Market Driven Manufacturing : A Requirements Analysis

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In this paper, Kunal Basu and Pankaj Chandra develop a framework for market driven manufacturing that identifies market conditions and success requirements for determining the necessary manufacturing focus. These are then mapped on to specific operational practices. Managerial and research implications of the above are presented followed by an illustrative network flow model that plans manufacturing capabilities under different marketing environments.

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Introduction

The challenge of enhancing industrial competitiveness has led to islands of excellence within different functional domains of industrial organizations. More recently, emphasis has been accorded on integrating functional domains into comprehensive decision support systems that satisfy simultaneously the requirements of individual functions while serving the firm's overall objectives. More and more, global success in terms of competitiveness is seen as derived out of successful integration of multiple tasks rather than isolated excellence in specific endeavours (Drucker, 1990).

An often encountered scenario involves the consideration of marketing requirements and manufacturing goals. For example, traditionally, sales organizations have viewed inventory as providing the necessary flexibility in servicing varied customer needs. Needless to say, the latter works against the effective utilization of manufacturing resources and contributes to poor cash flow. The benefits of synchronizing decisions such as the above have led to the notion of "market driven manufacturing" that takes into account a firm's competitive requirements and attempts to translate them into effective and profitable manufacturing practices. Toyota's development of just-in-time philosophy, for example, was aimed at coordinating product line decisions with the choice of shop floor technologies, extent of vendor support, and human resource structures. The benefits have prompted companies around the world to adopt similar approaches. A critical advantage of the said coordination is the ability to compete on the basis of shorter lead time. In one Northern Telecom division, linking manufacturing process improvement, new product introduction, and change in procurement policies led to almost 80 per cent reduction in one product's manufacturing lead time (Merrills, 1989) with accompanying reduction in receiving cycle by 97 per cent.

In recent literature, there appears to be a fairly broad recognition of the need for integration between the marketing and manufacturing functions. Shapiro

(1977), for example, lists eight common complaints that arise from insufficient appreciation of mutual roles and functions pertaining to inventory levels, lead times, costs, quality, product variety, service, and new product projects. Similarly, Montgomery and Hausman (1986) claim that appropriate and shared understanding of a company's strategic objectives is necessary for purposes of determining appropriate trade-offs within the two functions, for communication and cooperation. According to Crittenden (1991), the basis of conflicts can be traced to independent decision-making, without appropriate organizational and planning systems that ensure integration. There appears to be two general approaches towards addressing interface issues with respect to marketing and manufacturing. First, some studies of inter-functional partnerships have often focused on corporate level strategies without adequate linkage to actions that take place in the market place and operational networks (Crittenden, 1991; Hausman and Montgomery, 1990). A second stream of studies looks to incorporate marketing variables in existing (and sometimes new) models of production planning with joint optimization of the two functional objectives (Eliashberg and Steinberg, 1991; Abad, 1987; Pekelman, 1974; Chandra and Fisher, 1994). An obvious limitation of the latter is the inability to trace the impact of specific decisions on the overall strategic orientation of a firm, or even in the formulation of long-term strategy that takes into account changing market conditions and manufacturing needs.

While the utility of market driven manufacturing has been broadly appreciated, questions remain with respect to specifying a decision framework that actually allows a manager to identify the sequence of decisions that would serve the desired coordination. That is, while in principle it is attractive to seek integration, the literature hitherto does not provide the necessary interface that translates market requirements to specifics of manufacturing tasks. Toyota's decision to merge sales and manufacturing functions was aimed at reducing the business' total cycle time (Stalk, 1990). Yet what remains to be known is how manufacturing changed with market development and growth strategies. What is necessary then is to develop a framework that identifies key domains within the marketing-manufacturing interface along with key issues within each. In the next section, we present such a framework that organizes interface issues within three domains: strategic complementarities, infrastructural requirements, and value-delivery decisions. Next, we focus on a specific domain, that of value-delivery decisions, and suggest a market driven manufacturing decision framework. This is followed by an operational practice map consistent with marketing/manufacturing objectives. Finally, managerial and research issues are presented.

Marketing-Manufacturing Interface

Three key domains reflect the majority of issues within the marketing-manufacturing interface (Table 1). Strategic complementarities address a firm's strategic goals with respect to market presence and internal capabilities. Key issues here concern: (a) the choice of marketing strategies involving products and processes (Fitzsimmons *etal.,* 1990; Hauser and Clausing, 1988; de Groote, 1991); (b) the analysis of risk and uncertainty (Kurawarwala and Matsuo, 1993); and (c) innovation (Gerwin, 1993; Cohen, Eliashberg and Ho, 1992).

Analysis of infrastructure requirements to facilitate the interface has involved: (a) issues pertaining to organizational design (Radhakrishna and Varadarajan, 1991; St. John and Rue, 1991; McAllister, 1991); (b) performance evaluation, reward and incentive systems (Kamath *et al,* 1993; Porteus and Whang, 1991; Crittenden, 1992; Johnson, 1990); (c) interfunctional communication (Gold, 1991; Griffin and Hauser, 1992; Nobeoka and Cusumano, 1992); and (d) accounting procedures (Kaplan, 1990). While the above two domains are essential and may be viewed as preconditions for successful integration, little is known regarding the real bases or indices that would be useful in developing marketing-manufacturing correspondence once mutual strategic objectives have been defined, and the organization and communication systems for joint decision making are in place.

