

Formulation of Manufacturing Strategy

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With customers demanding high quality, low cost and shorter lead time, the manufacturing function plays a vital role in attaining a competitive advantage. Thus, to compete effectively, it is important to formulate and implement the appropriate manufacturing strategy. This paper presents the author's experience and the resulting generic methodology which has been successfully used in several organisations.

Keywords: Competitor analysis; Critical success factors; Industrial analysis; Manufacturing strategy; Performance objectives

1. Introduction

The market throughout most industries is becoming increasingly competitive owing to product diversity, short product life cycle and the subsequent reduction in profit margins. The focus has, therefore, been turning towards the manufacturing function to produce better quality products faster and cheaper, thereby contributing to a company's overall competitive success. It has been recognised that manufacturing can be a formidable competitive weapon if equipped and managed properly and that it is essential to develop and follow a coherent manufacturing strategy.

A manufacturing strategy is defined [1] as a statement of how manufacturing supports the overall business objectives through the appropriate design and utilisation of manufacturing resources and capacities. To support the overall business it is essential to align the manufacturing strategy with the marketing strategy and the overall business strategy. This paper explores, from practical experience, the use of theoretical methodologies and frameworks for the formulation of the manufacturing strategy and examines how it can be aligned with the overall strategy.

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2. Business Environment

Every organisation depends upon its environment (PEST):

1. Political (P)
2. Economic (E)
3. Social (S)
4. Technological (T)

It is fundamental, therefore, to understand the business environment, prior to studying the requirements of an organisation. The business environment can be broadly divided into (Fig. 1) [2]:

1. The macro environment
2. The market
3. The firm

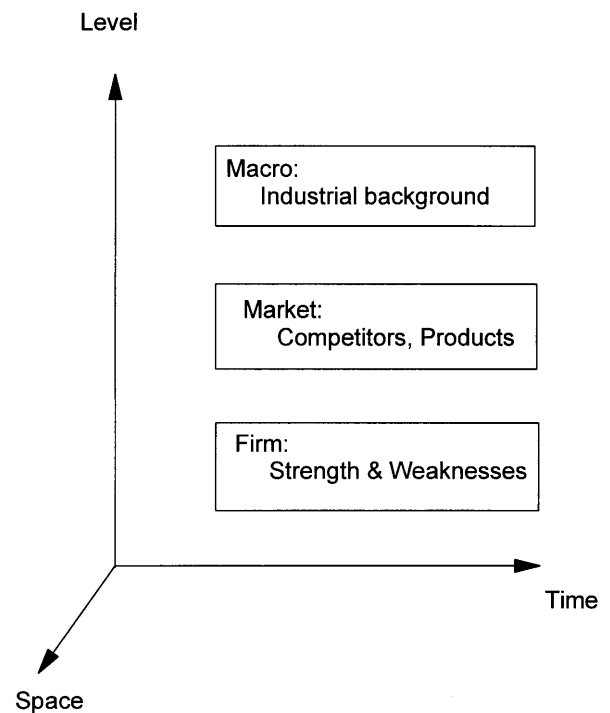


Fig. 1. Business environment framework.

The macro environment can be understood by examining the industrial background in terms of the nature of demand and the main drivers of it. The market consists of the customers and the competitors and, for a concentrated industry, an individual analysis of the competitors and their products will provide an insight into the market characteristics. With the background information from the macro environment and the market, the firm can be analysed and compared with its competitors.

2.1 Industrial Background

Consequently, the first phase of the analysis should commence with the industrial environment. For example, if a railway rolling stock manufacturer is considered, in broad terms the demand will be linked to the transportation need of each country, which is in turn related to the population and GDP growth. Other issues such as the importance given to railways in the transportation policy, energy costs, and conservation and environmental factors also play a part. Future demand depends on many variables which include:

1. The degree of rail transport in any given country.
2. The expected population and GDP growth.
3. The degree to which the railway is expected to contribute.
4. The age and condition of the existing rolling stock.
5. The need for scrapping and replacement of existing equipment.
6. The impact of environmental legislation.
7. The political stability and economic strength of the country.
8. The availability of finance for major projects.

The demand could, in this case, be divided into two broad segments:

1. New equipment due to growth in demand and
2. Replacement of scrapped units,

in addition to the geographical regions.

The nature of demand in this industry is also changing with the replacement demand taking a higher proportion of the total demand than before. The new demand due to growth is shifting from developed countries to developing countries where there is a shortage of capital to finance infrastructure expenditure. The demand is also influenced by local peculiarities. For instance, in the UK owing to the uncertainty caused by the future railway privatisation programme, the short-term demand is expected to be low, though the long-term replacement demand is expected to be high owing to the age of the existing railway equipment and infrastructure.

2.2 Competitor Analysis

Having analysed the demand and the market, the next step is to carry out a competitor analysis. In a fragmented industry with undifferentiated products, as in most of the agricultural commodities markets, the competition is the result of the action from a large number of players. Thus, analysing each of the players in the industry becomes tedious and difficult. In such

industries, the analysis could be limited to the market maker or the dominant firms that set the behaviour of the industry as a whole.

In a concentrated industry, such as the aircraft or the locomotive industry, where there are only a handful of competitors, the competitive environment of a company depends mainly upon the behaviour of a few rivals. In such industries, it is not possible to understand competition without understanding the competitors themselves. This requires the identification of their:

1. Goals
2. Strategies
3. Assumptions
4. Capabilities

together with the comparison of the current and future products in the market and the associated technologies.

Some of the information is readily available from the marketing department. In addition, a substantial amount of competitor information can be obtained from sources in the public domain such as:

1. Annual reports.
2. Specialist journals and magazines.
3. Papers published in seminars and conferences.
4. Relevant exhibitions and presentations.
5. Computer databases such as Moody and Amadeus.
6. Stockbroker reports on competitors.
7. Newspapers such as the Financial Times and the Wall Street Journal.

In the studies that were carried out, useful information was gathered from the above sources including some idea of the manufacturing cost and the lead time. It was apparent that the inhouse marketing departments did not have such detailed information on the competitors. The usefulness of these easily accessible sources, therefore, should not be underestimated. In addition to these, competitor information can be obtained by frequent discussions with customers, suppliers, subcontractors and with personnel from the company's sales, marketing and service departments.

2.2.1 Financial Analysis

The profile that has been built up can then be used for a comparison between the firm and its competitors. First, a comparison of basic financial information over a period of three to five years could provide some insight into the performance of the firm in relation to its competitors. A sample financial comparison is summarised in Table 1 with the best performances in each criteria highlighted for ease of comparison. The table includes the figures for the whole company and for the particular division that is being compared.

From the total revenue figures, it is clear that company C is the largest with about three times the turnover of its nearest competitor. The firm and company D are about the same size and are the smallest, with company C about 10 times larger. Company C has the smallest divisional contribution towards total revenue. This indicates that company C is the most

Table 1. Financial comparison.

