DESIGNING A MANUFACTURING STRATEGY

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Abstract

A manufacturing strategy is a critical component of the firm's corporate and business strategies, comprising a set of well-coordinated objectives and action programs aimed at securing a long-term, sustainable advantage over the firm's competitors. A manufacturing strategy should be consistent with the firm's corporate and business strategies, as well as with the other managerial functional strategies. We present a process and a structured methodology for designing such a manufacturing strategy. This methodology has been successfully tested in actual manufacturing environments.

1. Introduction

For most industrial companies, the manufacturing operation is the largest, the most complex, and the most difficult-to-manage component of the firm. Because of this complexity, it is essential for firms to have a comprehensive manufacturing strategy to aid in organizing and managing the firm's manufacturing system. This paper provides a process and a structured methodology for conceptualizing and formulating a manufacturing strategy.

The manufacturing strategy cannot be formed in a vacuum; it affects and is affected by many organizations inside and outside the firm. Because of the interrelationships among the firm's manufacturing unit, the firm's divisions and other functions, and the firm's competitors and markets, it is necessary to carry the process of manufacturing-strategy design beyond the borders of the manufacturing organization in a single firm. Figure 1.1 illustrates the extent of these interrelationships and emphasizes the two basic types of interactions that must be considered for manufacturing-strategy design. First, in developing and implementing the manufacturing strategy, the manufacturing function must work in concert with the finance, marketing, engineering and R&D, personnel, and purchasing functions. Cooperation and consistency of overall objectives are the keys to success in these types of interactions. Second, manufacturing strategy design requires careful monitoring of the markets external to the firm in conjunction with the aforementioned functional groups within the firm. For example, manufacturing managers, in conjunction with the engineering group, may monitor developments in the electronics industry so that they are aware of new applications of electronics to process technology in their industry. Similarly, manufacturing, in conjunction with marketing, monitors the product markets in which they compete so they are aware of the product improvements and product introductions of their competitors.

These observations suggest the necessary elements of manufacturing strategy

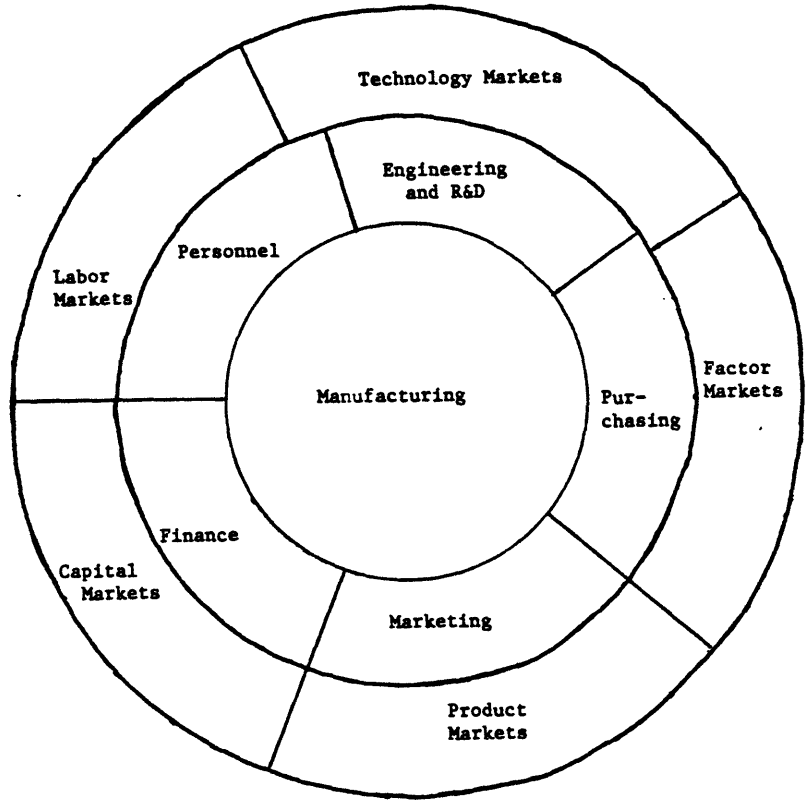


Figure 1.1 The Interface Among Manufacturing, The Remaining Functional Groups, and the External Markets

design and an outline for our approach to the problem. Following this suggested line of thought, we begin (in Section 2) with a brief discussion of the corporate strategic planning process and some of the conceptual issues that are important for manufacturing strategy design. Our principal contributions are in Sections 3 and 4 where we define and elaborate on the major strategic decision categories in manufacturing and provide a highly structured, and successfully tested, methodology for manufacturing strategy design. Section 5 contains a brief conclusion.

2. The Corporate Strategic Planning Process

A strategy can be either articulated formally, with the help of a structured planning process, or stated implicitly by the actions of the various managers

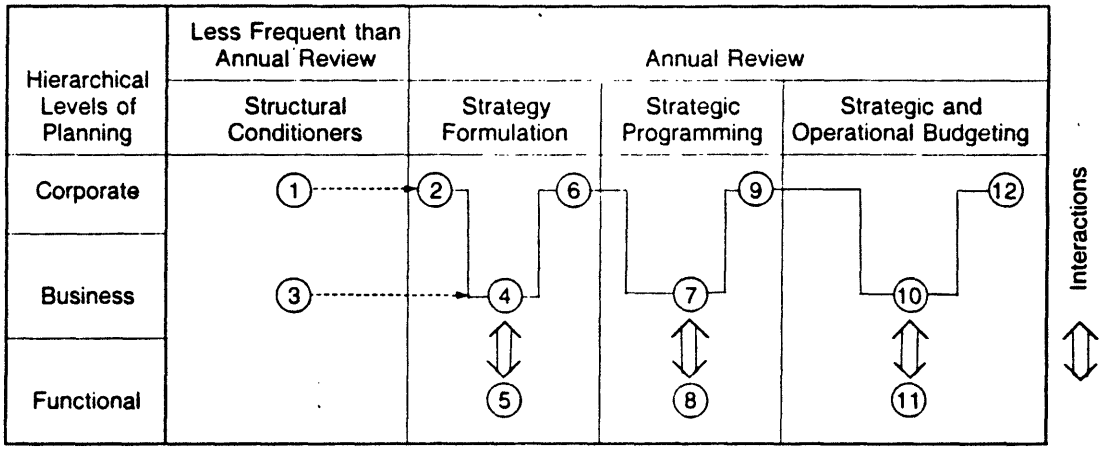
within the firm. Our objective is to describe how a formal manufacturing strategy can be developed. First, we feel it is important to discuss the overall corporate strategic planning process, the roles of the corporate, business, and functional managers in that process, and a number of factors that affect the allocation among those managers of manufacturing decision-making responsibility. This brief background will help to provide an understanding on how the design of a manufacturing strategy fits within the corporate process.