Within the realm of value delivery decisions, the key issues pertain to: (a) the correspondence between market requirements and manufacturing capabilities; and (b) identifying manufacturing practices consistent with strategic objectives. While a few studies (Karmarkar and Lele, 1989; Fitzsimmons *et al.* 1990; Hauser and Clausing, 1988) have attempted to address interface decisions, problems remain in defining a framework within which such decisions are made, and also in specifying the elements of functional interface.

Karmarkar and Lele (1989) identify relationships between two key manufacturing parameters, cost and capacity, and market variation in demand, most notably through promotions. This approach is important in identifying opportunities for specific marketing actions given certain manufacturing conditions and vice versa. However, in the absence of a comprehensive framework, the entire range of market/competitive conditions and their concomitant manufacturing requirements remain unexplored. Fitzsimmons *et al.* (1990) identify two key design variables (complexity and innovation), relate these to underlying dimensions of competition (price, speed, flexibility, performance, feature, reliability, conformance, durability, serviceability, aesthetics, and perceived quality) and draw linkage with manufacturing and marketing strategies. While the consideration of design strategy in conjunction with manufacturing and marketing represents a significant contribution towards suggesting functional interface, the treatment remains somewhat general in that it does not provide specifications of the elements that contribute towards the same. Further, it is not clear that every potential competitive environment can be characterized by a unique set of complexity and/or innovation conditions. For example, as a brand moves from its introduction to the growth stage of its life cycle, it may face new market challenges such as increased consumer demand without any accompanying design changes. This would require changes in manufacturing strategies without further adaptation in design. The suggested framework is probably most useful in the case of significant design changes as in new product introduction. To the extent that large number of small and medium size companies face evolving market situations for an existing line of products, mapping these with appropriate manufacturing actions would require close attention. A similar approach relating customer perception of quality and their design specifications is presented by Hauser and Clausing (1988). Once again, specific manufacturing practices that will yield the required design specifications thereby enhancing the product's competitiveness are not discussed. The objective, then, is to develop a decision framework for market driven manufacturing by :

* identifying competitive success requirements across a range of market conditions;
* relating the above to specific manufacturing objectives;
* specifying manufacturing practices that are approp riate in achieving these objectives, and providing a sequence of these that would provide options to a manager faced with certain competitive requirements and existing manufacturing resources; and
* suggesting a model for choosing a strategy involving manufacturing conditions required for specific market conditions.

The contribution of the above framework is in bringing together key marketing and manufacturing strategy objectives and linking them to appropriate manufacturing practices.

Marketing-Manufacturing: A Correspondence Framework

To specify requirements for a market driven manufacturing approach, it is important to identify those factors that contribute to market success and the corresponding manufacturing objectives. Consideration of the interface allows firms to either make strategic choices in terms of their marketing initiatives given existing manufacturing resources or develop appropriate manufacturing capabilities to pursue a chosen marketing strategy. Analysis of such a correspondence before embarking on new market ventures or technology acquisitions is likely to provide long-term sustainability of the process and profitability.

Before specifying market success requirements and the corresponding manufacturing foci, it is, however, important to consider potential growth strategies that a firm might undertake faced with specific environmental conditions. A generic approach considers growth opportunities in terms of three major classes: intensive growth, Integrative growth, and diversification (Kotler, 1988). In intensive growth, a firm seeks its opportunities within its current scope of operations, i.e., relying on existing product and market segments that are currently served. In seeking integrative growth, a firm attempts to integrate its own operations with other parts of the supply/distribution system. The third class, diversification, involves growth opportunities outside the scope of the present operations of the firm. Within each one of these general classes, specific growth varieties are available, selection of which renders salient specific market success requirements (Table 2). Choice within each set of growth strategies if made in isolation of existing manufacturing resources is likely to render implementation of these efforts problematic. Needless to say, the success of market driven manufacturing lies in the evaluation of the interface between the growth strategies and their success requirements.

Intensive Growth

Three potential approaches may be adopted within this strategic orientation. The first, market penetration, involves seeking increased sales for a firm's current line of products within the market segments that are currently served. Generally speaking, to succeed, it is necessary to encourage increased usage within the current segment of consumers, or encourage brand switching on the part of consumers who are loyal to competitors, or market the product to more segments albeit with similar profile as those currently served. A combination of the above may also enhance the level of sales and contribute to intensive growth. Success of any one of the above would lead to requirements of larger volumes and consequent ability to add capacity to manufacturing operations. However, increased consumption of the existing product may be brought about through manufacturing changes aimed at reducing cost which would allow reduced prices. Similarly, reduction in delivery time may enhance service capability and encourage intensive growth through brand switching or a firm's ability to reach disparate geographic segments profitably and reduce expensive inventory holdings. A second intensive growth strategy, **market development,** seeks to increase sales by marketing current products into new market segments. The latter could include new geographical markets, hitherto unserved segments (defined in terms of demographics, lifestyles or benefits sought), or different institutional markets. In doing so, the firm assumes new marketing tasks, i.e., developing marketing mixes (product, price, promotion, and distribution) that are different from those currently employed. Since product adaptation is not a key feature of this approach, it is feasible when the existing product quality is viewed as adequate by the new segments. However, cost and lead time reduction and capacity addition are germane in terms of both providing incentives to new customers and their serviceability. A third approach, **product development,** seeks increased sales through development and marketing of related, improved or new products for market segments currently served by the firm. Enhancing product quality could form the basis for competitive advantage in served markets, either through improved reliability or increased functionality. Product development may also assume the form of introduction of an innovation or substantial adaptation via current or new technologies to serve existing market segments. For both of the above, success requirements would be guided by the life cycle stage of the generic product category at which the firm considers entering the market. For an innovation, the product life cycle (PLC) stage would be that of introduction and market success requirements with corresponding manufacturing objectives would be different from that of an adapted product entering into a market place at a different stage of its life cycle. An extensive treatment of PLC stages and its manufacturing and marketing implications is presented following our discussion of integrative growth and diversification.