Year/company		A	B	C	D	Firm
Total revenue	Year 1	38.3	29	105	9.4	8.96
	Year 2	38.8	30	114	9.2	9.6
	Year 3	38.5	28	118	8.9	10.2
Growth rate	Year 1	0.8	8%	15.8%	2.3%	6.2%
	Year 2	1.3	2%	8.2%	-1.7%	8.4%
	Year 3	-0.7	-4%	3.8%	-4.1%	5.9%
Operating profit	Year 1	5.5	1.9	4.9	0.84	0.5
	Year 2	5.7	1.8	4.6	0.83	0.56
	Year 3	6.1	2.2	4.2	0.7	0.6
Profit margin	Year 1	14.4%	6.6%	4.7%	9.4%	5.7%
	Year 2	14.6%	6.1%	4.1%	9.0%	5.8%
	Year 3	15.7%	7.7%	3.5%	7.9%	6%
Divisional revenue	Year 1	6.2	6.8	7.2	3.0	3.7
	Year 2	6.4	6.9	9.5	3.2	3.8
	Year 3	6.7	7.9	12.5	3.1	4.2
% of total revenue	Year 1	16.2%	23.5%	6.8%	31.9%	42%
	Year 2	16.5%	23.3%	8.4%	34.7%	39%
	Year 3	17.4%	27.9%	10.6%	34.8%	41%
Divisional growth rate	Year 1	10.7%	44.6%	-13.7%		1%
	Year 2	3.2%	1.5%	22%	6.6%	8.4%
	Year 3	4.7%	14.5%	31.8%	-3.1%	5.9%
Divisional profit	Year 1	0.88	0.37		0.26	
	Year 2	1.04	0.44		0.24	
	Year 3	1.27	0.74		0.22	
% of total profit	Year 1	16%	19%		31%	Profit figures not published.
	Year 2	18%	24%		29%	
	Year 3	21%	34%		31%	
Divisional profit margin	Year 1	14.3%	5.4%	Profit figures not known.	8.7%	
	Year 2	16.3%	6.4%	However the profit margin is said to be much higher than the average.	7.5%	
	Year 3	18.9%	9.4%		7.1%	

diverse company while the firm and company D are the least diverse and are more reliant on the division. Being big and more diverse, company C has higher resources in comparison with the firm.

In terms of growth rate, company C has been stronger followed by the firm which has a healthy growth. In spite of being the second largest, company A has the highest profits, both overall and for the division, resulting in high profit margins. Though there could be several reasons for this, e.g. the difference in cost structure, productivity and efficiency between the companies, two external factors should be taken into consideration as the companies are based in different countries:

The difference in accounting standards between the countries. The greater emphasis placed in some countries to report higher profits to gain favourable reaction from the city.

Company C has the highest divisional revenue during the 3 year period. This coupled with its high divisional growth rate in year 2 and 3 indicates that it has been gaining market share

during these periods. This is clear from Table 2 which has been compiled using the total divisional revenue of the five companies as the industry is dominated by these five players. Company C has been gaining market share at the expense of the others, with Company B more or less maintaining its share. The firm under comparison has been gradually losing market share over the three year period, highlighting its poor performance.

If figures are available, it is also helpful to include in the comparison other factors such as the stock turnover, the sales or profit per employee and the percentage of research and development expenditure to sales.

Table 2. Market share analysis.

Year/Company	A	B	C	D	Firm
Market share Year 1	23%	25%	27%	11%	14%
Year 2	21%	23%	32%	11%	13%
Year 3	19%	23%	36%	9%	12%

2.2.2 SWOT Analysis

Following the financial comparison of the firm with the major players in the industry, a SWOT analysis can be carried out for the firm and the competitors. The SWOT analysis [3] is a simple form of presentation (Fig. 2) for describing the Strengths (S), Weaknesses (W), Opportunities (O) and Threats (T) of a business. The analysis helps the organisation in systematically identifying key environmental threats and opportunities. It is then used to pin-point both the organisational strengths available to meet these environmental challenges and the organisational weaknesses that must be overcome. Thus, SWOT analysis can help an organisation to change its position from a reactive stance to a proactive strategy. [4]

The SWOT analysis can also be used for listing the strengths and weaknesses of the competitors and examining how they are trying to attain a competitive advantage. Such comparisons together with the available opportunities and threats can be used to identify areas that need urgent attention at the strategic level.

2.3 Industrial Structure Analysis

The analysis of the business environment and the competitors, can be used for examining the industrial structure. It is argued by Porter that an industry's profit potential is determined by the interplay of five competitive forces (Fig. 3) [5]:

1. Industry rivalry.
2. Buyer power.
3. Supplier power.
4. Threat of new entrants.
5. Threat of substitutes.

2.3.1 Industry Rivalry

For most industries, the major determinant of the overall state of competition, and the general level of profitability, is competition amongst the firms within the industry. In some

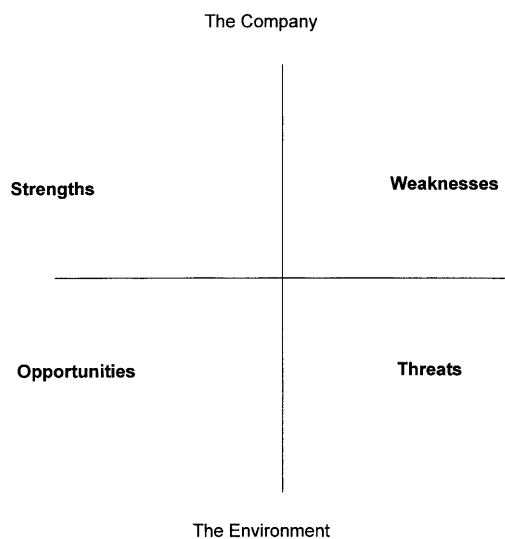


Fig. 2. SWOT analysis.

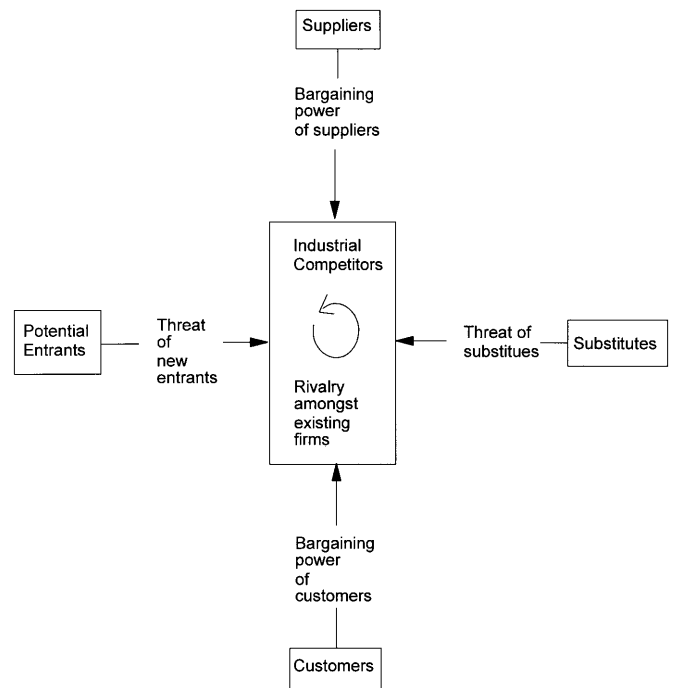


Fig. 3. Porter's five forces framework.

industries, competition is so intense amongst the existing firms that there is a constant squeeze on prices and consequently on margins. In others, competition is more in terms of other criteria like advertising, innovation or after-sales services. There are several major factors that determine the nature and intensity of competition between established firms, some of which are:

1. Industrial structure.
2. Concentration.
3. Diversity of competitors.
4. Cost structure.
5. Product differentiation.

In recent years, the buyer profile of most of the industries has been changing with increased privatisation. An example is the airline industry where privatisation has led to privatised establishments, compared to the large nationalised organisations, and these privatised firms are examining ways of decreasing cost to increase their profits. At the same time, markets in general are becoming global with increased international competition in comparison to the previously sheltered national markets. The search for cost reduction by customers and the opening up of the market for international competition has changed the industrial structure to that of a highly competitive environment from that of a stable one.