2.1 A Formal Strategic Planning Process

The essence of strategy is to achieve a long-term sustainable advantage over the firm's competitors in every business in which the firm chooses to participate.

The corporate strategic planning process is a disciplined and well-defined organizational effort aimed at the complete specification of corporate strategy. It identifies all the major tasks to be addressed in setting up corporate strategy and the sequence in which they must be completed. The specific characteristics of the planning process to be adopted by a firm depend on the degree of complexity of the firm's businesses, its organizational structure, and its internal culture. However, it is useful to recognize some fundamental tasks that can guide the strategic planning process of most firms. These tasks, described briefly in Figure 2.1, address the three basic hierarchical levels of the firm: the corporate, business, and functional levels. (For a comprehensive discussion of this subject, the reader is referred to Hax and Majluf [1984a,1984b].)

The first task at the corporate level is to provide a general direction to the firm by articulating the vision of the firm. This task involves selecting the domains in which the firm will compete (the identification of the strategic business units and their interactions), establishing the firm's mission (the determination of product, market, and geographical scopes, as well



1. The vision of the firm: corporate philosophy, mission of the firm, and identification of strategic business units (SBUs) and their interactions.
2. Strategic posture and planning guidelines: corporate strategic thrusts, corporate performance objectives, and planning challenges.
3. The mission of the business: business scope, and identification of product-market segments.
4. Formulation of business strategy and broad action programs.
5. Formulation of functional strategy: Participation in business planning, concurrence or non-concurrence to business strategy proposals, broad action programs.
6. Consolidation of business and functional strategies.
7. Definition and evaluation of specific action programs at the business level.
8. Definition and evaluation of specific action programs at the functional level.
9. Resource allocation and definition of performance measurements for management control.
10. Budgeting at the business level.
11. Budgeting at the functional level.
12. Budgeting consolidations, and approval of strategic and operational funds.

Figure 2.1: The Formal Corporate Strategic Planning Process
(Source: Hax and Majluf [1984a, 1984b])

as the unique competencies that the firm will employ in attaining a competitive advantage), and specifying its corporate philosophy (the policies and cultural values affecting the relationships between the firm and its stakeholders, as well as the broad expectations for growth and profitability). The vision of the firm is singled out as task 1 in Figure 2.1.

The second major task at the corporate level (task 2 in Figure 2.1) is to translate the broad and permanent statements inherent to the vision of the firm into pragmatic and concrete guidelines and challenges for the development of strategic proposals at the business and functional levels. This task is accomplished by means of the corporate strategic thrusts (the primary issues the firm must address in the next three to five years to establish a strong competitive position in its key businesses), the planning challenges (the responsibilities of key personnel who must respond to each strategic thrust), and the corporate performance objectives (quantitative measures for the overall performance of the firm).

The corporate level also has the responsibility for managing the portfolio of the firm's businesses. This responsibility includes the validation, consolidation, and sanctioning of the business and functional proposals for strategies, programs, and budgets. In these activities, tasks 6, 9, and 12 in the corporate planning process (illustrated in Figure 2.1), priorities are assigned and resources are allocated among the various businesses.

At the business level, managers must prescribe the mission of the business (a detailed statement of the product, market, and geographcal scope for the various business segments as well as the identification of unique competencies at the business level) and spell out the business strategies, programs, and budgets necessary to achieve competitive superiority. These activities are identified as tasks 3, 4, 7, and 10 in Figure 2.1.

The functional managers are responsible for defining functional strategies,

programs, and budgets that not only consolidate the requirements demanded by the composite of businesses of the firm, but also contribute to the creation of unique competitive strengths. These tasks are numbered 5, 8, and 11 in Figure 2.1.

2.2 The Role of Corporate, Business and Functional Managers in the Development of the Manufacturing Strategy

Each hierarchical level of the firm has a distinct and important role to play in the effort to achieve competitive advantage. Within the context of this paper it is appropriate to ask the question: at what level does the firm design its manufacturing strategy? The answer, obviously, is at all three hierarchical levels.

The corporate level, in its statements pertaining to the vision of the firm and its strategic thrusts, identifies the role that manufacturing should play in the pursuit of competitive superiority. Normally, the manufacturing objectives are expressed in terms of the four major dimensions of performance measurement used in formulating manufacturing strategy (Wheelwright [1981]): cost, quality, delivery, and flexibility. There are important trade-offs to be made among these objectives, since it is not possible to excel in all of them simultaneously. Defining the central manufacturing competitive thrusts and the tasks to accomplish them is at the heart of manufacturing strategy design.

With respect to cost objectives, frequently used measures include labor, materials, and capital productivities, inventory turnover, and unit costs. Quality measures include percent defective or rejected, field failure frequency, cost of quality, and mean time between failures. To measure delivery performance, percentage of on-time shipments, average delay, and expediting response time may be used. Flexibility may be measured with respect to product mix

flexibility, volume flexibility, and lead time for new products. This task of matching performance measures with corporate and business objectives can be difficult because of the often uncertain effects of changed short-term operating policies on long-term measures (Kaplan [1983,1984]).

The business level managers respond to the corporate objectives, assuring that all the managerial functions, including manufacturing, have plans that are consistent with the corporate vision and move the business toward the desired competitive position. Since business unit strategies are primarily a collection of well-coordinated multifunctional programs aimed at developing the fullest potential of each business; functional strategies, including manufacturing strategies, are developed primarily at the business level.

Finally, the functional managers, who might have participated actively in the development of the various business strategies, have to formulate the corresponding functional strategic programs. The nature of those programs and the strategic categories that must be part of a manufacturing strategy are the subject of Sections 3 and 4 of this paper.

It is important to emphasize once more that the central objective of manufacturing strategy is to achieve long-term competitive advantage. Obviously, this objective cannot be fulfilled unless the firm understands how to position its manufacturing skills vis a vis its competitors. Recently, it has become obvious that neglect by many American firms of the manufacturing function has contributed to a decline in our industrial competitive strengths. For some excellent discussion on this issue we refer the reader to Buffa [1984], Hayes and Wheelwright [1984], and Kantrow [1983].

2.3 Factors Affecting the Allocation of Manufacturing Decision-Making Responsibilities

We have dealt in general terms with the distinct role to be played by

corporate, business and functional managers in formulating both corporate and manufacturing strategies. In a particular business firm, the allocation of responsibilities pertaining to the development of manufacturing strategy is affected by a number of different factors. The most important of those factors are: the organizational structure of the firm, the organization's degree of product or process focus, the industry and competitive structure of the business in which the firm is engaged, and the individual firm's competitive strengths.