Integrative Growth

Integrative growth involves a firm's acquisition of its supply chain or its competitors. Control of supply chain could occur either through **backward integration** of raw materials/semi-finished goods/services vendors (i.e., inbound supply) or **forward integration** of transporters, wholesalers, and retailers (i.e., outbound supply). For either of these growth strategies to be successful, effective coordination of the supply chain is a manufacturing priority. Decisions relating the coordination of production and distribution activities, designing information systems, and physical movement of goods need to be focused upon.

A third approach to integrative growth, horizontal integration, seeks ownership or increased control of a firm's competitors. Two clear sets of success requirements are germane, one related to preacquisition and the other in the context of post-acquisition. Achieving a superior resource base is obviously a condition for acquisition of competitors. Manufacturing can play a critical role by providing competitive advantage in terms of excellence on cost, quality, flexibility, delivery dimensions and in terms of adequate capacity to meet the increasing customer demand rapidly. At the post-acquisition stage, the manufacturing challenge becomes one of coordinating multiple facilities (e.g.. plants, warehouses, etc.). Decisions regarding allocation of product lines, sales force, streamlining of sourcing and warehousing activities, and reorganization of resources (people and technology) warrant attention.

Diversification

When current market segments and product lines do not appear to provide adequate growth opportunities, a firm may decide to diversify into new product markets either through adoption of completely new technologies and marketing mixes, i.e., conglomerate diversification, through seeking synergies with existing technologies for a new market segment, i.e, concentric diversification, or synergies with served segments through new technologies, i.e., horizontal diversification. For each of the above, success requirements would depend on the life cycle stage of the product market at which the firm considers its entry. Consequently, an analysis similar to the PLC discussion is relevant here.

Product Life Cycle Considerations

In considering product development or diversification based strategies, it is necessary to analyse the life cycle stage of the product market at which the firm will enter. This is so because the nature of market characteristics is likely to be different at the various stages (Day, 1981) leading to varying emphasis on success characteristics and manufacturing objectives. As Wheelwright and Sasser (1989) describe, mapping the evolution of product lines allows a manager to identify both marketing and technological opportunities as well as challenges. Our treatment goes beyond the product-process matrix by delineating specific market success requirements and in describing the corresponding manufacturing foci. Table 3 describes four basic PLC stages, their respective market characteristics, desired strategic focus, and corresponding manufacturing emphasis.

The **introduction stage** generally signifies an innovation that serves either to enhance functional benefits over existing substitutes or increments in reliability, durability, serviceability, aesthetics, etc. (Fitzsimmons *et al,* 1990). The objective of innovation, thus, is to provide a quality advantage. At this stage, the market is usually characterized by low variety in product design and few, if any, competitors. In the absence of prolonged communications, awareness of the new product is usually low with consequent low sales volume. High costs of product development and marketing lead to negligible profits for the firm. The strategic objective at introduction is to expand the market by reaching the targeted customers and persuading them regarding the advantages of the new product. Evidently, the basis for success lies in the consumers' perception of superior benefit delivery. Associated with this process is the requirement of ensuring that manufacturing is able to design processes that will produce the product with the desired superior quality. For example, low first pass yields are often encountered at this stage especially in semiconductor based industries which result in considerable delays in new product introduction. There is a need to build quality into the product design itself while simultaneously choosing technologies, process controls, adequate training programmes, ensuring quality of vendor supplies, etc. to achieve the desired quality goals. In addition, the priority of ensuring superior quality through manufacturing actions is likely to reduce the manufacturing lead times thereby allowing speedy market introduction of new product ideas.

The early growth stage is characterized by a similar lack of variety in product design and early indication of competitive activity. Initial success leads to acceleration in sales volume albeit with low profits since marketing expenditures are likely to remain at fairly high levels. Achieving full market coverage or penetration is the appropriate strategic focus up to a point when a manager is able to assess the state of the market in terms of the likely nature of demand and competition. Accelerating sales volume will require additions in capacity both at the plant and in the distribution networks. As consumer awareness and preference increases, ensuring availability of the product at chosen outlets is imperative which requires the ability of the manufacturing facility to produce increasing volumes with lower delivery lead times. Traditionally, firms have relied on accumulation of inventory to service growing demand. However, the new competitive environment requires servicing markets with short delivery times and at low cost. As a result, firms need to consider reorganizing their manufacturing activities to enable them to reduce lead times and provide the desired volumes with minimal investment in inventory.

