Practice of manufacturing strategy: evidence from select Indian automobile companies

G. S. DANGAYACH† and S. G. DESHMUKH‡*

This paper presents findings based on an extensive survey of Indian automobile companies. Five companies have been selected for detailed case studies. Their experiences in the manufacturing strategy process are analysed. Although the companies represented a diversity in terms of sales volume, product range and geographic location, they shared several commonalities including use of advanced manufacturing technologies and other improvement activities. Competitive strength was sustained through quality, innovation and delivery. The process of strategy formulation varied among the companies in terms of participants, complexity and degree of formalization, the practice of each company is different. The process of manufacturing strategy formulation seems to be in line with corporate strategy, though the companies followed a traditional top down approach in formulation of manufacturing strategy under the umbrella of corporate strategy. A taxonomy is proposed using cluster analysis where the companies are classified in four strategic manufacturing groups: reactive enterprise, neutral enterprise, active enterprise and proactive enterprises. Competitive priorities, order winners and critical success factors are identified for these companies after rigorous discussions with the managers. Based on strategic manufacturing issues, the manufacturing competence index for the companies has been worked out. A framework for manufacturing strategy is also proposed based on experiences of the case companies.

1. Introduction

Manufacturing companies are under increasingly diverse and mounting pressures due to more sophisticated markets, changing customer choice and global competition. The market for products is becoming increasingly international. In such a competitive scenario companies have to search for new processes, new materials, new vendors, new shop floor designs and new channels to deliver products and services at competitive price. Indian companies have quite often followed an opportunistic approach to growth as opposed to a capability driven approach that seeks to strengthen key aspects of manufacturing and paid very little strategic attention to their shop floors in the last few decades (Chandra and Sastry 1998). This was reflected in the poor quality of products, no awareness about competitiveness and no integration of various business functions such as marketing, sales, production, etc. Total manufacturing value in India is only 18% of Gross Domestic Product (GDP) (Statistical outline of India 1998–99).

Between the 1950s and 1990s, India’s industrial development policy was characterized by excessive regulation. Initially set up to avoid over capacity in a capital

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scarce economy, it spawned a maze of regulations governing product, capacity, technology and foreign exchange availability. In the late 1980s, inflows of foreign technology and equity were permitted and manufacturing capacity constraints lifted. The gradual opening of the Indian economy resulted in the entry of foreign competitors and expanded production by domestic manufacturers. By the 1990s, the Indian economy was undergoing structural change and imports were largely unregulated (Upadhyay and Kanavi 1999).

Since introduction of economic reforms in 1991, Indian firms are facing a very different competitive scenario compared with the past. The abolition of license regime meant end of protection and control measures. Manufacturing in India is at a critical juncture. Generally in Indian perspective manufacturing is a support activity for marketing and finance and therefore have got little top management attention. Most of firms are still very far from world class practices. Meanwhile international competitors are continuously working on improving manufacturing, bringing in new products and making manufacturing more proactive and responsive (Chandra and Sastry 1998). Indian industry is facing competition both from imports and multinational companies in the domestic markets. The new competition is in terms of reduced cost; improved quality, products with higher performance, a wider range of products and better service, and all delivered simultaneously. The automobile industry is no exception to this. Here the term ‘automobile industry’ is used to include two-wheeler, four-wheeler (passenger cars) and auto component manufacturers.

The automobile industry world over has been an important component of industrial and economic progress and its development has characterized global competitiveness of leading industrialized economies. The automobile industry is fairly developed one and involves huge investments in research and development and technology and is seen as an indicator of the economic progress of the country. An understanding of the automobile industry in some of the developed countries enables one to study the emerging trends in developing countries (Choudhary and Goyal 1997).

Indian automobile industry has witnessed entry of global players such as Ford, General Motors, Suzuki, Honda, Mercedes, Daewoo, Santro, etc. in four-wheeler segment, whereas Piaggio, Suzuki, Honda, Yamaha, Kawasaki, etc. in two-wheeler segment. The Indian market for two-wheelers is the second largest in the world after China. Scooters represented 45% of these unit sales, motorbikes 37%, and mopeds 18% (Kumar 1998). The two-wheeler industry today has a significant role in the Indian economy. With an annual turnover of $155 billion and a compounded average growth rate of 10% in recent years, it is one of the few industrial sectors in the growth phase today. The consumer who wants to be mobile today considers personal transportation as one of his basic needs. In India two-wheeler is used for a variety of purposes, particularly in urban areas like commuting to work, visiting people, carrying loads, for outdoor jobs, etc. as opposed to the leisure/fun use common in developed countries. In rural areas, where the rough road conditions requires a sturdy vehicle, it enables people to travel more frequently to nearby towns for their daily needs. Younger, single male consumers, between 21 and 30 years of age, looking for power and style, prefer a motorbike for his personal transport.

Owing to the robust growth of rural market, the Indian automobile sector is experiencing a growth. A series of favourable climatic conditions for agricultural commodities has increased the purchasing power of rural customers. Today the rural
market of over six lakhs Indian villages contributes \( \sim 35\% \) of two-wheeler sales (Kumar 1998). All above facts about automobile industry provided motivation for this research.

The Indian automobile industry seems to have a growing market, since by the end of present decade, passenger car sales are expected to reach 800,000. Table 1 shows the trends in production and sales of passenger cars and two-wheelers. The turnover of automobile sector is 4.55\% of GDP in 1996–97. The growth came with expanding middle class increased the purchasing power of Indian consumers, the increasing competition in auto industry and easy auto financing (Ramchandran 1998). Table 2 shows the three eras of Indian automobile industry.

The Indian auto component industry is one of the growing industries. It is reflected in the figures (Ganesh 1998): production ($290 billion), export ($28 billion), investment ($150 billion) and employment (250,000 persons). No automobile company can produce all the components needed in an automobile. These companies have to purchase (even multinationals) various components from local suppliers. This is the boost to the auto component industry.

In this light manufacturing strategy is urgently needed for Indian auto companies to:

<table>
<thead>
<tr>
<th>Year</th>
<th>Production (000s)</th>
<th>Sales (000s)</th>
<th>Production (000s)</th>
<th>Sales (000s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995–96</td>
<td>348.240</td>
<td>345.340</td>
<td>2656.017</td>
<td>2658.288</td>
</tr>
<tr>
<td>1996–97</td>
<td>407.539</td>
<td>411.305</td>
<td>2979.227</td>
<td>2963.497</td>
</tr>
<tr>
<td>1997–98</td>
<td>401.002</td>
<td>416.408</td>
<td>3072.607</td>
<td>3044.074</td>
</tr>
<tr>
<td>1998–99</td>
<td>529.606</td>
<td>525.996</td>
<td>3250.430</td>
<td>3212.345</td>
</tr>
</tbody>
</table>

Source: (Ramchandran 1998).

Table 1. Trends in production and sales of passenger cars and two-wheelers (in thousands).

<table>
<thead>
<tr>
<th>Year</th>
<th>Era</th>
<th>Two-wheelers</th>
<th>Passenger cars</th>
</tr>
</thead>
<tbody>
<tr>
<td>1950–80</td>
<td>era of limited supply</td>
<td>• long waiting list</td>
<td>• limited buying capacity of consumers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• huge pent up demand</td>
<td>• limited number of companies</td>
</tr>
<tr>
<td>1981–90</td>
<td>era of take off</td>
<td>• entry of new global players such as Suzuki, Kawasaki, Honda, Piaggio, etc.</td>
<td>• entry of new global players such as Hyundai, Daewoo, Toyota, Ford, Mercedes Benz, etc.</td>
</tr>
<tr>
<td>1991 onwards</td>
<td>era of consolidation</td>
<td>• rapid acceptance in urban and rural markets</td>
<td>• increase in buying capacity of consumer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• average growth rate 12% p.a.</td>
<td>• easy finance</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• more variety</td>
</tr>
</tbody>
</table>

Table 2. Eras in the Indian auto industry.
respond to business strategy or corporate objectives;
• correct present weaknesses or to exploit strengths;
• cope with anticipated environmental changes;
• get distinctive competence which is currently not available;
• make manufacturing function strong; and
• achieve performance objectives.

The research described here has two objectives:

• To identify the important manufacturing strategy issues in Indian automobile companies based on which they are competing.
• To assess their competitive strength.