With respect to organizational structure, the degree of decentralization and divisionalization of the firm affects the allocation of decision-making responsibilities among corporate and business unit managers, whereas the relative use of cost and profit centers within a business unit affects the allocation among business unit managers and functional manufacturing managers. Divisionalized companies with highly decentralized decision-making tend to give little or no manufacturing decision-making to corporate managers. Only in the areas of facilities and perhaps vertical integration, because of the size of the required financial commitments, are the corporate people likely to wield much influence. Highly centralized corporations, on the other hand, are likely to also have the corporate staff get involved in decisions related to technology choice, manufacturing of new products, human resource policies, quality policies, and possibly vendor selection and purchasing.

Within a business unit, the functional manufacturing managers will usually have significant control over production planning and scheduling, materials management, and some other infrastructure decisions. Decisions on technology and human resources will also be primarily the responsibility of functional manufacturing managers, but this will depend on the degree of decentralization in the business unit. Business unit managers generally keep significant control over capacity, vendor relations, quality, new product introductions, and vertical integration decisions, regardless of the degree of decentralization.

The second major factor that affects the allocation of responsibility is whether the dominant manufacturing focus in the organization is product focus or process focus. Hayes and Schmenner [1978] describe the product-focused organization as one with many "plant with staff" suborganizations: each plant is set up as a profit center and is responsible for a set of products. Product-focused organizations are flexible and fast-reacting. This structure tends to be better suited for organizations that have a low capital intensity, that have little opportunity for manufacturing economies of scale, that need flexibility and innovativeness, and that have a dominant orientation to a single market or consumer group, rather than to a technology or material. Process-focused organizations tend to have a series of plants, each of which adds value to the final product (see Figure 2.2). Plants in process-focused organizations tend to require large capital investments, tend to be relatively inflexible to changes in product mix or product volume, tend to be run as cost centers, and tend to have high central overhead costs.

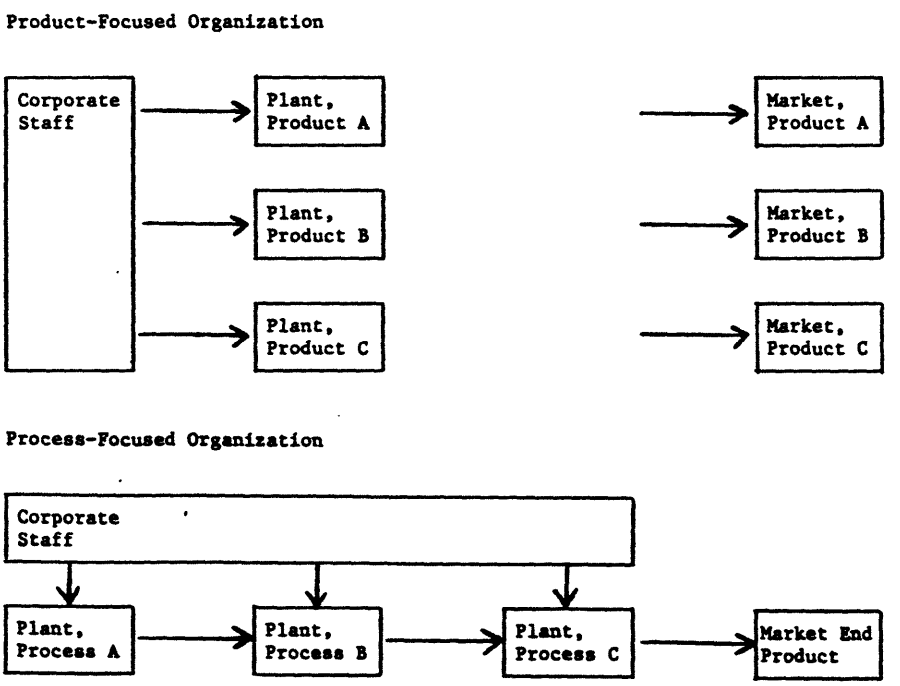


Figure 2.2: Two Polar Examples: The "Product-Focused Organization" and the "Process-Focused Organization"
(Source: Hayes and Schmenner [1978])

In product-focused organizations, the functional manufacturing managers (e.g., the plant managers) tend to have responsibility over a wide range of decisions. They tend not to be inhibited by a large business unit staff. Functional manufacturing managers in process-focused organizations have a much narrower range of authority. Process-focused plants are coordinated by the business unit management.

The third factor that affects the allocation of manufacturing decision-making power is the industry and competitive environment in which the firm operates. The standard approach to industry and competitive structure (Porter [1980]) analyzes potential entrants, buyers, suppliers, substitutes, and rivalry among firms to develop an understanding of the environment. For our purposes, one only needs to determine the extent to which the firm competes with market power (i.e., large scale, low costs) or flexibility and innovation. In the former case, centralization tends to be the required organizational mode and relatively more decision-making power resides with the corporate managers. In the latter case, decentralization is essential for rapid responses to changing environments, so that business unit managers and, especially, functional manufacturing managers make most of the important decisions.

The final factor that affects the allocation of manufacturing decision responsibilities is the individual firm's set of competitive strengths. If a firm's success is tied to a top-notch corporate R&D lab, whose innovations are sent out to the divisions to be made marketable, then the corporate managers will tend to have much influence over new product development and perhaps technology choice. In such a case, the business unit managers can retain power over other decision areas without damage to the firm's competitive strengths. If the firm's comparative advantage comes from low costs due to scale economies, efficient plant design, and shared experience, then corporate managers will generally control the decisions relating to facilities, capacity, product

design, technology choice, and purchasing, while the business unit and manufacturing managers will control the operating level decisions. If the firm's strength is in its ability to respond rapidly to new competitors and new products, then business unit and functional manufacturing managers are likely to have much control over decisions on capacity, technologies, new products, quality, human resources, vendor relations, production planning, and materials management. If a large corporate bureaucracy were in control of these decisions, the firm would be unable to mount rapid responses to various challenges.

Thus, we have seen that organizational structure, product or process focus, industry and competitive structure, and the firm's competitive strengths each play a role in the allocation of decision-making responsibilities in the firm.

3. The Strategic Decision Categories in Manufacturing

A manufacturing strategy must be comprehensive in the sense that it should provide guidelines for addressing the many facets of manufacturing decision-making. At the same time, the complex web of decisions required in manufacturing management must be broken down into analyzable pieces. Nine strategic decision categories provide a comprehensive coverage of the broad set of issues that must be addressed by a manufacturing strategy while dividing the manufacturing decision-making task into small, easy-to-analyze pieces.

These nine strategic decision categories are facilities, capacity, vertical integration, processes/technologies, scope/new products, human resources, quality, infrastructure, and vendor relations. Figure 3.1 displays the nine decision categories and suggests which other functional departments in the firm have input into each set of decisions. Due to space limitations, we can only describe a small number of key issues in each category that must be addressed by the manufacturing strategy. Section 4 then describes how these categories

are used in the manufacturing strategy design methodology.