Concentration refers to the number of competitors in the industry and their relative sizes. The industry is concentrated if there are a small number of large players in the market. With each competitor having high stakes in the segment, there will be intense competition in the industry. The aeroengine industry is a good example of a highly concentrated industry. One of the advantages of a concentrated industry is the ease with which the activities of each of the competitors can be

monitored on a regular basis. The disadvantage, of course, is the ability of each company to take appropriate action to counteract any advantage that can be gained by the other. This prevents the possibility of sustaining a competitive advantage on a long-term basis.

The ability of the firms to avoid competition also depends on their similarities in terms of origins, objectives, costs and strategies. The more diverse the industry is, the higher will be the competition. Compared to the western companies, the main objective of Japanese companies is to increase their market share even at the expense of lower profitability. This diversity in objective has brought about intense competition globally, almost wiping out most of the well-known western brand names.

The more similar the products are in the market, the more willing are the customers to substitute between them, and the greater is the incentive for the firms to cut prices to expand business. In such industries, as each of the firms tries to introduce better products in the market, the others either imitate the innovation or try to outperform, leading to almost similar products. Thus, product differentiation becomes difficult and the customers can easily switch suppliers. To improve continuously and to be ahead of the competition therefore requires a high R&D expenditure and a greater effectiveness in spending this R&D money. On the other hand, in industries where product differentiation is high, such as management consultancy, customers are unwilling to consider alternative products simply on the basis of small price differences.

The aggressiveness with which rivals compete for market share is also crucially dependent upon the cost conditions and the exit barriers. The more important the scale economies in an industry are, the greater the incentives for expanding sales at the expense of the competitors. The higher the ratio of fixed to variable cost, in terms of installation of sophisticated manufacturing facilities, the greater is the willingness of the firms to reduce prices in order to utilise spare capacity. This also acts as a high exit barrier preventing companies from getting out of the market. When a division contributes a major part of the total revenue, the firm will be very reluctant to retreat from the market.

2.3.2 Buyer Power

If the buyers have more power than the suppliers, the buyers will try to force prices down, demand more quality of service and set competitors against each other, at the expense of profitability of the sellers. Buyers' bargaining power grows when:

1. They become more concentrated or organised.
2. The product represents a significant proportion of the buyers' cost.
3. The product is undifferentiated.
4. The buyers' switching cost is low.
5. The buyers' are price sensitive because of low profits.
6. The buyers can integrate backwards.

Considering the aircraft manufacturing industry, the airlines have high bargaining power in terms of the purchase or lease of aircraft. Aircraft have a long lifetime and are highly capital

intensive. Thus, the airlines are very sensitive to the price and take every opportunity to look for alternative bids and press for a favourable discount. In addition, the products are generally less differentiated and the major suppliers have good experience and reputation, making it possible for the customers to switch supplier on the basis of price. Owing to the large size of the contracts, losing one contract could determine the profitability of an organisation. Also, losing a contract to a competitor and the following adverse publicity can be seen as a loss of reputation for the supplier. Therefore, it is increasingly becoming necessary for the suppliers to maintain long-term relationships with current and prospective customers and to form a partnership instead of the traditional customer supplier relationship. Through this relationship, the supplier will have an intimate knowledge of the requirements of each of the customers and will be able to respond positively to their needs.

2.3.3 Supplier Power

The analysis for supplier power is similar to that of buyer power. Thus, the suppliers' power tends to be greater when:

1. They are concentrated or organised.
2. There are few substitutes.
3. The supplied product is an important input.
4. The switching cost is high.
5. The suppliers can integrate forward.

When the supplier's have higher bargaining power, the best defence is to neutralise it by building good relationships with many suppliers rather than relying on one.

2.3.4 Threat of New Entrants

A segment becomes vulnerable if it is likely to attract new competition which could bring new capacity, substantial resources and a drive for market share growth. The question is whether newcomers can easily enter. They will find it hard if there are high barriers to entry coupled with sharp retaliation from the incumbent firms.

For instance in the aeroengine industry, owing to the years of experience gained by the existing manufacturers, it will be difficult for newcomers to enter the market on equal terms to those of the established firms. Moreover, the industry is capital and research intensive requiring long lead times and high expenditure for developing new engines. Thus the entry barriers are high. However, in Japan, MITI has identified aeronautics as the most important "sunrise" industry of the 21st century. Simultaneously, some of the Japanese companies are collaborating with major aeroengine manufacturers like GE to improve their knowledge of the technology. Thus there is a possibility, in the long term, that the Japanese companies may enter this market with their own products.

2.3.5 Threat of Substitutes

The availability of substitute products makes an industry very competitive as these products place a limit on the potential prices and profits that can be earned. In the power generation industry for example, the gas turbine is becoming popular and is reducing the role played by the conventional coal-fired

power stations. However, the threat of substitutes may not always come from the same industry as has been the case with electronic calculators wiping out the demand for slide rules.

3. Critical Success Factors

After understanding the industrial structure and the intensity of competition, it is necessary to identify the potential for competitive advantage in the industry in terms of the factors which are important in determining a firm's ability to survive and prosper. These are referred to as the critical success factors and are the variables that can be influenced by management decisions to significantly affect the overall competitive position of the firm in an industry [6]. To survive and prosper in an industry a firm must meet two criteria:

- It must supply what the customers want to buy.
- It must survive competition.

The first criterion implies that the customers' needs and the basis on which they select the offerings of one supplier in preference to that of the others have to be identified. The second requires the examination of the basis of competition in the industry. The basic framework for identifying the critical success factors is shown in Fig. 4 [6]. Thus to identify the critical success factors, two questions have to be answered:

1. What do the customers want?
2. What should the firm do to achieve these wants and survive the competition?

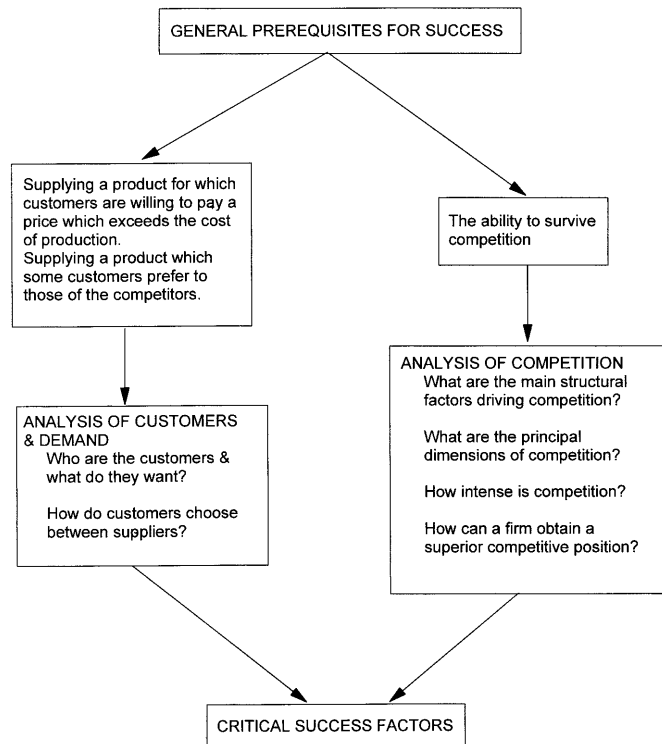


Fig. 4. Identifying critical success factors.