The outline of the paper is as follows: Section 2 deals with the literature on manufacturing strategy. Research methodology for exploratory survey is discussed in Section 3. Findings of the survey are presented in Section 4. Case studies of automotive companies are reported in Section 5. Manufacturing competence index is worked out in Section 6. Finally the paper concludes with a proposed framework for manufacturing strategy.

At the macrolevel, a comprehensive industry-wide survey was carried out. This was followed by a case study approach to identify specific issues and mechanisms to formulate manufacturing strategy. Based on the learning of these cases, a model framework is proposed for manufacturing strategy.

2. Manufacturing strategy

Since Skinner’s (1969) landmark paper, a number of researchers have depicted the manufacturing function as the missing link in corporate strategic processes and emphasized that manufacturing can be a formidable competitive weapon, if equipped and managed properly (Hayes and Wheelwright 1984, Hill 1987, Miller and Roth 1994, Hayes and Pisano 1995, Berry et al. 1999). Hayes and Wheelwright (1984) categorized manufacturing organizations in four stages according to manufacturing’s strategic role. Stage I organizations react blindly to the demands placed on them from the top and offer no strategic advantage to the firm. Stage II organizations follow the trends of industry practice. The difference between stages III and IV firms lies primarily in their pro-activeness. Three dimensions distinguish organizations in stage IV:

• Manufacturing is involved up front in major marketing and engineering decisions.
• Efforts are made to anticipate the potential of new manufacturing practices and technologies.
• Long-range programmes are pursued in order to acquire manufacturing capabilities in advance of needs.

Stage IV organizations are proactive and they follow world class practices. Proactiveness is the single characteristic that discriminates between manufacturing functions that offer strategic benefit to the firms, whereas reactive manufacturers are
forced to catch up with the leader when their product engineering departments responded to the competitive challenge.

Various researchers (Skinner 1969, Hill 1987, Gerwin 1993, De Toni and Tonchia 1998) elaborated on customer expectations on attributes such as cost, quality, delivery, flexibility and innovation, which are popularly termed as competitive priorities or manufacturing performance objectives. These competitive priorities can be defined as follows:

- **Cost**: production and distribution of product at low cost.
- **Quality**: manufacture of products with high quality or performance standards.
- **Delivery dependability**: meet delivery schedules.
- **Delivery speed**: respond quickly to customer orders.
- **Flexibility**: react to changes in production, changes in product mix, modifications in design, fluctuations in materials, changes in sequence.
- **Innovation**: introduction of new product and processes.

Hill (1987) introduced the concept of order winners and order qualifiers and differentiated between them. Order qualifiers are those criteria that a company must meet for a customer even to consider it as a competitor. Order winners are those criteria that win the order. To provide qualifiers companies need not only to be as good as competitors, but also to provide order winners they need to be better than competitors. Similar to competitive priorities, Hill also identified various order winners and qualifiers that are market- and time-specific. He categorized them into manufacturing-related and non-manufacturing-related criteria. Manufacturing-related criteria includes price, delivery reliability, delivery speed, quality, demand increases, product range, design and distribution. Non-manufacturing-related criteria may include design leadership, marketing and sales, brand name, technical liaison, and after sales service.

The manufacturing strategy is a plan that describes the way to produce and distribute the product. It is defined by the APICS Dictionary as ‘A collective pattern of decisions that acts upon the formulation and deployment of manufacturing resources. To be most effective, the manufacturing strategy should act in support of the overall strategic directions of the business and provide for competitive advantages’ (Cox and Blackstone 1998). Manufacturing strategy must describe the contribution that manufacturing makes to the cost, quality, availability and future objectives of the business.

The studies on manufacturing practices specific to some countries such as Hungary (Chikan and Demeter 1995), Brazil (Rohr and Correa 1998), Singapore (Ward et al. 1995), Belgium (Gelders et al. 1994), Sweden (Horte et al. 1991, Lindberg and Trygg 1991), New Zealand (Corbett 1996), USA (Kim and Arnold 1993, Baines et al. 1999, Kathuria et al. 1999), UK (Neely et al. 1994), Japan (Hitomi 1997), and erstwhile USSR (Ardishvili and Hill 1992) have been reported in literature. In context of India six studies on manufacturing strategy have been reported (Chandra and Sastry 1998, Sharma and Upadhayay 1998, Nagabhushana and Shah 1999, Saxena and Sahay 2000, Dasgaya and Deshmukh 2000, 2001). Chandra and Sastry (1998) reported in their survey of manufacturing companies that Indian companies are in the quality stage. In their study sample size is small (56) with an 8% response rate. Sharma and Upadhyay (1998) studied manufacturing strategy (MS)-
related aspects in 20 manufacturing organizations. Nagbhushana and Shah (1999) identified manufacturing priorities and action programmes in their study of 38 manufacturing companies from the electronics and machine tool sector. Saxena and Sahay (2000) found that most of the Indian companies have fragmented information systems rather than an integrated one. The sample size in their study was 57 with an 8% response rate. Dangayach and Deshmukh (2000) observed manufacturing strategy practices in three case companies from automotive and electronics sector. Dangayach and Deshmukh (2001) studied 25 process companies situated all over the country and concluded that Indian process companies are investing in advanced management systems to manage the competition. To the best of our knowledge no systematic study is reported on Indian auto companies. We have administered a structured questionnaire to these companies spread all over the country.

3. Research methodology

Since this research is exploratory in nature, the survey methodology is used for study and focus of study is cross-sectional. The objective of study is to become more familiar through survey and information is collected at one point in time. The methodology was based on a questionnaire survey and personal interviews.

3.1. Creation of industry database

A database of 57 automobile companies (producing four- and two-wheeler vehicles and automotive components) has been created based on industries from all over the country. This contains name of company, location, main products, type of industry and postal addresses. The target companies were selected from the following two sources:

- Industrial directory (1999).

3.2. Design of questionnaire and data collection

A structured questionnaire was developed on five-point Likert scale, details of which are given in appendix A. The questionnaire contained two sections, A and B. Section A contained 15 questions pertaining to an organization’s strategy; section B contained 40 questions related to competitive strengths, performance measurement activities, quality improvement criteria, environmentally friendly technologies, information technology applications, world class manufacturing practices, order-winning criteria, functional integration, customer satisfaction and supplier orientation of an organization. Implementers (i.e. middle management level) were required to fill section B. Annexure was given in the end of questionnaire, which contained key for responses and explained in brief the terminology used in the questionnaire to avoid unknown bias.

To assess content validity a ‘dry run’ was made and few questionnaires were administered to leading practitioners, consultant and academicians. Based on their feedback the present form has been evolved and final version of the questionnaire was sent to the CEOs of 57 companies. Twenty-seven valid responses in the form of filled questionnaire have been received, which includes four two-wheeler manufacturers, five four-wheeler manufacturers and 18 auto component manufacturers. The
response rate is 47.4%, which is good in Indian context. Figure 1a–c presents the sales turnover, employee strength and export figures of respondent companies.

Inter-item analysis is used to check the scales for internal consistency or reliability. Cronbach’s coefficient $\alpha$ is calculated for each scale, as recommended for

![Graph](image)

**Figure 1.** (a) Sales turnover of respondent companies. (b) Employee strength of respondent companies. (c) Exports of respondent companies.
empirical research in operations management (Flynn et al. 1990, Malhotra and Grover 1998). Cronbach’s $\alpha$ for each scale is >0.5, which is considered adequate for exploratory work (Nunally 1978). Appendix A gives the results of reliability analysis (Cronbach’s $\alpha$) along with the format of the questionnaire.

3.3. Profile of respondents

Of 27 respondents, 13 were CEO/General Manager/President/Vice-President/Executive Director with 20-30 years’ experience (average age 45 years). With 10-20 years experience (average age 40 years), eight respondents were of Divisional Manager/Production Manager/Head-Operations/Works Manager/Director-Technical level. Six respondents were Assistant Manager/Production Engineer/Quality Engineer with 5–10 years’ experience (average age 32 years). Area-wise distribution of respondent companies is observed as in table 3.

4. Observations

The discussion of the results is divided into five sections. The first describes cluster analysis used for classification of respondent companies. The following sections are devoted to the competitive priorities, order winners, stages according to Hayes and Wheelwright’s model, and activities of improvement.