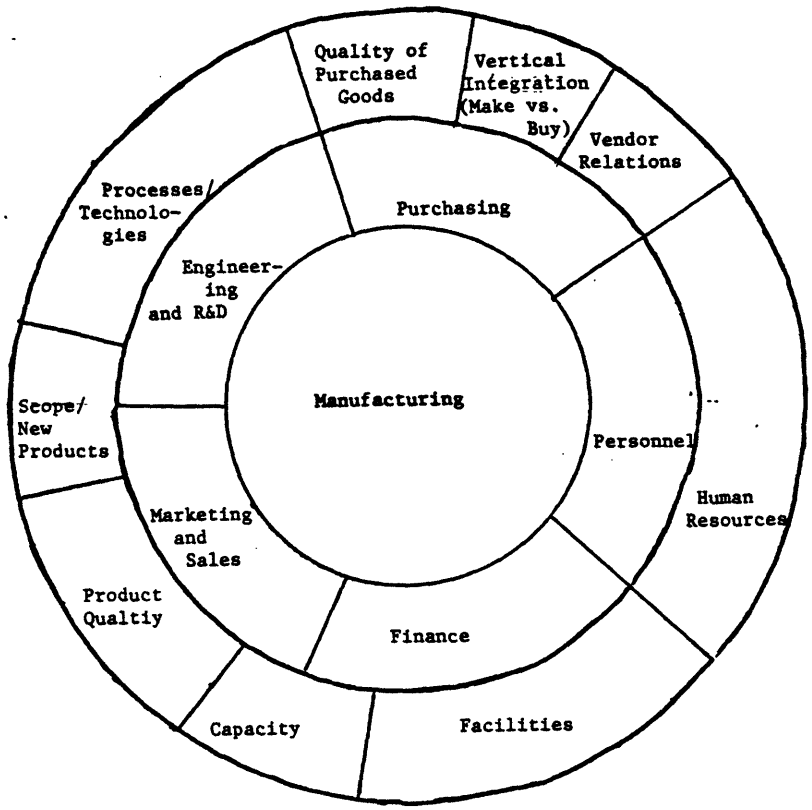


Figure 3.1: The Nine Strategic Manufacturing Decision Categories

3.1 Facilities

Facilities decisions are the classic example of long-term, "cash-in-concrete" manufacturing decisions. A key step in facilities policy-making for a multi-facility organization is choosing how to specialize or focus each facility. Facilities may be focused by geography, product groups, process types, volumes, or stage in the product life cycle.

In any given industry, such facilities-focus decisions usually depend on the economics of production and distribution for that industry. For example, due to the economies of scale in refining and the cost of transporting crude oil, oil companies tend to have process-focused plants that are located near

crude oil sources (oil wells or ports). Consumer product companies have large, centralized plants when there are significant manufacturing economies of scale and non-critical delivery response requirements (e.g., non-perishable food manufacturers), and they have small, product- and location-focused plants if scale economies are not significant or closeness to the customers is important (e.g., furniture manufacturers). Firms in industries in rapidly changing environments, such as semiconductor firms, often focus plants by stages in the product life cycle. One such configuration is to have low volume, high flexibility facilities for manufacturing prototypes; and high volume, dedicated plants for maturing products that are experiencing high demand.

Developing a well-thought-out facility focus strategy automatically provides guidance to the firm in other facilities decisions such as determining the size, location, and capabilities of each facility.

3.2 Capacity

Capacity decisions are highly interconnected with facility decisions. Capacity is determined by the plant, equipment, and human capital that is currently under management by the firm. Important capacity decisions include how to deal with cyclical demand (e.g. by holding "excess" capacity, by holding seasonal inventories, by peak-load pricing, by subcontracting, etc.), whether to add capacity in anticipation of future demand (aggressive, flexible approach) or in response to existing demand (conservative, low-cost approach), and how to use capacity decisions to affect the capacity decisions of one's competitors.

3.3 Vertical Integration

Operations managers are directly affected by vertical integration decisions because they are responsible for the task of coordinating the larger and more complex integrated system that usually results from vertical integration. The decision to vertically integrate involves the replacement of a market mechanism

over which the operations managers have limited control by an internal, non-market mechanism that is the sole responsibility of the managers in the firm. Before making such a decision, a firm must assure itself that it has the capability of designing and controlling such a non-market mechanism that will be more efficient than the market it replaces.

Important issues related to vertical integration include the cost of the business to be acquired or entered, the degree of supplier reliability in the important factors of production, whether the product or process to be brought in-house is proprietary to the firm, and the relative transaction costs (Williamson [1975]) related to contracting through market or non-market mechanisms. Other important issues are the impact of integration on the risk, product quality, cost structure, and degree of focus of the firm.

Legal ownership of the series of productive processes may not be the key element that determines the benefits of having integrated processes. Toyota Motor Company in Japan plays a very large role in directing the operations of its legally independent suppliers. Toyota gets the benefits of lower transaction costs (through what Porter [1980] calls a "quasi-integrated" market mechanism) because they coordinate the production of independently owned suppliers with the just-in-time system. The success of this system raises the question of whether the crucial element for success of integrated operations is ownership of the series of productive processes or management and coordination of the processes.

3.4 Processes/Technologies

The traditional approach to process choice has been to identify the principal generic process types (project, job shop, assembly line, continuous flow) and to choose among them for the production task at hand by matching product characteristics with process characteristics. (See, for example, Marshall et al. [1975] and Hayes and Wheelwright [1979].)

Although crude, this framework is quite useful for conceptualizing some important tradeoffs in process choice. Relative to assembly lines, job shops tend to use more general purpose machines and higher skilled labor, provide more product flexibility, and yield higher unit production costs.

Recent innovations in computer-aided design (CAD), computer-aided manufacturing (CAM), robotics, and flexible manufacturing systems have added more complexity to technology decision problems. New highly-automated factories can be extremely expensive (e.g., see Bylinsky [1983] about Deere's $500 million factory in Waterloo, Iowa and GE's $300 million improvement in a factory in Erie, Pennsylvania). Many firms decide to invest in these new technologies because they believe their survival depends on it. Traditional financial and accounting evaluation tools are often unable to capture all of the benefits that can be attributed to the installation of these systems. Because of these shortcomings, thorough strategic analysis is required to properly evaluate these investment choices.

3.5 Scope/New Products

The degree of difficulty of the manufacturing management task is influenced strongly by the scope or range of products and processes with which the manufacturing organization must be proficient (Skinner [1974]), as well as the rate of new product introductions into the manufacturing organization. In well-run manufacturing organizations, the manufacturing management must have significant input into product scope and new product decisions. Firms in environments that demand rapid and frequent product introductions or broad product lines must design flexible, responsive, efficient manufacturing organizations, must have product designers who have intimate knowledge of the effects of product design on the demands put on manufacturing, and must have good communication among design, marketing, and manufacturing.