A critical decision at early growth concerns the nature of likely diversity in the product market with progression of the cycle. As competitors are attracted to a seemingly successful market, variety in the product both in terms of functionality and quality is likely to emerge to serve different consumer segments. Some product markets are characterized by a broad variety that requires a firm to compete in multiple segments with multiple brands that are differentiated from each other. Consequently, designing and manufacturing a varied product line is the key to success. In some other product markets, product variety is low with substantially large segments preferring a standardized product or a limited range. The latter affords the opportunity to a firm to specialize in a single or limited range of products without in vesting in differentiation. The above is a critical distinction, one that a manager needs to predict based on market trends and by analogy with related product markets in order to build service capabilities as the PLC progresses from early to late growth. A critical choice concerning manufacturing technology and practices needs to be made at this stage. A decision to go with dedicated manufacturing technology provides competitive advantage in a highly specialized product market with high volumes. However, it precludes the ability to enter into related product markets quickly at a later stage. Flexible technologies afford such advantages although with substantial start-up costs. The timing of this marketing/manufacturing decision is vital as implementation of the choice is likely to involve substantial investment in reorganization and training.

At the late growth stage, product differentiation and competitive activity are enhanced. This is also the period of high sales growth accompanied by high profits. In attempting to differentiate, a firm's manufacturing emphasis rests more heavily on managing costs once the decision to implement flexible technologies has been made. With either of the above types of technology modes, manufacturing practices need to be designed to provide adequate cost reduction. Dynamic competitive performance measures and appropriate reward and incentive systems need to be instituted at this stage as market forces tend to assume relative stability looking forward towards the onset of market maturity.

The maturity stage, typically, witnesses the highest degree of product differentiation, spurred by competition that is fairly well entrenched. Sales volume tends to decline with market saturation and profits decline as well as a function of increased competition. Defending a firm's market share, i.e., preventing brand switching, assumes strategic focus. It is interesting to note that manufacturing objectives at this stage mirror the relevant dimensions of competition. For most consumer and industrial products, it translates to competing on the basis of enhanced product quality, lower delivery time, and lower cost. As is apparent, capabilities related to flexibilities remain mostly unaltered here. However, incremental improvements on the shop floor, material substitutions, supply chain coordination, etc. could enhance the level of flexibility currently installed.

Attempts to rejuvenate the PLC often take the form of product adaptations and/or search for new market segments that provide the necessary growth opportunities. Interaction of process-product innovations often lead to the beginning of a new product life cycle. The chosen strategy for growth, of course, will depend upon the market success requirements and the technological resources available. The analysis, in essence, would be similar to that of our correspondence framework.

At the decline stage, generally speaking, product variety is reduced with the emergence of generic substitutes. This is also the stage when a shake-out leaves fewer competitors. Sales volumes and profits decline with rationalization as a key strategic target for the manager. From a manufacturing point of view, reduction in product variety leads to reallocation of human and material resources. The latter may take the form of sub-contracting the declining operations, merging operations from different facilities, and choosing a new mandate for the manufacturing function. The challenge may range from establishing new technologies, practices, and product to managing a mix of new and old technologies for current and new ventures.

Manufacturing Focus-Practice Map

While it is necessary to determine the manufacturing objectives corresponding to the key market success requirements, this translation does not guarantee successful implementation of the goals at all levels. To do so, a manager needs to identify appropriate technologies and specify alternative manufacturing practices aimed at utilizing these effectively. Once this task is completed, the engine for a market driven manufacturing would be in place. The manager would then need to design appropriate performance measures, develop manufacturing-sensitive accounting procedures, and implement intelligent human resource practices.

Table 4 outlines some of the relevant practices that lead to the respective manufacturing goals. This list is not meant to be exhaustive but rather a reflection of some of the important developments in manufacturing management. An operations manager is often faced with a decision problem regarding the choice of manufacturing management goals and the technology / practices that could be adopted to fulfil the goals. Needless to mention, in today's new manufacturing environment, TQM, set up reduction programmes, Concurrent Engineering, etc. need to exist at any plant if it is to remain competitive. However, all these practices cannot be implemented at the same time. Some are prerequisites to the others. Some of these, at times, can be implemented without additional allocation of resources in terms of new technology. Consequently, the decision problem of a manager, often, is to choose the sequence of practices that provides the optimum benefit. Philosophically, we believe that a firm should first try to utilize its existing technology effectively before embarking upon a major technology related solution to a manufacturing management problem. If a firm does not utilize its existing technology effectively, there is little guarantee that it will do so with any new technology. We will briefly discuss the manufacturing focus-practices map of Table 4 which has been developed with the above perspective in view.

The goal of **adding capacity** can be achieved in several ways. In most modern discrete part manufacturing practices, the cost of set up is essentially the opportunity cost of lost capacity. Consequently, any reduction in setups not only recovers this lost capacity but also provides an opportunity for positive cash flows. Effective batching or implementation of Quick Changeover Programmes (e.g., SMED of Toyota) provide the desired results. Use of flexible practices of overtime and/or subcontracting also provides a firm with the capability to manage changing demand volumes and to strategically define the core business. Finally, flexible technologies with negligible setup times enhance the production rate of the system thereby providing the capability to produce more units in the defined time. As noted earlier, the presented sequence of alternatives is aimed at modifying practices to achieve the desired goal before looking for technology as a solution.