4.1. Cluster analysis

Cluster analysis was employed to identify the manufacturing strategy (MS) types from the respondent scores of competitive priorities and improvement activities. The proposed classification is based on two criteria: importance given to competitive priorities, and degree of investment in improvement activities.

We have expanded the five competitive priorities (quality, delivery, innovation, flexibility, and cost) identified by various researchers (Hayes and Wheelwright 1984, Hill 1987, Gerwin 1993) into 12 attributes: conformance quality, product durability, product reliability, product performance, delivery speed, delivery dependability, new products, product customization, product mix changes, design changes, volume changes and low cost. Respondents were asked to indicate the degree of importance on a five-point Likert scale (1, least important; 5, most important).

Based on the literature (Mechling et al. 1995, Clark 1996, Udo and Ehie 1996, Bolden et al. 1997), we have identified 27 activities of improvement relevant for Indian companies to address issues in manufacturing strategy. We have classified these activities into advanced manufacturing technologies (AMT), integrated information systems (IIS), and advanced management systems (AMS). AMT encompasses activities such as computer-aided design (CAD), computer-aided

<table>
<thead>
<tr>
<th>Region</th>
<th>Number of respondents (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northern India</td>
<td>17 (63)</td>
</tr>
<tr>
<td>Southern India</td>
<td>4 (15)</td>
</tr>
<tr>
<td>Eastern India</td>
<td>4 (15)</td>
</tr>
<tr>
<td>Western India</td>
<td>2 (7)</td>
</tr>
<tr>
<td>Total</td>
<td>27 (100)</td>
</tr>
</tbody>
</table>

Table 3.
engineering (CAE), computer-aided process planning (CAPP), etc. IIS represents material requirement planning (MRP), manufacturing resource planning (MRPII), enterprise resource planning (ERP) and activity-based costing (ABC). AMS includes activities such as office automation (OA), customer relations (CR), total quality management (TQM), recycling (RC), business process reengineering (BPR), etc. Respondents were asked to indicate degree of investment in above activities in their companies on five-point Likert scale (1, no investment; 5, heavy investment). Table 4 gives the definition of these 12 competitive priorities and 27 improvement activities.

We used SPSS quick cluster procedure, K-mean algorithm for non-hierarchical clustering to evolve different strategic groups. Details of the algorithm used are given in Appendix B. In non-hierarchical cluster analysis number of clusters are known, a priori. To determine the final number of clusters, we sought managerial interpretability of the clusters on the defining variables (12 competitive priorities and 27 improvement activities) using ANOVA and the Scheffe pair wise comparison tests of mean differences (Harrigan 1985). The four cluster model best satisfied these criteria. The four manufacturing strategic groups have been named as reactive enterprise, neutral enterprise, active enterprise, and proactive enterprise. Table 5 describes the group mean scores and their relative ranking in the set of 12 competitive priorities, and standard error of the estimate of the mean for each group. F-statistics and associated $p$ derived from one-way ANOVA are also given in the table 5. Similarly the groups mean scores, standard error, relative rankings, F-statistics and associated $p$ for improvement activities are given in table 9. Distribution of companies in four clusters is found as in table 6 and figure 2.

4.1.1. *Cluster 1: Reactive enterprise (RE)*

Cluster 1 companies labelled as reactive enterprise (RE) place low emphasis on the development of competitive capabilities. Efforts are made to win competition through opportunistic approach instead of capability driven approach. Characteristics of RE are:

- Manufacturing function produces as per marketing needs.
- Top management stresses on short-term gains through incremental improvement.
- There is no explicit manufacturing strategy formulation.
- Low cost appears to be dominant competitive priority for the members of this cluster, followed by delivery speed and dependable delivery.
- Human resource issues are not given due importance.

Such a strategy would correspond to the stage I of the Hayes and Wheelwright’s model, i.e. internally neutral approach. This is the smallest group in our study representing only 4% of the companies who responded.

4.1.2. *Cluster 2: Neutral enterprise (NE)*

Neutral enterprise places highest emphasis in conformance quality (CQ), followed by product reliability (PR) and product durability (PD). Companies of this cluster improve their manufacturing function as marketing strategy. Characteristics of NE are:
<table>
<thead>
<tr>
<th>Type</th>
<th>Abbreviation</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Competitive priorities (CP)</td>
<td>CQ</td>
<td>Conformance quality: improve conformance to design specifications</td>
</tr>
<tr>
<td></td>
<td>PD</td>
<td>Product durability: provide durable product</td>
</tr>
<tr>
<td></td>
<td>PR</td>
<td>Product reliability: offer consistent, reliable quality</td>
</tr>
<tr>
<td></td>
<td>PP</td>
<td>Product performance: provide high performance product</td>
</tr>
<tr>
<td></td>
<td>DS</td>
<td>Delivery speed: provide fast deliveries</td>
</tr>
<tr>
<td></td>
<td>DD</td>
<td>Dependable delivery: make on time delivery or meet delivery schedules</td>
</tr>
<tr>
<td></td>
<td>NP</td>
<td>New product introduction: Introduce new products quickly</td>
</tr>
<tr>
<td></td>
<td>PC</td>
<td>Product customization: customize products to customer needs</td>
</tr>
<tr>
<td></td>
<td>PM</td>
<td>Product mix changes: make rapid product mix changes</td>
</tr>
<tr>
<td></td>
<td>DC</td>
<td>Design changes: make rapid design changes</td>
</tr>
<tr>
<td></td>
<td>VC</td>
<td>Volume changes: make rapid volume changes</td>
</tr>
<tr>
<td></td>
<td>LC</td>
<td>Low cost: ability to profit in price competitive markets</td>
</tr>
<tr>
<td>Advanced manufacturing</td>
<td>CAD</td>
<td>Computer aided design: computer supported design and drafting system</td>
</tr>
<tr>
<td>technologies (AMT)</td>
<td>CAE</td>
<td>Computer aided engineering: computer assisted engineering methods</td>
</tr>
<tr>
<td></td>
<td>CAPP</td>
<td>Computer aided process planning: computer assisted systems and techniques</td>
</tr>
<tr>
<td></td>
<td>CNC</td>
<td>Computer numerical control: numerically controlled machine tools</td>
</tr>
<tr>
<td></td>
<td>DNC</td>
<td>Direct numerical control: numerically controlled machine with centralized</td>
</tr>
<tr>
<td></td>
<td>RO</td>
<td>Robotics: use of Robots for pick and place or other material handling work</td>
</tr>
<tr>
<td></td>
<td>GT</td>
<td>Group technology: the associated hardware and software for cellular</td>
</tr>
<tr>
<td></td>
<td>FMS</td>
<td>Flexible manufacturing systems: computer integrated systems which have</td>
</tr>
<tr>
<td></td>
<td>AMHS</td>
<td>Automatic material handling systems: automatic material handling devices</td>
</tr>
<tr>
<td></td>
<td>AGVs</td>
<td>Automated guided vehicles: driver less vehicles run on special painted paths</td>
</tr>
<tr>
<td></td>
<td>BC</td>
<td>Bar coding bar identification system</td>
</tr>
<tr>
<td></td>
<td>AS/RS</td>
<td>Automated storage and retrieval system (AS/RS): mechanized stock management</td>
</tr>
<tr>
<td>Integrated information systems</td>
<td>MRP</td>
<td>Material requirement planning: computer assisted material planning system</td>
</tr>
<tr>
<td>(IIS)</td>
<td>MRPII</td>
<td>Manufacturing resource planning: computer based system for planning</td>
</tr>
<tr>
<td></td>
<td>ERP</td>
<td>Enterprise resource planning: integrated information management system</td>
</tr>
<tr>
<td></td>
<td>ABC</td>
<td>Activity based costing: philosophy of cost reduction through activity based</td>
</tr>
<tr>
<td></td>
<td>OA</td>
<td>Office automation: computerization of office systems</td>
</tr>
<tr>
<td></td>
<td>CR</td>
<td>Customer relations: improve customer satisfaction, customer-supplier</td>
</tr>
<tr>
<td></td>
<td>TQM</td>
<td>Total quality management: approach to improving the competitiveness of</td>
</tr>
<tr>
<td></td>
<td>RC</td>
<td>Recycling: reusing waste materials</td>
</tr>
<tr>
<td></td>
<td>BPR</td>
<td>Business process reengineering: fundamental rethinking and radical redesign</td>
</tr>
<tr>
<td></td>
<td>SPC</td>
<td>Statistical process control: the use of statistical methods to control</td>
</tr>
<tr>
<td></td>
<td>JIT</td>
<td>Just-in-time: produce and deliver reconditioned goods in-in-time to be sold</td>
</tr>
<tr>
<td></td>
<td>BM</td>
<td>Benchmarking: comparing a company's performance against the best practice</td>
</tr>
<tr>
<td></td>
<td>WI</td>
<td>Workforce involvement: giving worker more planning responsibility</td>
</tr>
<tr>
<td></td>
<td>EE</td>
<td>Employee empowerment: philosophy of handing responsibility and decision</td>
</tr>
<tr>
<td></td>
<td>MT</td>
<td>Management training: training and skill development programs for managers</td>
</tr>
</tbody>
</table>

Table 4. Variables used for classification.
Informal strategy formulation at top level and manufacturing managers are only informed about strategic decisions instead of involvement in formulation.