A study carried out on the above basis for an equipment manufacturer found that the industry was concentrated with a few large companies with substantial experience and good reputation. This indicates that the customers do not have an incentive to stick to one supplier and that they are free to choose the product depending on the cost and performance. However, once a product is chosen, the customer is tied, on a long-term basis, to the specific supplier for spares, technical expertise and probably for after-sales services. This long-term after-sales business is generally more profitable for the supplier. The performance of the supplier during this period will to an extent influence the customer's policy for the next purchase. However, owing to the competitiveness of the industry, the particular supplier's product should be competitive in the market for the customer to commit himself to a repeat purchase. The supplier, therefore, cannot be assured of a repeat of a replacement purchase even if the long-term relationship has been very successful.

On the other hand, if the relationship with the existing supplier has not been satisfactory, the customer will be very reluctant to shortlist him for the next contract. If a customer selects a supplier with whom he has had no previous relationship, it is usual to request the existing customer base for references. This information is used by the customer to enquire and check on the performance and the relationship of the supplier with his existing clients. Such recommendations from existing customers play a major part in the selection process. Generally, it is common for the major players in the industry to maintain on-going contacts or discussions with the prospective customers even if the company products have not been sold to them before. Thus long-term close customer relationship is an important criteria.

From the customers point of view, the running cost of the equipment forms the major part of the lifetime cost and a slight improvement in performance level saves a substantial sum over the plant's life. This is followed by the capital cost. Being capital intensive, the customers are also looking into the possibility of some form of project financing arrangement from the suppliers. Thus performance, capital cost and project financing are becoming critical issues.

Another major criteria for the customers is the lead time. With the economic environment being volatile, it is becoming difficult to plan on a long-term basis, especially for high capital intensive investments. This means that the planning horizons are getting shorter and therefore suppliers with faster response times in terms of order to delivery lead times are being given preference. An additional advantage of shorter lead times for the customer is that the benefit of his large capital layout can be realised faster. It is, therefore, appropriate for the customers to demand shorter lead times.

Accordingly, to be successful in the industry, the company studied should be able to provide high-performance machines faster and cheaper and to the required specification of the customer. Hence the critical success factors for the industry can be summarised as:

1. High performance through good design.
2. Low cost and speed through manufacturing productivity.
3. Long-term relationship with the customer.

4. Manufacturing Strategy

Having arrived at the critical success factors for the firm, therefore, it is vital to examine how the manufacturing function can contribute towards these objectives.

4.1 External Performance Objectives

The critical success factors represent the needs of the customers and are the external performance objectives that should be satisfied by the firm. However, all these objectives do not have the same priority for the customers and an easy way of distinguishing the priorities of these objectives is to divide them into order-winning, order-qualifying and less important criteria [7,8] (Fig. 5).

4.1.1 Order-Winning/Qualifying and Less Important Criteria

The order-winning criteria are the factors that directly contribute to gaining more business and which are regarded by the customer as the key to competitiveness. Therefore, an increased performance in these criteria will improve the chances of gaining more business for a company. On the other hand, for the order-qualifying criteria, the company's performance should be above a threshold level for it to be even considered by the customer. Below this level, it will not be considered, while above the threshold it will only be considered in terms of its order-winning criteria. Thus, further improvement in the order-qualifying criteria will not improve the competitive advantage of an organisation. The less important objectives are relatively unimportant compared to the other performance criteria. Customers rarely consider these when making a purchasing decision.

These criteria can be defined in terms of five manufacturing performance objectives [8]:

- | | |
|------------------|------------------------|
| 1. Quality | Making things right. |
| 2. Speed | Making things fast. |
| 3. Dependability | Making things on time. |
| 4. Flexibility | Changing what is made: |
| 5. Cost | Making things cheap. |

The manufacturing quality assurance ensures that products are made error free and always in accordance to the design specification. Speed of manufacture ensures that products reach customers in the shortest possible time from the commencement of the manufacturing process. Through manufacturing dependability, the firm is able to both accurately estimate the delivery time and deliver according to the promised schedule. To be able to change the process fast enough to suit the customer needs, provides the manufacturing flexibility. Manufacturing cost advantage is achieved through producing the product cheaper than the competitors. Though the above five performance objectives are the basic criteria that provide competitive advantage through manufacturing, it is essential to rank them according to their relative importance and to categorise them into order-winning, order-qualifying and less important objectives.

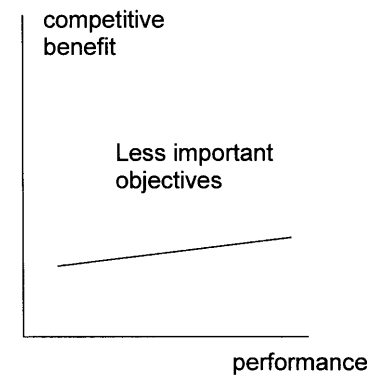
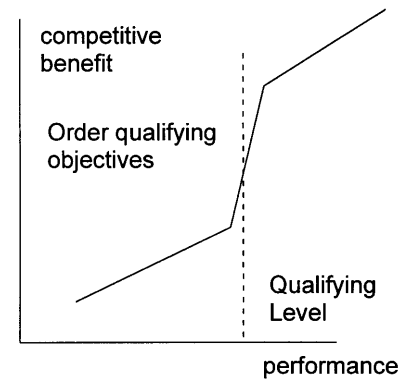
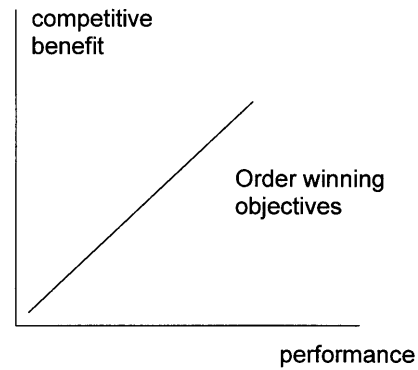


Fig. 5. Manufacturing objectives.

However, there are also other non-manufacturing performance objectives that are important to the customers. For example, to manufacture a quality product that is suitable, the design should be appropriate to the customer needs. This depends on the capability of the engineering design function and their interaction with marketing and manufacturing. Another example is the provision of after-sales service.

In the equipment manufacturing industry considered earlier, customers demand a minimum level of performance, especially in terms of fuel consumption, from the suppliers, prior to even considering them for an order. Owing to this, the suppliers

compete intensively to comply with the industrial standard on the performance levels. If the performance level of a particular supplier is lower than the current industrial standard, the product will not be shortlisted by the customers. Hence the performance level becomes one of the order-qualifying criteria.