To **reduce cost,** a firm must focus on identifying opportunities to eliminate waste. Lack of functional coordination results in considerable loss of resources since decisions to save resources in one area, when not coordinated with decisions in another area, often result in higher costs. Hence, considerable gains may be made by increasing functional coordination. Minimizing scrap and/or rework reduces waste in material cost as well as time spent on additional processing. TQM forces managers and workers to identify and control such expenditures. Moreover, the goal of reducing lead time, which in turn reduces the time over which cash flow is not positive, is further assisted by the presence of reliable materials and processes. Bhatnagar and Chandra (1994) have shown that synchronized lines need to first improve yields before removing other types of variability which directly affect manufacturing costs. Similarly, by reducing inventory or adopting advanced technologies, a firm can be effective in reducing operational costs.

The effort to **reduce delivery** time ranges from the choice of appropriate practices to reduce setup times to the acquisition of excess capacity for reducing the impact of setups. The choice of an alternative would depend on the resources that can be appropriated for such an improvement as well as the stage of any delivery reduction programme that may be currently under implementation. For instance, it would be meaningless to implement a cellular manufacturing layout where an operator can operate both a CNC machine and the material handling robot until the operator is cross trained to perform both tasks. Choosing appropriate batch sizes, improving first pass yields, integrating design operations with manufacturing, streamlining layout, etc. are some of the other methods that have shown to reduce lead times.

The simple task of clearly defining shop floor related procedures goes a long way in preventing confusion that often leads to poor workmanship. **Enhancing quality** begins with placing decision-making in the hands of people who are responsible for meeting the manufacturing objectives. TQM as a manufacturing philosophy aims at such an empowerment. Concomitant with this endeavour is the responsibility of the firm to train these decision-makers, the true assets, with respect to the tools of their specific decision-making tasks. Moreover, the compression of consumption time (i.e., setup, waiting, and process times) will assist managers in meeting delivery schedules thereby improving the service quality of a firm. Finally, by improving procedures (e.g., SPC) and technologies (e.g., sensors, etc.) for monitoring conformance to specifications or for detecting faults, a manager can enhance quality levels on the shop floor. The recent practice of certifying vendors for an acceptable level of incoming quality of raw materials/ semi-finished products not only improves quality levels but also leads to substantial savings in inspection time.

The process of enhancing flexibility begins with the task of ensuring that the work force is multi-functional. Often, a key impediment is the multitude of job classifications that restricts cross training of workers across functions. Reduction of setup times (via conversion of internal to external setups) and modular addition of capacity enhance the ability of the plant to meet the customers' changing demand (in terms of style, functionality, and volume) quickly. Beyond a certain point, technology has to be used in reducing setups substantially or even eliminating them. Flexible technologies for both production and material handling are used to render operations more flexible.

Attempts to **enhance supply chain coordination** should start with synchronizing the decisions that link the various entities of the supply chain, i.e., the vendors, the core manufacturer, and the distributors. Such a coordination, e.g., of procurement, production, and distribution quantities, could not only lead to reduction in costs but also to lower inventories in the entire system. JIT reduces waste in the entire chain by coordinating decisions using a pull mode of operation. New technologies like EDI improve the efficiency of communicating information. By minimizing the delay in the availability of information, it assists in integrating the activities in the supply chain by reducing the need for investment in wasteful resources, e.g., inventory (which is often used to manage uncertainty due to delay). Likewise, CIM provides the ability to evaluate the impact of a decision in one functional domain on another thereby better coordinating the activities across the supply chain. The above mentioned manufacturing practices, among others, give a firm the competitive edge or superior capabilities required to achieve the resource base needed to bring about horizontal integration of the market. As can be seen, such an ability is developed via excellence on various manufacturing goals discussed above.

Finally, the objective of coordinating multiple facilities requires adequate attention to decisions regarding the re-allocation of product lines among different plants to take advantage of product, process, and resource commonality, to rationalize investments, and to enhance market serviceability. Moreover, by developing an integrated decision making framework for production and supply (both inbound & outbound), management planning across different facilities could be coordinated effectively. Absence of such a system could lead to excessive build up of inventories, longer lead times, idle systems, duplication of tasks, etc.

In the next section, the impact of coordinating manufacturing practices to be consistent with marketing-manufacturing foci are discussed from both a managerial and a research perspective.