The catalyst for change is the marketing function.

Uses legacy information systems such as management information systems (MIS).

Human resource issues are given functional importance.

Aim is to neutralize the competitive advantage of competitor.

Top three preferred improvement activities for NE are management training (MT), customer relations (CR) and total quality management (TQM).

On five-point Likert scale (interval scale 1–5: 1, least important; 5, most important). Note: the observed F-statistics were derived from one-way ANOVAs and p are associated with the observed F-statistics.

* There is a statistically significant difference at 0.05 level.

Table 5. Competitive priorities.

<table>
<thead>
<tr>
<th>Competitive priority</th>
<th>Mean (rank)</th>
<th>Standard error (SE)</th>
<th>F-statistic</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conformance quality (CQ)</td>
<td>4.25 (4)</td>
<td>0.19</td>
<td>9.459</td>
<td>&lt;0.0001*</td>
</tr>
<tr>
<td>Product durability (PD)</td>
<td>4.37 (2)</td>
<td>0.16</td>
<td>0.665</td>
<td>0.582</td>
</tr>
<tr>
<td>Product reliability (PR)</td>
<td>4.33 (3)</td>
<td>0.15</td>
<td>2.733</td>
<td>0.067</td>
</tr>
<tr>
<td>Product performance (PP)</td>
<td>4.25 (5)</td>
<td>0.15</td>
<td>5.896</td>
<td>0.004</td>
</tr>
<tr>
<td>Overall mean/SE</td>
<td><strong>4.30</strong></td>
<td><strong>0.16</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Delivery</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Delivery speed (DS)</td>
<td>3.88 (10)</td>
<td>0.23</td>
<td>1.583</td>
<td>0.221</td>
</tr>
<tr>
<td>Delivery dependability (DD)</td>
<td>4.59 (1)</td>
<td>0.12</td>
<td>0.927</td>
<td>0.444</td>
</tr>
<tr>
<td>Overall mean/SE</td>
<td><strong>4.23</strong></td>
<td><strong>0.17</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Innovation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New products (NP)</td>
<td>3.88 (9)</td>
<td>0.16</td>
<td>4.747</td>
<td>0.010</td>
</tr>
<tr>
<td>Overall mean/SE</td>
<td><strong>3.88</strong></td>
<td><strong>0.16</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flexibility</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Product customization (PC)</td>
<td>4.07 (6)</td>
<td>0.17</td>
<td>2.526</td>
<td>0.083</td>
</tr>
<tr>
<td>Product mix changes (PM)</td>
<td>4.07 (7)</td>
<td>0.14</td>
<td>3.536</td>
<td>0.031</td>
</tr>
<tr>
<td>Design changes (DC)</td>
<td>3.66 (11)</td>
<td>0.23</td>
<td>2.293</td>
<td>0.105</td>
</tr>
<tr>
<td>Volume changes (VC)</td>
<td>3.96 (8)</td>
<td>0.16</td>
<td>1.722</td>
<td>0.190</td>
</tr>
<tr>
<td>Overall mean/SE</td>
<td><strong>3.94</strong></td>
<td><strong>0.17</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low cost (LC)</td>
<td>3.66 (12)</td>
<td>0.16</td>
<td>1.886</td>
<td>0.160</td>
</tr>
<tr>
<td>Overall mean/SE</td>
<td><strong>3.66</strong></td>
<td><strong>0.16</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 6.

- Informal strategy formulation at top level and manufacturing managers are only informed about strategic decisions instead of involvement in formulation.
- The catalyst for change is the marketing function.
- Uses legacy information systems such as management information systems (MIS).
- Human resource issues are given functional importance.
- Aim is to neutralize the competitive advantage of competitor.
- Top three preferred improvement activities for NE are management training (MT), customer relations (CR) and total quality management (TQM).
This strategy is similar to stage II of Hayes and Wheelwright’ model, i.e. externally neutral, since in this strategy actions are taken afterwards to neutralize the competitive advantage of other firms. Seven members of this cluster represent 26% companies.

4.1.3. *Cluster 3: Active enterprise (AE)*

The top three competitive priorities for active enterprises (AE) are dependable delivery (DD), product reliability (PR) and product durability. Low cost is the least preferred competitive priority for AE. Characteristics of AE are:

- Functions of firms are well integrated.
- MS is formulated with active involvement of manufacturing function.
- Companies of this group invest more in computer-aided design (CAD) as compared with RE and NE, since its top priority is dependable delivery.
- These companies have active knowledge base in line with learning organizations.
- Top three improvement activities are customer relations (CR), management training (MT) and TQM.

Such a strategy is similar to stage III of Hayes and Wheelwright’ model, i.e. internally supportive, as all functions of AE are well integrated and manufacturing provide credible support to marketing strategy. AE are the largest group, accounting 37% of companies.

4.1.4. *Cluster 4: Proactive enterprise (PE)*

Cluster four companies, labelled as proactive enterprise (PE) place high importance to competitive priorities such as conformance quality (CQ), product reliability (PR) and product performance (PP). Characteristics of PE are:
- More investment in innovation and R&D.
- Flexibility aspects such as design changes (DC); product mix changes (PM) are given more importance as compared with other three groups.
- Objective is to outperform the competition in terms of product performance and quality of service.
- Manufacturing function is proactive and involved up front in strategic decisions.
- Manufacturing strategy is aligned with business strategy and there is cohesion in timing between manufacturing and business strategies.
- Here emphasis is on teamwork and continuous improvement and desire is to become world class manufacturer.

This strategy corresponds to the stage IV of Hayes and Wheelwright’s model, i.e. externally supportive as companies of this group pursue a manufacturing-based competitive advantage. Top five preferred activities of improvement are customer relations (CR), TQM, workforce involvement (WI), employee empowerment (EE) and management training (MT). PE emerged as second largest group with 33% companies. Figure 3 shows the distribution of the clusters across various functions.

4.2. Competitive priorities
Manufacturing capabilities represent a holistic set of tasks that should be performed by the manufacturing function in order to support the business strategy; and the degree of relative emphasis given to each of them represents manufacturing’s competitive priorities (Hayes and Pisano 1996, Kim and Arnold 1996). Table 5 shows mean, standard error, F-statistics and $p$ of competitive priorities. For each priority respondents were asked to indicate the degree of importance on a five-point Likert scale (1, least important; 5, most important).

We have expanded the five competitive priorities (quality, delivery, innovation, flexibility, cost) identified by various researchers (Hayes and Wheelwright 1984, Hill 1987, Gerwin 1993) into 12 dimensions. Table 5 depicts that top most competitive priority for the companies is dependable delivery followed by product durability, product reliability, conformance quality and product performance, whereas overall mean is the highest for quality, i.e. 4.30. However delivery (overall mean 4.23), flexibility (3.94), innovation (3.88), and cost (3.66) are accorded next priorities.

