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Information systems in manufacturing for competitive advantage

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INFORMATION SYSTEMS IN MANUFACTURING

FOR COMPETITIVE ADVANTAGE

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by coursework.

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ABSTRACT

Opportunities for competitive advantage using manufacturing information systems are matched to Porter's (1980) theory of competitive strategy. A number of theories of corporate strategy are discussed with special reference to those which deal with competitive advantage. Porter defines three generic strategies for a company : cost leadership, differentiation and focus; and a means of examining potential competitive advantage in a company, the value chain (1985). The so-called islands of automation each automate a specific area of the manufacturing process and can be integrated via computer integrated manufacturing. The benefits of manufacturing information systems are numerous. Seven opportunities for manufacturers using information systems are identified : cost savings, higher quality output, quicker responses to customer needs, customisation of products, economies of scope, and the use of interorganisational and product maintenance systems. The nature of the competitive advantage which each of these opportunities makes available is defined using the value chain theory. The information system/s which can be used by a company which has adopted one of the three generic corporate strategies are then identified.

DECLARATION

I declare that this report is my own, unaided work. It is being submitted in partial fulfilment of the requirements of the degree of Master of Commerce (by coursework) in the University the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in any other university.

Andrew Lyndall Brown

25th day of September, 1989.

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CHAPTER ONE

INTRODUCTION

The fading of the post World War II industrial boom in USA in the late 60's showed up the popular myth of American manufacturing invincibility. Suddenly, the much maligned Japanese were able to produce better quality products at lower prices than their counterparts in the USA. This superiority has continued, in certain industries, to the present day. A common feeling among large American corporations seemed to be that it was impossible to compete with Japanese products without sending their manufacturing offshore to make use of cheaper labour rates. However, not all companies responded in this way and many have studied the management principles employed by Japanese companies in order to improve their own ability to compete. Particularly significant results of such studies are the new emphases on product quality and elimination of waste. These have led to certain identifiable trends in manufacturing, the most notable of which are the reduction of inventory levels, higher quality products, production based on orders, cellular production and automation of many production processes. Many companies which have employed such measures have enjoyed at least competitive parity with Japanese companies which, a few years previously, were believed to be competitively invincible.

The past two decades have seen enormous improvements in the computer systems available to companies. Hardware processing speed, disk and memory capacity have improved at exponential rates as a result of advances in microchip technology while improved manufacturing techniques have resulted in major price reductions. The marketing of microcomputers has placed computing power at the fingertips of huge numbers of people who had previously believed computers to be the domain of data processing professionals only. Software improvements include database management systems which allow users to integrate numerous

different applications without the attendant fears of data redundancy; and the provision of packages allowing non computer literate people to extract and manipulate data from corporate databases. Advances in communications technology have allowed the creation of data links between and within companies, improving both the speed and accuracy of communication.

The improvements in information technology have led to many applications for computers in manufacturing. Computer aided engineering (CAE) and computer aided design (CAD) have allowed the production of product prototypes and storage of the attendant specifications on computer systems. Computer aided manufacturing (CAM) systems control manufacturing processes via computers. Material handling systems provide control over the materials passing through a production process. Material Requirements Planning (MRP) and Manufacturing Resource Planning (MRP II) systems assist in production planning. Computerisation of all these areas can lead to so-called "islands of automation" within the manufacturing process. Integration of these "islands" can be achieved via computer integrated manufacturing (CIM). Without these and other computer systems, the accomplishment of many of the trends in manufacturing described above would be impossible. Thus the two trends, the search for improvement in manufacturing, and the enormous advances in computer technology have not operated in parallel but have had important effects on each other.

A question arising from this discussion is whether companies, by identifying and implementing modern trends in manufacturing, can obtain competitive advantage over competitors which continue to operate as before? Would such advantages be sustainable? Further, are there areas in manufacturing where information systems *per se* provide opportunities for competitive advantage? This report seeks to identify such areas, using Porter's (1985) "value chain" concept to show the nature of the competitive advantage. Thereafter it will synthesise them into a model which will indicate their appropriateness *vis a vis* different corporate strategies.

The potential of the use of information systems for competitive advantage is well documented - Parsons (1983), Ives & Learmonth (1984), MacFarlan (1984), Wiseman & MacMillan (1984), Porter & Millar (1985), Rackoff *et al* (1985), Wyman (1985) and Johnston & Vitale (1988). A number of these studies make use of Porter's (1980) model of competitive strategy - Parsons, MacFarlan and Porter & Millar. Other authors have discussed the use of manufacturing information systems to achieve competitive advantage - Jelinek & Goldhar (1984), Doll & Vonderembse (1987), Huber (1987), Meredith (1987), Meredith & Hill (1987), Biggs & Long (1988) and Michaels (1988). However, within the parameters of the literature survey carried out for the purposes of this paper, there seems to have been no attempt to link the advantages gained from the use of information systems in manufacturing with a formal theory on competitive strategy. This paper seeks to provide that link, using Porter's (1980 & 1985) theories of competitive strategy and competitive advantage respectively. This will be done by :

- defining seven generic opportunities that information systems offer maufacturers,
- showing how competitive advantage can be achieved from each of these opportunities, and
- identifying the opportunities and information systems appropriate for each of Porter's (1980) generic corporate strategies.

The methodology of the report is the following.

- a number of different approaches to corporate strategy will be examined. Special emphasis will be placed on Porter's (1980 & 1985) theory of competitive advantage (chapter two).
- the different types of manufacturing information systems will be described (chapter three).
- examples of companies which have used manufacturing information systems with strategic success will be cited. Seven generic opportunities available to manufacturers using these information systems will then be defined (chapter four).

- the nature of the competitive advantage offered by each of the strategic opportu identified in chapter four will be defined in terms of Porter's (1985) value chain theory. Possible corporate strategies will then be matched with the opportunities and with specific manufacturing information systems (chapter five).
- some points regarding the application of manufacturing information systems in practice will be raised (chapter six).
- a short conclusion will follow.

CHAPTER TWO

STRATEGIES FOR COMPETITIVE ADVANTAGE

The basic premise of this report is that a company can apply information systems in its manufacturing operations in such a way that this application will support a defined corporate strategy to achieve competitive advantage. This chapter will start with a general discussion on the nature of corporate strategy and will then cover a number of approaches to strategy formulation. Porter's (1985) thesis of setting strategy to achieve competitive advantage follows, after which a number of theories of the use of information systems for competitive aovantage will be discussed.

Corporate strategy has been defined by Chandler (1962 : 12) as "the determination of the basic long term goals and objectives of an enterprise, and the adoption of courses of action and allocation of resources necessary for carrying out these goals." Two distinct processes are identified in this definition : the formulation, and the implementation, of the strategy (Andrews, 1971 : 37). Although many companies do not explicitly publish a statement of corporate strategy, in most cases a corporate strategy can be deduced by observing the operations of the company. The obvious question which arises from the previous statement is whether it is worthwhile expending resources on defining and controlling an explicit strategy when most organisations do not do so. Andrews (1971 : 41,42) gives four reasons in favour of such expenditure :

- to state a company's goals in terms of maximum profit only is inadequate,
- when a company has long lead times, long range planning is vital,
- there are benefits in influencing rather than simply responding to changes in the business environment, and
- the setting of visible goals will help to motivate and obtain the cooperation of employees.

Tilles (1963) points out potential shortcomings in statements of corporate strategy. Statements of corporate objectives often include little more than a specific financial objective and a broad statement about growth. Alternatively, the strategy is based only on current products. There is more to strategy than stating the amount of profit or turnover required of the company at a certain date as this leaves many basic questions unanswered. Growth for growth's sake would not necessarily be beneficial to many companies because of their inability to support the growth financially or in terms of infrastructure. A myopic view of a future in which current products will continue to perform as they do at present has been the downfall of many companies. Thus a statement of corporate strategy should avoid addressing only a single dimension and should be flexible enough to allow for changes forced upon the company by the outside world.

2.1 THE TRADITIONAL APPROACH TO SETTING CORPORATE STRATEGY

What might be referred to as a "textbook" approach to setting corporate strategy is described by such writers as Andrews (1971) and McCarthy *et al* (1979). In summary, this approach identifies the current strategy and then evaluates its appropriateness in terms of internal and external conditions. The evaluation process includes decisions on whether changes to the current strategy are required and the publication of the new strategy, where necessary.

2.1.1 Identifying the Current Strategy

As noted above, companies do not always explicitly state a strategy. Other problems in identifying the current strategy exist when there is no obvious direction to corporate decision making but simply a series of reactions to events; and when an explicitly stated strategy is not being followed. The identification process should thus consider both written statements of strategy and the actions of the organisation in order to arrive at a reasonable approximation of the current strategy. Major areas for analysis include the company's objectives, product-market

considerations, plant and operations facilities, financial considerations and human resources (McCarthy *et al*, 1979 : 287 - 291).

2.1.2 Evaluating the Strategy

Once the current strategy has been identified, it should be evaluated in order to determine its appropriateness in the light of prevailing internal and external circumstances. Tilles (1963) identifies six criteria for evaluating strategy :

- the different elements of the strategy should be internally consistent,
- the strategy should take account of potential changes in the environment in which the company operates, including possible new opportunities,
- the strategy should make the best use of the resources available to the company, especially financial resources, manpower and facilities,
- the degree of risk implicit in the strategy should be taken into account,
- the time horizon of the strategy should be reasonable, and
- the strategy should be workable.

The output of the process described above will be the recommendation of a future strategy for the company, whether unchanged from the previous strategy or incorporating new elements. Changes in the strategy are likely to be considered when results of operations have been unsuccessful, when new opportunities present themselves or when the company experiences changes in available resources. Effects of such changes should also be carefully considered as changes in strategy could dramatically alter the values of the company.

The exercise described above should be carried out on a regular basis in order not to be surprised by the constant changes in the environment in which a company operates.

2.2 THE GROWTH SHARE MATRIX

Robinson (1985a, 1985b & 1986) describes the approach of the Boston Consulting Group (BCG) to strategic planning. This type of strategy attempts to :

i) identify whether a potential investment would be attractive to a company, and

ii) assist with the management of a company's different investments.

The model considers a company's different products or businesses as a portfolio rather than individually because the latter approach would "inherently suboptimiz[e] the corporation as a whole" (Robinson, 1985b) as a result of inappropriate resource allocation. Assessment of a portfolio rather than individual businesses allows a company to channel resources from a mature, cash-rich business to a younger, riskier enterprise thus allowing the latter to avoid having to approach equity or debt markets.

The model is concerned with i) the market share, and ii) the rate of market growth of a product or business. Whereas entry into a market with a low rate of growth is likely to lead to a strongly defensive action on the part of existing competitors, high growth markets allow entrants to concentrate on the differential growth of the market while existing competitors, producing the same or even higher volumes, do not perceive their loss of market share. Areas of high growth consume cash because of the investment required to fund the growth. Reported returns, although impressive on paper, must necessarily be reinvested to maintain competitive position and are thus not paid over to shareholders in the form of dividends for a considerable period of time. In general, the competitor with the highest market share tends to have the lowest costs and therefore the highest profit. When industry growth rate starts to slacken off, this advantage allows the leader to maintain its position while paying out the highest dividends. However, smaller players, because of their higher cost structure, will struggle to pay out anything more than the smallest dividends. So it is vitally important to secure market leadership during high

rates of market growth. A company should seek out products which will provide either high growth or cash.

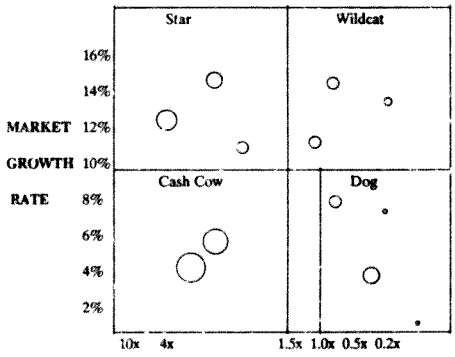


Figure 2.1 : The Growth Share Matrix

From : Robinson (1985a)

The BCG's analysis of a company's portfolio of products or businesses is based on the so-called growth share matrix, a 2 x 2 matrix on which relative market share and market growth rate are plotted (see Figure 2.1 above). The market growth rate is shown on the vertical axis with 10% given as the mid point. Relative market share, defined as the company's market share divided by that of the largest competitor, appears on the horizontal axis in log scale, with 1.5 given as the mid-point (this is appropriate for high-growth businesses; in low growth markets, 1.0 should be used.)

Each product is plotted on the matrix using a circle whose area indicates the relative magnitude of that product in the company's portfolio, usually measured in terms of sales. The size of the

circles thus provides a visual indication of the key business areas. Four principles should be considered when viewing the matrix :

- high market share is associated with low costs and high margins,
- a market with a high rate of growth requires large cash investments,
- obtaining an increase in market share is costly, and
- when a market matures, growth rate slows. This implies a cash surplus, especially where market share is high.

Products are classified according to the quadrant in which they fall :

1. Cash Cows. Low market growth, high market share products have low costs and surplus cash. There is little point in investing excess cash in products in this area because any potential for growth is severely limited. Excess funds should rather be channelled to areas where growth prospects are better. The major strategic concern should be to to maintain market dominance.

2. Stars. The high growth, large market share area typically produces large profits coupled with a need for cash. Investment in such products is vital to retain market share in order to realise the potential cash cow when the growth rate slackens. Losing market share in this position will result in the loss of promised future cash flows.

3. Wildcats. These are the most difficult products for management to deal with. They are in high growth areas, but with low market share and are thus extremely cash hungry. There are three possible strategies for wildcats :

- heavy investment in order to gain the necessary market share to become a star,
- divestment, in order to milk such cash as is available, and
- movement to a strategic niche in the market where dominance is possible.

4 Dogs. Low market growth and share are a recipe for low profits and there is seldom reasonable opportunity to increase market share. Strategies here usually attempt to restrict investment in products in this area and to harvest whatever cash is available. A possible strategic option here is price cutting, in an attempt to unsettle the market leader.

An important concept within the model is that the matrix is merely a "photograph" of the state of a corporation at a moment in time and that changes do occur over time. Thus both cash cows and wildcats can become dogs and a star could move to become a wildcat and then a dog. Vertical changes upwards are usually the result of forces beyond a single company's control although there are cases where substantial cost savings could be passed on to buyers, resulting in an increase in overall market demand. Robinson (1985a) defines four basic goals which management should follow, given the dynamic nature of the phenomena measured by the matrix :

- maintain the position of cash cows and do not invest any further funds in them,
- use surplus cash from the cash cows to invest in stars that are not self funding to prevent their becoming wildcats,
- invest any further cash in the most promising wildcats to achieve market dominance, and
- invest nothing in other wildcats and dogs : if they are not self-funding, they should be divested.

In addition to these four goals, a company should aim for a well-balanced portfolio with a number of products in each quadrant, an example of which is shown below in Figure 2.2. A base of two large cash cows will provide sufficient cash flow for a few well-placed wildcats. A number of stars promise future cash flows upon market maturity, and other wildcats and dogs are probably sufficiently small that, if well-managed, they should not prove to be a cash drain. This matrix can be contrasted with the one in Figure 2.3 which is severely unbalanced with an inadequate amount of cash being generated by cash cows. This impacts on the company's ability to fund wildcats adequately. Only a severe policy of funding only one or two of the most promising wildcats out of the limited resources available is likely to help the company out of impending disaster.