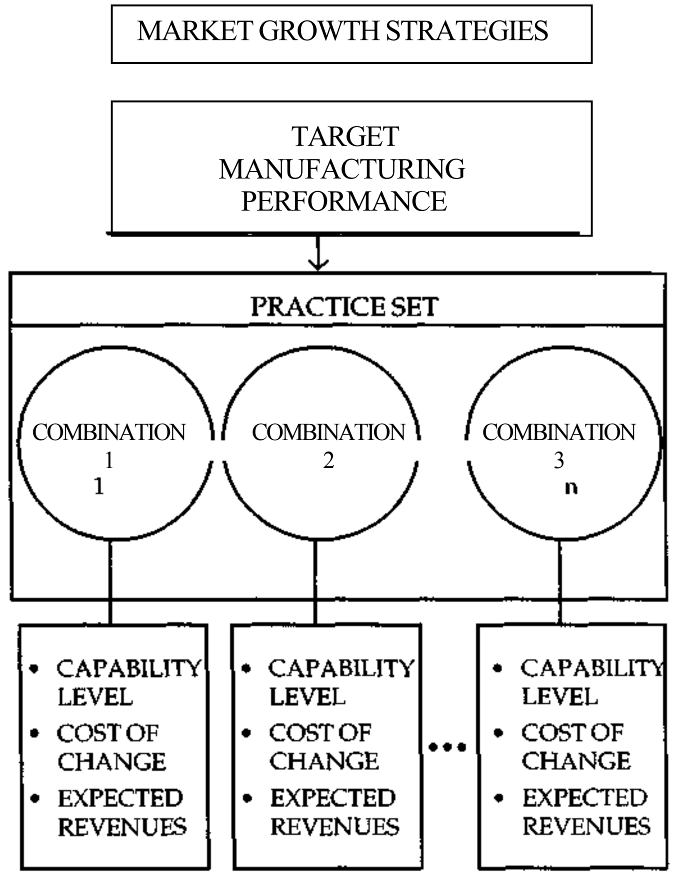
Managerial and Research Implications

The challenge faced by a manager is to anticipate future market conditions and design manufacturing systems accordingly. The decisions are complex because any future change in strategy would necessitate operational changes at the plant level that are costly in terms of resources and time. Consequently, a decision framework that incorporates present as well as future market requirements and their corresponding manufacturing capabilities is likely to be useful in sustaining long-term competitiveness and profitability.

Figure 1 provides a sequence of decision-making steps for market driven manufacturing. Let us suppose that a firm wishes to seekmarket growth through product development efforts (i.e., to develop a new brand with improved functionality/quality for a market segment currently served). In doing so, the firm needs to take into account the PLC stage of the new brand's product-market. If the product is an innovation, the said stage would be that of INTRODUCTION. However, if the product market has been extant, the manager needs to determine appropriate market orientations consistent with the present stage when entry is being contemplated. As Table 3 shows, the choice of strategy will lead to identification of the appropriate focus. For example, if the product-market is at the onset of MATURITY, specific capability levels of quality (say, durability of 2 years), delivery time (say, 30 days) and cost (say, not more than $1000) will be needed to compete effectively. Several combinations of manufacturing practices can be employed to achieve or exceed the above at varying levels of resource requirements (i.e., cost of changing existing operations). Needless to say, these practice combinations will also be associated with expected revenue levels. For a manager, at the beginning of the MATURITY stage, the challenge is to choose strategic directions with respect to manufacturing capabilities that will allow profit maximization over the two remaining stages of the life cycle of the product-market. This leads to the following research challenges that must be addressed for successful implementation of market driven manufacturing.

Three key directions may be identified in terms of a research agenda for the future: decision models, interface evaluation, and interface re-design. A market driven manufacturing framework requires the development of decision models to facilitate the process of planning within the functional domains and their integration. Research is needed to: (a) specify analytical models that determine the optimal mix of manufacturing capabilities under different market requirements. While it is important for a manager to identify convergence of

Figure 1: A Market Driven Manufacturing Decision Flow



marketing and manufacturing objectives and relate these to specific practices (as described in the above sections), it may be worthwhile to develop more sophisticated decision tools that allow determination of key manufacturing parameters. These would be specially useful in determining precisely both current as well as future manufacturing requirements. In Appendix 1 we present a network flow model as an illustration of the above; (b) develop decision frameworks that take into account alternative approaches towards determining market requirements. While the PLC based approach relied upon in this paper is commonly utilized, there may be alternative formulations that incorporate competitive strategies and customer based needs (e.g., leader/follower/challenger/nicher strategies and their respective market support needs); (c) evaluation of the impact of a particular action on the market and the manufacturing performance of a firm. These include analysing the impact of early or late market entry, repositioning decisions, changes in product line, etc. on dimensions such as market share, profitability, manufacturing capacity, etc; and (d) management of the interface for a variety of environments such as multi-product (at varying life cycle stages) or multi-plant facilities (with varying capabilities).

In the area of interface evaluation, research needs exist in: (a) defining the appropriate parameters that need to be considered for purposes of jointly optimizing manufacturing and marketing objectives. Empirical research could contribute to our understanding of the level of correlation between different functional decisions and parameters; (b) developing measures that evaluate and monitor the process of managing an interface from one market condition to another (e.g., as a firm moves from the growth to the maturity stage of a product, certain infrastructural and human resource related changes may be warranted for adapting competitive capabilities, with concomitant measurement of the process of change). In addition, it may be necessary to conceptualize indices that capture the interaction between functions both at levels of joint inputs and outputs; and (c) designing evaluation procedures for selecting practices that may serve a given manufacturing focus.

Within interface re-design, it is necessary to take into account existing practices that characterize inter-functional relationships within firms and the process of initiating change. Empirical studies that analyse the factors that contribute to conflict or absence of functional integration will enhance our understanding and facilitate selection of processes that are necessary to achieve an efficient interface.

Our analysis of market driven manufacturing has led to a strategic framework incorporating growth strategies and the PLC as indications of market requirements and consistent manufacturing objectives. In addition, a set of practices has been proposed to achieve the latter. Managerial implications for enhancing efficiency of the interface as well as a set of research questions are raised. An illustration of an analytical model that designs a market driven manufacturing plan has been presented in Appendix 1.