4.3. Order winners
We have identified 10 criteria as order winners common to all industry sectors. Respondents were asked to indicate the degree of agreement for their organizations on a five-point Likert scale. From observation of table 7, we find that three most important order-winning criteria for most of the companies in general are product durability, conformance quality and efficiency, whereas three least important criteria are attractive packaging, competitive price and product range. According to Hill (1987), order-winning criteria are market- and time-specific. Whereas Corbett and Wassenhove (1993) argued that order qualifiers and order winners are dynamic in nature. The criterion, which is order winner today, will become order qualifier in future due to competitive squeeze.
Criteria | Mean (rank) | Standard error
---|---|---
Product durability | 4.37 (1) | 0.16
Conformance quality | 4.25 (2) | 0.19
Efficiency | 4.22 (3) | 0.15
Speed of new product development | 3.88 (4) | 0.16
Variety in design | 3.88 (5) | 0.20
Versatility of product | 3.85 (6) | 0.21
After sales service | 3.81 (7) | 0.22
Product range | 3.81 (8) | 0.16
Competitive price | 3.66 (9) | 0.16
Attractive packaging | 2.59 (10) | 0.25

On a five-point Likert scale (interval scale 1–5: 1, least important; 5, most important).

Table 7. Order-winning criteria.

<table>
<thead>
<tr>
<th>Stage</th>
<th>Description</th>
<th>Attributes</th>
<th>Mean</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>internally neutral</td>
<td>minimize manufacturing’s negative potential</td>
<td>3.77</td>
<td>0.20</td>
</tr>
<tr>
<td></td>
<td>internally neutral</td>
<td>we use internal control systems to control manufacturing</td>
<td>4.00</td>
<td>0.14</td>
</tr>
<tr>
<td></td>
<td>internally neutral</td>
<td>fire fighting is common at our plant</td>
<td>3.29</td>
<td>0.24</td>
</tr>
<tr>
<td></td>
<td>internally neutral</td>
<td>short term performance is emphasized</td>
<td>3.11</td>
<td>0.19</td>
</tr>
<tr>
<td></td>
<td>internally neutral</td>
<td>outside experts are called in, to make decisions about strategic manufacturing issues</td>
<td>2.62</td>
<td>0.29</td>
</tr>
<tr>
<td></td>
<td>internally neutral</td>
<td>manufacturing is kept reactive and unfocused</td>
<td>1.85</td>
<td>0.17</td>
</tr>
<tr>
<td>II</td>
<td>externally neutral</td>
<td>industry practice is followed</td>
<td>3.40</td>
<td>0.17</td>
</tr>
<tr>
<td></td>
<td>externally neutral</td>
<td>capital investment is the primary means for catching up with competition</td>
<td>2.70</td>
<td>0.20</td>
</tr>
<tr>
<td></td>
<td>externally neutral</td>
<td>aim is to achieve parity with competitors</td>
<td>3.37</td>
<td>0.24</td>
</tr>
<tr>
<td>III</td>
<td>internally supportive</td>
<td>manufacturing investments are screened for consistency with the business strategy</td>
<td>3.74</td>
<td>0.19</td>
</tr>
<tr>
<td></td>
<td>internally supportive</td>
<td>manufacturing strategy is formulated and pursued</td>
<td>4.03</td>
<td>0.21</td>
</tr>
<tr>
<td></td>
<td>internally supportive</td>
<td>functions of our firm are well integrated</td>
<td>3.77</td>
<td>0.20</td>
</tr>
<tr>
<td></td>
<td>internally supportive</td>
<td>we actively develop proprietary equipment</td>
<td>2.85</td>
<td>0.27</td>
</tr>
<tr>
<td>IV</td>
<td>externally supportive</td>
<td>manufacturing function provides credible support to the business strategy</td>
<td>3.92</td>
<td>0.16</td>
</tr>
<tr>
<td></td>
<td>externally supportive</td>
<td>manufacturing is involved up front in major marketing and engineering decisions</td>
<td>3.59</td>
<td>0.22</td>
</tr>
<tr>
<td></td>
<td>externally supportive</td>
<td>long range programmes are pursued in order to acquire manufacturing capabilities in advance</td>
<td>3.77</td>
<td>0.21</td>
</tr>
<tr>
<td></td>
<td>externally supportive</td>
<td>aim is to pursue a manufacturing-based competitive advantage</td>
<td>3.77</td>
<td>0.22</td>
</tr>
<tr>
<td></td>
<td>externally supportive</td>
<td>efforts are made to anticipate the potential of new manufacturing policies and technologies</td>
<td>3.88</td>
<td>0.17</td>
</tr>
<tr>
<td></td>
<td>externally supportive</td>
<td>target is to achieve superior position than competitor</td>
<td>4.22</td>
<td>0.22</td>
</tr>
</tbody>
</table>

On a five-point Likert scale: 1, strongly disagree; 5, strongly agree.

Table 8. Application of Hayes and Wheelwright model to companies in the survey.
4.4. Application of Hayes and Wheelwright’s model

Attributes of various stages I-IV, given by Hayes and Wheelwright (1984), have been classified in table 8. Respondents were asked to indicate their degree of agreement for the attributes present in their companies on five-point Likert scale (1, totally disagree; 5, totally agree). It is observed from table 8 that the mean is highest for stage IV, which depicts that companies of automobile sector started activities of improvement driven by global competition. Entry of multinationals (such as Suzuki, Daewoo, Ford, Santro, Mercedes, Toyota, Honda, General motors, etc.) forced the companies to improve their performance.

4.5. Activities of improvement

Based on the literature (Mechling et al. 1995, Clark 1996, Udo and Ehie 1996, Bolden et al. 1997), we have identified 27 activities of improvement for Indian companies to address issues in manufacturing strategy. These include advanced manu-

<table>
<thead>
<tr>
<th>Activity type</th>
<th>Activities of improvement</th>
<th>Mean (rank)</th>
<th>Standard error</th>
<th>F-statistic</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMT</td>
<td>CAD</td>
<td>3.62 (6)</td>
<td>0.17</td>
<td>0.244</td>
<td>0.865</td>
</tr>
<tr>
<td></td>
<td>CAE</td>
<td>2.74 (16)</td>
<td>0.23</td>
<td>0.452</td>
<td>0.718</td>
</tr>
<tr>
<td></td>
<td>CAPP</td>
<td>2.59 (19)</td>
<td>0.27</td>
<td>1.494</td>
<td>0.243</td>
</tr>
<tr>
<td></td>
<td>CNC</td>
<td>3.70 (3)</td>
<td>0.24</td>
<td>3.924</td>
<td>0.021</td>
</tr>
<tr>
<td></td>
<td>DNC</td>
<td>2.70 (18)</td>
<td>0.28</td>
<td>4.168</td>
<td>0.017</td>
</tr>
<tr>
<td></td>
<td>RO</td>
<td>1.55 (26)</td>
<td>0.15</td>
<td>1.691</td>
<td>0.197</td>
</tr>
<tr>
<td></td>
<td>GT</td>
<td>2.25 (23)</td>
<td>0.23</td>
<td>3.032</td>
<td>0.050</td>
</tr>
<tr>
<td></td>
<td>FMS</td>
<td>2.81 (15)</td>
<td>0.25</td>
<td>6.222</td>
<td>0.003</td>
</tr>
<tr>
<td></td>
<td>AHMS</td>
<td>2.29 (22)</td>
<td>0.24</td>
<td>1.251</td>
<td>0.314</td>
</tr>
<tr>
<td></td>
<td>AGVs</td>
<td>1.51 (27)</td>
<td>0.18</td>
<td>1.243</td>
<td>0.317</td>
</tr>
<tr>
<td></td>
<td>BC</td>
<td>2.11 (24)</td>
<td>0.26</td>
<td>4.822</td>
<td>0.010</td>
</tr>
</tbody>
</table>

Overall mean/error 2.47 0.22

<table>
<thead>
<tr>
<th>Activity type</th>
<th>Activities of improvement</th>
<th>Mean (rank)</th>
<th>Standard error</th>
<th>F-statistic</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>IIS</td>
<td>MRP</td>
<td>3.48 (9)</td>
<td>0.24</td>
<td>7.345</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>MRPII</td>
<td>3.14 (12)</td>
<td>0.27</td>
<td>16.605</td>
<td>&lt; 0.0001*</td>
</tr>
<tr>
<td></td>
<td>ERP</td>
<td>2.74 (17)</td>
<td>0.28</td>
<td>3.194</td>
<td>0.043</td>
</tr>
<tr>
<td></td>
<td>ABC</td>
<td>2.33 (20)</td>
<td>0.25</td>
<td>3.686</td>
<td>0.021</td>
</tr>
</tbody>
</table>