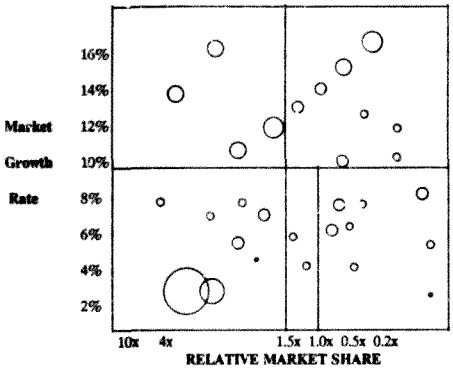


Figure 2.2 : A Well-Balanced Portfolio

From : Robinson (1985a)

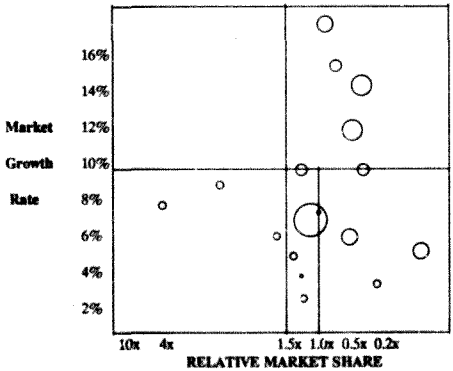


Figure 2.3 : A Poorly-Balanced Portfolio

From : Robinson (1985a)

A further element of the BCG's model is an analysis of the company's position *vis a vis* its competitors. This is carried out by comparing the company's growth share matrix with matrices derived for each of the competitors. Although these might not be completely accurate, they will give an indication of competitors' strengths and weaknesses and overall strategies. Products which will receive the most attention are those whose market share is close to that of the dominant competitor, wildcats with the potential to become stars and products with the highest market share. After strategies have been tentatively stated, competitors' matrices can be used in order to determine their likely responses to the planned moves and therefore the likely overall effect of the strategy can be analysed.

2.3 STRUCTURAL ANALYSIS

An extremely influential and oft-quoted author on the formulation of competitive strategy is Harvard Professor Michael Porter (1980 & 1985). The basis of a competitive strategy in his model is an analysis of the competitive forces in the industry in which a company competes or is considering competing. These are :

- the threat of new entrants,
- the intensity of rivalry in the industry,
- the power of buyers,
- the power of suppliers, and
- the threat of substitute products.

They are illustrated in Figure 2.4.

These five forces interact to determine the competitive atmosphere of an industry. They differ between industries and can change over time within an industry. Thus in certain industries all competitors can earn a reasonable rate of return, whereas in others few will earn more than a

mediocre return. The formulation of a firm's competitive strategy depends on the relative strength or weakness of the forces within its own industry.

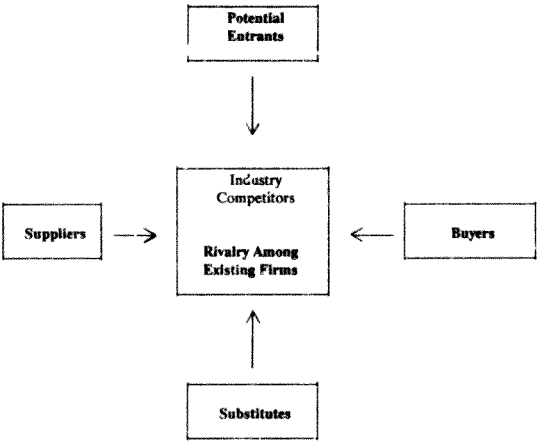


Figure 2.4 : The Five Competitive Forces That Determine Industry Profitability

From : Porter (1980 : 4)

2.3.1 Competitive Forces

2.3.1.1 *Threat of New Entrants.* New entrants to an industry threaten to take a share of the existing market (or the incremental market when an industry is experiencing high growth). The profitability of existing competitors is threatened by entrants either as a result of price cutting or cost increases. The strength of the threat of new entrants to an industry depends on the barriers to entry and expected retaliation from existing competitors. Barriers to entry include the economies of scale enjoyed by dominant competitors, product differentiation

where it is difficult for the entrant to overcome customers' loyalties, large capital investment requirements, high switching costs of buyers from the industry, restricted access to distribution channels and cost advantages not dependent on scale that are enjoyed by existing competitors. Existing competitors can be expected to retaliate vigorously to an entry by a new competitor if there is a history of retaliation in the industry, if there are established companies in possession of significant resources with which to compete, if existing competitors have large illiquid investments in the industry and if industry growth is slow. Potential competitors can be expected to enter the industry when expected income from participation in the industry exceeds the costs of overcoming barriers and surviving retaliation efforts.

2.3.1.2 *Intensity of Rivalry Among Existing Competitors.* A company will initiate a strategic move in an effort to improve its competitive position. Retaliatory moves are inevitable and the effects thereof, positive or negative, will be felt by all competitors. Such strategic moves are likely to occur when there are many competitors, when competition is evenly balanced, when the industry growth is slow and expansion can only be achieved at the expense of other companies, when there is little differentiation between products, when switching costs for buyers are low, when competitors have different goals or competition strategies, when companies place high strategic value on success in an industry and when exit barriers are high. The strength of this particular force is not fixed : the slowing of growth of a maturing industry, new entrants and competitive moves by players can all affect the intensity of rivalry within an industry.

2.3.1.3 *Pressure from Substitute Products.* Substitute products are those which "perform the same function as the product of the industry" (Porter, 1980 : 23). An analysis of an industry should specify all substitute products (not necessarily an easy task) because they effectively

place price ceilings ir an industry's products. Substitute products of most concern to an industry are those :

i) whose price-performance tradeoff with that of the industry is improving and

ii) whose own industry produces high profits.

A concerted campaign by all competitors in an industry is often required to head off the threat of a substitute; in other cases, strategic planning should recognise the inevitability of the emergence of substitutes.

2.3.1.4 *Bargaining Power of Buyers.* Buyers can affect industry profitability by forcing down prices, demanding h gher quality and trading off suppliers against each other. The buyer group of an industry is powerful when it purchases large volumes relative to the sales of suppliers; when the products it purchases represent a significant proportion of costs; when it earns a low rate of return and is therefore more price sensitive; when buyers' backward integration is a possibility; when the product purchased is not vital to the quality of buyers' products; and when buyers have information about industry costs. A company should attempt to formulate a strategy of selecting buyers who have the least possible power.

2.3.1.5 *Bargaining Power of Suppliers.* Suppliers who have the power to increase costs to an industry which is unable to recover those costs in its prices can severely affect the profitability of an industry. Suppliers to an industry are particularly powerful when they are more concentrated than the buying industry, when there are no substitute products, when the industry is not important to the supplier group, when the product is important to the buying industry, when products are differentiated, when th ;re are switching costs and when they have the potentia. fo forward integration.

When analysis has defined the forces acting within an industry and their causes, a competitive strategy needs to be defined whereby either :

1. the five forces are taken as given and the company adopts a defensive position accordingly,
2. the company seeks to make competitive moves which will change the balance of the forces to its advantage, or
3. potential changes in the existing balance of forces are predicted and counter-active strategies are devised before competitors can do so.

Having described the five competitive forces, Porter (1980 : 34) defines three generic strategies which, if applied can assist companies in "creating ... a defendable position in the long run and outperforming competitors in an industry". These are :

- overall cost leadership,
- differentiation, and
- focus.

The difference between these three strategies is illustrated in Figure 2.5.

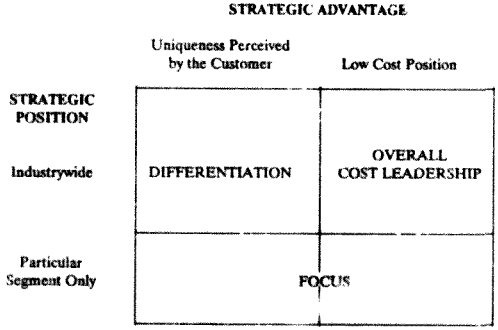


Figure 2.5 : The Three Generic Strategies

From : Porter (1980 : 39)

2.3.2 Generic Strategies

2.3.2.1 *Overall Cost Leadership*

This strategy, to become the cost leader in a given industry, requires that every aspect of the company's operations be run in accordance with the desire to achieve lower costs than every other competitor. Every aspect of cost saving, from economies of scale through refusal to take on marginal customers to cutting sales and marketing costs, should be pursued aggressively. High market share tends to be a prerequisite for this strategy. Heavy capital expenditure is thus required to build up capacity and invest in the most efficient plant. Losses may be incurred initially to buy market share by pricing products below those of competitors. When the cost leadership position has been achieved, excess profits may be reinvested in modern equipment in order to maintain the cost leadership position. The cost leadership position provides an effective defence against all the five competitive forces. It provides a barrier to potential entrants in the form of economies of scale and other cost advantages. If rivalry between competitors is intense, having the lowest cost allows a firm to earn profits even after all the competitors have competed away their returns. Powerful buyers will only be able to bargain prices down to the level of the next most efficient competitor. Having the lowest cost position enables a company to deal with price increases imposed by powerful suppliers in a more flexible way. The cost leader will cope best with substitute products because it will continue to earn a return when all competitors are suffering losses.

2.3.2.2 *Differentiation*

This strategy is to "creat[e] something that is perceived *industrywide* as being unique" (Porter, 1980 : 37). This can be achieved by design or brand image, technology, features, customer service, dealer network or, preferably, a combination of a number of these dimensions. Differentiation is often incompatible with a low cost position because building a

unique product may be costly. Not all customers will be willing to pay the premium for a differentiated product; so this strategy is not usually compatible with high market share.

At first glance a differentiation strategy might appear only to deal with buyer power by building in switching costs and lowering price sensitivity because of the lack of comparable products. However, the four other competitive forces are also addressed. Increased customer brand loyalty lowers price sensitivity and therefore reduces the threat of competitive rivalry. This loyalty and the uniqueness of the product act as barriers to potential entrants and makes the differentiated company less sensitive to substitute products. Differentiation results in higher margins which allow the company more space to deal with powerful suppliers.

2.3.2.3 *Focus*

This strategy involves targeting a particular buyer group, segment of the industry's product line or geographic market and focusing on that target "sub-market". Thus, while the cost leadership and differentiation strategies are aimed at whole industries, the focus strategy seeks to serve its target market better than the industrywide competitors are able to do, or to reduce costs in serving a target market. The focus strategy therefore adapts either the cost leadership or differentiation strategy (or both) to the market niche which has been chosen.

The defences against the five competitive forces for cost leadership and differentiation are also relevant for the appropriate focus strategy. In addition, the target of the focus strategy can be chosen where the threat of substitutes is least or where the competition is weakest.

When one of these three strategies is not applied aggressively and consistently, a company can be in the the position that Porter (1980 : 41) describes as being "stuck in the middle". This is a

very weak position. Even if elements of each strategy are present, there will not be sufficient features of any one of the strategies to provide an adequate defence against the competitive forces. High volume customers will be lost to the low cost producer; high margin customers will be lost to those firms which have achieved differentiation or have focused on the high margin portion of the market. Furthermore, because very different organisational features are necessary to pursue the different strategies, the corporate culture of a company stuck in the middle is likely to be confused and pass conflicting signals about priorities to employees.

A firm in this position needs desperately to make some vital decisions about the strategy that is to be followed, depending on the nature of the industry and the resources at its disposal. The movement from being stuck in the middle to applying one of the generic strategies successfully necessarily takes both a good deal of time and sustained effort. The temptation to switch to another (seemingly easier) approach whenever difficulties are encountered should be avoided, otherwise the organisation is bound to find itself stuck in the middle until liquidation.

Each of the generic strategies has its attendant risks. The generalised risks in pursuing a strategy are :

i) failure to achieve or sustain a strategy, and

ii) erosion of a favourable position as the industry evolves.

More specifically, the risks of the cost leadership position are :

- technological change making past investments obsolete,
- imitators achieving low cost positions,
- failure to apply necessary product or market changes, and
- inflation in costs making it difficult to offer a sufficient discount on the prices of differentiated competitors.

The risks inherent in the differentiation strategy are :

- the premium over the low cost producer becoming too large to ensure brand loyalty,
- buyers no longer require the differentiating dimension, and
- imitator[illegible]ve differentiation.

The risk[illegible] the focusing strategy are the following :

- industrywide low cost competitors offer a lower cost than the firm seeking a cost-based focus strategy,
- industrywide low cost competitors offer a significant discount on the price of [illegible]irm seeking differentiation through focus,
- the product offered to the industry as a whole starts to contain the same features as the differentiated product, and
- competitors define a further niche within the target market and erode the customer base.

2.4 COMPETITIVE ADVANTAGE

Porter's (1980) model for competitive strategy is extended in his 1985 work *Competitive Advantage* where a further concept, the "value chain", is introduced into the analysis of a company. "The value chain disaggregates a firm into its strategically relevant activities in order to understand the behavior of costs and the existing and potential sources of differentiation" (Porter, 1985 : 33).

2.4.1 The Value Chain

The value chain of a company (see Figure 2.6) is a representation of the value activities which it performs in order to "design, produce, market, deliver and support its product" (Porter, 1985 : 36). The value chain should be constructed at the business unit level. The value chain denotes

the total value of a product, ie. the amount that buyers are willing to pay for the product. Value is the sum of the total cost of the value activities and margin. Porter (1985 : 38) asserts that value, rather than cost, is appropriate for competitive analysis because some companies deliberately raise their cost in order to achieve differentiation.

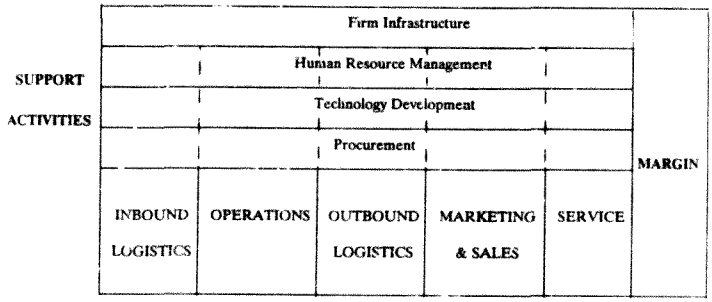


Figure 2.6 : The Generic Value Chain

Adapted From : Porter (1985 : 37)

The value chain of a company should not be seen in isolation but rather as part of a value system which consists of the firm's own value chain, upstream value chains (those of suppliers) and downstream chains (those of channels and buyers). So an organisation's value chain should not be seen only in isolation but also as part of a value system.

When a firm's value chain is being defined, it is necessary to divide each of the value activities into different discrete activities. In deciding how the value activities should be split up, the analyst should apply the principle that if activities

- have different economics,
- have a high potential impact on differentiation, or

- represent a significant or growing proportion of cost

they should be treated individually (Porter, 1985 : 45).

2.4.2 Value Activities

Value activities make use of purchased inputs, human resources, some form of technology, and information. Outputs are information and, in certain cases, financial assets or liabilities such as accounts receivable, inventory or accounts payable. Value activities can be divided into two types : primary activities, which are involved in producing, selling and supporting the product; and support activities which provide support to the primary activities and each other. An analysis of the differences between the value activities of a firm and those of its competitors will show where competitive advantage lies within an industry.

2.4.2.1 *Primary Activities*. There are five generic primary activities, each of which can be divided into sub-activities depending on the industry and the firm's strategy :

- Inbound logistics : activities concerned with receiving, storing and issuing inputs for the final product.
- Operations : activities which produce the final product from the different inputs.
- Outbound logistics : activities which receive, store and distribute the final product.
- Marketing and sales : activities which ensure that buyers are able to purchase the product and which induce them to do so.
- Service : activities which provide for the maintenance of the product.

Although each of the primary activities will exist in some form or another in all companies and will play a role in planning for competitive advantage, different activities will be critical in different industries.

2.4.2.2 *Support Activities.* There are four generic support activities. As with primary activities, these can be divided into sub-activities :

- Procurement : this is the function of purchasing inputs to the firm's value chain. Inputs can be raw materials, consumables, plant and equipment, buildings, and consulting services, etc. Obviously many people will be responsible for the procurement of the various inputs and this will tend to obscure the extent of resourses used by the different purchasing functions in an organisation. This means that insufficient attention is often paid to this area of an organisation's activities.
- Technology development : all value activities use one or more types of technology to perform the activity. Technology development refers to any activities which concentrate on improving the product or the process.
- Human resource management - this consists of the activities involved in recruiting, hiring, training, developing and compensating employees in all areas of the company. As with procurement, the responsibility for this activity tends to be spread over a number of areas; so its magnitude is not often appreciated. Human resource management is vital for competitive advantage in any company because it determines the skill and motivation of employees as well as the overall cost of labour.
- Firm infrastructure : activities falling under this label would include general management, planning, finance, accounting and legal services. Unlike the three other support functions, infrastructure usually supports the whole value chain rather than individual activities. Infrastructure activities can often contribute to competitive advantage, eg. the development of appropriate management information systems.