The reliability and availability depend largely on the after-sales service support provided by the manufacturer. It is therefore normal for the customer to verify the supplier's past performance in customer services prior to considering him for a bid. If the customer has purchased previously from the supplier, the service level can be ascertained from past experience. If not, it is usual for the customer to approach some of the supplier's current customer base for reference purposes. If the supplier's past performance does not conform to a required level, he will not be considered further. This means that for consideration by the customer, the supplier should have reached a minimum level of performance in after-sales services; making it another order-qualifying criterion.

Owing to the capital intensity of the product, customers try to negotiate with the suppliers for a lower price. Thus the prime order-winning criteria is the price of the equipment. To reduce planning uncertainty for the customers, short lead times are being demanded from the suppliers. In the industry, owing to the high capital cost involved, the shorter the lead time the faster the customer can recover the costs, leading to substantial financial savings. Consequently, a short lead time becomes an advantage and therefore is the other order-winning criterion.

Generally, each purchase agreement is covered by a legal contract in the industry consisting of penalty clauses for non-compliance to specification and for late delivery. This means that suppliers have to pay heavy penalties if the delivery is late or if the plant does not comply with the initially agreed specification. The penalty, being very heavy, could jeopardise the profitability of a firm and therefore suppliers are careful not to commit themselves to very demanding targets that are hard to achieve. Thus, the customers are not worried about the external performance objectives such as quality and dependability as they are clearly covered in the contract. As far as the supplier is concerned these are essential criteria. In general, however, suppliers tend to comply with the contract and hence it is very rare for the penalty clauses to be enacted. Any default on the contract also brings bad publicity damaging the reputation of the supplier. Hence quality and dependability are less important criteria as far as the customers are concerned.

Thus the order-winning criteria for the considered industry are:

1. The product price.
2. The delivery lead time while.

The order-qualifying criteria are:

1. The performance level.
2. The customer support.

4.2 Internal Performance Objectives

The manufacturing operation consists of a collection of smaller units and each of these units can be judged using the five

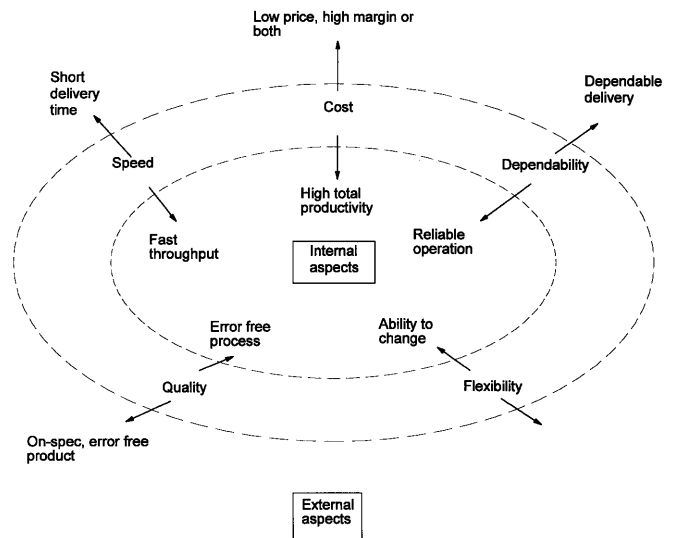


Fig. 6. Internal and external aspects of performance objectives.

performance objectives that have already been defined. The internal performance of each unit contributes to the external performance of the total operation (Fig. 6) [8]. Unlike the external performance objectives which can be separated, the internal performance objectives are interconnected in a complex manner (Fig. 7) [8].

Quality is fundamental for all the other internal performance objectives. In addition to ensuring external quality, the internal quality improves other internal aspects, especially speed, dependability and cost. Increase in speed internally reduces the total throughput cycle time, in turn benefiting the customer in terms of short delivery time. It also improves the internal performance by:

1. Reducing the speculative activity leading to more planning flexibility and better forecasts, lowering the work in progress and the requirement for working capital.
2. Enabling "just in time" techniques to be applied thereby exposing bottlenecks and weak links in the system.

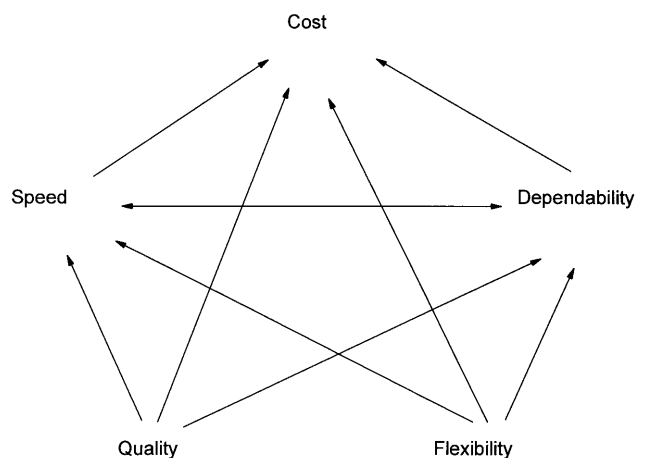


Fig. 7. Interaction of internal performance objectives.

Dependability is defined in terms of delivery performance and is related to speed. Dependability in delivery is judged by the customer over the long term or through inquiry from previous customers. Internally, dependable operation provides stability which is fundamental in improving speed. Flexibility of operation is generally needed to improve the performance related to the other objectives. Flexibility improves dependability by making it possible to cope with unexpected interruptions. Flexible operation also provides faster set-up times and smaller batch sizes, thereby improving the speed and reducing the cost. Lower cost is important but is obtained through improvement in the other performance objectives. The cost of a product also depends on the volume and the variety required.

According to the sand cone model (Fig. 8) [8,9], the precondition for any lasting improvement is quality. Once a minimum acceptable level of quality has been achieved, the internal dependability should be tackled. However, at the same time, quality should be further improved to gain improvements in dependability. The next important factor is speed but at the same time further improvement in quality and dependability is necessary. Then comes flexibility with further improvements in quality, dependability and speed. According to the theory the cost should be tackled last, but the improvement in the other factors should continue. Hence, only through cumulative improvements in other internal performance objectives can the manufacturing cost be reduced.

4.3 Formulating Manufacturing Strategy

The first step in formulating manufacturing strategy is to define the order-winning, order-qualifying and the less important factors and to prioritise them on a nine-point importance scale [8]:

Order-winning objectives:

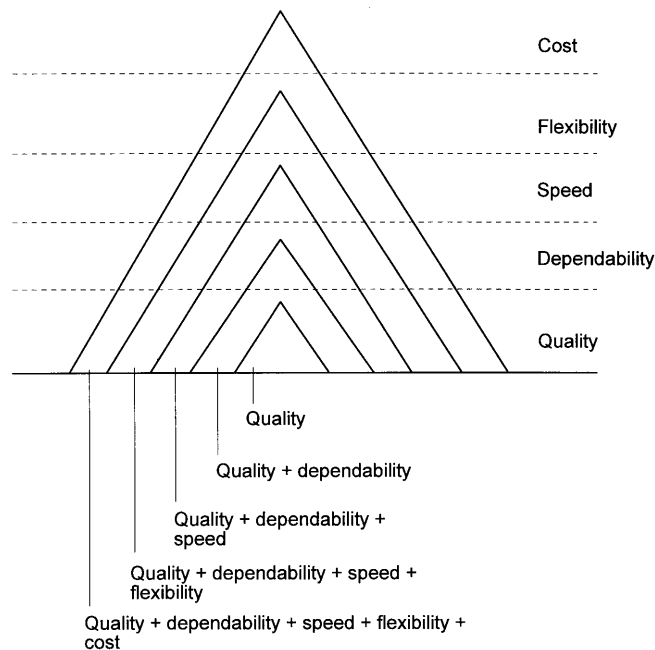


Fig. 8. Sand cone model of manufacturing improvements.