Overall mean/error 2.92 0.26

<table>
<thead>
<tr>
<th>Activity type</th>
<th>Activities of improvement</th>
<th>Mean (rank)</th>
<th>Standard error</th>
<th>F-statistic</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMS</td>
<td>OA</td>
<td>2.92 (14)</td>
<td>0.23</td>
<td>3.931</td>
<td>0.021</td>
</tr>
<tr>
<td></td>
<td>CR</td>
<td>3.66 (5)</td>
<td>0.19</td>
<td>1.812</td>
<td>0.173</td>
</tr>
<tr>
<td></td>
<td>TQM</td>
<td>4.11 (1)</td>
<td>0.15</td>
<td>2.071</td>
<td>0.132</td>
</tr>
<tr>
<td></td>
<td>RC</td>
<td>2.29 (21)</td>
<td>0.19</td>
<td>5.164</td>
<td>0.007</td>
</tr>
<tr>
<td></td>
<td>BPR</td>
<td>3.14 (13)</td>
<td>0.21</td>
<td>2.216</td>
<td>0.114</td>
</tr>
<tr>
<td></td>
<td>SPC</td>
<td>3.33 (11)</td>
<td>0.20</td>
<td>3.559</td>
<td>0.030</td>
</tr>
<tr>
<td></td>
<td>JIT</td>
<td>3.57 (7)</td>
<td>0.20</td>
<td>2.501</td>
<td>0.085</td>
</tr>
<tr>
<td></td>
<td>BM</td>
<td>3.55 (8)</td>
<td>0.19</td>
<td>1.541</td>
<td>0.231</td>
</tr>
<tr>
<td></td>
<td>WI</td>
<td>3.44 (10)</td>
<td>0.17</td>
<td>18.727</td>
<td>&lt; 0.0001*</td>
</tr>
<tr>
<td></td>
<td>MT</td>
<td>3.70 (2)</td>
<td>0.21</td>
<td>1.455</td>
<td>0.253</td>
</tr>
</tbody>
</table>

Overall mean/error 3.39 0.19

On a five-point Likert scale (interval scale 1–5: 1, no investment; 5, heavy investment).

Note: The observed F-statistics were derived from one-way ANOVAs and p are associated with the observed F-statistics.

*There is a statistically significant difference at 0.05 level.

Table 9. Activities of improvement.
facturing techniques (AMT), integrated information systems (IIS) and advanced management systems (AMS). Respondents were asked to indicate degree of investment in above activities in their companies on five-point Likert scale (1, no investment; 5, heavy investment). Table 9 shows mean, standard error, F-statistics and $p$ of improvement activities. Top 10 activities of improvement in Indian automotive companies are TQM, management training (MT), CNC, workforce involvement (WI), customer relations (CR), CAD, JIT, benchmarking (BM), MRP and employee empowerment (EE), whereas least preferred 10 activities are AGVs, robotics (RO), AS/RS, bar coding (BC), GT, AMHS, recycling (RC), ABC, CAPP and DNC. Another interesting observation from table 9 is that overall mean for AMT is the least, i.e. 2.47, and that of for AMS is the highest, i.e. 3.39, which reflects that Indian companies want to gain competitive advantage without investing in technology but laying more emphasis on advanced management systems. It is the AMT that provides flexibility dimension in manufacturing and gives long-term competitive edge to the company.

5. Case studies

Based on the exploratory survey, five cases of automobile sector companies are present. Of these, two companies (A, B) are leading two-wheeler manufacturers, one (C) is the major four-wheeler manufacturing company and remaining two companies (D, E) belongs to the auto component sector. Companies A–C are the automobile (four and two-wheelers) manufacturers and D and E are auto component manufacturers. We have adopted case study method for our research, after exploratory survey, since survey research may have some errors in it (Malhotra and Grover 1998).

Case studies are longitudinal in nature and one attribute is to be discussed with more than one manager for collection of data, therefore non-response bias is reduced to minimum. Various researchers used case study for their research (Maruchek et al. 1990, Shrivastava 1995, Cheng and Musaphir 1996, Menda and Dilts 1997). The primary object of this study is to gain in-depth understanding of manufacturing strategy practices in leading Indian automobile companies. Table 10 gives an overview of the companies A–E. The specific issues involved in the study are:

- Manufacturing mission/vision.
- Methodology used for formulation and implementation of manufacturing strategy (MS):
  - how is MS formulated?
  - how is MS related to marketing strategy?
  - who is responsible for the formulation of the strategy?
  - how is MS related to corporate strategy?
- Organization culture:
  - human resource policy
  - quality policy
  - supplier/customer orientation
- Competitive priorities of the companies.
- Order winners/order qualifiers.
- Relative position of the companies in Hayes and Wheelwright model.
<table>
<thead>
<tr>
<th>Attributes</th>
<th>Product</th>
<th>Automobile manufacturers</th>
<th>Auto component manufacturers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Company A,</td>
<td>Company D,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>two- and three-</td>
<td>automotive</td>
</tr>
<tr>
<td></td>
<td></td>
<td>wheeler vehicles</td>
<td>component</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Company B,</td>
<td>Company E,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>two-wheeler</td>
<td>automotive</td>
</tr>
<tr>
<td></td>
<td></td>
<td>motorbikes</td>
<td>component</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Company C,</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>all type of four-</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>wheeler vehicles</td>
<td></td>
</tr>
<tr>
<td>Sales turnover ($ million)</td>
<td>662</td>
<td>180</td>
<td>1870</td>
</tr>
<tr>
<td>Number of employees</td>
<td>11000</td>
<td>3000</td>
<td>7000</td>
</tr>
<tr>
<td>Domestic market share</td>
<td>40% in scooter segment</td>
<td>45% in motorbike segment</td>
<td>50% in LCVs</td>
</tr>
<tr>
<td>Exports as % of total sales</td>
<td>10</td>
<td>10</td>
<td>16</td>
</tr>
</tbody>
</table>

|                         |                                  | 25%                      | 49%                         |
|                         |                                  | 72% in MCVs/HCVs         |                            |
|                         |                                  |                          |                            |
|                         |                                  | 20                       | 10                          |

LCV, light commercial vehicle; MCV, medium commercial vehicle; HCV, heavy commercial vehicle.

Table 10. An overview of the companies under study.
Activities of improvement.
Critical success factors.
Manufacturing competence index of the companies.

5.1. Company A

The setting. Company A is one of the oldest two-wheeler automobile manufacturing company (established in 1945). It belongs to a big industrial group and operates in a multi-plant environment (two plants). Other companies of this group produce electrical appliances, sugar, etc. Both plants are located in the central part of India. The company produces two-wheeler (nine models) and three-wheeler (three models) vehicles. Two wheelers include scooters (five models), two- and four-stroke motorbikes (three models), and mopeds (one model). In 1960 the company came into technical collaboration (for scooter manufacturing) with a leading Italian two-wheeler manufacturing company. In 1984 it entered in motorbike and moped production segment after technical collaboration with Japanese two-wheeler giant. In 1985 it established second plant after relaxation in industrial policy. With 11000 employees, it enjoys 40% market share in two-wheeler segments. Presently company A is the third largest manufacturer of two- and three-wheeler vehicles in the world and has 15% exports of total sales.

Previous approach. During 1950–80, an era of limited supply, the government’s industrial policy was restrictive and regulative, therefore the company’s production was very less than demand. During this period the waiting list for scooters was 10 years. Being the oldest company in the two-wheeler sector, the company enjoyed a monopoly status in earlier years. Initially the company did not have a marketing department since demand outstripped capacity and it enjoyed a protected seller’s market. Therefore it had no specific strategy till the 1980s. After relaxation in industrial policy many new companies have entered in this sector with Japanese collaboration. In the 1980s the company has grown explosively and its production volume has increased from 172,000 to 800,000 units a year.

Present approach. Owing to increased competition the company created a marketing department (in 1993) that focused on increasing annual sales to 1 million units. The company decided to modernize plants and increase production efficiency. It invested in advanced manufacturing technologies (AMT) such as CAD, CAM, CNC machines, etc. and framed a marketing strategy.