3.6 Human Resources

Many students of management believe that the most important and the most difficult-to-manage assets of a firm are the human assets. (See, for example, Peters and Waterman [1983].) The principal issues in human resource management are incentives and compensation, investment in human capital, labor union relations, hiring or screening policies, tenure policies, and job design. The principal challenge in human resource management is to design a set of policies that motivate and stimulate employees to work as a team to achieve the mission of the firm.

The design of such a set of policies can be quite complex. For example, with respect to incentives and compensation, a firm must decide whether to compensate its people as a function of hours worked, quantity or quality of output, seniority, skill levels, effort expended, loyalty, etc. Informational asymmetries (e.g. skill levels or effort levels are not costlessly observable by management) complicate the matter because the firm can only base compensation on observable measures. Aside from pecuniary compensation, employees often are rewarded with perquisites (such as cars or loans), training (human capital investments by the firm), employment guarantees, recognition for achievement, promotions to better jobs, etc. A well-thought-out incentive system will consist of a combination of these elements that promote quality, efficiency, and employee satisfaction.

3.7 Quality Management

Quality topics can be divided usefully into the categories of design quality and conformance quality. Although manufacturing managers should be involved in some degree with design quality (especially with respect to the design for manufacturability issue), conformance quality is the area where manufacturing managers play a most crucial role.

Three important issues related to managing for conformance quality are

quality measurement, economic justification of quality improvements, and allocation of responsibility for quality. The two principal tools of quality measurement are statistical quality control (SQC) and cost of quality (COQ). Since both of these topics are well-covered elsewhere (SQC in Grant and Leavenworth [1980], and Burr [1976,1979]; COQ in Juran [1974], and Juran and Gryna [1980]), we will not elaborate on them here.

Economic justification of quality improvements is a difficult and controversial subject. (See Fine [1983] for a discussion of the controversy.) Cost of quality accounting, the only economic tool that is widely used to evaluate quality projects or quality improvement programs, has two severe drawbacks. First, COQ ignores revenue effects of quality such as market share benefits and price premia for high quality products. Second, it emphasizes short-term cost effects without consideration of the long-term consequences of quality decisions. (See Fine [1983] for a model that demonstrates one aspects of this shortcoming and allows for long-term effects.) A system for measuring revenue effects of quality as well as cost effects is needed for sound economic decision making in the quality area. We know of no instances where measurement of the revenue effects of quality has been attempted.

Responsibility for product quality has traditionally resided in the quality assurance or quality control organization in the firm. (See, e.g. Juran [1974].) Recently (Deming [1983], Schonberger [1982]), this viewpoint has been challenged by the school of thought that each worker in the organization should be responsible for the quality of his or her work. Implementing this proposal would require a significant change in many companies where hourly workers are not expected to exercise judgment on the job. Where implemented successfully, this corporate cultural regime has proven to be very efficient (Schonberger [1982]).

3.8 Manufacturing Infrastructure

To support decision making and implementation in the manufacturing function,

it is essential to have a solid organizational infrastructure. As a part of this infrastructure, planning and control systems, operating policies, and lines of authority and responsibility must be in place. A corporate culture that reinforces the manufacturing strategy is also crucial as a cornerstone of the supporting structure. For a discussion of the integration among managerial processes, organizational structure, and corporate culture, see Hax and Majluf [1984b, Chapter 5].

We include decisions on materials management, production planning, scheduling, and control as a part of the manufacturing infrastructure decision set. With respect to materials management, firms should consider the relative merits of classical production and inventory systems, materials requirements planning (MRP), and just-in-time (JIT) in designing a system to fit their needs.

Production planning and scheduling decisions are typically thought of as tactical, rather than strategic decisions. However, in the areas of aggregate production planning and delivery system design, strategic considerations must be evaluated. In aggregate planning, the firm must decide how to match productive capacity to variable demand over the medium-term (12 to 18 months) planning horizon. The choices are usually to hire or lay off workers, schedule overtime or undertime, increase or reduce the number of work shifts, or build up or run down seasonal inventories.

With respect to design of the delivery system, the principal decision is whether the system should produce to stock or produce to order. In a make-to-order shop, where flexibility is a crucial asset, the scheduling task is generally difficult, but the system responds readily to varying customer requirements. Make-to-stock shops are generally "under the gun" less often because they have finished goods inventories to buffer the production operation from customer demand. However, these operations tend to have significant finished goods holding costs. In many machine shops, where the number of possible

products is extremely high, a make-to-stock system is not feasible.

3.9 Vendor Relations

There are two popular, but diametrically opposed, views on purchasing and vendor relations strategy - the competitive (Porter [1980]) approach and the cooperative or Japanese (Schonberger [1982]) approach. The competitive approach recommends the development of multiple sources for most or all materials inputs. The idea is to have a number of firms that must compete among themselves to retain their supply contracts. Buyer-supplier relationships resemble spot contracting more than long-term contracting because suppliers can be dropped on short or no notice. Tapered integration is recommended as an additional threat to take business away from errant suppliers. All contracts are formal with many contingencies accounted for. Dependence on a supplier is to be avoided to as great a degree as possible.

The cooperative approach recommends developing long-term relationships based on mutual dependence and trust. Suppliers are given advice and training if their performance is unsatisfactory. Contracts are informal and contingencies are dealt with as they occur. Single sourcing is common.

The contrast between these two views is quite sharp. Each approach is practiced by successful firms. However, the recent trend in the U.S. seems to be toward trying the cooperative approach.

4. A Methodology for Structuring the Development of Manufacturing Strategy

The objective of this section is to describe briefly the methodology we propose for the development of the manufacturing strategy of a firm. Although we recognize that any such methodology should be tailor-made to accomodate the idiosyncrasies of a given firm, we find that there are enough common issues

in the formulation of a manufacturing strategy that it is possible to generate a useful, general-purpose process to guide managerial thinking in this area. Moreover, we desire to be as structured as possible in the specification of this methodology to allow managers to translate the basic concepts and principles of manufacturing strategy into pragmatic and concrete action programs.

The basic steps of the methodology we propose are summarized in Figure 4.1. Each step will be reviewed, with occasional presentation of some of the forms we use to facilitate the reporting of the results of a given step. Obviously, strategic planning is not a form-filling exercise and there are significant dangers in over-specifying the planning process with detailed forms. We use those forms judiciously and we include them in here simply to allow for a more explicit understanding of the objectives of each step of our methodology.