Each of the support activities other than firm infrastructure exists within each of the primary activities (as the dotted lines in Figure 2.6 indicate). For example, there is no single procurement activity but rather an operations procurement support activity, an inbound logistics procurement support activity, etc.

2.4.2.3 *Activity Types*. For each primary and support activity, there are three types of sub-activity :

- Direct : activities which are directly involved in creating value for the buyer.
- Indirect : activities which allow the continued performance of direct activities.
- Quality Assurance : activities which ensure that direct and indirect activities are performed according to laid down standards.

This classification is important when competitive advantage is being considered because a change in the way one type is performed can affect the others. For example, more attention to maintenance (indirect) can reduce manufacturing costs (direct). Indirect activities can also contribute to differentiation via their effect on direct activities but the conventional accounting policy of charging all indirect costs to "overheads" hides this fact. Quality assurance is also often not quantified at a firm level and therefore reductions in the cost of these activities tend not to be sought. However these costs can be reduced by introducing changes in the way direct and indirect activities are performed.

Companies need to observe the ways in which the different types of activities interact in order to determine an optimal mix of the three types of activity for each primary and support activity.

2.4.3 Linkages

The value activities that make up the value chain are interdependent. They are connected by means of linkages which Porter (1985 : 48) defines as "relationships between the way one value activity is performed and the cost or performance of another". Competitive advantage can arise not only from the value activities but also from linkages. The most obvious examples of linkages occur between support and primary activities. For example, better procurement practices can reduce the costs of inbound logistics, operations through lower production costs and service through better product quality. Less obvious linkages exist between primary activities and thus

can be difficult to identify. An example would be inspection of incoming raw materials reducing production downtime.

Linkages give rise to competitive advantage in two different ways : via optimisation and via coordination. Often a number of different linkages will achieve the same goal, and the optimum needs to be found. For example, a company might wish to lower service costs by increasing product quality. This could be achieved in a number of different ways. Management would have to choose the method which will prove most beneficial to the organisation. In other cases, several activities may need to be coordinated in order to achieve a stated goal. Coordinating the linkages between these activities may well reduce costs or achieve differentiation.

Porter (1985 : 49,50) defines four different sources of linkages :

- the same function can be performed in different ways,
- the cost or performance of direct activities is improved by more effort in indirect activities,
- activities performed within the firm reduce the need to demonstrate, explain or service a product in the field, and
- quality assurance functions can be performed in different ways.

Because linkages are often vital to competitive advantage it is important that a company examines the ways in which each value activity is affected by others in order to identify opportunities for the exploitation of linkages.

Linkages do not only exist within a company's value chain but can also occur between the firm's value chain and those of suppliers and channels. These "vertical" linkages can be the source of cost or differentiation advantage. Suppliers produce the raw materials that are used in the company's value chain and their value chains can also affect the firm's value chain at other points. A supplier's order entry system can interact with the firm's procurement system yielding reductions in cost for both the sales activity of the supplier and the procurement activity of the

company. Downstream linkages with channels or buyers can produce similar mutual benefits. Differentiation arises out of creating value for the buyer through contact with the buyer's value chain - lowering the buyer's costs or raising performance. The buyer will then be willing to pay a premium for the product. As with linkages within the firm's value chain, one should continually seek opportunities to convert potential vertical linkages into competitive advantage for both parties.

2.4.4 Competitive Scope

The decision regarding the competitive scope of a company is important because the scope chosen will affect the value chain. A company can choose broad or narrow scope in a number of different dimensions. Broad scope allows a company to perform more activities internally and to exploit interrelationships between value chains serving different areas; narrow scope enables a company to tailor its value chain to the specific needs of a target market and to use the expertise of outsiders to perform tasks that could be feasibly performed in-house. Porter (1985 : 53,54) defines four "dimensions" of scope :

- *Segment scope* : the product varieties produced and buyers served. The tailoring of a value chain to serve a particular buyer group can lead to competitive advantage through focusing. However, serving a number of different segments within an industry can provide advantageous linkages between the value chains serving the different segments.
- *Vertical scope* : the extent to which activities are performed in-house rather than by independent firms. The value chain assists in deciding the appropriate level of vertical scope by identifying vertical linkages which may be easier to exploit if vertical integration is employed.
- *Geographic scope* : the range of regions, countries or groups of countries in which a company competes with a coordinated strategy. There may be substantial savings or improved differentiation if value activities can be shared between geographic areas; but

increased costs or differences between areas could make a broad geographic scope an unattractive option.

- *Industry scope* : the range of related industries in which a company competes with a coordinated strategy. As with geographic scope, wide industry scope can provide competitive advantage through the coordination of similar value activities but the costs of sharing activities may well outweigh the benefits obtainable.

The industry in which a firm is competing and the current position of major competitors will assist in determining the appropriate competitive scope in each of the four dimensions. Furthermore, defining value chains for wide and narrow scope for similar business activities, will show the extent of shared activities and provide insight on the relative advantages of broad or narrow scope.

In summary, Porter's thesis of competitive advantage relies entirely on the value chain concept. Opportunities for competitive advantage can be found :

- within value activities, both primary and support;
- in linkages between the different value activities within the value chain of a firm;
- in vertical linkages between the value chain of a firm and its suppliers and channels or buyers; and
- in the competitive scope chosen by the firm.

These, then, are the areas on which an analysis of any company seeking competitive advantage should be based.

2.5 INFORMATION SYSTEMS FOR COMPETITIVE ADVANTAGE

Within the last decade, many articles have been written in the management journals citing case studies of instances where companies have made use of information systems (IS) to obtain competitive advantage (eg.McFarlan 1984, Ives & Learmonth 1934, Wiseman & MacMillan 1984, and Wyman 1985). A number of models, many of which depart from the theory of competitive strategy as defined by Porter (1980) (see Section 2.3 above), describe the use of IS for competitive advantage.

2.5.1 Following Porter's (1980) Competitive Strategy

McFarlan (1984) points out that the nature of the industry in which an organisation competes will determine the strategic importance of information technology (IT) in that organisation. He suggests that a company should answer five questions which correspond closely to Porter's (1980) five competitive forces :

- Can IS technology build barriers to entry?
- Can IS technology build in switching costs?
- Can the technology change the basis of competition?
- Can IS change the balance of power in supplier relationships?
- Can IS technology generate new products?

An affirmative answer to any one of these questions will indicate that IT is of strategic importance to the company and should send a signal to top management that IS planning should be conducted at the very highest level.

Parsons (1983) considers the impact of IT on three different levels: the industry level, the firm level, and the strategic level. At the industry level, he shows that IT can affect the products and services provided, the markets, and the production economics of the industry. At the firm level,

he provides a number of examples of how information technology has assisted companies in responding to the five competitive forces. At the strategic level he suggests ways in which a company can use IS to support the generic strategy which it has chosen, cost leadership or differentiation. A firm is able to expend only a limited amount of resources on different information systems and the range of applications to be developed should therefore be planned carefully. In particular, it is important that the systems support the generic strategy selected by the company because the payoff from such systems will be far higher than the payoff from systems which do not support the strategy. Systems which can be developed when a cost leadership strategy is in place are those which will reduce cost in design or manufacturing, those which will help to eliminate waste in any area of the business, those which improve productivity, and those which can identify marginal customers. A differentiation strategy calls for systems which will improve quality, improve customer service, assist in providing products tailored to customer needs or create better product designs.

2.5.2 The Customer Resource Life Cycle

Ives & Learmonth (1984) take Porter's (1980) three generic strategies as a starting point. They state that their model is successful for all of the strategies but is most appropriate for the differentiation strategy. As its name suggests, the customer resource life cycle (CRLC) concentrates on the relationship between a company and its buyers. The CRLC is a thirteen stage model which describes each stage in the interaction between a firm and a customer. The supplier company can build an IS to provide a service for the buyer at each stage of the CRLC (although it may well not prove economically feasible to install an application for *all* thirteen stages). Developing such systems will obviously enhance differentiation and, in many cases, build in switching costs.

The stages of the CRLC are (with examples in brackets) :

1. *Establish requirements* for resources to be acquired, by estimating future needs of the resource. (Salespeople can be provided with terminals which access the supplier's mainframe and provide immediate quotations.)
2. The customer must *specify* the attributes of required resources. (Systems which will automatically generate orders on suppliers of spare parts when the customer requires maintenance or some item.)
3. The customer must *select* a *source* from which the resource will be delivered. (Airline timetables which list all flights meeting the customer's criteria.)
4. The customer places an *order*. (Certain suppliers provide on-line order entry systems at customers' sites.)
5. The customer must *authorise* the expenditure *and pay for* the resource. (On-line credit authorisation facilities.)
6. The customer *acquires* the resources. (Software or any form of data that is purchased can be downloaded onto the customer's computer or television set.)
7. The resource is *tested and accepted*. (Systems which display an evaluation of the supplier's delivery performance.)
8. The resource is *integrated into inventory and managed*. (Systems which allow on-line update of a customers' inventories when goods are shipped.)
9. *Monitor use and behaviour* of resources to ensure that they are acceptable while still in inventory. (Systems which monitor returns to a magazine distributor to determine the optimum product mix for the customer.)
10. *Upgrade* resources *if required*. (Systems which monitor sales at customer sites and then provide advice on how best to use shelf space.)
11. *Maintain* the resource. (Systems which prompt customers when resources are due for maintenance.)

12. *Transfer or dispose* of resource. Usually, the supplier is not involved unless the resource is rented. (Systems which allow customers who have rented cars to conclude the transaction using a terminal.)

13. *Account for the funds* that have been spent on resources. (Credit card companies' systems which advise customers of the amount spent on travel.)

Using this fairly detailed model of the points of contact between a supplier and its customers, a company can decide on the area or areas where IS can make the biggest impact on relationships with customers and thereby enhance a differentiation strategy.

2.5.3 The Theory of Strategic Thrusts

Wiseman & MacMillan (1984) present what they refer to as an option generator. This is a series of questions which planners can ask when searching for strategic opportunities using IS. The questions and potential answers are given below:

- *What Is The Strategic Target?* The focus of the potential competitive advantage could be customers, suppliers or competitors.
- *What Strategic Thrust Can Be Used Against The Target?* Here again, three possible answers are given - differentiation, cost advantage, and innovation. Innovation would include the use of IS to change the nature of the industry or to devise new products.
- *What Strategic Mode Can Be Used?* Would the systems to be implemented be used offensively (to increase a competitive edge) or defensively (to reduce a competitor's edge)?
- *What Direction Of Thrust Can Be Used?* The IS could be used by the organisation or provided to customers or suppliers.
- *What Information System Skills Can Be Used?* Potential applications can make particular use of either processing, data storage or transmission skills, although these are not mutually exclusive.

	STRATEGIC TARGET		
STRATEGIC THRUST	Supplier	Customer	Competitor
Differentiation			
Cost			
Innovation			
Growth			
Alliance			

Figure 2.7 : Framework for Identifying Strategic Information Systems Opportunities

From : Rackoff *et al* (1985)

Rackoff *et al* (1985) expand the Wiseman & MacMillan (1984) model by adding two further strategic thrusts. The one is growth via volume or geographical expansion, or vertical integration. The other is alliance, where agreements are formed or acquisitions made relating to one of the other strategic thrusts. The authors construct a 5 x 3 matrix where each of the strategic thrusts is matched to the strategic targets (see Figure 2.7). This matrix acts as a framework for the process of planning the development of strategic information systems in a company. Rackoff *et al* (1985) describe the use of the model in a telecommunications company. More than 300 ideas were generated by participants from all disciplines in the company, of which six were rated as having "very high potential". In addition to this, the process showed managers from all parts of the company the strategic importance of IT.

2.5.4 A Unified Model

Porter & Millar (1985) present a five-step method that allows organisations to identify opportunities for achieving competitive advantage via the use of information systems. This model comfortably encompasses most of the concepts used in the previous three and can thus be used to unify the different models in a single planning process.

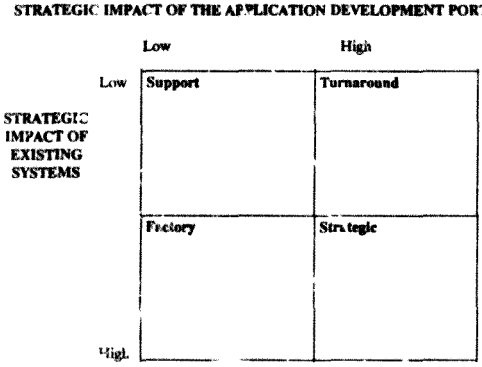


Figure 2.8 : Position of Information Systems in Various Types of Companies

From : McFarlan (1984)

2.5.4.1 *Assess Information Intensity.* A company can determine the information intensity of its different business units. Resources should typically be allocated to those areas where the information intensity is highest. McFarlan (1984) provides a model for such an assessment. A 2 x 2 matrix is constructed with the strategic impact of existing systems on the vertical axis plotted against the strategic impact of the applications under development for each business unit (see Figure 2.8). The quadrant marked "strategic" indicates the area where information intensity is highest, followed by "turnaround", "factory" and then "support". Business units

where the information intensity is highest shou[illegible]he bulk of corporate funding for IS and should be the subject of the most attention.

2.5.4.2 *Determine the Role of Information Technology in Industry Structure.* The effect of IT trends on a company's industry sh[illegible]ld be carefully studied in order to predict how they might affect the five competitive forces in the indusry and therefore industry structure. A number of studies, such as those of Parsons (1983) and McFarlan (1984), show how IT has affected the five competitiv[illegible] forces in certain industries. These give an indication of likely trends which can be used by management to assist in the examination of their own industry.

2.5.4.3 *Identify and Rank the Ways in Which Information Technology Might Create Competitive Advantage.* The customer resource life cycle model of Ives & Learmonth (1984) and the theory of strategic thrusts of Wiseman & MacMillan (1984) and Ackoff *et al* (1985) can be used to good effect here.

2.5.4.4 *Investigate How Information Technology can Spawn New Businesses.* Three general areas of opportunity exist : sell information created during normal operations, sell excess processing capacity, and use IT to produce new products related to the existing product line.

2.5.4.5 *Develop a Plan for Taking Advantage of Information Technology.* The information generated in the first four steps of the model should already have identified more than enough opportunities to use IT str[illegible]gically. In this phase one should develop an action plan whereby the different opportunities are ranked in terms of likely payoff and corporate resources are assigned to the most promising areas.

CHAPTER THREE

INFORMATION SYSTEMS IN MANUFACTURING

"It has been demonstrated that a factory is 75% information handling system and only 25% a materials handling system" (Skinner, 1985 : 63).

The trends in manufacturing identified in Chapter 1 : reduction of inventory levels, higher product quality, demand-pulled production and flexible manufacturing all require a vital ingredient : information. Without the speedy and accurate processing of information, such concepts would be mere figments of manufacturers' imaginations. This chapter describes the different types of information system (IS) in manufacturing, the benefits of their use, and the potential of their integration into one large manufacturing system. Other systems that can be used to good effect by manufacturers but which are not generally considered part of the portfolio of manufacturing IS, interorganisational IS, and IS which assist companies in the maintenance of their products, will then be discussed.

3.1 ISLANDS OF AUTOMATION

Except where otherwise acknowledged, the information in this section is drawn from the studies of Ford *et al* (1985) and Doll & Vonderembse (1987).

Until recent times (and still currently in many cases), information systems in manufacturing tended to be installed discretely, without any links to other systems in the manufacturing environment. One would thus have a system controlling the product design phase, another controlling production planning, a third controlling material requirements, and so on. As a

result, the various manufacturing information systems are referred to as "islands of automation". This section describes the different islands.