Vision. To become market leader in two-wheeler segments.
Mission. To provide low cost, fuel-efficient two-wheelers to customers.

Elements of the marketing strategy:

- Increase dealer network all over the country including rural area.
- Dealers are not to be permitted to have other two-wheeler brands.
- Periodically introducing a new product (company increased its models from five in 1985 to 12 in 1992).
- 50% components to be produced through vendors.
- To improve product distribution and service network by deploying 50 service engineers at dealership to upgrade the technical capability of dealer service personnel.
To provide service and advertising support to the dealers, by giving training to their staff in the company’s plants.

To sell the product at competitive price, i.e. lowers than competitors.

Increase investment in advertising and describe additional features.

To address competitor claims head on.

To start its own financing company to finance the vehicles.

Manufacturing strategy development methodology. After setting up of marketing department, the CEO and key marketing managers framed a manufacturing strategy. Figure 3a shows the manufacturing strategy development procedure of company A. Essential features of its manufacturing strategy are:

- Speed up the new product development by using AMT like CAD, CAM.
- Mission of manufacturing is continuous improvement with zero defects.
- Quality circles to be established to get suggestions for improvement at shop floor.
- Matching competitor product features by constantly improving existing product.

After implementation of manufacturing and marketing strategy the company improved its lost market share. It increased its dealer network. The company had computerized distribution system with 30% of dealers connected through the network and orders were directly fed into the company’s production schedule. It seems that after rigorous changes in its manufacturing and marketing strategy, the company is in transition from stage II to III of Hayes and Wheelwright’s model. Table 10 shows the vital economic indicators of the company A, which reflect its better economic performance and supports our view.

Competitive priorities. Rank-wise competitive priorities of the company are:

- Product performance.
- Low cost.
- Product durability.
- Conformance quality.
- Product reliability.
- New products.
- Delivery speed (provide fast deliveries).
- Dependable delivery (on time delivery).
- Product customization.
- Product mix changes.
- Design changes.
- Volume changes.

Order qualifiers:

- Low cost.
- Product durability.
- Resale value.
Order winners:

- Brand image.
- New product development.
- User friendliness.
- Cost effectiveness.
- After sales management.

Critical success factors:

- Product durability.
- Large and loyal dealer network.
- Brand image.
- Advertising.
- Economic price.
- Use of AMT.
- Better HR policy.

5.2. **Company B**

The setting. Company B operates in a multi-plant and multi-divisional environment in northern India. It has collaboration with leading a Japanese motorbike company with 26% equity share and produces four models of a four-stroke motorbike (coded as MB1, MB2, MB3, MB4). The company was established in 1983 and its production rate is 1000 motorbikes/day. Present turnover of the company is $18 billion and market share (Indian) is ~45% in 100 cc motorbike segment. The company has ~3000 employees.

Previous approach. Before liberalization (1991) in India, company B was following traditional industry practice due to a license regime in India. Much of the time was spent in moving papers from one department to other. Total production of vehicles was 42,000 per year, whereas booking of vehicles was nearly 500,000. The decision-making process was centralized due to rigid vertical integration.

Present approach. After liberalization, due to intense competition, spurred by entry of multinationals, the CEO of the company in consultation with group and division heads set a vision and mission for the company.

**Vision.** To be the leader in motorbike sector by following world class practices.

**Mission:**

- Continue efforts for the development of motorbike industry through new product development, technological innovation, investment in equipments, facilities and efficient management.
- Develop core competencies and human resource to become the market leader in economic and dependable transport system.

The company has developed a testing facility (with spending 1% of total sales on research and development) in which 90% of the testing (static and dynamic) is done locally. Most of the machines are computer numerical control (CNC) type.

Manufacturing strategy development methodology. Figure 3b shows the procedure adopted by company B for manufacturing strategy development. Broad corporate
strategic objectives are formulated at corporate level, which provides a set of expectations for lower level strategy formulation such as marketing and manufacturing strategies. Plant-level manufacturing strategy is being formulated by manufacturing personnel of various plants, which sets the norms for division level manufacturing strategy. Assessment of manufacturing objectives is reviewed through a monthly meeting of division heads.

Observations. After liberalization in India (1991), i.e. after 8 years of establishment, company B has started thinking towards alignment of manufacturing and marketing strategy. It is clear with the statement that in spite of having good demand (500,000 units) firm could produce only 42,000 vehicles in a year. After having clear-cut vision and mission and top management commitment company developed a manufacturing strategy which states: develop enough technological capabilities to take maximum leverage from the resources committed to the technology of the firm’s products and processes. To support this strategy and to meet the market demand, decision was made to start one more unit within 50-km area of the existing plant.

Before 1991 the company was in stage II (according to the Hayes and Wheelwright’s model) since it followed industry practice, emphasized short-term performance and manufacturing was reactive and unfocused. After formulating a manufacturing strategy it plans to reach in the category of stage III organizations. The following points indicate this:

- Functions of the firm are well integrated.
- Manufacturing investments are screened for consistency with business strategy.
- Vendors are motivated to take up innovative ideas for implementation to bring down or maintain the cost and to improve the quality of the component.
- New product development time is reduced, i.e. 3 models MB2, MB3 and MB4 have been developed in 7 years time. This is done through CAD/CAM.
- Environmental concerns have now been given weightage by avoidance of waste, pollution control check, effluent treatment plant and by carefully selecting environment friendly process technologies.
- It uses various advanced manufacturing technologies like robotics (for welding and sheet metal processing), CAD, CAM, concurrent engineering and automated material handling systems.
- The firm aims to use flexible manufacturing systems (FMS) in which the motorbikes will be produced in small batches without sacrificing the elements of scale.
- The whole organization is networked through use of information technology.
- The firm won National Productivity Council (NPC) award for automobile sector.
- In the last 3 years, there is an increasing trend observed in market share and sales turnover each by 10%.
- Cost reduction strategy has been identified by reducing production costs, increase in labour productivity, reduce inventory and increase capacity utilization.
Competitive priorities. Rank-wise competitive priorities of the company B are:

- Product performance.
- Conformance quality.
- Product durability.
- Product reliability.
- New products.
- Delivery speed (provide fast deliveries).
- Dependable delivery (on time delivery).
- Product customization.
- Product mix changes.
- Design changes.
- Volume changes.
- Low cost.

Order qualifiers:

- Technology leadership.
- On time delivery.
- Product quality.
- Useful life.

Order winners:

- Excellent mileage.
- New product development.
- User friendliness.
- Cost effectiveness.
- After sales management.
- Free test ride.

5.3. Company C

The setting. Company C is a leading manufacturer of all types of four-wheeler vehicles. It produces a wide range of diesel commercial vehicles (heavy, medium and light commercial vehicles) and passenger cars. It manufactures 24 models of these vehicles. The company is the largest motor vehicle manufacturer in India and sixth largest commercial vehicle manufacturer in the world. It was established in 1945 and belongs to a giant industrial group of India, which produces diverse range of product in the plants all over the country. The company operates in multi-plant environment with three plants in various parts of the country. It enjoys 60% market share in domestic market for light commercial vehicles and 72% in medium and heavy commercial vehicles. Annual turnover of the company was $187 billion in 1996–97. The company exports are ~16% of total sales. It exports its products to countries such as Paraguay, Hungary, Argentina and Chile.

Vision. To develop the company with excellent capabilities in design, engineering, manufacturing and marketing.
Mission. To be a leader in all types of vehicle manufacturer

Marketing strategy. The company sets high target for future. It plans to achieve a turnover of $500 billion by 2000 and exports to increase up to 30% of total sales. The company focuses at a time one-market segment, develop capability and then move into the next segment, taking advantage of previous one. It is reflected with following facts:

- 1956-85: devoted to development of heavy commercial vehicles (trucks and buses).

Corporate strategy:

- Develop indigenous competence with acquisition of technology from abroad.
- Upgrade the manufacturing technology.
- Producing a variety of products that can cater to all major segments.
- Development of a large dealer network.
- Systematic human resource development.
- Continue investment in research and development.