1. Provide a framework for strategic decision making in manufacturing.
2. Assure linkage between business strategies and manufacturing strategy.
3. Conduct an initial manufacturing strategic audit:
   (a) to detect strengths and weaknesses in the current manufacturing strategy by each decision category, and
   (b) to assess the relative standing of each product line regarding the strategic performance measurements against the most relevant competitors.
4. Address the issue of product grouping:
   (a) by positioning the product lines in the product/process life cycle, and
   (b) by assessing commonality of performance objectives and product family missions.
5. Examine the degree of focus existing at each plant or manufacturing unit.
6. Develop manufacturing strategies and suggest allocation of product lines to plants or manufacturing units.

Figure 4.1: A Methodology for Structuring the Development of Manufacturing Strategy

4.1 A Framework for Strategic Decision Making in Manufacturing

A foundation of a manufacturing strategy is the conceptual framework that organizes the thought processes of the managers involved in the articulation of that strategy. The framework we use (which borrows heavily from Wheelwright [1984]) consists of defining the nine major categories of manufacturing strategic decision making (discussed in Section 3) and identifying the four manufacturing performance measures to address the objectives of the manufacturing strategy (discussed in the early part of Section 2.2). This framework is briefly summarized in Figure 4.2.

1. Major Types of Decisions Linked to the Manufacturing Function
   - Facilities (number, size, location, focus)
   - Capacity (amount, excess or tight capacity, expansion sequence, handling of peaks, competitive interactions)
   - Vertical Integration (direction, extent, capacity balance among stages)
   - Technologies and Processes (general or specific purpose, labor skills required, degree of automation, flexibility)
   - Scope/New Products (product breadth, rate of new product introduction, length of product life cycle)
   - Human Resources (incentives, skills, selection, training, security, unionization, participation)
   - Quality Management (definition of quality, quality improvement programs, responsibility, training, quality control, prevention and testing)
   - Manufacturing infrastructure (organization, planning and scheduling systems, control and information systems, inventory policies, forecasting, degree of centralization, lines of authority and responsibility)
   - Vendor Relations (vendor strategies, selection, qualifications, degree of partnership, use of competitive bidding, controls)
2. Measuring Manufacturing Strategic Performance
   - Cost (unit cost, total cost, life cycle cost)
   - Delivery (percentage of on-time shipments, predictability of delivery dates, response time to demand changes)
   - Quality (return rate, product reliability, cost and rate of field repairs, cost of quality)
   - Flexibility (product substitutability, product options or variants, response to product or volume changes)

Figure 4.2: The Basic Elements of the Framework for Manufacturing Strategy

4.2 Linking Business Strategies to Manufacturing Strategy

As we saw in Section 2, the strategic planning process is hierarchical in nature. First, the corporate level articulates the vision of the firm and its strategic posture; next, the business managers develop business strategies in consonance with the corporate thrusts and challenges; and finally, the functional managers provide the necessary functional strategic support.

It is important, therefore, to assure the proper linkage between the business strategies and the resulting manufacturing strategy. To accomplish this, we start by identifying the manufacturing requirements imposed by the set of broad action programs of each strategic business unit (SBU). Figure 4.3 displays a form for this purpose. The collection of manufacturing requirements represents the demands placed by the business managers on the manufacturing function. Occasionally, disagreements might occur between business and manufacturing managers as to the effectiveness or even feasibility of some of these manufacturing requirements. If concurrence cannot be reached by a direct process of negotiation, the nonconcurrence issues escalate to higher levels of the organization for resolution.

MANUFACTURING UNIT _____

SBU	BROAD ACTION PROGRAMS	MANUFACTURING REQUIREMENTS

Figure 4.3: Requirements Placed on Manufacturing by SBU's Broad Action Programs

4.3 Initial Manufacturing Strategic Audit

At this early stage of the manufacturing strategic planning process, it is desirable to perform a strategic audit on the current manufacturing strategy. Although analysis in subsequent stages of this methodology will contribute to the development of a more thorough diagnosis, we believe it is useful, at the outset, to extract from the participating managers their feelings about the status of their manufacturing function.

This initial audit has two objectives. The first is to assess the strengths and weaknesses of the existing manufacturing policies in each of the nine manufacturing strategic categories. Figure 4.4 presents a format for this evaluation. The second objective is to establish the competitive standing of each major product line according to the four measures of manufacturing performance. Figure 4.5 suggests how to conduct that evaluation. Notice that each product line compares itself against the leading competitors in each strategic dimension, and also establishes the relative importance of each dimension.

4.4 Addressing the Issue of Product Grouping

One of the most difficult problems in manufacturing planning revolves around the issue of product grouping. Even in relatively small firms, one encounters an extraordinary proliferation of manufactured items. Since it is impossible and undesirable to deal with each item in isolation, one has to find ways to aggregate individual items into product groups. This step in our manufacturing strategy methodology sheds light on the question of aggregation: how to group product lines into strategically sensible product groups that share common attributes?

We attack this question through two different analytical devices. The first is the product-process life cycle matrix, originally proposed by Hayes and Wheelwright [1979]. This matrix, depicted in Figure 4.6, positions each product line in a two-dimensional grid. The horizontal axis represents the

MANUFACTURING UNIT _____

DECISION CATEGORY	DESCRIPTION OF PAST POLICY	STRENGTHS	WEAKNESSES
FACILITIES			
CAPACITY			
VERTICAL INTEGRATION			
PROCESS/ TECHNOLOGIES			
SCOPE/ NEW PRODUCTS			
HUMAN RESOURCES			
QUALITY MANAGEMENT			
MANUFACTURING INFRASTRUCTURE			
VENDOR RELATION			

Figure 4.4: Characterize Your Present Manufacturing Policies Regarding the Strategic Decision Categories

MANUFACTURING UNIT _____

PRODUCT LINE	EXTERNAL PERFORMANCE MEASURES								LEADING COMPETITORS
	COST		QUALITY		DELIVERY		FLEXIBILITY		
	IMPORT.*	PERFOR.**	IMPORT	PERFOR	IMPORT	PERFOR	IMPORT	PERFOR	

* IMPORT. = IMPORTANCE
** PERFOR. = PERFORMANCE

ALLOCATE 100 POINTS ACROSS IMPORTANCE MEASURE. USE THE NOTATION = (STRONG DISADVANTAGE, - (MILD DISADVANTAGE), E (EVEN), + (MILD ADVANTAGE), ‡ (STRONG ADVANTAGE) FOR PERFORMANCE RANKING.