3.1.1 Engineering Systems

Computer-aided design (CAD) allows the automation of the product design phase in the manufacturing process. CAD consists of four basic activities : geometric modelling, analysis, testing and drafting (Ford *et al*, 1985). CAD systems allow the designer to change specifications and simulate a mechanism's parts. When the task is complete, the specifications are stored electronically by the system. An enhancement to CAD is computer-aided engineering (CAE) which allows the designer to check for interference and perform stress and strain tests on mechanical parts

The benefits of computer based engineering systems are the following :

- designer productivity improves because there is no need to re-draw a design when a mistake is made, scale adjustments are made automatically, and commonly used elements in the design process can be stored for future use.
- shorter product development lead time occurs as a result of improved designer productivity.
- improved design quality arises from the precision which CAD packages demand and supply.
- the ability to design a number of similar products efficiently because of the facility to store a design and then use that design as a starting point for subsequent products.

3.1.2 Manufacturing Systems

Computer-aided manufacturing (CAM) is the automatic control of a number of numerically controlled (NC) machines. To understand the implications of CAM, it is necessary to summarise the history of NC machines (Gerwin, 1982). Developed shortly after World War II,

the first NC machines were used for metal cutting operations. They ran from a set of coded instructions which were punched onto paper tape. Any changes to the design would thus require only a change to the coded instructions. In 1959, machining centres were first commissioned. These combined, into one area, jobs which were previously performed by several dispersed machines. Tools could be changed extremely quickly by instructions from the tape. The machining centre concept thus not only reduced floor space utilisation but also setup time. Computer numerical control (CNC) made its appearance in 1969 when a minicomputer took over the control of the NC system. This was followed in 1974 by the use of cheaper microcomputers to perform the control function. The use of computers rather than punched tape made the updating of designs far quicker and also provided information about machine usage

CAM was first introduced in 1969 with direct numerical control (DNC). Here a number of NC machines (up to 250) are connected to a central computer. The benefit was the centralisation of the different parts programs rather than each being stored at the NC machine itself. In the early 1970's the final step in the evolution of CAM was taken - the addition of automated material handling to DNC. This uses automated storage and retrieval systems (AS/RS) and automatic vehicle guidance systems (AVGS) to retrieve and transport tools and materials to different machines and gives the CAM system the ability to deduce the optimal routing for the production of a part from production data. In addition, should one machine break down, the CAM system will re-route materials to machines which are still operative.

When CAM is implemented as described above, the logical method of organising the factory floor is to ensure that machines which produce similar parts are grouped together. This arrangement is known as cellular manufacturing. Setup times are reduced because similar parts can be produced at the same time, and routing and material handling requirements are simplified. Cellular manufacturing is supported by group technology (GT) which classifies parts

according to their geometric or manufacturing characteristics. This classification has been extended to the standardisation of part specifications for both design and manufacturing purposes. GT thus plays a vital role in setting up manufacturing plans directly from CAD output.

Computer-aided process planning (CAPP) uses detailed information on cell layout, machining requirements and machine capacity to generate a plan containing the sequence of work centres and the various machining instructions. In certain circumstances, design specifications will be queried by the CAPP system and preferred alternatives will be suggested by the application of GT information. If product mixes or volumes change, the CAPP system will assist in optimal routing to avert potential capacity shortfalls.

Numerous benefits accrue to the users of the various manufacturing systems :

- reduction in lead time via the programming of part and machine requirements;
- reduction in set up time because the necessary tools can be retrieved and fitted to the NC machines automatically.
- reduction in throughput time because GT techniques specify similar parts which can be produced on dedicated machines, common tooling, and cellular manufacturing reduces the distance travelled in the production process;
- reduction in waste and improved product quality through more precise specifications and the NC machines' precision (assuming that the quality of raw materials is sufficiently high);
- reduction in material handling via the use of AS/RS and AVGS, cellular manufacturing and GT techniques;
- better response to small design changes in products because of the ability to re-program NC machine instructions in a CAM system;
- work-in-process (WIP) and finished goods inventory reduction because of higher quality production and improved scheduling methods;

- more efficient use of floor space resulting from cellular manufacturing techniques to rationalise the use of floor space and reductions in WIP inventories;
- optimal capacity utilisation through better scheduling techniques; and
- the ability of CAM to re-route production when a particular machine becomes unavailable.

3.1.3 Production Planning and Control Systems

Material requirements planning (MRP) is the computerised process of determining material requirements for future production volumes. Biggs & Long, (1988) give an example of the use of MRP in a small company which produces dry product processing feeders. A weekly *master production schedule* is constructed from marketing and sales forecasts. It involves subassemblies which are to be made for stock, final assemblies and special items. Each item on the master production schedule is matched to its *bill of materials*, producing a *material requirements plan* and works orders. The bill of materials provides information on each different part that is needed for the whole week's production, the quantity to be used and timing requirements. The material requirements plan lists the different parts required, the lead times and the date on which the job should be completed. Inventory requirements are determined from the MRP report.

Manufacturing resource planning (MRP II) takes MRP a step further. It provides manpower planning, capital and capacity requirements, and cash flow and shipping forecasts in addition to material requirements. MRP II also provides the facilities to monitor production activities and produce information on costs, target volumes, quality and inventory levels. This type of system includes both input from and output to such diverse departments as engineering, finance, personnel, marketing and, of course, manufacturing. The goals of an MRP II system are the improvement of production and cost control; reduction in inventory; better decision making; and coordination of the purchasing, receiving, scheduling, production and shipping functions.

Although just-in-time (JIT) can be considered to be a production planning system, it is usually viewed at a wider angle : as a manufacturing or management philosophy. Lubben (1988 : 8) defines two main aims for JIT :

- creating the simplest possible manufacturing process, and
- a devotion to the elimination of all waste in manufacturing.

Companies applying JIT will be seeking to reduce set up times and lead times; to improve product quality by reducing defects; and to minimise raw material, WIP and finished good inventories with the ultimate goal of zero inventory. JIT production supports the goal of zero WIP and finished goods inventories by allowing production at a particular workstation only when there is demand from the next activity in the production process. So the final assembly line "pulls" component parts from all the previous processes and is itself authorised by customer demand. This implies that if a single machine on the line breaks down, the whole production line is halted because there are no raw materials for upstream processes and no demand for downstream processes. Because of the rigour of this type of system, commitment to it by people at every level in a production department has to be absolute, otherwise it cannot succeed.

3.2 COMPUTER INTEGRATED MANUFACTURING

Each island of automation discussed in the previous section offers potential to provide improvements to the company implementing it. However, as more islands are developed within a company, the stand-alone nature of these islands will impede further improvements. For example, if a company runs both CAD and CAM systems but these are not connected in any way, a vast amount of complicated data output by the CAD system would have to be input manually into the CAM system before it could develop instructions for the NC machines under its control. Computer integrated manufacturing (CIM) seeks to integrate these different islands into a common system. Martin (1988) points out that the definition of CIM has evolved from

being associated with large scale plant automation, through a networking and communications concept, to an IS concept; with shared data being used by numerous users from different disciplines. Doll and Vonderembse (1987) describe CIM as "provid[ing] a shared database, a database management capability, and a communications network to link engineering, flexible manufacturing and business information systems."

COMPUTER INTEGRATED MANUFACTURING

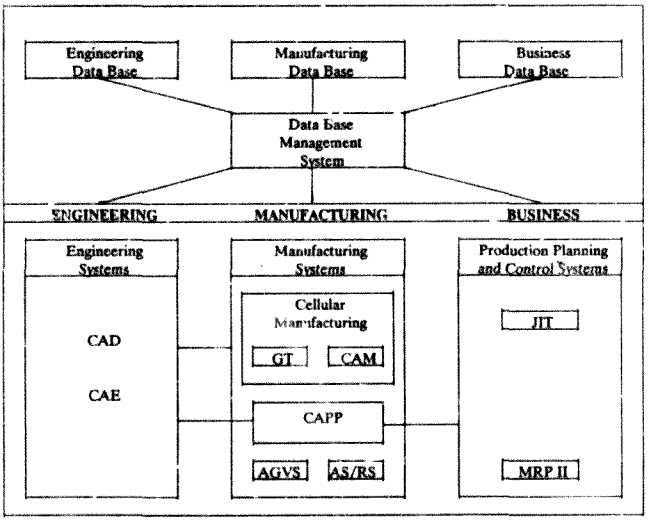


Figure 3.1 : The CIM Partnership

From : Doll & Vonderembse (1987)

3.2.1 The Concept of Computer Integrated Manufacturing

Harrison *et al* (1986) point out the necessity of understanding the difference between the *integration* and the *linking* of two or more computer modules, eg. CAD and CAM, on two different hardware bases

- Linking occurs when data transmission is possible between the two modules using a data format which is acceptable to both modules. Thus component geometry can be specified in CAD, the data converted to, say, ASCII format and then transferred to the CAM module, transferred from ASCII format to the CAM format once received by the CAM module, and then used to produce NC instructions in the CAM module.
- Integration provides a two-way communication between modules. In the CAD/CAM example, the user of the CAD system can access the CAM tool files and the CAM operator can make use of CAD geometry. In addition, all product information will be available to both modules. The discussion below will assume integration as described here is in force.

Figure 3.1 provides a graphic representation of CIM. The data from engineering, manufacturing and business systems are made available to all the components of the CIM system. A typical scenario of the effect of a planned new product on the system might be:

- Engineering Systems : basic specifications of the product are received by engineering from sales. A design is prepared using a CAD system which specifies dimensions, materials to be used, etc. The product data from the CAD system is used by a CAE system which tests it for potential stress problems. Certain changes have to be made and the product information is updated. The CAE operator can then make immediate use of the CAD system to produce new design printouts.
- Manufacturing Systems : when the product design has been completed on the engineering systems, production personnel can access the specifications with group technology and CAM systems in order to set up instructions for production of the product. Certain design

specifications do not meet the requirements of the NC machines. These are identified by the CAM system and can be modified on the CAD system either by the production person operating the CAM system or by the designer. Material and processing costs can now be determined from the product specifications.

- Production Planning Systems : when the new product is scheduled for production, the MRP II system accesses the product specification and determines the various resource requirements such as machine time, direct labour and materials. Total production time is calculated and distribution and the sales department notified as to when to expect the finished product. With a JIT system in place, an order for the required raw materials is automatically generated for delivery shortly before production is about to begin. When the product is being manufactured, information from the factory floor is input into the MRP II system and any variances can be reported to the appropriate places, eg. costing information to the costing department.

The following benefits flow from the integration of the different islands of automation :

- integration of the islands reduces the indirect labour which would previously have been used to provide an interface between the different modules,
- a single set of specifications exists for each product rather than multiple sets. This reduces the risk of changes not being transmitted to all the relevant modules,
- small changes to products are dealt with far more efficiently because of shared data,
- lead times for new product development are shorter because design information can be used more rapidly by production personnel,
- the manufacturing process is more flexible because lead times are reduced and small changes can easily be made. This enables the company to respond more rapidly to changes in the market and to produce one-off products, if required,

- the informational output of the multiple-module system improves management's ability to manage a complex multi-product environment and improves their control over the manufacturing function.

3.2.2 Problems of Integration

Despite the promised benefits of CIM, a recent study has shown that European companies tend rather to opt for islands of automation when purchasing computer systems for use in manufacturing (De Meyer, 1987). Whether this reflects planning for a phased implementation of CIM or a desire to avoid the potential difficulties perceived in CIM is not clear. What is certain is that the integration of the different islands of automation is not a simple matter and should not be treated lightly. Two major problems in this process are identified in the literature, namely redundant data, and lack of hardware and software standards. These are discussed below.

3.2.2.1 *The Need for Common Treatment of Data.* In most companies, databases are distributed because each discipline's database has been created in response only to the needs of the creator and without any heed to potential redundancy (Martin, 1988). This leads to the kind of situation described by Appleton (1984) where "the typical manufacturer has at least five (and up to 35) different types of part numbers, three (and up to 10) types of bills of materials, and from six to 20 types of costs." The potential problems involved in creating an organisation-wide database and standardising manufacturing information are enormous. The Ingersoll Milling Machine Co. spent two years reprogramming their entire system into an integrated corporate database system in order to overcome this problem (Dornan, 1987).

3.2.2.2 *Non-Standard Hardware and Software.* Many companies that use more than one of the islands of automation will find that the various applications run on hardware from different vendors with different operating systems. Also, applications packages are usually written in different programming languages. (Appleton, 1984). In such situations, there will be major problems in developing an interface protocol to allow data transfer at the levels required to integrate rather than link (see Section 3.1 above) the different systems and, in some cases, this is impossible. In other cases many of the stand-alone packages, although excellent in their own sphere, cannot be integrated at all (Huber, 1987).

3.3 INTERORGANISATIONAL INFORMATION SYSTEMS

This section is entirely drawn from the article by Johnston & Vitale (1988).

An interorganisational information system (IOS) is one which is shared by two or more companies, allowing information to be transferred across organisational boundaries. Such a system will be initiated by one of the organisations using it (the sponsor) and will provide benefits for each of the participants. A well-known example of an IOS is the ASAP system run by American Hospital Supply. Terminals linked to the ASAP system were placed in the buying departments of American Hospital Supply's customers, allowing them to enter their orders directly into the system. Subsequent enhancements to ASAP were the addition of an inventory control module for customers and a facility for customers to order competitors' products through ASAP, for which service American Hospital Supply charges a fee. Significant benefits from the system include built-in switching costs for customers, fee income from an infrastructure which was already in place, information about market trends and a significant reduction in the indirect labour required to support sales. The company tripled its sales volume with a negligible increase in customer support staff.

3.3.1 Categorising Interorganisational Information Systems

An IOS can be categorised in three different ways to assist with the identification of strategic opportunities :

1. *The Business Purpose.* An IOS can be designed either to gain advantage over competitors in the basic business of the sponsor, or to create an entirely new business for the sponsor via the use of the IOS. The sponsoring company then decides who may participate, what information will be made available to participants and what costs the participants will face.

2. *Participants.* Customers, dealers, suppliers and competitors are potential participants. The sponsor must ensure that the system will provide a perceived benefit to every participant, both to the organisation as a whole and to the individuals within the organisation using the system. The sponsor must be certain of its relationships with participants in order to decide on appropriate levels of data availability, security and privacy for every participant.

3. *The Function of the IOS.* Three functional levels are possible.
   - Boundary transactions are those which only provide access to the "boundary" of the sponsor's systems, eg. order entry transactions. Some of these will also include alternative product suggestions, delivery alternatives or special promotions, thus beginning two-way transfers of data.
   - Shared systems allow participants to retrieve and analyse certain items of information as well as perform boundary transactions.
   - Internal modules of the IOS enable participants to input, store and manipulate data which are not accessible by the sponsor. Participants can therefore make use of the processing power provided by the sponsor.

These three levels progressively increase in complexity. The usual route taken by a sponsor is to begin by providing boundary transactions and then gradually increase the complexity of the facilities offered.

When considering the development of a potential IOS, management of the sponsor should determine the thrust of the system in each of the categories defined above based on the costs and benefits of the envisaged system.

3.3.2 Potential Benefits of Interorganisational Information Systems

3.3.2.1 *Benefits for the Sponsor*

Possible benefits to the sponsor of an IOS are :

- cost reduction, both internally and at the interorganisational level,
- fee income from IOS participants,
- increased sales from :
  1) a larger scope of customers,
  2) more visible products,
  3) participants rewarding the sponsor for a useful system, and
  4) customers wishing to deal with a technologically advanced supplier,
- increased switching costs for buyers,
- increased barriers to entry in the industry, and
- better relationships with buyers.

3.3.2.2 *Benefits for the Participant*

No one would participate in an IOS without benefitting from it. Therefore sponsors must attempt to include as many benefits as possible to induce other firms to participate in their IOS. The benefits available could include :

- reduction in order entry and inventory costs,
- increased sales through improved customer service and a "high-tech" image,
- decision support, based on sales trends, and
- the potential of supporting a just-in-time purchasing programme.

3.4 INFORMATIONS SYSTEMS FOR PRODUCT MAINTENANCE

This section is entirely drawn from the article by Ives & Vitale (1988).