Table 1: Marketing-Manufacturing Interface

Domains	*Issues*
I. Strategic Complementarities	Choice of Markets, Products, and Processes Risk and Uncertainty Analysis-Innovation
2. Infrastructure Requirements	Organizational Design Performance Evaluation, Reward and Incentive System Interfunctional Communication Accounting Procedures
3. Value Delivery Decisions	Marketing Strategies and Success Requirements Manufacturing Focus and Appropriate Practices

Table 2: Marketing-Manufacturing: A Correspondence Framework

Market Growth Strategies	*Market Success Requirements*	*Manufacturing Focus*
I. Intensive Growth		
Market Penetration	Increase Usage Encourage Brand Switching Market to More Segments (with similar profile)	• Add Capacity • Reduce Cost • Reduce Delivery Time
Market Development	Market to New Segments	• Add Capacity • Reduce Cost • Reduce Delivery Time
Product Development	*Develop and Market Closely Related, Improved, or New Product for served Segment*	• Enhance Quality • Choose Focus Based on Product Life Cycle Stage

(Table 2 Contd.)

Market Growth Strategies	Market Success Requirements	Manufacturing Focus
II. Integrative Growth		
Backward Integration	Enhance Control of Inbound Supply Chain	Enhance Supply Chain Coordination
Forward Integration	Enhance Control of Outbound Supply Chain	Enhance Supply Chain Coordination
Horizontal Integration Reduction of Competitors	Enhance Market Share through Achieve Resource Base	Develop Superior Capabilities to (Pre-Acquisition) Coordinate Multiple Facilities (Post-Acquisition)
III. Diversification		
Concentric Diversification	• Seize New Product-Market Opportunities through Technology/ Marketing Synergies	Choose Focus Based on Product Life Cycle Stage
Horizontal Diversification	• Seize New Product Opportunities for Served Segments through New Technologies	Same as Above
Conglomerate Diversification	• Seize New Product-Market Opportunities through New Technology/Marketing Mix	Same as Above

Table 3 : PLC Stages, Market Characteristics, Strategic Focus and Manufacturing Focus

PLC *Stage*	*Market Characteristics*	*Strategic Focus*	*Manufacturing Focus*
Introduction	Basic Product Design Few (if any) Competitors Low Sales Volume Negligible Profit	Expand Market	Ensure Superior Quality
Early Growth	Basic Product Design [1] Entry of Competitors [1] Accelerating Sales Volume [1] Low Profit	Market Penetration	Add Capacity [1] Reduce Delivery Time [1] Decision Concerning Flexibility or Dedicated System [1] Reduce Cost
Late Growth	[1] Increasing Product Differentiation [1] Active Competitors [1] High Sales Volume • High Profit	Differentiation/Cost -Leadership	
Maturity	[1] High Product Differentiation [1] Entrenched Competition [1] Slow Sales Volume [1] Declining Profit	Defend Market Share	[1] Enhance Quality [1] Reduce Delivery Time [1] Reduce Cost
Decline	Reduction in Product Variety Fewer Competitors Declining Sales Volume Low Profit	Rationalization	Reallocation of Resources and Opportunities

Table 4: Manufacturing Focus - Practices Map

Manufacturing Focus	*Practices*						
Add Capacity	Reduce Setup Time (Quick Changeover Programmes)	Flexible Labour Practices/ Subcontracting	Enhance Production Rate (Technology)				
Reduce Cost	Functional Coordination	Reduce Scrap/Rework (TQM)	Reduce Lead Time (Synchronized Manufacturing; JIT)	Lower Inventory (Better Forecasting; JIT)	Advanced Technology (Reduction of Space/Overhead/ Labour/ Inventory)		
Reduced Delivery Time	Reduce Batch Sizes	Cross Functional Training	Better Layout (Group Technology)	Reduce Setup Times	Higher First Pass Yield Kaizen	Concurrent Engineering/	Build Excess Capacity
Enhance Quality Enhance Flexibility	Better Shop Floor Procedures Cross Training of Workforce	Empowerment of Workers (TQM) & Better Training Reduce Setups (Waste)	Vendor Certification Modular Addition of Capacity	Reduced Lead Time (on Time Delivery Schedules) Flexible Technologies (FMS)	Improved New Monitoring Technologies (Sensors, Bar-coding, Process Control)		
Enhance Supply Chain Coordination	Vendor Linkage	Production-Distribution Integration	New Technologies (EDI)	JIT	Computer Integrated Manufacturing		
Develop Superior Capabilities to Achieve Resource Base (Pre-Acquisition)	Manufacturing practices that provide competitive advantage consistent with success requirements in served product markets (i.e., through focus on excellence on cost, quality, flexibility and delivery dimensions and on capacity)						
Coordination of Multiple Facilities (Post- Acquisition)	Production Line Allocation	Production Commonality	Integrated Production and Supply Management				
Based on PLC Stage	Practices contingent on PLC stage of product (see Table 3)						

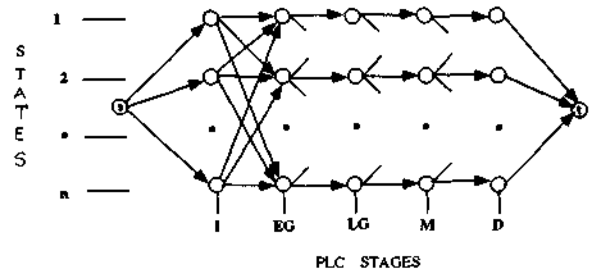
Appendix 1: Market Driven Model For Manufacturing Strategy

A key objective for a manager is to maximize profits over the entire life cycle of a product. In order to do so, it is necessary to make ex-ante decisions regarding key manufacturing variables (capacity, cost, quality, delivery, and flexibility) that are required at different stages of the life cycle, i.e., faced with changing market conditions. At any given stage, say introduction, the manager not only needs to decide his or her manufacturing requirements for the present, but also for the forthcoming market requirements of the next stage, i.e., growth. Thus, the choice of an optimal path connecting stage requirements must be made as part of the strategic plan.

