.F. (1985), "Organizational adaptation: strategic choice and environmental determinism", *Administrative Science Quarterly*, Vol. 30 No. 3, pp. 336-49.

Kim, Y. and Lee, J. (1993), "Manufacturing strategy and production systems: an integrated framework", *Journal of Operations Management*, Vol. 11 No. 1, pp. 3-15.

Kim, L. and Lim, Y. (1988), "Environment, generic strategies, and performance in a rapidly developing country: a taxonomic approach", *Academy of Management Journal*, Vol. 31 No. 4, pp. 802-26.

Kotha, S. and Orne, D. (1989), "Generic manufacturing strategies: a conceptual synthesis", *Strategic Management Journal*, Vol. 10 No. 3, pp. 211-31.

Kotha, S. and Vadlamani, B.L. (1995), "Assessing generic strategies: an empirical investigation of two competing typologies in discrete manufacturing industries", *Strategic Management Journal*, Vol. 16 No. 1, pp. 75-83.

March, A. (1985), "Allegheny Ludlum Steel Corporation", Case No. 9-686-087, Harvard Business School, Boston, MA.

McDougall, P.P., Deane, R.H. and D'Souza, D.E. (1992), "Manufacturing strategy and business origin of new venture firms in the computer and communications equipment industries", *Production and Operations Management*, Vol. 1 No. 1, pp. 53-69.

McGrath, R.G., Tsai, M., Venkataraman, S. and MacMillan, I.C. (1996), "Innovation, competitive advantage and rent: a model and test", *Management Science*, Vol. 42 No. 3, pp. 389-403.

Miles, R. and Snow, C. (1978), *Organizational Strategy, Structure, and Process*, McGraw-Hill, New York, NY.

Miller, D. (1986), "Configurations of strategy and structure: towards a synthesis", *Strategic Management Journal*, Vol. 7 No. 3, pp. 233-49.

Miller, D. (1987), "The structural and environmental correlates of business strategy", *Strategic Management Journal*, Vol. 8 No. 1, pp. 55-76.

Miller, D. (1988), "Relating Porter's business strategies to environment and structure: analysis and performance implications", *Academy of Management Journal*, Vol. 31 No. 3, pp. 280-308.

Miller, D. and Friesen, P.H. (1984), *Organizations: A Quantum View*, Prentice Hall, Englewood Cliffs, NJ.

Miller, J.G. and Roth, A.V. (1994), "A taxonomy of manufacturing strategies", *Management Science*, Vol. 40 No. 3, pp. 285-304.

Mintzberg, H. (1988), "Generic strategies: toward a comprehensive framework", *Advances in Strategic Management*, Vol. 5, pp. 1-67.

Penrose, E. (1959), *The Theory of the Growth of the Firm*, Wiley, New York, NY.

Porter, M.E. (1980), *Competitive Strategy: Techniques for Analyzing Industries and Competitors*, Free Press, New York, NY.

Schendel, D. and Hofer, C. (1979), *Strategic Management: A New View of Business Policy and Planning*, Little, Brown & Co., Boston, MA.

Schroeder, R.G., Anderson, J.C. and Cleveland, G. (1986), "The content of manufacturing strategy: an empirical study", *Journal of Operations Management*, Vol. 6 No. 3-4, pp. 405-15.

Schroeder, R.G., Scudder, G.D. and Elmm, D.R. (1989), "Innovation in manufacturing", *Journal of Operations Management*, Vol. 8 No. 1, pp. 1-15.

Skinner, W. (1969), "Manufacturing – missing link in corporate strategy", *Harvard Business Review*, Vol. 47, May-June, pp. 136-45.

Skinner, W. (1992), "Missing the links in manufacturing strategy", in Voss, C. (Ed.),*Manufacturing Strategy: Process and Content*, Chapman-Hall, London, pp. 13-25.

Skinner, W. (1996), "Manufacturing strategy on the "S" curve", *Production and Operations Management*, Vol. 5 No. 1, pp. 3-14.

Stalk, G., Evans, P. and Schulman, L.E. (1992), "Competing on capabilities: the new rules of corporate strategy", *Harvard Business Review*, March-April, pp. 58-69.

Swamidass, P.M. and Newell, W.T. (1987), "Manufacturing strategy, environmental uncertainty and performance: a path analytic model", *Management Science*, Vol. 33 No. 4, pp. 509-24.

Swink, M. and Way, M. (1995), "Manufacturing strategy: propositions, current research, renewed directions", *International Journal of Operations & Production Management,* Vol. 15 No. 7, pp. 4-27.

Upton, D.M. (1994), "The management of manufacturing flexibility", *California Management Review*, Winter, pp. 72-89.

Utterback, J.M. and Abernathy, W.J. (1975), "A dynamic model of process and product innovation", *OMEGA*, Vol. 3 No. 6, pp. 639-56.

Vickery, S.K, Droge, C. and Markland, R.E. (1993), "Production competence and business strategy: do they affect business performance?", *Decision Sciences*, Vol. 24 No. 2, pp. 435-55.

Vickery, S.K., Droge, C. and Markland, R.E. (1994), "Strategic production competence: convergent, discriminant, and predictive validity", *Production & Operations Management*, Vol. 3 No. 4, pp. 308-18.

White, R.E. (1986), "Generic business strategies, organizational context and performance: an empirical investigation", *Strategic Management Journal*, Vol. 7 No. 3, pp. 217-31.

White, G.P. (1996), "A meta-analysis model of manufacturing capabilities", *Journal of Operations Management*, Vol. 14 No. 4, pp. 315-31.

Wheelwright, S.C. (1978), "Reflecting corporate strategy in manufacturing decisions", *Business Horizons*, Vol. 21 No. 1, pp. 57-66.

Wheelwright, S.C. (1984), "Manufacturing strategy: defining the missing link", *Strategic Management Journal*, Vol. 5 No. 1, pp. 77-91.