In 1986, the car repair industry in the United States was worth $50 billion. Further billions were spent on the repairs of household appliances, industrial machinery and farming equipment; and on computer hardware maintenance contracts. Despite the vast amounts of money expended on maintenance in one form or another, the potentials of this market have, in the main, been ignored by management. This section cites some examples of companies which have installed maintenance systems, then covers the different areas in maintenance where IS can be used, and finally lists some potential benefits of the use of IS for maintenance.

3.4.1 Examples of Installed Maintenance Information Systems

1. *Ship Engines*. A manufacturer of freighter engines has installed a system which allows ship captains to link into it via satellite when an engine on their vessel breaks down. Information about the damage and the ship's position is transmitted. The system then identifies the repair facilities closest to the current position of the ship, initiates the transportation of the necessary replacement parts and tells the crew how to prepare for repairs.
2. *Elevators*. Otis Elevator, Inc. has recently installed a new system to control requests for elevator repairs. Calls are switched to a central corporate switchboard whence service personnel are dispatched from local offices. Service personnel can access a database

containing maintenance records of all elevators. The system has proved extremely successful in improving the quality and response of Otis' service function and also provides corporate management with previously unavailable information on the company's service function.

3. *Credit Cards*. American Express have launched a programme which doubles the manufacturer's guarantee period for any appliance purchased with an American Express card. Card users qualify by simply mailing proof of purchase to American Express. The programme has increased the number of cardholders and the number of high cost purchases, and also provides valuable market information to American Express.

3.4.2 Areas in Maintenance Where Information Systems can be Used

Any maintenance task can be viewed in the following way : a *trigger* alerts the user that something is wrong; various information *inputs* are obtained to assist with the performance of the maintenance; the maintenance task is performed; and a number of information *outputs* are produced as a result of the maintenance. IS can be used in setting up triggers, providing inputs, and accepting outputs.

3.4.2.1 *Triggers* notify the user of a problem requiring maintenance. The worst possible trigger for a user is when the product ceases to work. IS can provide less drastic triggers for the following types of maintenance operation :

- Repair : self-diagnostic control systems can be built into high cost products to alert the user when maintenance is required. Another possibility is the use of computer systems which accept critical data about the product and then identify required repairs.
- Prevention : IS can assist in the identification of preventative maintenance requirements, either in terms of elapsed time, or as result of operating criteria. Once again, high cost items could possess a built-in trigger or a simple application could call or inform users by post when sufficient time had elapsed to justify preventative maintenance.

- Enhancements : customers are often unaware of potential enhancements unless they are contacted by the supplier. Information systems which contain information about the users of a company's products could provide the trigger although this information is difficult to obtain and would probably require creative thinking on the part of the manufacturer.

3.4.2.2 *Inputs* to the maintenance process are vital and IS can assist in getting appropriate inputs so that the maintenance can be carried out speedily :

- Personnel inputs. IS can track the whereabouts of service personnel, match skills with damaged products and schedule the time of maintenance.
- Products. In certain cases, locating a broken down piece of equipment might be a difficult task. An IS can contain information about the locations of a customer's equipment.
- Symptoms of defect. High priced products can include built-in sensors which provide information on operating problems.
- Parts. Having identified what parts need replacement, service personnel need to obtain those parts. Parts inventories which include the location of each item in stock are extremely useful here. Also, systems which monitor maintenance can inform the maintenance person which parts are most likely to be needed when he/she is making a call.

3.4.2.3 Once information from the maintenance process is captured, *outputs* provide a multitude of useful information.

- Customers are informed that the maintenance is completed. This could take the form of a call or a monthly listing of the types of maintenance performed and a breakdown of the costs.

- Production and design departments can be advised if an inherent problem is detected in the design of a product.
- Suppliers can be given feedback of the quality of their goods.
- Management can be informed as to status of a request for maintenance,and productivity information can be provided about individual employees, departments and customer accounts.

3.4.3 Benefits of Maintenance Information Systems

Possible benefits from IS applied to the maintenance function are :

- improved customer relationships arising out of quicker response to problems,
- higher re-purchase rates of previous customers resulting from greater satisfaction,
- lower costs in the maintenance function, and
- higher future production quality due to feedback from maintenance.

CHAPTER FOUR

STRATEGIC OPPORTUNITIES AVAILABLE TO MANUFACTURERS

"The computer has c' ged production economics more than any other single factor" (Jelinek & Goldhar, 1984).

The previous chapter concentrated on the use of IS in manufacturing. Although it identified some potential benefits from the different types of system, little mention was made of possible strategic advantages to companies using IS in manufacturing. Strategic advantages from using IS in manufacturing become available when a company makes use of the technology at its disposal to act on its own unique competitive situation, the product of environmental, industry and organisational characteristics. Thus, "just *having* the technology does nothing for the firm. The trick is to put it in the hands of creative, innovative people who will develop novel uses and applications ..." (Meredith & Hill, 1987).

This chapter will consider some of the strategic opportunities which have arisen in practice and which could be used by companies. Specification of seven generic opportunities will follow, and finally some strategic possibilities for the future will be suggested.

4.1 EXAMPLES

4.1.1 The Boeing Corporation (Goldhar & Jelinek, 1983)

Boeing has used CAM technology to set up a parts control system for 1.5 billion parts. A CAD system allowed designers to design the 757 and 767 aircraft simultaneously, rather than having to start the second design from scratch.

4.1.2 Cypress Semiconductor (Meredith, 19[illegible])

Cypress has installed automated wire-bonding equipment which allows a three-day turnaround time. Overseas competitors might take up to six weeks between order and delivery. Cypress thus has a major advantage over the offshore competition.

4.1.3 General Electric (Jelinek & Goldhar, 1984 and Kaplan, 1986)

Substantial use of computers was made when the General Electric dishwasher plant in Louisville and locomotive works in Erie were automated . The dishwasher plant is operated by four workers (as opposed to thirty previously), WIP inventories have been reduced by 50%, and its service call rate dropped 50%. The production volume that would previously have required sixteen days of operation at the locomotive factory can now be produced in sixteen hours.

4.1.4 General Motors (Jelinek & Goldhar, 1984)

General Motors used CAD to reduce the size the Cadillac Seville and to produce the X-body car a year quicker than manual methods would have allowed.

4.1.5 Illinois Tool Works (ITW) (Meredith, 1987)

ITW operates in a market which has reduced the time taken to develop, test and sell products from three years to six months. Introduction of GT at one of their plants has enabled them to compete at this level and has dramatically reduced inventory levels and labour usage. In addition, increased flexibility allows ITW to customise products for customers.

4.1.6 Ingersoll Milling Machine Co. (Dornan, 1987)

Ingersoll was one of the leaders in implementing CIM in the U.S.A. Results of the programme include 92% uptime, running three shifts seven days a week; 70% of parts produced are being run for the first time - flexibility is thus a major demand on the factory; and the 20 weeks previously allowed for manufacturing have been reduced to 14 weeks.

4.1.7 Intel Corporation (Meredith, 1987)

Intel, previously not prepared to produce customised integrated circuits which only one customer would buy, are now making use of a CAD package which allows customers to design their own chips.

4.1.8 Messerschmitt-Bolkow-Blohm (Jelinek & Goldhar, 1984)

The Messerschmitt factory machines various metals into components for fighter jets. There are twenty four machining stations all controlled by one computer. Benefits achieved from the system are : reductions in lead times by 26%, the number of machines by 44%, floor space by 39%, personnel by 44% and overall annual costs by 24%; as well as machine utilisation of 75-80% compared to 15-30% for standalone machines.

4.1.9 Peerless Saw Co. (Meredith, 1987)

Peerless invested in a computer controlled laser cutter rather than conventional punch presses. This reduced lead time from 14 to 3 weeks. When customers heard that Peerless was using the laser cutter, they began to ask for small modifications to previous orders. The company responded to this by supplying sales representatives with terminals which could link in to the Peerless computer, enabling the salesperson and the customer to specify the required design together.

4.1.10 Yamazaki Machinery Company (Kaplan, 1986)

The installation of a flexible manufacturing system by Yamazaki led to reduction in machines from 68 to 18, in employees from 215 to 12, in floor space from 103 000 square feet to 30 000, and in average processing time from 35 days to 1.5.

4.2 GENERIC OPPORTUNITIES AVAILABLE

Although seven generic opportunities are specified below in a discrete way, it should be noted that the nature of the benefits to be gained is not discrete. Certain systems can contribute to all of the generic opportunities, and if one opportunity can be achieved by a system, others might flow naturally. The categorisation is not intended to imply some form of mutual exclusivity between the different opportunities which are defined.

4.2.1 Cost Savings

Perhaps the most obvious opportunities which are available to a company contemplating the implementation of IS in its manufacturing operations are cost savings. These savings can be achieved without complete integration of the islands of automation so a company can make a reasonably modest investment in technology and still achieve benefits. Substantial cost reductions can be achieved without spending the billions of dollars which a number of American companies have invested in installing CIM systems. The potential savings can be divided into five different categories :

1 Labour savings. These can arise from reductions in labour requirements or from improved productivity. Reductions in the labour requirements occur when :

- a company changes from manually operated machines to NC machines,
- the information transfer functions in CIM make clerical workers redundant,
- reduced inventory levels lower the requirement for warehouse staff, and
- higher quality output reduces the requirement for manual quality checking.

Productivity improvements are numerous :

- designer productivity through CAD,
- programmer productivity when stand alone NC machines become computer controlled,

- decisions about the machines to be used, the routes through the factory and the materials required for each product are made by the CAM system rather than by production personnel,
- production management previously responsible for daily scheduling are freed by MRP II to address urgent production line problems,
- an MRP II system will optimise manpower utilisation in production, and
- the information output from an MRP II system will replace that previously collected manually by costing department personnel.

2 Space savings. These occur when :

- cellular manufacturing techniques improve factory floor layout,
- less storage space is required because of smaller inventory holding,
- changeover from manually operated to NC machines reduces the number of machines used, and
- clerical staff become redundant.

3 Investment savings. A company investing in manufacturing, MRP, MRP II or JIT systems is likely to experience a dramatic reduction in raw material, WIP and finished goods inventory levels. This releases funds previously invested in inventory. By improving inventory management and allowing production-to-order, these systems will reduce the holding of obsolete stock. More accurate machining and less human intervention in the physical production process reduces waste and rework. This saves investments that would have been made in materials, labour, machine capacity and other overheads when waste products were produced or reworked.

4 Downtime savings. NC machines tend to be more reliable than those operated manually and are less likely to break down. This reduces the losses implicit in downtime : lost sales, deterioration in customer relations, and non-recovery of labour and other overheads. Losses are even greater when JIT production methods are being used : the whole line stops when a single machine breaks down. A CAPP system can re-route production when a machine breaks down thus avoiding most of the downtime costs.

5 Maintenance savings. Two types of maintenance cost are considered here : maintenance by the manufacturer of its own products after sale, and plant maintenance. A CIM system will manufacture products of higher quality than those produced by conventional systems (see following section). As a result, the products used by customers require significantly less maintenance. An integrated CAD/CAM system allows a company to make rapid changes when minor design faults are detected. This will in turn reduce maintenance costs caused by the fault. Plant maintenance costs are also reduced because more reliable machines are in use (see previous point).

If a cost saving strategy is followed, the cost of the systems to be implemented should be weighed up against the expected savings in production costs. Although savings may not be easy to quantify in some cases, assuming zero savings in the cost-benefit calculation (which often happens by default) is less accurate than estimating an amount. Lower costs are bound to flow from any programme to provide some or all of the systems mentioned above. However, the more complex a system is, the higher the cost. In many cases, it would be difficult to justify a complete CIM system on the basis of cost savings only. The use of other generic strategies would probably be necessary to justify such a system.

4.2.1 Quality

A notable aspect of the philosophies of companies which have implemented IS in manufacturing is their emphasis on high quality of production, quality being defined as conformance to specifications (Kaplan, 1986). Most quality-related improvements will flow from the attitudes of employees : the best manufacturing system in the world will yield no payoff if production personnel are not concerned with the quality of their work.

Using IS in manufacturing can provide opportunities for higher quality in three ways :

- the automation of the product design via a CAD package leads to better specifications and therefore the quality of the output will be higher,
- the machines used in a CAM system are likely to produce higher quality output than those operated manually,
- the use of machines which have 100% automated inspection means that defects are signalled as they occur and preventative action can be taken. This results in far higher quality of total output than a manual production system where a whole production lot might be manufactured before defects are discovered, and
- when CIM is in place, data are transferred automatically thus reducing the likelihood of defects from incorrect specifications.

As suggested earlier in this section, the most important component of any strategy for higher quality is the participation of employees. If employees resent the implementation of new systems or are not sufficiently motivated, any strategy which seeks to improve quality of output is unlikely to succeed.

4.2.3 Response Times

Introducing a CIM system in place of a manual system would result in massive reductions in lead time and throughput time. Time can be saved :

- by using a CAD system rather than a manual design system,
- by allowing the manufacturing systems to access product specifications directly from the CAD system rather than inputting them manually,
- by using a CAM system to program machining requirements rather than manually programming a machine,
- bu using CAM specifications to set up machines,
- by GT and CAPP determining possible routings (including the optimal routing) for a product rather then using a manual system whose output would most likely be a single (not necessarily optimal) routing,
- by using AS/RS and AVGS rather than manual labourers to transport tools and materials to the appropriate machining centre,
- by using NC rather than manually operated machines, and
- by an MRP II system which ensures that raw materials are ordered in time for a job and that personnel are scheduled optimally.

Obviously, the relevance of certain of the areas mentioned above depends on the types of application being run and the level of system integration.

The reduction in both lead time and throughput time is of strategic importance. Although customers will not always be willing to pay a premium (although in some cases they will) for quick delivery, a company which can consistently deliver quicker than its competitors is likely to land more orders. Customer relationships will also be strengthened if consistently fast delivery times are achieved. There may well be first mover advantages to this strategy because any customers who are won over on the strength of quick delivery are unlikely to order elsewhere

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unless competitors better the firm's delivery times. Quick delivery is an especially strong advantage over competitors whose products have to be imported.

A further advantage of reduced lead and turnaround times is the company's ability to respond to changes in the market. If market trends are carefully tracked, trends towards changes in product preferences will be noted in their early stages. Assuming that all competitors in the market receive this information at the same time, the company which has the shortest lead and turnaround time will extract the best advantage from the change. An important aspect in this area is that of communication between the marketing and production functions, as production must be informed immediately any changes are considered in order to make optimum use of the advantage.

4.2.4 Customisation:

The use of a completely integrated manufacturing system offers companies the opportunity to develop custom-built products for different customers. Using CAD with the customer's participation, exact specifications for the desired product can be obtained. The link between the CAD module and the manufacturing systems allows a swift transfer of data to the CAM and/or GT and CAPP modules which then determine the machining requirements and operations schedule for the product. The product is then ready for production. The extra cost of such a service to customers over the cost of a mass produced item would be the designer's time (unless the product was designed entirely by the customer), the processing costs of the CAD and manufacturing systems and possible telecommunications costs (if the design is performed at the customer's site).

Successful implementation of a product customisation strategy is likely to reduce the power of buyers by introducing switching costs. However it is vital to ensure that a newly installed flexible

manufacturing facility is actually sufficiently flexible to provide such a service before offering it to customers : failure to meet promises would severely affect the company's image in its target market. If an organisation is the first in its industry to offer such a service successfully in its industry, first mover advantages (a sustainable competitive advantage for the first company to introduce a technological advancement) might well accrue, thanks to new customers who would be won over (and kept) by the new technology.

A number of important issues need to be addressed before a company can expect to achieve a strategic advantage through customisation :

- Meredith (1987) suggests that, in certain industries, customisation might become so commonplace that it will be the basis of competition. Companies' strategic success will depend on whether their systems are able to customise products efficiently, and on their ability to communicate with customers in order to ascertain their needs.
- in many organisations there is virtually a civil war between different departments. The type of system contemplated here would affect the design, engineering, manufacturing, sales, marketing and finance departments in one way or another. If one or all of them believes that the system or the customer is their personal property, the system is bound to fail. Unless departments are prepared to "integrate", there is no point even contemplating such a strategy.
- although customers will undoubtedly be prepared to pay a premium to obtain a customised product, the premium cannot be set too high if competitors are producing standard products of good quality. The objective of the computer systems contemplated here must be to provide customisation at competitive prices.