We present a network flow model which determines the optimal level of manufacturing capabilities (operationalized as **states** corresponding to levels of capacity, cost, quality, delivery, and flexibility) for differentmarket conditions (operationalized as **stages** of the PLC : introduction, early growth, late growth, maturity, and decline) faced by this product. The above decisions are constrained by the availability of resources at different stages.

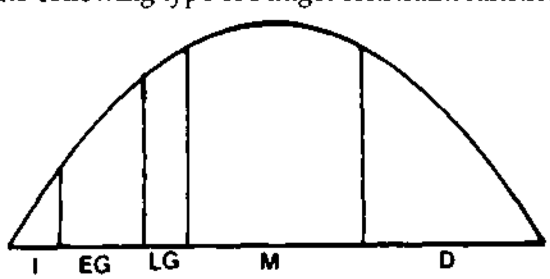
Figure 2 shows the strategy network including different stages of a PLC and alternative manufacturing capabilities as represented by states, associated with each of the five stages. As the product market moves through each of the stages, a manager is faced with the option of either maintaining the current level of manufacturing capabilities (capacity, cost, quality,

Figure 2: A Market Driven Manufacturing Strategy Network

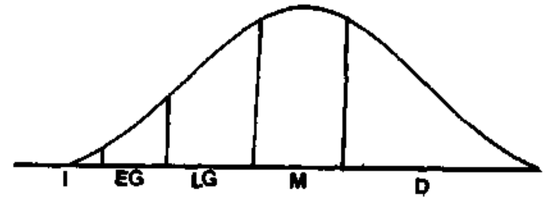


delivery, flexibility) or changing one or more of these capabilities, i.e., moving to another state. For example, as demand for a particular type of product increases at early growth, a manager may choose to enhance capacity but maintain current levels of other manufacturing capabilities. The network model allows the manager to determine an optimal strategy for modifying manufacturing capabilities over the entire life cycle of that product market. In other words, we determine the levels of capacity, cost, quality, delivery, and flexibility that the plant should possesr at different stages of the PLC to meet the firm's market plans. We make the following assumptions with respect to the model:

1. An estimate of time intervals between PLC stages is available to the manager based on prior experience with related product categories.
2. The resources available for making manufacturing related investments is known at the beginning of each PLC stage and changes over subsequent stages as a function of generated revenues. Based on strategic resource allocation models, we assume the following type of budget constraint function.



3. The cost involved in making manufacturing changes is assumed to increase between states and stages though not necessarily proportionately. This is because some stages may require more extensive changes in manufacturing capabilities than others (see Table 3).
4. Revenues to the firm are expected to change over PLC stages and specific manufacturing states as discussed in Table 3. A likely function is shown below:



Let a stage p and state q be denoted by node i in the directed graph, $G = (V,E)$ shown in Figure 2, where $|V| = N$ and $|E| = M$. N is the number of nodes and M is the number of connected arcs. Then define A_i to be the set of nodes j directly connected to node i and which have an arc of the formi-j (i.e., emanating from node i). Also, let S_p be the set of all nodes associated with stage p (including the source and sink stages). i,j, and k are indices for nodes.

Parameters

c_{ij} = cost associated with moving from node i to node j

r_{ij} = revenue associated with moving from node i to node j

B_i = external infusion of capital at node i

f = per cent of profit available from previous stage

Variable

$$X_{ij} = \begin{cases} 1 & \text{if a path from } s \text{ to } t \text{ includes the arc connecting nodes } i \text{ and } j \\ 0 & \text{otherwise} \end{cases}$$

The problem of determing the optimal states for PLC stages can be formulated as :

$$\text{Max} \sum_i \sum_j (r_{ij} - c_{ij}) X_{ij}$$

subject to

$$\sum_{i:j\in A_i} X_{ij} - \sum_{k:k\in A_j} X_{jk} = 0 \qquad \forall j \qquad (1)$$

$$\sum_{\substack{j\in S_p \\ k:k\in A_j}} c_{jk} X_{jk} - f \sum_{\substack{j\in S_p \\ i:j\in A_i}} (r_{ij} - c_{ij}) X_{ij} \le B_p \qquad \forall p \qquad (2)$$

$$X_{ij} \in \{0,1\} \quad \forall i,j \quad (3)$$

Constraint 1 is the flow conservation constraint at each node in the network. It establishes a unique strategic path, i.e., once a state node is selected, subsequent paths (or arcs) would emanate out of this node alone for the selection of a state in the next PLC stage. Constraint 2 represents the budget restriction. The budget at each stage comprises a fraction of the profits from the previous stage as well as fresh allocation of capital by the firm. At introduction, of course, the budget comprises purely of a firm's capital allocation. Constraint 3 enforces the binary restriction. The objective function maximizes the flow of profit between the source (s) and the sink (t) nodes.

The above reflects an initial attempt in developing a framework for determining manufacturing capabilities over an extended time horizon. The stochastic nature of events may call for executing the model on a rolling horizon basis, and incorporating the impact of uncertainty in the cost, revenue, and budget functions.

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