1. Provide a crucial advantage with the customers – the main factor of competitiveness.
2. Provide an important advantage with most customers – factor always considered.
3. Provide a useful advantage with most customers – factor usually considered.

Order-qualifying objectives:

4. Need to be at least up to good industry standard.
5. Need to be around the median industry standard.
6. Need to be within close range of the industry.

Less important objectives:

7. Not usually considered, but could become important in future.
8. Very rarely considered by the customer.
9. Never considered and not likely to be considered by the customer.

Secondly, the firm’s achievement for these performance objectives should be judged against that of the major competitors. This could also be evaluated in terms of a nine-point performance scale [8]:

1. Consistently and clearly better than our nearest competitor.
2. Consistently considerably better than our nearest competitor.
3. Consistently marginally better than our nearest competitor.
4. Often marginally better than most competitors.
5. About the same as most competitors.
6. Often within striking distance of the main competitors.
7. Usually marginally worse than main competitors.
8. Usually worse than most competitors.
9. Consistently worse than most competitors.

The result of these steps for the equipment manufacturer is shown in Table 3. The capital cost is given an importance scale of 1 as it definitely provides a crucial advantage for winning orders while the lead time from order to delivery, being an important advantage, has been given a scale of 2. Competitors claim that they can produce the equipment 30% cheaper using their manufacturing facilities in Eastern Europe compared to manufacturers concentrated in Western Europe. Being the least diversified in manufacturing, the firm is definitely at a cost disadvantage and can be considered as usually worse than most competitors with a scale of 8. As for lead time, the industrial standard is about 33% shorter than that of the firm. This seems to indicate that the firm has the worst performance in the industry with a performance scale of 9.

The above exercise of assigning scales is subjective and it can be argued that the above performance scales can be

Table 3. Performance on order-winning criteria.

Objective	Importance Scale	Current Performance	Industrial Performance	Performance Scale
Cost	1	100%	70%	8
Lead Time	2	100%	67%	9

considered as pessimistic. However, it is clear that the firm's performance is lower than its major competitors which seems to be in agreement with the previous analysis. Therefore, it is better to start with a pessimistic view which will stress the need for improvement rather than express an optimistic view which might breed complacency.

The next step is to put the two scales together using the "importance performance matrix" (Fig. 9) [8] to assess the areas where improvements are urgently needed. The matrix is divided into four zones [8]. The first priority for improvement is to achieve performances up to or above the "appropriate zone" boundary. Performance objectives that are in this area can be considered satisfactory in the short term. In the long term, however, most competitors will wish to improve their performance towards the upper boundary of the zone. The performance objectives that lie below the lower bound of the "appropriate zone" and in the "improve zone" should be improved. However, more critical are the objectives that lie in the "urgent action zone". The achievements in these aspects, though important to the customer, are so low that business is probably being lost as a result. The short-term objective therefore should be to raise the level at least up to the "improve zone" and eventually in the medium and long term to the "appropriate zone". Any performance objectives that lie in the "excess zone" may mean that unnecessarily high resources are being concentrated in this area.

Incorporating the performance figures (Table 3) in the Importance Performance Matrix (Fig. 9), it is clear that the firm's performance is poor compared to the competitors and that urgent action is needed to improve its competitiveness. Therefore, it comes as no surprise that the firm has been gradually losing market share for three years consecutively (Table 2) as its performance in both order winning criteria is well below that of its competitors.

Once the criteria to be improved have been identified, the next step, is to decide how the improvements can be achieved. The manufacturing strategy is therefore to coordinate tasks and to take decisions on how manufacturing is to achieve the required performance objectives of the business [8]. These performance objectives have to be secured through the internal manufacturing performance objectives, quality, flexibility, dependability, speed and cost, the complex interrelationships among which have already been discussed.

5. Role of Manufacturing

After formulating the manufacturing strategy, it is necessary to examine the role of the manufacturing function in an organisation and to see whether its full potential is being used for gaining competitive advantage. A four-stage evolutionary model [10] has been defined for this purpose (Fig. 10):

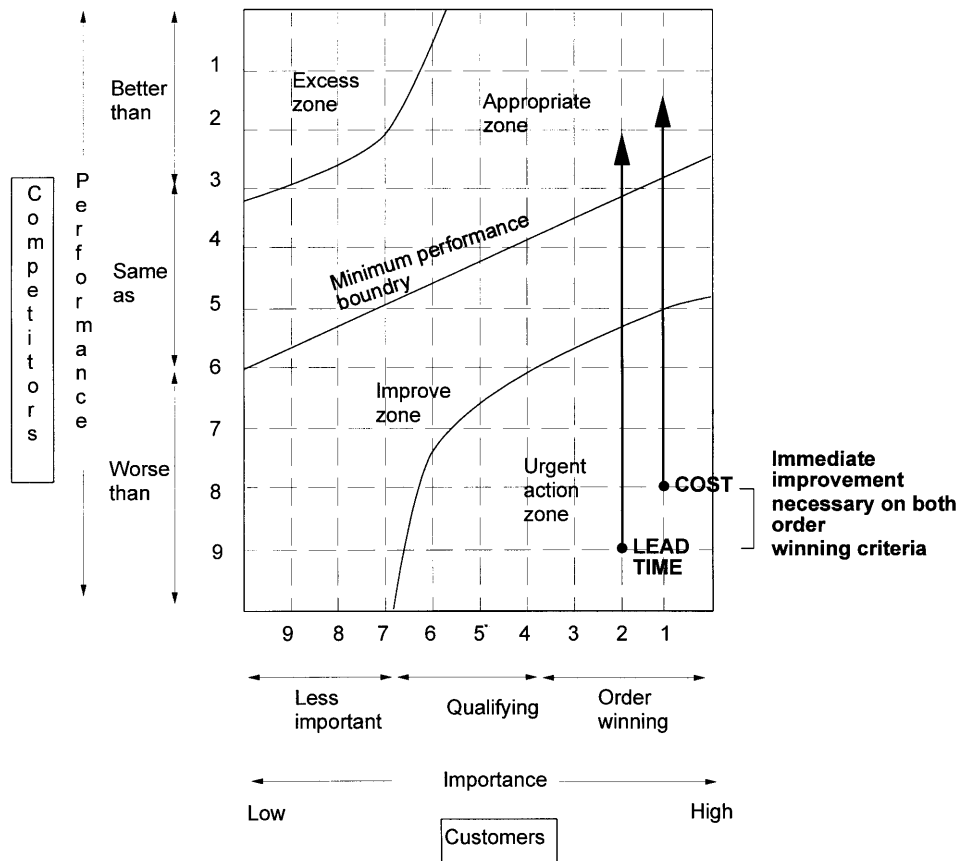


Fig. 9. Importance performance matrix for the firm.