It seems clear that if the CAD and CAM islands of the system are not integrated, such high levels of customisation could not be achieved because of the lengthy and costly process of manual data transfer between design and manufacturing.

4.2.5 Economies of Scope

Traditional manufacturing systems were based on the Henry Ford philosophy : "You can have any colour you want so long as it is black". These systems were constructed to provide economies of scale - the production of many identical components in order to reduce unit costs as much as possible. The main reason for this method of production was the fact that setting up the production of a new component was enormously time consuming and therefore costly.

When NC machines are set up automatically, setup times, and therefore costs, are dramatically reduced. So the necessity for economies of scale disappears. Companies can now aim for *economies of scope*, the production of a wide range of similar products at a cost close to that of mass producing one product. A company is no longer forced by its manufacturing economies to compete for huge volumes but can produce exactly what its market requires, both in terms of volume and product characteristics.

Goldhar & Jelinek (1983) proposed two major criteria for success in a strategy for economies of scope :

- the company's manufacturing facility must be sufficiently flexible to allow production of similar products, and
- the company must have the necessary capabilities to manage a multi-product environment. To this end, Doll and Vonderembse (1987) suggest that an important part of such a strategy would be the development of applications which provide decision support for product entry and exit decisions, quality management and product design and selection decisions.

Production personnel whose whole working life has been spent attempting to eke further economies of scale out of their machines may find the concepts of economies of scope difficult to accept. As the production environment typically resists change, this could be a serious

obstacle to the success of an economies of scope strategy. The problem should be addressed by setting up training programmes, which stress the necessity for change and the benefits of the strategy to the company.

While perhaps outside the sphere of the IS usually associated with manufacturing, the interorganisational information systems and information systems for product maintenance which were discussed in detail in Chapter Three provide two further generic opportunities for manufacturing companies.

4.2.6 Interorganisational Information Systems

Interorganisational information systems and the benefits which they can offer are described in detail on pages 47 - 49.

4.2.7 Information Systems for Product Maintenance

IS applied to product maintenance and their potential benefits to manufacturing companies are described on pages 49 - 52.

4.3 STRATEGIES FOR THE FUTURE

Trends in information technology should be watched carefully by manufacturing companies to ensure that technological opportunities are put to the best possible use in corporate strategy. A number of areas where technological advances could assist manufacturers are discussed below.

4.3.1 Improvements in Database Technology

Technological advancements in relational database management systems are making it increasingly feasible to integrate all manufacturing (and other departmental) data into one large corporate database system. The ORACLE database management system is an example of such advancement. It is compatible with a large number of hardware and operating system bases and claims better performance than any comparable system. Thus even if companies have implemented a number of information systems on hardware from different vendors, such a product could alleviate many of the problems associated with integration of islands of automation.

4.3.2 Advanced Decision Support Systems

Improvements in database technology will also impact the ability of firms to develop decision support systems using product data drawn from several disciplines. For example, product entry and exit decisions could be suggested by drawing market trends from marketing, product values from sales cost information from design, production and costing, and capacity information from production.

Considering that material costs typically account for 55% and overhead for 35% of product cost, systems which can provide decision support for the reduction of material or overhead costs will be of great strategic value to a firm (Doll & Vonderembse, 1987).

4.3.3 Expert Systems

Although many people might be sceptical about expert systems, their potential in manufacturing is enormous. Intellegent "NC" machines could determine the machining requirements of different parts using embedded knowledge. Systems could be developed to make scheduling decisions based on information about the current status of the production facility. (Both of the above suggestions are drawn from Martin, 1988). Diagnostic systems could effect repairs to machines that were broken down.

Information technology researchers are aiming at goals which might seem incredible to many people. However, IT has provided the world's manufacturers with some astounding tools in the past. Why, then, should the same not apply to the future? Many (but admittedly not all) companies which have grappled with young, risky technologies in the past have had their investments repaid many times over. Those companies which are prepared to do the same in the future will have the best chance of achieving advantage over competitors who merely stand and wait.

CHAPTER FIVE

MATCHING OPPORTUNITIES WITH STRATEGIES

"[Computer integrated manufacturing] allows the new production strategy to become a true competitive weapon in the marketplace" (Meredith & Hill, 1987).

The composition of this report thus far may well have given the reader the impression that its call is "Automation at any cost!" This is not the case. The costs implied by the kind of systems discussed above would warn any sensible manufacturer that there is more to success in manufacturing than ordering a CIM system from the local computer supplier. This can be as risky as "you bet your company" (Goldhar & Jelinek, 1983). It is tempting for some managers to want the most technologically advanced manufacturing equipment on their shop floor for reasons of prestige. Here, performing a justification is the process of finding the numbers to support the proposal for specific equipment rather than an attempt to find the equipment that best suits the company's needs of the moment.

Martin (1988) suggests that a key factor in the success of any CIM project is viewing the project at *enterprise level*. Thus, a programme should not simply be aimed at pulling the manufacturing function into shape but at re-shaping all inefficiencies in the organisation. A decision on a major investment in manufacturing systems should not be made from the bottom up, as Michaels (1988) asserts happens in most cases, but rather as a consequence of a particular corporate strategy. Manufacturing systems would then be justified as "tools of strategy" rather than as investments (Huber, 1987).

This chapter will explore the possibilities for competitive advantage by linking the generic strategic opportunities offered by information systems in manufacturing (see Chapter Four) to

Porter's (1980) generic competitive strategies. Porter's (1985) value chain will be used in the process to illustrate the nature of the potential competitive advantage. The first section of the chapter reviews Porter's theory of competitive advantage, which was covered in detail in Chapter Two. The next section will define how each of the seven generic opportunities can give rise to competitive advantage and give the appropriate strategy/ies for each opportunity. The different manufacturing systems which support each of the generic strategies will be summarised and a table will be drawn up linking generic strategies, generic opportunities and information systems.

5.1 A SUMMARY OF PORTER'S THEORY OF COMPETITIVE ADVANTAGE

A company can adopt one of three different strategies to achieve competitive advantage :

- overall cost leadership,
- differentiation, and
- focus.

The value chain (see Figure 2.6) is a representation of all the value activities that a firm undertakes in order to "design, produce, market, deliver, and support its product" (Porter, 1985 : 16). There are five *primary* value activities within a company :

- inbound logistics,
- operations,
- outbound logistics,
- marketing and sales, and
- service.

In addition to the primary value activities, there are four *support* value activities :

- procurement,
- technology development,

- human resources management, and
- firm infrastructure.

Firm infrastructure supports the value chain as a whole. The other support activities exist within the different primary activities. Therefore each of the primary activities includes procurement, technology development and human resource management "sub-activities".

Areas where opportunities for competitive advantage are to be found are :

- within value activities,
- in linkages between the different value activities within the value chain of a firm where the cost or performance of an activity is affected by another activity's method of operation,
- in vertical linkages between the value chain of a firm and those of its suppliers, or those of its channels or buyers, and
- in the competitive scope chosen by the firm.

5.2 COMPETITIVE ADVANTAGE IN THE SEVEN GENERIC STRATEGIES

In terms of Porter's value chain theory, the purchase of manufacturing information systems would increase costs in the operations primary value activity. For competitive advantage to result from the purchase, the investing company must derive some benefit from the installation of the system. The benefit could take the form of substantial cost reductions or the creation of differentiation. Using Porter's definition, a linkage would have been created between the operations activity (where the investment occurred) and the activity where the benefit was achieved.

5.2.1 Cost Savings

The benefits of utilising the cost savings opportunity can mainly be attributed to linkages between the operations activity and other primary activities in the firm's value chain. However savings can also occur within the operations activity as a result of the investment in IS :

5.2.1.1 *Cost savings in operations*

In the Primary Activity

- space savings in operations from improved factory floor layout and switching to NC machines. This reduces costs by the amount of rent that is saved or by the income which is generated by further production taking place on the saved space.
- reduction in waste from better scheduling and higher quality production cuts operations costs because of the reduced investment in waste and reworked items.
- Downtime can be reduced by installing reliable NC machines, and by re scheduling production when breakdowns occur. The costs which would normally have been incurred as a result thereof will be saved - the amounts spent on labour, capacity and other overheads which are not utilised during the downtime period; and the costs of repairing the broken down machine.

In the Support Activities

1.Human resource management

- the labour requirement for the operations activity can be reduced in three areas : machine operators through introduction of NC machines, clerical staff because of automatic information transfer and quality controllers because of higher quality production. This will reduce the operations cost of human resources management. It should however be noted that there are potential negative effects on human resources management when staff reductions are effected. Trade union reaction of one form or another could raise the costs of the activity. The retrenchment of a

significant number of workers might affect the motivation of those who are left behind, and that would affect the performance of the activity. The net amount of the financial outcomes of all these effects will be the saving (or cost) to the company of this linkage.

- the manufacturing information systems will usually perform onerous tasks such as machine usage for different products, scheduling of production, and capturing of costing data. This will improve the performance of the human resources support activity within the operations activity. Freeing personnel to perform other tasks is likely to reduce costs elsewhere because production management will be able to concentrate on goals such as improved quality or reduced downtime. Costing staff will be able to spend more time on providing better decision support data.

2. Technology development

- productivity improvements in the design function and in the programming of NC machines reduce the process costs of the operations activity.
- better scheduling of production improves the utilisation of manpower and capacity. This improvement in the process of the operations activity lowers the unit cost of production.

3. Procurement

- the accurate specification of materials requirements will improve the processes of the operations procurement support activity. Receiving accurate and timely information from the IS on what to purchase allows procurement to reduce lead times and cut administrative costs.

Linkages exist between the operations activity and other primary activities :

5.2.1.2 *Inbound logistics*

- reductions in raw material inventories from better scheduling will require less staff to administer inventories. This will lead to reduction in the human resource management cost for this activity.
- the scheduling of material requirements for production provides information which allows inbound logistics to ensure that materials are ready when required by operations. This process improvement increases the productivity of this activity which in turn will decrease costs of idle time in operations.
- reduced raw materials inventories will reduce the investment in both the raw materials and the space they previously occupied.

5.2.1.3 *Outbound logistics*

- finished goods inventories can be reduced by systems which allow production to order. Fewer workers are required in outbound logistics and human resource management costs in that activity are reduced.
- production scheduling will inform outbound logistics of daily requirements, thus improving the logistical processes. The consequent on-time deliveries benefit the customer, thereby creating a vertical linkage.
- lower finished goods inventories result in cost savings for this activity because of reduced investment in finished goods and the space which they previously occupied.

5.2.1.4 *Service*

- a production scheduling report will provide the service activity with information on the timing of required installation at customers' sites. Once again, on-time delivery creates a vertical linkage with the value chain of the customer.

- higher quality of output from the installation of NC machines or better product specification reduces the likelihood of products breaking down or proving unacceptable to customers. Maintenance requirements will therefore decrease and this will reduce the costs of the service activity.

Linkages exist betwen the operations primary activity and the value chains of customers :

5.2.1.5 *Vertical linkages*

These are created between the operations activity and the value chains of customers when the cost savings opportunity is exploited :

- the reduction in downtime makes on-time delivery more probable, with attendant benefits for customers.
- improved production quality means that products are less likely to break down or be unacceptable for a customer's production processes. Smoother production will add value for customers.

So a variety of costs can be saved by the use of IS in manufacturing. This opportunity closely matches Porter's cost leadership strategy and the cost leadership option of the focus strategy. Therefore if a cost leadership strategy has been specified by top management, the types of savings cited above (and reasons for their existence) should be closely studied by those responsible for implementing the strategy in manufacturing. However many of the cost savings mentioned above are not easy to quantify, and creative ways of attaching a figure to them will have to be found when a justification is being prepared. Further, as mentioned in Chapter Four, the magnitude of the benefits depends on the level of integration of manufacturing systems contemplated.

5.2.2 Quality

Higher quality products are produced as a result of the employee motivation to seek quality improvements in all that they do, the use of machines wh :h produce a better quality of product, and the implementation of design systems with improved product specifications.

The main purpose in producing products of high quality is to provide customers with superior inputs into their operations activities. Higher quality inputs into the customers' processes result in cost savings associated with reductions in downtime and maintenance. In terms of Porter's model this creates a vertical linkage between the firm's value chain and that of the customer. This means the customer will be prepared to pay a premium price over that commanded by the standard product of the industry.

When a company establishes a quality programme, which is often the case when installing a CIM system or parts thereof, the commitment which employees show towards improving quality often bears remarkably positive fruit. An important result of such a programme would be cost reductions in the operations activity. The operations technology develo ent support activity would also benefit from employees' suggestions for improvements to the operations processes. Such a programme would usually be initiated by the operations human resources management support activity. Therefore advantage would be created by improvements within the operations activity.

An important point to make in connection with a quality strategy is that high quality and low cost are not necessarily mutually exclusive, as conventional logic suggests. Rather, "... if quality is the goal, total costs can in fact be reduced" (Ferdows & Skinner, 1987). Any premium price paid by customers for higher quality products would then be pure profit.

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Higher quality products can achieve both cost savings for the manufacturer and benefits for the customer. This opportunity could thus be part of both cost savings and differentiation strategies. The goal of the use of the quality opportunity should be carefully considered to avoid being "stuck in the middle" (Porter, 1980 : 41 - see section 2.3.2). The company with the differentiation strategy would be most concerned with the premium prices paid by customers while the cost leadership strategy would imply a careful monitoring of the cost savings. This opportunity is also appropriate for the focus strategies.

5.2.3 Response Times

Improvement in response times occur in two different ways :

- if a company is able to reduce the time interval between the perception of a potential market for a new product and the time when that product is available to buyers,
- if a company is able to reduce the time interval between the placement of an order and the delivery of the product.

5.2.3.1 *Market response time*

A linkage is created here between the operations and the marketing and sales primary activities. Being in a position to get a product to the market quicker than competitors is likely to increase turnover because of early availability. It should be noted that any attempt to use this opportunity requires that the company have the shortest response time in the industry. Being second will not provide an advantage (but companies may well need to follow leaders in the industry simply to remain in touch).

5.2.3.2 *Customer response time*

A shorter time between order and delivery will provide significant benefits to the buyer. He will be able to respond quicker to the changes in his target market. This improved response

time will give the customer all the advantages mentioned in the previous section. Because successful outcomes of business decisions are more probable with decreasing time span, the later a customer's procurement department is able to place an order, the more certain is the need for the product ordered. Reduction in uncertainty is a major benefit to customers. If raw materials are being supplied for the customer's production process, the probability of an out of stock situation is reduced by the faster response time. Reducing customer response time thus creates a vertical linkage between the operations activity and the customer's value chain.

Because the response time opportunity gives a company a "free shot" at the market while competitors are still struggling to manufacture a comparable product and allows the company to respond efficiently to customers' orders, buyers are prepared to pay a premium for the product (only while it it still unique in the market). The opportunity thus matches the differentiation strategy, or the differentiation option of the focus strategy.

5.2.4 Customisation

In order to manufacture products to satisfy each customer's specific requirements completely, an extremely flexible manufacturing system is required. It must be integrated with a design system and have quick lead times. The customer must be able to specify, with or without the aid of salespeople from the supplying firm, the exact design of the product to be purchased.

The most obvious application of this opportunity in the value chain concept is the vertical linkage between the firm's and the customer's value chains. The cost increase in the producing firm's operations activity impacts on a number of the customer's value activities :

- the procurement activity's performance is enhanced because it has negotiated a product better than the standard offering of the supplier's industry; so its cost may be reduced because of a more efficient ordering process.
- the operations activity will be enhanced by receiving a product which exactly suits its requirements, whether it be capital equipment, a raw material for further processing or a final product for resale.
- if the product purchased is a raw material, the customer's marketing and sales activity will be enhanced because the product which it sells will be of higher quality than one whose input was standard rather than customised.