Figure 4.5: Assessment of Relative Importance and Performance of Each Product Line

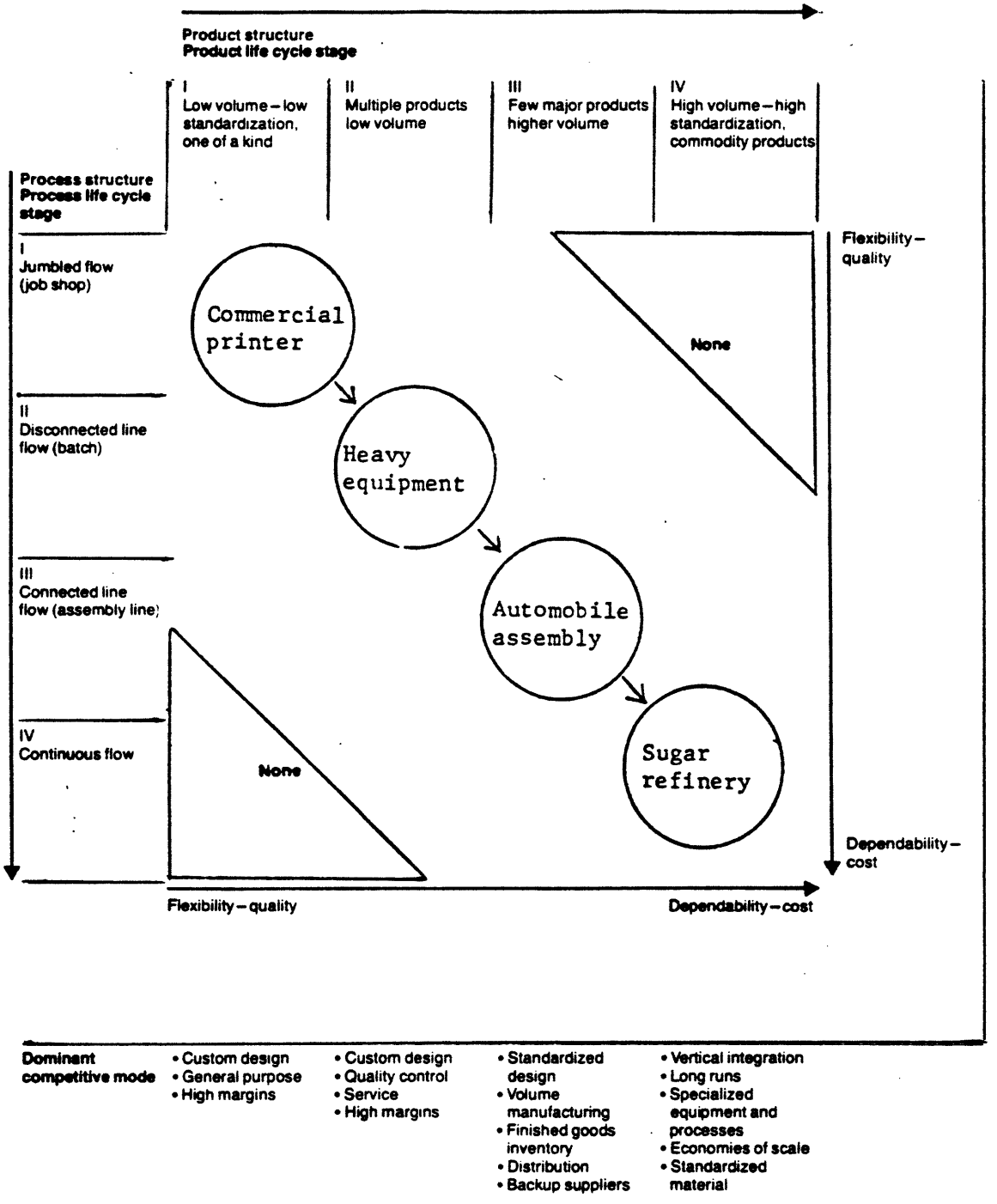
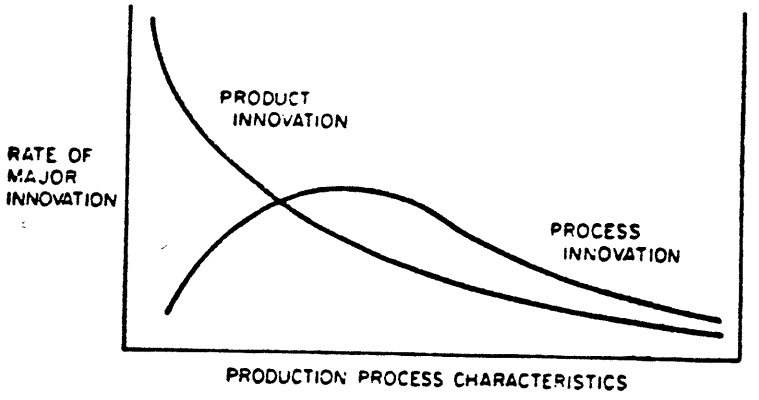


Figure 4.6: The Product-Process Life Cycle Matrix
(Source: Hayes and Wheelwright [1979])

stages in the product-life cycle. The managerial implications of the product-life cycle have long been recognized as a valuable tool for analyzing the dynamic evolution of products and industries (Hax and Majluf [1984b], Chapter 9). As depicted in Figure 4.6, this evolution is displayed as a four-phase process initiated by low-volume, one-of-a-kind products, and culminating in highly standardized, commodity products. Similarly, the production processes used to manufacture these products travel through a corresponding evolution. The process evolution usually starts with highly flexible, but costly, job shop processes, and culminates with special purpose, highly automated manufacturing processes.

The matrix illustrated in Figure 4.6 captures the interaction between product and process life cycles. For the purpose of our analysis it provides two useful insights. First, it can show which of the firm's product lines are similarly positioned within their product-process cycles. This generates obvious candidates to be members of homogeneous strategic groups. Second, and more important, it is useful for detecting the degree of congruency existing between a product structure and its "natural" process structure. The natural congruency exists when product lines fall in the diagonal of the product-process matrix. A product line positioned outside the matrix diagonal could either by explained by inadequate managerial attention, or by concerted strategic actions seeking to depart from conventional competitive moves. (Utterback [1978] provides an excellent analysis of the matching characteristics of product and process as they evolve from a "fluid" to a more "specific" state. Figure 4.7 summarizes that analysis.)

We use Figures 4.8 and 4.9 to establish product line groupings by product and market characteristics and map these groupings onto the product-process life cycle matrix.