Stage 1. Minimise Negative Potential of Manufacturing: Internally Neutral

The manufacturing function is seen as an unfortunate necessity and thus it is kept flexible and reactive to changes in the business strategy. The effectiveness is monitored through detailed cost and performance control systems.

Stage 2. Achieve Parity with Competitors: Externally Neutral

The necessity of keeping manufacturing up to date with the industry standard is realised and therefore industrial practices are followed. Resources are allocated to keep up with the competitors.

Stage 3. Provide Credible Support to Business Strategy: Internally Supportive

Changes in business strategy are automatically translated into manufacturing strategy, and investments are made to ensure manufacturing can remain supportive of the business strategy.

Stage 4. Pursue a Manufacturing-Based Competitive Advantage: Externally Supportive

Manufacturing has become a competitive advantage of the organisation and influences the overall strategy. Long-term programmes are pursued to acquire manufacturing capabilities in advance of needs.

In stage 1, the manufacturing function is regarded as neutral at best and does not make any significant positive contribution. Firms in the second stage seek to maintain parity with major competitors by following the industrial practice. In the third stage, the firm expects its manufacturing function to provide credible and significant support to its overall competitive strategy. Firms that pursue a stage 4 manufacturing strategy, seek a balance of excellence in all of their functions and pursue an externally supportive role for each of them. In this stage, manufacturing resources are looked upon as providing major opportunities for enhancing the firm's competitiveness. The function of the model is to use it to judge the current status of the manufacturing function within a firm and for planning how it can be transformed from a passive non-contributing function to a proactive role as represented in stage 4.

The firm that is under consideration has been investing in the manufacturing facility to bring it up to the industrial standard by increasing the quality, flexibility and dependability of the operations. However, currently the competitors have an edge in terms of the performance objectives and therefore it can be said that the role of manufacturing within the firm is at between the level of stage 1 and 2. However the target should be to reach stage 4 as shown in Fig. 10.

To enable the manufacturing function to be externally supportive (stage 4) for providing competitive advantage to the firm, further improvement is necessary. The competitive environment is dynamic and the competitors themselves are trying to make further improvements. This means that by the time the firm catches up with the competitors, they would have improved further and the cycle of improvement has to

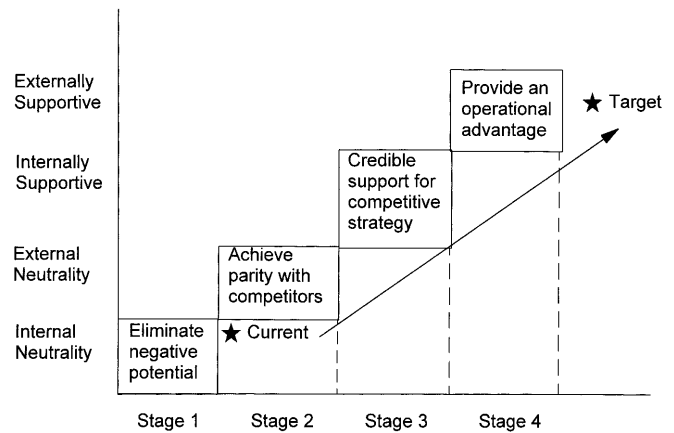


Fig. 10. Current and future role of manufacturing.

continue. If the initial target is to beat the current performance of the competitors, then through continuous improvement, it can maintain the lead and provide competitive advantage through manufacturing. This requires the best industrial performance in cost and lead time.

6. Implementation

An important step in the strategy making process is the implementation. This requires specific action to be planned for the improvement in close collaboration with the manufacturing experts of the plant in order to gain their full commitment to the programme. The plans should be worked out in close collaboration with the manufacturing experts in the factory and could mean changes in [8]:

1. The process technology.
2. The organisation and the development of human resources.
3. The supply network both for information and material flow.

The selected action plan should be feasible and acceptable and should include a detailed timetable of the improvement programme. However, frequent feedback and corrective action are necessary to ensure that the performance objectives are improved to the required level. In addition, the environment is dynamic and, therefore, it is necessary to constantly monitor changes in the environment, customer preferences and the competitors' performance. Thus, the strategy-making process is an iterative, collaborative and continuous process. One of the practical difficulties in implementation is the need to keep up the momentum for continuous improvement. It is a common phenomenon that after the initial acceptance and enthusiasm of the improvement programme, a gradual disenchantment sets in with the whole process, which becomes difficult to reverse (Fig. 11) [8].

The best way to keep up the enthusiasm for continuous improvement is through continuous awareness programmes to make the employees aware of the comparison of the firm's performance against that of the competitors. The employees at all levels should be aware of the gap in the performance level and should be kept informed periodically, say every 6 months,

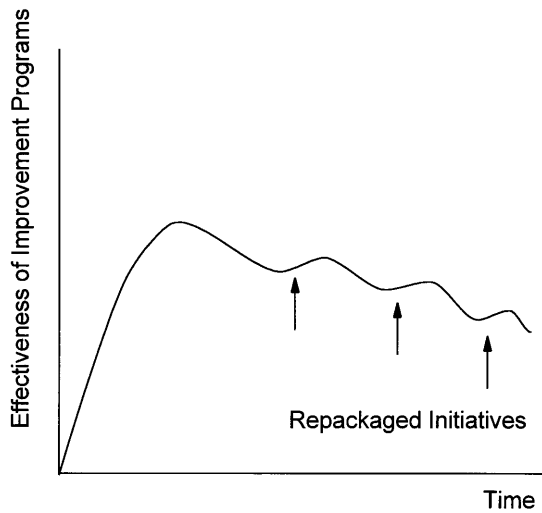


Fig. 11. Droop in effectiveness.

not only of the progress achieved so far but also how this has affected the performance gap. The aim should be to become the best in the industry in terms of the performance objectives and this can only be achieved through effective feedback and communication of the improvement programmes and through regular monitoring of the progress of the competitors.

7. Integration

The aim of the formulation of manufacturing strategy is for the manufacturing function to help in attaining a competitive advantage. However, in order to succeed in the market, a

concerted effort should be made by all the different functions within an organisation, so that the whole organisation is moving towards a common objective.

The value chain analysis [11] (Fig. 12) helps to analyse how different functions in an organisation could contribute towards achieving the critical success factors. The purpose of the analysis is to ensure that all the different functions in an organisation work towards the same objective rather than trying to optimise individual functional objectives.

Every firm is a collection of activities that are performed to design, produce, market, deliver and support its products. The value chain disaggregates a firm into nine strategically relevant activities consisting of five primary and four support activities. The primary activities represent the sequence of bringing materials into the business, operating on them, sending them out, marketing them and servicing them. The support activities occur throughout all of these primary activities.

The task is to examine each value-creating activity to see how it could contribute towards achieving the critical success factors for the firm to gain a competitive advantage. The firm should also look for a competitive advantage beyond its own value chain, into the value chain of its suppliers, distributors, and ultimately, customers. Thus, the company might help a major supplier reduce its costs and thereby pass on the savings to the supplier; or it might help customers perform some activity better or cheaper and win their loyalty. Clearly, the value chain provides the firm with a comprehensive framework for systematically searching for ways to provide superior value to customers.