The improvements in the customer's value chain will persuade him to pay a premium over the price of the standard industry product.

There are also a number of linkages within the firm's own value chain. Firstly, between the operations activity and :

- the marketing and sales activity, in which performance is improved by the opportunity to market and sell customised rather than standard products. If the order entry process is changed to include on-line design specification, perhaps with a module which allows salespeople (or customers) to link into the system directly from the customer's site, the performance of the marketing and sales activity is further enhanced. Also, there might be cost savings due to order entry being more efficient or being carried out by the customer.
- the service activity, in which maintenance costs (and installation costs, in the case of capital equipment) are likely to be reduced because the product exactly meets the customer's specifications.

The competitive advantage afforded the firm offering customisation is quantified in the following way : the premium price which the customer is willing to pay for the advantages which it is afforded is set off against the incremental costs of being able to provide the customisation

service. The difference between these two amounts is added to margin in the value chain and is the value to the company of the service offered to customers.

The increase in costs as a result of the customisation strategy and the premium which the customer is prepared to pay indicate that this strategy can be used as a tool of a company's differentiation strategy or of a focus strategy if the main thrust thereof is differentiation.

5.2.5 Economies of scope

Economies of scope are possible if a company possesses a sufficiently flexible manufacturing facility to allow the production of a wide range of similar products. The facility allows the company to tailor its product to meet the specific needs of its target market. This is especially useful for a small company aiming to service a limited market.

Where a company makes use of economies of scope to home in on a narrow market, a linkage is created between the operations and marketing and sales activities. The latter's performance is enhanced by the manufacturing system's giving it the ability to target a particular niche of the market. By being able to meet the needs of the customers in that market niche exactly, the company should be able to gain a substantial share of the market. Thus the marketing and sales strategy is achievable, thanks to operations.

Economies of scope can also be used at another level. The aim would be to compete on an industry-wide level, producing a wide range of similar products. Competitors without sufficiently flexible manufacturing systems would compete directly with only one product in the company's range. An example would be a competitor of Henry Ford (he only produced black cars) who could produce cars with features similar to those offered by Mr Ford, but in a range of colours. Here the company has broadened its segment scope thus allowing it to serve a

number of different customer segments by the provision of a wide range of products. Once again the performance of the marketing and sales activity is enhanced by the system provided by the operations activity, creating a linkage between the two activities.

The two economies of scope opportunities described here match different strategies. The focus strategy with the emphasis on differentiation could use economies of scope to service a narrow market niche. Where a broad range of similar products is produced, the differentiation strategy is suggested because the market would perceive the company's products to be different to others offered in the market (eg. a range of coloured cars) and would be prepared to pay a premium price for them.

5.2.6 Interorganisational Information Systems

An IOS is a system which links two or more organisations. An IOS creates synergy : all participants in the system can reap benefits from it. A common format is one where a single supplier (the sponsor of the system) initiates an IOS which links a number of customers to the supplier. Usually the IOS will take the form of an order entry system, although there are IOS which offer more advanced facilities such as data retrieval and manipulation. This section will consider a company's participation in an order entry IOS both as supplier and customer.

5.2.6.1 *Supplier*

The supplier will usually be the sponsor and will thus incur most of the costs of the system, ie. the hardware, software, development and possibly communications costs. The costs of the system should be considered to be borne by the technology development support activity of the marketing and sales primary activity because it completely changes the order entry process.

The internal benefits of the system lie mainly within the marketing and sales activity. The major benefit is the cost saving arising from customers capturing their own orders. A successful IOS could also promote the product and improve the company's image in the eyes of the customer. Once an IOS terminal is installed at a customer's site, removing it becomes a costly procedure for the customer. The consequent switching costs ensure a high probability of making future sales to the customer. All of these points will improve the performance of the marketing and sales activity.

Externally, a vertical linkage with the customer's value chain is created. The customer's most immediate benefit is the reduction in procurement costs via the simplification of the order entry process. Other possible advantages could arise from reduced inventory levels, the receipt of relevant data about purchases made, and the possibility of the IOS supporting a JIT purchasing philosophy. As mentioned in Section 3.3.2.2 above, a company is unlikely to participate in an IOS unless it perceives some benefit for itself. The benefits described above would probably induce customers to participate in the IOS but installing an IOS would not differentiate the *product* offered by the sponsor. Therefore the sponsor could not expect a premium on the price of its product. If the supplier provides other facilities in addition to the order entry system, customers might well pay for those facilities. They would, however, be paying for information or for processing time, and not for the product.

Clearly an IOS must be justified on cost savings to the supplier and, perhaps, on fee income. If the supplier receives some form of income from the IOS, it would be considered a separate product and would therefore have its own value chain. Part of the costs of the system should then be borne by that value chain.

Because the IOS reduces cost both for the sponsor and the participants, it matches a cost leadership strategy. Although vertical linkages exist with customers and the product is

enhanced by the order entry system, the absence of a price premium makes the differentiation strategy inappropriate. The development of an IOS will require a fair amount of data processing expertise - of the kind typically found in larger companies and thus unlikely to be on the agenda of a smaller company with a focus strategy.

5.2.6.2 Customer

Here the company's role is that of a customer using a supplier's IOS. There is a vertical linkage between the value chains of the firm and the supplier. The major benefit to the company would result from lower costs in the operations procurement support activity due to an improved order entry process. Raw material inventory levels would probably be reduced with attendant benefits in inbound logistics. The system might also support JIT purchasing which would further enhance the performance of inbound logistics and operations. Another factor is the switching costs which participation in the system introduces for the customer. This cost should be set off against the benefits of participation before the decision on whether to participate is made.

Participation in an IOS as a customer will provide a company with cost savings and this opportunity would thus be appropriate under a cost leadership strategy. In many cases, customer participants in IOS are likely to be smaller companies and in such cases a better strategy match might well be the cost leadership aspect of the focus strategy.

5.2.7 Maintenance Information Systems

A company can install a number of different types of IS to improve the maintenance of its products. They can be broken down into three categories :

- those which improve the triggering of the need for maintenance;
- those which provide inputs into the maintenance process; and
- those which accept information output from the maintenance process.

5.2.7.1 *Triggers*

- Repair triggers. These will inform the user of the need for repairs or maintenance. Such IS would usually have to be built into the product during the manufacturing process. IS which are able to diagnose the impending breakdown of a product provide an important vertical linkage with the customer. The customer benefits greatly by avoiding the breakdown of an item. If, for example, the item is a passenger aircraft, the benefits to the carrier of it not breaking down in mid-flight are immense. Customers will be willing to pay a premium when the IS performs such a function.
- Prevention triggers inform the user when preventative maintenance is required, either as a result of the passage of a certain period of time or when some other usage criterion is met. Once again a vertical linkage with the customer's value chain would be created because of the breakdown costs avoided. A product with such features could command a premium price.
- Enhancement triggers inform customers when an enhancement to the product is available. Although not as vital to customer operations as repair and prevention triggers, an IS which performs this function can provide a vertical linkage with the customer if the enhancement promises to improve some element of its operation. In such a case, the customer will pay a premium for the facility.

In all three cases above, the product is enhanced by the service which the IS provides, and the customer will pay a premium for it. Consequently, the use of any of these three opportunities will support a differentiation strategy, or a focus strategy with an emphasis on differentiation.

5.2.7.2 *Inputs*

IS which provide inputs to the maintenance process contain information on resources which are necessary for the maintenance job. Thus an IS can schedule repair personnel, make suggestions as to what parts should be used and trace parts required in order to repair the product.

The cost of such a system would be carried by the service technology development support activity. An advantage is created within the service activity because the information provided by the IS will improve the productivity of the maintenance function thereby reducing costs and improving performance.

A vertical linkage also exists between the company and the customer. The customer benefits by faster maintenance. In the case of preventative maintenance, this means that the product will be ready for use sooner than otherwise. In the case of a repair job, the costs due to downtime are reduced. A customer will thus be prepared to pay a premium for a product with this feature.

The cost reductions in the service activity and the premium price received for the product as a result of the input IS, indicate that this opportunity could match either a cost leadership or a differentiation strategy. The magnitude of the cost savings and the premium price would determine which strategy best fits the opportunity.

5.2.7.3 *Outputs*

Information from maintenance jobs can be captured by an IS which establishes trends on products maintained and the people or equipment involved in producing the product. Inherent design problems could be identified and referred to the design department in order to ensure that future products would not be subject to the same problems.

As with an input maintenance IS, this type of system would be considered to be the responsibility of the technology development support activity. An output provides a strong linkage between service technology development and operations as most of the benefits of the system will be felt in operations. The effectiveness of workers and machines can be guaged from the number and types of maintenance activities performed on products for which they were responsible and the problems highlighted for production management attention. As stated above, any design problems can be rectified thanks to the system. This feedback on the previous quality of production will presumably lead to higher quality in future. So over time the company's product quality will be noted by the market and customers will be induced to pay more for the product than for standard industry output.

Another advantage of such a system flows from the increased future quality. This will in turn reduce costs in the service department because fewer maintenance calls will be necessary.

Although there are cost advantages in the use of an output maintenance IS, the major benefit is the incremental quality improvement in production and the premium value which will be attached to the product. Therefore the differentiation strategy, or the focus strategy with a differentiation thrust, is the most appropriate strategy for this opportunity.

5.3 SYSTEMS FOR STRATEGIES

Although this section is in no way intended to be rigidly prescriptive, it will hopefully provide some insights on the different types of systems available to support a strategy that has been selected by a manufacturing company. Once again, it is stressed that the strategy should determine the system/s selected and not vice versa. The suggestions do not take into account the differences in cost between alternative systems which perform similar functions. The analysis of costs and benefits before installing systems is thus vital.

The discussion below will focus only on the cost leadership and differentiation strategies because it is assumed that the proposed systems will be appropriate for the respective options in the focus strategy. Comments will be made at the end of each section as to its applicability to the focus strategy.

5.3.1 The Cost Leadership Strategy

The definition of this strategy implies that a company intends to cut rigorously every possible cost, especially in the production process. So there is an extremely important trade off when IS are purchased for manufacturing as a result of this strategy : the savings resulting from the purchase *must* exceed the cost of the system. Systems which have potential application under this strategy include the following :

- MRPII and JIT systems provide numerous cost savings mainly as a result of the enormous reductions in inventory which they can achieve. Thus there are savings in space, in investment in inventory, and in materials handling. In addition, this type of system eases the clerical load on production workers, which will reduce manpower requirements (or at least allow personnel to be more profitably employed elsewhere).
- CAM systems will yield large savings in labour costs *vis a vis* manually operated machines but these will not be as evident if NC machines or DNC machines are upgraded to CAM status. Other cost savings arising from the introduction of CAM would be reductions in downtime, scrap and rework because of the finer precision of the machines and their programmed requirements. If cellular manufacturing techniques are adopted together with the CAM technology, space and flow savings will result. It should however be noted that cellular manufacturing can be implemented without running CAM simultaneously.
- CAD packages will improve designer efficiency. If many similar products are to be designed or if the design process is extremely complicated, substantial savings will arise.

- the sponsoring of an IOS which allows customers to punch orders directly into the supplier's order entry system can provide significant savings to the supplier because of a reduction in manpower requirements. (Participation as a customer will also provide cost savings.)
- where a company performs a great deal of maintenance on products purchased by customers, IS which provide inputs into the maintenance process can assist in the reduction of costs for this function.

The following systems will provide cost savings but, because of their high cost of implementation, are unlikely to be purchased solely for their cost saving abilities :

- CIM providing for the integration of the different islands of automation. CIM would undoubtedly provide cost savings over an islands of automation approach, especially in terms of the labour which would be required (without CIM) to transfer data between modules. The flexible manufacturing ability provided by CIM would lead to reductions in setup costs and throughput time with commensurate reductions in product costs. However, the cost of installing CIM would be probably so high that integration could scarcely be justified on the grounds of cost savings alone.

  automated storage and retrieval systems and automatic vehicle guidance systems would also reduce labour costs but, once again, their cost of implementation would be unlikely to justify their use in a cost reduction strategy.
- the use of both trigger and output maintenance systems can reduce the costs of the service activity but in both these cases the consequent product enhancement will provide a more substantial benefit than cost savings.

The suggestions above should assist a company which has intentions of adopting a cost leadership strategy. However the comments about CIM, AS/RS and AVGS above may not be appropriate for very large companies where the scale of operations might well justify the investment in such systems in support of a cost leadership strategy.

Where a company has opted for the cost leadership option within the focus strategy, it will probably be relatively small in comparison with companies competing in an industry at a national level. The cost of the potential systems would thus weigh more heavily on the management of such companies than on those of a larger company. The scale of operations is likely to reduce the attractiveness of costly systems such as CIM, AS/RS, AVGS, IOS and perhaps CAM. The focused would-be cost leader should probably concentrate on the cost benefits offered by JIT and MRP/MRPII systems and certain of the less costly islands of automation. For a smaller company, acting as a paticipant in an IOS would support this strategy.

5.3.2 The Differentiation Strategy

Where a company has opted for the differentiation strategy, the cost of systems will be justified on a different basis than the cost leadership strategy. Whereas for the latter the cost of the system must be more than offset by the savings which it will provide, the differentiation strategy demands that the system induces more marginal income than its total cost. Thus the cost of a system is not as important as its ability to generate more income by means of the special features that it adds to the company's products. Furthermore, by its nature a cost leadership strategy virtually demands that the company choosing it is the dominant market competitor. The differentiation strategy does not have the same requirement because it does not depend on the cost of production. In fact, because the majority of customers in any market are not likely to be prepared to pay a premium for a superior product, the differentiated company is unlikely to be the major player in its market.

Of all the systems mentioned in this report, CIM is the system most likely to provide significant benefits to a company adopting the differentiation strategy. The flexible facilities offered by a CIM system allow a company to manufacture products of higher quality than would otherwise be possible, provide customisation (or at least near-customisation), improve its response to

market trends and customer orders, and achieve economies of scope. The market will perceive all of these features as symptomatic of superior products or service. This will induce a certain type of customer to pay a premium over the price of the average product in the industry.

Although individual islands of automation discussed in Chapter Three will provide some of the features mentioned above to a greater or lesser extent, the full benefits are unlikely to be experienced unless the islands are integrated. The islands most likely to provide support for a differentiation strategy are production planning and control systems such as MRP/MRPII and JIT. These will tend to improve lead and throughput time because of production scheduling, and quality because of their underlying philosophies.

In addition to the islands of automation and CIM, the use of trigger and output maintenance systems will also support a differentiation strategy by providing superior servicing of customers through maintenance triggering and improving the product from the feedback provided by maintenance statistics respectively.

The points above apply equally to the differentiation thrust of the focus strategy and the market-wide differentiation strategy. Companies choosing either are not likely to be very large relative to the average competitor in the industry because of the limited size of the market prepared to pay a premium for a differentiated product. However if the companies selecting a differentiation strategy are small, they may experience problems in justifying the large investment in a CIM system. Thus many companies which have chosen a differentiation strategy may well be unable to invest in CIM and have to choose between the various options available among the different islands of automation. In this case, the production planning and control systems are likely to offer the most benefit.

5.4 STRATEGIES, OPPORTUNITIES & SYSTEMS - A SUMMARY

This section provides a graphical representation of the findings in this chapter linking Porter's (1980) three generic strategies, the seven generic opportunities defined in Chapter Four, and the different IS available to manufacturers.

Strategy	Opportunity	System	Benefit/Comment
Cost Leadership	Cost Savings	CAD	designer productivity
		NC machines	labour reduction
			machine reduction
			machine reliability
		CAM	routing, machine utilisation decisions
			programmer productivity
		CAPP	routing decisions
		MRP/MRPII	resource allocation decisions
			inventory reductions
		JIT	inventory reductions
			production to order
		Cellular Mfg	better layout
		CIM*	better quality products
			quick fix of faulty design
			automated information flows
		AS/RS & AVGS*	reduced handling costs
	Quality	See Differentiation Section below	Fewer defects, less rework
	IOS as Sponsor		reduced order entry costs
	Maintenance	Input	improved service productivity
		Trigger*	reduce service costs
		Output*	reduce service costs

Note : the * indicates that this is not likely to be a primary contributor to the strategy.