Fluid Pattern	Transitional Pattern	Specific Pattern
INITIAL CONDITIONS		TERMINAL CONDITIONS
Product Innovation - Emphasis on maximizing product performance - Stimulated by information on user needs - Novelty or radicalness high - Frequency rapid - Predominant type is product rather than process	Product Innovation - Emphasis on product variation - Increasingly stimulated by opportunities created through an expanding technical capability - Predominant type is process required by rising volume - Demands placed on suppliers for specialized components, materials, and equipment	Product Innovation - Emphasizes cost reduction - Predominant mode is incremental for product and process - Effect is cumulative - Novel or radical innovations occur infrequently and originate outside productive unit - Stimulation arises from disruptive external forces
Production Process - Production process and organization is flexible and inefficient - Size or scale is small - General purpose equipment used - Available materials used as inputs - Product is frequently changed or custom designed	Production Process - Some sub-processes are automated creating "islands of automation" - Production tasks and control become more specialized - Process changes tend to be major and discontinuous involving new methods of organization and changed product design - At least one product design is stable enough to have significant production volume	Production Process - Production process is efficient, system-like, capital-intensive - Cost of change is high - Scale and facility market share is large - Special purpose process equipment used - Specialized input materials used, or vertical integration is extensive - Products are commodity-like and largely undifferentiated

Figure 4.7: The Relationship of Product Innovation and Production Process Characteristics
(Source: Utterback [1978])

PRODUCT LINE	PRODUCT/MARKET CHARACTERISTICS				
	BREADTH OF PRODUCT LINE	MARKET VOLUME	MARKET GROWTH	PRODUCT STANDARDIZATION	PACE OF PRODUCT INTRODUCTION

USE HIGH, MEDIUM, AND LOW (IF QUANTITATIVE MEASURES NOT AVAILABLE)

Figure 4.8: Assessment of Product Grouping

PROCESS STRUCTURE / PROCESS LIFE CYCLE STAGE	PRODUCT STRUCTURE / PRODUCT LIFE CYCLE STAGE →			
	I LOW VOLUME-LOW STANDARDIZATION ONE OF A KIND	II MULTIPLE PRODUCTS LOW VOLUME	III FEW MAJOR PRODUCTS HIGHER VOLUME	IV HIGH VOLUME-HIGH STANDARIZATION COMMODITY PRODUCTS
JOB SHOP				
BATCH				
ASSEMBLY LINE				
CONTINUOUS FLOW				

Figure 4.9: Position Each Product Line in the Product/Process Matrix

The second mechanism used to generate suggestions for product groupings is to identify families of product lines sharing similar competitive success requirements and product family missions. We recommend listing all of a firm's product lines, as indicated in Figure 4.10, to search for product clusters with similar strategic performance characteristics and missions. Carrying out this task after the product-process life cycle matrix exercise tends to produce additional insights for grouping products.

PRODUCT LINE	COMPETITIVE SUCCESS REQUIREMENTS					PRODUCT FAMILY MISSION
	COST	QUALITY	DELIVERY	FLEXIBILITY		
				VOLUME	PRODUCTION CHANGES	

USE HIGH, MEDIUM, AND LOW (IF QUANTITATIVE MEASURES NOT AVAILABLE)

Figure 4.10: Assessing Commonality of Performance Objectives and Product Family Missions

4.5 Asessing the Degree of Focus at Each Plant

Ever since Wickham Skinner [1974] wrote his now classic paper on the focused factory, manufacturing managers in the U.S. have been giving significant attention to this important, but simple, concept. The central idea of focused manufacturing is that a plant cannot do a large variety of very different tasks exceptionally well. A factory that focuses on a narrow product mix for a well-

defined market with a clear competitive objective, will outperform a conventional plant that attempts to do too many conflicting tasks with an inconsistent set of manufacturing policies.

To detect the degree of focus at each plant of a firm, we decided to use again the product-process matrix. This time we prepare one matrix for each plant, positioning within the matrix every product line manufactured at that plant. The resulting plot allows us not only to judge the degree of focus of the plants, but also to examine the degree of consistency between the products and the processes employed to manufacture them.

The final diagnosis can be summarized in a form like that exhibited in Figure 4.11.

PLANT _____

EXISTING PRODUCT LINES MANUFACTURED IN EACH PLANT OR OPERATING UNIT	STRATEGY FOR PRODUCT LINE	STAGE OF PRODUCT LIFE CYCLE	PROCESS TECHNOLOGY CURRENTLY USED

CONCLUSIONS: (COMMENT ON WHETHER THE PLANT OR OPERATING UNIT IS PRODUCT-FOCUSED, PROCESS-FOCUSED, OR HYBRID.)

Figure 4.11: Diagnosis of the Degree of Plant or Operating Unit Focus

4.6 Development of Manufacturing Strategies

The preceding analysis gives the necessary understanding of the basic issues involved in setting up a manufacturing strategy. The next step is to state strategic objectives, articulated through broad action programs, for each of the manufacturing strategic decision categories. Action programs may be targetted at one or more product groups. Figure 4.12 is helpful for performing this task.

DECISION CATEGORY	OBJECTIVES		BROAD ACTION PROGRAMS
	LONG RANGE	SHORT RANGE	
FACILITIES			
CAPACITY			
VERTICAL INTEGRATION			
PROCESS/ TECHNOLOGIES			
SCOPE/ NEW PRODUCTS			
HUMAN RESOURCES			
QUALITY MANAGEMENT			
MANUFACTURING INFRASTRUCTURE			
VENDOR RELATION			

Figure 4.12: Define Broad Action Programs for Each Manufacturing Strategic Decision Category

Each broad action program has to be supported by a set of specific action programs that can be monitored easily and whose contributions are measurable. Thus, for each manufacturing decision category, we suggest spelling out the information pertaining to its corresponding specific action programs, as indicated in Figure 4.13.

A final analysis to be performed is to consider the reallocation of products to plants, if the previous analysis of products and plants suggest such a change. Figure 4.14 represents the summarized output of the product-plant allocation exercise.

DECISION CATEGORY _____

PROGRAM DESCRIPTION	PRIORITY	COST	MANPOWER REQUIREMENTS	SCHEDULED COMPLETION	RESPONSIBILITY

CATEGORIZE AS FOLLOWS:

A = ABSOLUTE 1ST PRIORITY - POSTPONEMENT WILL SIGNIFICANTLY HURT OUR POSITION,
B = HIGHLY DESIRABLE - POSTPONEMENT WILL ADVERSELY AFFECT OUR POSITION IN THE MARKET,
C = DESIRABLE - IF FUNDS WERE TO BE BE AVAILABLE TO ENHANCE OUR POSITION

Figure 4.13: Define Specific Action Programs to Support the Broad Action Programs for each Manufacturing Strategic Decision Category

PLANT OR OPERATING UNIT / PRODUCT LINES							

Figure 4.14: Proposals for Allocation of Product Lines to Current Plants or Operating Units and Potential New Plant(s) or Operating Unit(s)

5. Conclusion

The manufacturing function can be a formidable weapon to achieve competitive superiority. After a set of painful experiences in a wide range of industries, this is clearly understood by most American managers today. With this work, we have attempted to provide a conceptual framework as well as a set of pragmatic methodological guidelines to design a manufacturing strategy for a business firm.

We recognize that different companies will pursue different paths to manufacturing strategy design. However, we have tried to capture in our framework and methodology the essential elements that must be considered by any firm attempting to design a manufacturing strategy.

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