The value chain analysis for the firm considered is shown in Fig. 12. The following sections provide brief explanations of how the primary and support activities can help achieve the necessary improvements.

Support activities	Monitor supplier performance Collaboration for improvement Infrastructure activities	Support (computer assisted) for planning & for tracing work in progress Highlighting of production problems in advance		Competitor monitoring Customer monitoring	Monitoring of customer feed backs customer service	MARGIN
	Development of close linkage with few suppliers but with back up Collaboration with suppliers on new designs Research, Development, Design	Concurrent engineering for ease of manufacture Process development to improve lead-time, quality and to reduce cost	Tailor made solution for each customer Increased modularity & standardisation to increase repeatability	Fast introduction of new products to suit customer needs Continuous improvement of existing technology through customer feedback	Design for ease of repair & maintenance Increased life time of critical components	
	Training on supplier relationship Human Resource Development	Quality manufacturing engineers Concurrent engineering team development Formal & informal interaction between design & manufacturing	Close co-operation between marketing & manufacturing Regular interactions	Training on customer relationship & competitor behaviour	Developing commitment to customer service Training for good quality service and responsiveness	
	Good quality components Short delivery times Reliable supply Minimum stock levels Inbound Logistics	High quality products Cost reduction Lead time reduction Increased outsourcing Production	Manufacturer to order than to stock Inventory reduction Warehousing & Distribution	Intimate knowledge of customer needs Long term relationship with customers Close knowledge of competitors & products Sales & marketing	Fast reliable repair Immediate availability of spare parts Good quality maintenance Good dealer support After sales support	
Primary activities						

Fig. 12. Value chain analysis for the firm under consideration.

7.1 Inbound Logistics

To be effective in manufacturing, the purchasing policy should be to procure good quality and reliable raw materials and components. At the same time, to reduce the inventory levels, suppliers should be committed to short delivery times. To achieve these objectives, a long-term relationship should be formed with a minimum number of suppliers who should be fully aware of the production schedules, and the possible changes, well in advance. During new product development, these suppliers should be involved at an early stage to make them aware of the new requirements and enable them to contribute in terms of their manufacturing knowledge.

To prevent excessive supplier power, such a relationship should be formed with at least two suppliers. Their performance should be monitored on a regular basis and appropriate advice and help should be provided for improving their support.

7.2 Production

The contribution from the manufacturing function has already been discussed above. The manufacturing function should be geared towards producing high-quality products fast and at comparatively low cost. To improve the manufacturing process, experienced and qualified staff should be recruited. The ease of manufacturing should also be considered at the design stage through the formation of concurrent engineering teams and through regular discussions between design and manufacturing. Support systems, perhaps computer assisted, should be in place to assist in the production engineering functions such as production planning, monitoring, highlighting of production problems and the possibility of easily tracing work in progress.

Outsourcing of components to specialist suppliers is becoming a common practice to reduce the lead time. For this approach to be successful, the manufacturing function should be fully supported by the inbound logistics, as was discussed earlier.

7.3 Warehousing Distribution

Currently the equipment is manufactured to forecast rather than to order. If the forecast has not been realistic, the finished components will end up as stock. Though this could aid in the reduction of lead time, it is not economical to hold high-value items in stock. To reduce the amount of stock held, there should be effective communication between marketing and the manufacturing functions. Efforts should also be made by the design and development functions to modularise the system so that an increased number of standard modules could be used for configuration. By increasing the repeatability, the lead time could be reduced through the reduction in manufacturing time.

The aim should be to reduce the lead time to such an extent that the equipment can be manufactured to order rather than to forecast.

7.4 Sales and Marketing

To accurately forecast the future demands, the marketing department should have a close relationship with the current and potential customers. This will enable the marketing department to be aware of the customer needs. In the meantime, they must also have a good understanding of the capabilities and the strategies of the competitors. Thus, customer and competitor monitoring becomes an essential part of the marketing function. Such monitoring also provides the necessary information for the development of new products and for undertaking improvements to the existing ones.

7.5 After-Sales Service

Customer service has also been identified as one of the important factors. First, the products should be designed with the aim of increased availability, repairability and maintainability. Secondly, to increase the reliability, the supplier should provide a good quality and reliable repairs and maintenance service, and immediate availability of spare parts. When there is no local presence, a good dealership network becomes essential to provide these after-sales services. Monitoring customer feedback, both in terms of performance levels and service history, becomes important for providing a satisfactory after-sales service.

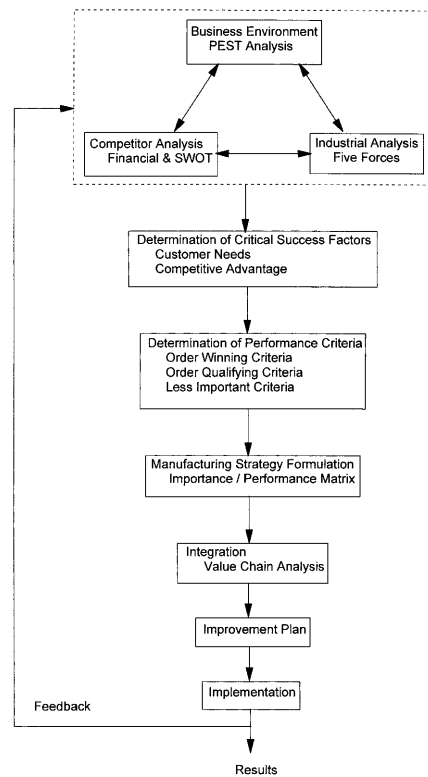


Fig. 13. Manufacturing strategy formulation process.

8. Conclusion

From the practical experience of formulating manufacturing strategy for different companies, a generalised methodology can be proposed as shown in Fig. 13. This methodology has been successfully used for the strategy formulation of several organisations. It is clear from the methodology that a thorough analysis of the industrial competitiveness is a precursor to the manufacturing strategy and that a holistic approach should be adopted in its formulation.

The strategy formulation process is not a one-off exercise. As the environment is dynamic, with customer requirements and the performance levels of the competitors changing over time, the strategy should be reviewed on a regular basis. This not only provides the chance of updating the customer and competitor information but also enables corrective action to be incorporated for the failure of a previous implementation of the strategy. Thus the feedback loop is an important aspect of the whole strategy formulation process.

The success of the strategy can only be measured in terms of successful implementation. Any effective improvements in the performance levels should be understood and supported throughout the organisation. This means that everyone within the organisation should be fully aware of:

1. What improvements are needed?
2. Why are they needed?
3. How are they to be achieved?
4. Who is responsible for each of the improvements?
5. What is the timetable for the improvements?

Without the full participation from every level of the organisation, changes cannot be effectively implemented. Thus, proper

communication and participation are the key for successful improvement. To keep up the momentum for continuous improvement, the gap in performance levels with that of the competitors should be periodically communicated throughout the organisation. At the same time, the eventual aim of trying to be the best in the industry should be reiterated by stressing the need for continuous improvement. It is only through regular communication and participation from the employees that the necessary attitude for continuous improvement can be inculcated.

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