Strategy	Opportunity	System	Benefit/Comment
Differentiation	Quality	CAD	more accurate specifications
		CAM machines	higher quality output
		CIM	automatic transfer of design data
	Response Times	CAD	automated design
		CAM	programming efficiency, faster setup
		GT/CAPP	optimal routings
		AS/RS & AVGS	quicker transport of materials
		NC machines	quicker machining
		MRPII	optimal scheduling of resources
	Customisation	CIM	total integration allows for quickest response to customer requirements
		CAD/CAM Integration	minimum requirement for this opportunity
	Economies of Scope	CAM and AS/RS & AVGS	automatic machine setup vital
	Maintenance	Repair Trigger	prevents breakdown
		Prevention Trigger	need for preventative maintenance
		Enhancement Trigger	updated product availability
		Input	quicker maintenance of products
		Output	improved future product quality
Focus (Cost Leadership)	Cost Savings	CAD	designer productivity
		NC machines	labour reduction
			machine reduction
			machine reliability
		CAM	routing, machine utilisation decisions
			programmer productivity
		CAPP	routing decisions
		MRP/MRPII	resource allocation decisions
			inventory reductions
		JIT	inventory reductions
			production to order
		Cellular Mfg	better layout
	IOS as Participant		reduced procurement costs
	Maintenance	Input	improved service productivity

Strategy	Opportunity	System	Benefit/Comment
Focus (Differentiation)	Quality	CAD	more accurate specifications
		CAM machines	higher quality output
		CIM	automatic transfer of design data
	Response Times	CAD	automated design
		CAM	programming efficiency, faster setup
		GT/CAPP	optimal routings
		AS/RS & AVGS	quicker transport of materials
		NC machines	quicker machining
		MRPII	optimal scheduling of resources
	Customisation	CIM	might be too expensive for strategy
		CAD/CAM Integration	minimum requirement for this opportunity
	Economies of Scope	CAM and AS/RS & AVGS	automatic machine setup vital
	Maintenance	Repair Trigger	prevents breakdown
		Prevention Trigger	need for preventative maintenance
		Enhancement Trigger	updated product availability
		Input	quicker maintenance of products
		Output	improved future product quality

CHAPTER SIX

CONSIDERATIONS FOR APPLICATION

"The challenge is not technological; it is managerial" Jelinek & Goldhar (1984).

Previous chapters have provided suggestions regarding the most appropriate manufacturing information systems given a defined corporate strategy. However, the implementation of systems which are found to represent a significant investment for any company should not be regarded merely as a production project but rather as a company-wide project. A carefully structured plan is required to achieve success. This chapter identifies a number of factors to be considered when planning the development of such systems.

6.1 TOP MANAGEMENT TO INITIATE DEVELOPMENT

As stated above, a project of the type contemplated here cannot be viewed as the responsibility of manufacturing only. If it is necessary to shape the production function to support a defined corporate strategy, production management cannot be expected, or indeed allowed, to bear the brunt of the success or failure of such a programme. Indeed, the thinking of personnel throughout the company often has to be altered radically before a competitive strategy of the type suggested by Porter (1980) can be successful.

It is up to top management to initiate and monitor a programme to develop and implement IS in the manufacturing function. Their insight into the strategic reasons for the system and the potential effect on the company of success (or failure) makes their participation in the programme vital. Only top management has a a sufficiently broad perspective to decide to appropriate level of manufacturing system. It is only top management which has the political

power in the organisation to forge the partnership of engineering, management, manufacturing, data processing and marketing personnel necessary to make a success of the programme. Only the word of top management has sufficient power to force certain employees to support the programme despite any misgivings they might have. Rather than being viewed as a manufacturing or computer project, the programme should be seen (and advertised to employees) as a management philosophy (Appleton, 1984).

6.2 AN EVOLUTIONARY PROCESS

At the price which a company might have to pay for a CIM system, one might expect that the suppliers would arrive with the hardware boxes, connect a few wires and then the benefits would start to flow. Nothing could be further from the truth. Successful installation of CIM involves a great deal of effort. Myriads of data have to be input, costs can be expected to increase before they decrease (Huber 1987) and many temporary setbacks will be experienced. The truth is "you cannot buy CIM; what you can buy are islands of automation, integrated by a logo" (Appleton, 1984).

The achievement of full integration usually requires a step by step evolutionary process. Success is impossible if a company tries to "leapfrog" a necessary stage on the route to integration. For example, to install MRP successfully, inventory records must be 95% accurate and bills of materials 98% accurate. Although a company may have been operating perfectly with less accurate records and there may appear to be no payoff for the cost of the increased accuracy, the immediate installation of an MRP system will produce suboptimal results at best. No steps can be left out (Meredith & Hill, 1987).

It is suggested that a CIM be planned as a phased implementation. The Ingersoll Milling Machine Co's project started with the use of a CAD package and database. When that was

running successfully, the next system was installed, etc. Now the CAD database drives an integrated flexible manufacturing system (Huber, 1987). An incremental project allows management to control the process and ascertain that each phase has been satisfactorily completed before embarking on the next. Management would experience a massive information overload if the whole project were run in one fell swoop. They would almost certainly find it well-nigh impossible to control the project with any degree of certainty as to the outcome. The overall direction of the project can also be debated after each phase and altered if necessary; this could save a great deal of money if the alternative was that the whole (wrong for the company) system was purchased at once.

The discussion above has been based on the assumption that the company in question is planning to install a CIM system from scratch. Obviously companies already on the path to CIM should adopt a phased approach for the same reasons advanced above.

6.3 BENEFITS OF PREPARING FOR AUTOMATION

A company which intends to install an automated production system might well employ a manufacturing technology of older descent than that described in this report. The philosophy of two technologies is bound to differ and one of the differences is likely to be the way the production line is set up. The emphasis of the new technology is on reduced product flow and concepts like cellular manufacturing. Reorganisation of the factory floor *per se* will lead to remarkable benefits : Meredith (1987) states that a number of companies, in reorganising for automation, improved manufacturing results to the extent that they decided that automation was unnecessary. This point will be of special interest to smaller companies which may lack the resources to invest in CIM but wish to improve the manufacturing function. This point underlines the fact that the IS discussed here are not ends in themselves but merely tools of the end : the corporate strategy.

6.4 THE EFFECT OF DIFFERENT MANUFACTURING PROCESSES

Throughout this report a production process involving machining of parts has been assumed. Obviously many manufacturers run operations that are completely different to this stereotype. Many production processes will have no need of a CAD system, for example. This does not imply that the discussion above would have no relevance to such a company. Manufacturing IS and CIM can be applied successfully in any manufacturing operation (assuming that the system is justified by the benefits gained); they simply need to be tailored to the type of operation. For example, all types of manufacturing operation could apply the scheduling and inventory control supplied by an MRP II system. Once again, the point is that the technology supports rather than supplies the philosophy : all production departments could improve their flow lines even if computers are not involved.

6.5 COST BENEFIT ANALYSIS

Before making an investment decision regarding manufacturing IS, the expenditure ought to be justified. The usual method of performing a cost benefit analysis is the discounted cash flow approach involving analysis of cash flows in and out of the company as a result of the investment. The timing of the flows is taken into account by using the so-called hurdle rate (usually the firm's cost of capital) as a discounting factor.

Kaplan (1986) reports a growing disenchantment with this model because of its apparent inability to deal with proposed investments in CIM systems. He suggests that the problem does not so much lie with the model but rather with the way that it is applied to CIM-type investments. He makes the following comments :

- companies tend to use an unnecessarily high hurdle rate rather than the project's opportunity cost of capital (the return that could be received from the market for investment in projects of similar risk). An unreasonably high discount rate also penalises a CIM project because of its long term nature.
- the "no investment" option in the appraisal assumes a continuation of current turnover. In many cases this is inappropriate because some competitors are likely to invest in the new technology and benefit at the expense of the firms which do not.
- many companies have an investment approval procedure whereby managers of certain seniority have the authority to approve expenditure up to a certain ceiling. The result is often that a number of small projects whose cost (coincidentally) is just below the ceiling are approved discretely. This is almost certain to lead to suboptimal manufacturing processes.
- many costs which would be incurred as a result of the project are not included in the analysis because they may be written off for taxation purposes in the year in which they arise. Items of expenditure such as software development, site preparation and personnel training must be included in the investment appraisal calculation.
- if costs are expected to increase in the early stages of implementation, this should be taken into account in the analysis.
- benefits which are difficult to quantify are often simply not taken into account in the cost benefit analysis. To use zero as the expected benefit resulting from better quality and flexibility, and reduced floor space, inventory levels and throughput time may be prudent but it is certainly not more accurate than a sensible estimate.

Jelinek & Goldhar (1984) add a further point : often the discounted cash flow calculation takes into account only the benefits during the life span of a single product or range of products. By implication, the investment ceases to exist thereafter. This trap should be avoided when analysing a CIM system because the flexibility of the system promises life after the first product, and future enhancements to the system will increase the value of the existing base.

The point which should always be borne in mind when a cost benefit analysis of proposed IS in manufacturing is performed is that this type of project cannot be treated in a simplistic way. Creative thinking will have to be used in order that all the costs and benefits are reflected in the final calculation. The complexities should be addressed rather than avoided : even if the numbers representing some costs and benefits are not absolutely correct, they will reflect the outcome of investment better than if they were ignored.

6.6 COMPETITION

Much of the discussion in this report has centred on the effect of manufacturing IS on the company installing them. The picture might well have been presented as though the company were operating in a given competitive vacuum : surrounded by caring competitors who looked on kindly while competitive advantage was wrested from them. This is obviously not the case. Each company operating in a particular market will be doing its utmost to become more profitable. There are a number of points relating to competitors which a company contemplating utilising more advanced manufacturing systems should bear in mind.

6.6.1 First Mover Advantages

Certain competitive moves will provide sustainable first mover advantages. For example, an industry might be notorious for poor production quality. The first competitor to supply consistently high quality products will win, and keep, market share. A company should search for areas where manufacturing technology will provide sustainable first mover advantages.

6.6.2 Stay Ahead

In other areas, a competitive move will provide temporary first mover advantages. A product enhancement marketed first will win some sales but is unlikely to retain customers if competitors reply with a product of similar quality. To retain those customers a company must avoid resting on its laurels but rather work on further enhancements. By ensuring that it is always (at least) one jump ahead of the competition, a company should be able to win a higher share of the market.

6.6.3 Second Best?

If a competitor makes a strategic move which gives it a first mover advantage, what should a company do? The answer is based on the company's strategy. Perhaps it does not to meet that competitor head on. However, if the strategy is to compete directly with that competitor, the company should attempt to match the move. If the first mover advantage is sustainable, the move to match the competitor will hopefully allow the company to avoid further loss of market share. If it is not sustainable, matching the move should restore parity - unless the competitor has planned further moves as suggested in the previous section. The company thus matches the competitor with no thought of extra profit; only reduced future losses. It should be noted that in some cases matching the competitor will not require a company to match the technology used. However, in moves which require, say, flexible manufacturing, the competitor's technological advancement must be matched.

Information systems in manufacturing provide numerous opportunities to win competitive advantage. A company should assess the use of IS based not only on what it could achieve but also on what competitors could achieve. A decision not to reap benefits might turn out to be a decision to incur losses.

6.7 EMPLOYEE CONSIDERATIONS

The employees who will drive the new system within the manufacturing function are vital to its success. Traditionally, many people who work in manufacturing are suspicious of change and are content to continue with operations which are working well for them. A major effort is required to overcome the resistance to change which is bound to occur. As mentioned above, top management can play a role in motivating employees by being seen to be sponsoring the project. The aims of the project and the benefits of success should also be clearly spelt out to employees in all departments. The fact that the project will involve all functional areas and also the supporting strategy behind it should be stressed so that there is no temptation for staff to think that the programme affects manufacturing only.

An important consideration for top management is the availability of suitably qualified people to manage the project. Manufacturing is not perceived as the most attractive career area and is not paid sufficient attention at most universities. Consequently few people are available with the diverse skills required for such a position. Personnel with some of the requisite skills might well have to be "head hunted" out of marketing, finance or data processing. Motivating such people might not be as difficult as it would seem at first glance : the recognition of the strategic role of manufacturing in the company's fortunes is likely to promote the position of manufacturing within the company and provide attractive career paths to capable people.

6.8 DISASTER RECOVERY

When a company is running a CIM system, the manufacturing operation is totally dependent on the IS which drive it. Surprising as it may seem, "smoke and rubble" (Stamps, 1987) (to use the commonly-used phrase in the computer disaster recovery industry) may not actually pose too much of a threat to manufacturers - if the computer is in that state, the probability is that the

rest of the plant will be too. However, a problem which disables the computer while the rest of the factory is in perfect working order could prove to be a major disaster.

A common data processing solution to such potential problems is to plan to move the computer operation to a backup site. In the case of CIM, however, unless the data communications between the factory and the backup site are perfected, the computer processing needs to be performed at the usual site.

A possible, but costly, solution would be to have both hardware and software suppliers guarantee backup configurations within a specified turnaround time. This suggestion could certainly not be justified in most companies because of the expense of such a contract. Consequently, there is a need for some other plan with costs pitched at the appropriate risk level. The important thing is that manufacturers recognise the risk of computer malfunction and plan how to deal with it.

CHAPTER SEVEN

CONCLUSION

From the previous chapters it is clear that numerous benefits are available to companies via the use of information systems in manufacturing. The pivotal role which manufacturing can play in a company's fortunes is becoming increasingly well-understood and a corporate executive would ignore such benefits at his peril.

This report has applied Porter's (1985) model for analysing competitive advantage via the use of the value chain in an attempt to specify the most attractive opportunities available to a company considering the use of information systems in its production processes. It has further linked Porter's (1980) three generic corporate strategies to those systems most likely to support the chosen strategy. A vital consideration when identifying the IS to be implemented is that they should support the competitive strategy of the company. If the systems installed do not specifically support a company's strategy, although some advantages might accrue to the company from their use, the return on the (usually sizeable) investment in the systems may well be less than an alternative which does support the company's strategy.

Of the two general strategies for competitive advantage, the differentiation strategy is best supported by CIM systems, whereas the cost leadership strategy is supported by the application of selected "islands of automation". This is not a prescriptive view, however, as the idiosyncrasies of different types of manufacturing process and of individual companies may well lead to different conclusions than those suggested above. Therefore it is necessary to perform some form of cost-benefit analysis on any proposal for implementating an IS in manufacturing in order to ascertain its appropriateness for the competitive strategy chosen for the company.

Despite the attractive prospects which IS in manufacturing might offer, a cost benefit analysis may well show that the *status quo* is actually preferable to the implementation of such costly systems. A possible recipe for manufacturing disaster is the "technology-driven" process where each time the latest development in the area is unveiled, it is purchased simply because it is the most modern system available. Failure to address the specific strategic needs of the company could turn such a system into a corporate millstone. Although this is true for all computer systems, it is especially true for those applied in manufacturing because of their high cost and the importance of the production process to the operations of the average manufacturing company.

This warning is not intended to dissuade corporate executives from examining the potential use of manufacturing IS but rather to sound a warning as to what can go amiss. Indeed, neglect of the possible benefits from such systems could also prove to be a corporate millstone. If competitors are reaping massive benefits from their manufacturing IS, they are likely to increase their market share at the expense of the laggard company.

What is required of a company is a cold, hard look at the facts of the IS available in its area of operation without starry-eyed wonder at the amazing feats of the latest technology but with a determination to remain undaunted by the technological demands which installation might make on the company. Although not necessarily appropriate for every manufacturer, IS in a company's production processes could make an enormous addition to its profits. Failure to recognise and act on that potential can only lead to future enormous profit increases for a company's competitors.

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