Manufacturing strategy development methodology. The company has a formal method of formulation of manufacturing strategy (MS) in line with marketing strategy. Owing to its clear-cut corporate, marketing and manufacturing strategies the company seems to be in stage IV of Hayes and Wheelwright’s model. Figure 3c shows the process of manufacturing strategy formulation method of the company C. Vital elements of its MS are:

- High investment in advanced manufacturing technology such as CAD, CAM, Shop floor automation, and concurrent engineering.
- Emphasis on continuous improvement of manufacturing system.
- High innovation rate, (the company has its own engineering research centre with 1100 employees. Its R&D expenditure was $30 million in 1995-96).

Human resource policy:

- The company had established a fully fledge training centre in the eastern part of the country in 1966.
- Linked career progress with skill development.
- Recognition of employees for excellent work.

Competitive priorities. Rank-wise competitive priorities of the company C are:

- Conformance quality.
- Product durability.
- Product performance.
- Product reliability.
- Delivery speed (provide fast deliveries).
3(a)  
Top Management Formulates Business Objectives  
  
Strategic Manufacturing Objectives  
  
Production Plan  

3(b)  
CEO and Presidents of each plant Formulates Corporate Mission Statement  
  
Corporate Strategy  
  
Strategic Manufacturing Objectives  
  
Plant Level Manufacturing Strategy  
  
Manufacturing Strategy at Divisional Level  
  
Subject to Business plans  

3(c)  
Vision and Mission  
  
Corporate strategy  
  
Manufacturing strategy  
  
Marketing strategy  
  
Divisional manufacturing strategy  

(continued)
- Dependable delivery (on time delivery).
- New products.
- Low cost.
- Product customization.
- Product mix changes.
- Design changes.
- Volume changes.
Order qualifiers:

- Technology leadership.
- On time delivery.
- Product quality.

Order winners:

- User friendliness.
- Cost effectiveness.
- After sales management.

Critical success factors:

- Excellent dealer network all over the country.
- Clarity of vision.
- Brand image.
- High quality of products.
- Good after sales service.
- Investment in core technology.
- High innovation rate.
- Continuous improvement of manufacturing.
- Strong customer focus.

5.4. Company D

The setting. Company D is a manufacturer of automotive components such as steering systems, vehicle wiring, Shock absorbers, catalytic converters, etc. It is a multinational company operating in multi-plant environment with four plants located all over the country. It is a subsidiary of an American automotive giant and was established in 1995. The company’s turnover is about $5 billion and number of employees is 1100. Its export amounts to 20% of total turnover.

Vision. Be recognized by our customers as their best supplier.

Mission:

- Global automotive systems supplier with component excellence.
- Passionate pursuit of customer satisfaction through technology, quality, cost, responsiveness and attitude.
- Grow revenue across a diversified customer base.
- Increase stakeholder value through revenue growth and superior returns.
- Create an environment where every employee can contribute.

Manufacturing strategy development methodology. The company has clear-cut manufacturing strategy aligned with marketing strategy. Manufacturing strategy (MS) formulation method is shown in figure 3d. Company D is relatively new in Indian auto component market, however due to following improvement activities it seems in stage III of Hayes and Wheelwright’s model. Main elements of its MS are:
High use of AMT.
Continuous emphasis on waste elimination.
Lean manufacturing.
Work place organization.
Employee environment and involvement.
Fostering quality at source.
Reduction in non-productive time.
Smooth material movement.
Integration of business functions using ERP.

**Competitive priorities.** Rank-wise competitive priorities of the company are:

- Delivery speed (provide fast deliveries).
- Dependable delivery (on time delivery).
- Product performance.
- Product durability.
- Conformance quality.
- Product reliability.
- New products.
- Product customization.
- Product mix changes.
- Design changes.
- Volume changes
- Low cost.

**Order qualifiers:**

- Product durability.
- Dependable delivery (on time delivery).

**Order winners:**

- New product development.
- Cost effectiveness.

5.5. **Company E**

The setting. Company E is a leading manufacturer of technologically advanced automotive components and assemblies in India. Its products (such as steering systems) are used in passenger cars, jeeps and light commercial vehicles. The product range covers steering system, propeller shaft assemblies, rear axle assemblies and different subassemblies. The company has technical and commercial links with a leading Japanese company. It is an ISO 9002 certified company, situated in northern India. The company was established in 1985 and started production in 1987. Annual turnover is about $4 billion. It enjoys a 49% market share and it supplies components to leading Indian automobile companies. The firm exports ~10% of total
sales. It operates in a multi-plant environment and has eight units in different parts of the country. The number of employees in the firm is ~1000.

**Mission.** To become a world class quality supplier of auto components.

**Manufacturing strategy development methodology.** Figure 3e shows the process of manufacturing strategy formulation adopted by company E. The firm produces steering system components for all types of vehicles. CEO and plant heads frames the corporate strategy after assessment of market demand and manufacturing capabilities. This is being reviewed annually. They set the manufacturing objectives for each plant, then manufacturing heads of various plants meet and formulate the plant-level manufacturing strategies.

**Observations.** The company E is presently in stage III in the Hayes and Wheelwright’s model, since it adopted following strategies:

- Identify world leaders in technology.
- Energize employees through continuous education and training.
- On time delivery at competitive costs.
- Invest in human resource policies by providing training in areas of housekeeping, statistical process control (SPC) and quality function deployment (QFD).
- R&D expenditure is ~5% of total turnover.
- Use of CAD, CAM, CNC, DNC, TQM, Kaizen, etc.
- Systematic technology management.

**Competitive priorities:** Rank-wise competitive priorities of the company are:

- Product reliability.
- Product durability.
- Product performance.
- Conformance quality.
- Delivery speed (provide fast deliveries).
- Dependable delivery (on time delivery).
- New products.
- Low cost.
- Product customization.
- Product mix changes.
- Design changes.
- Volume changes.

**Order qualifiers:**

- Competitive price.
- Product quality.

**Order winners:**

- On time delivery.
- Product reliability.
- Product durability.
Critical success factors:

- Clarity of mission.
- Skilled and flexible workforce.
- Focus on training of workers.
- Indigenous vendor development.
- Effluent treatment plants towards environment friendly techniques.
- Elimination of waste.
- Full customer satisfaction.

6. Manufacturing competence index

Manufacturing competence is a measure of the combined effects of a manufacturer’s strengths and weaknesses in certain strategic manufacturing issues (Cleveland et al. 1989). Manufacturing competence index as given by:

\[ C_j = \sum \{ W_i \log K_i \}, \]

where \( C_j \) is manufacturing competence index for company \( j \), \( i \) is strategic manufacturing issue, \( R \) is rank of strategic manufacturing issue, \( K_i \) is inverse rank (If \( R = 1, K = 9 \), when \( i = 9 \), and if \( R = 2, K = 8 \), and \( W_i \) is weight of strategic manufacturing issue.

We have identified following nine strategic manufacturing issues:

- Quality: various dimensions of quality (such as conformance quality, product durability, product reliability, and provide high-performance products).
- Delivery: provide fast deliveries (delivery speed), dependable delivery (on time delivery).
- Innovation: new products.
- Flexibility: product customization, product mix changes, design changes, and volume changes.
- Cost: low cost.
- Use of advanced manufacturing technology (AMT): AMT includes computer-aided design (CAD), computer-aided engineering (CAE), computer-aided process planning (CAPP), computer numerical control (CNC) machines, direct numerical control (DNC) machines, robotics (RO), group technology (GT), flexible manufacturing system (FMS), automated material handling systems (AMHS), automated guided vehicles (AGVs), bar coding/automatic identification (BC) and automated storage and retrieval system (AS/RS).
- Alignment of manufacturing strategy and corporate strategy.

Companies under study (A–E) were asked to indicate degree of importance for above-mentioned strategic manufacturing issues on five-point Likert scale (1, not important; 5, very important). Values given in table 11 are the mean values for the above dimensions.

- Exports: score values given in table 11 for all companies A–E, is based on the criteria in table 12.
<table>
<thead>
<tr>
<th>Strategic manufacturing issue (i)</th>
<th>Company A mean (rank) ([W_i])</th>
<th>Company B mean (rank) ([W_i])</th>
<th>Company C mean (rank) ([W_i])</th>
<th>Company D mean (rank) ([W_i])</th>
<th>Company E mean (rank) ([W_i])</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality</td>
<td>4.0 (2) [+1]</td>
<td>4.2 (2) [+1]</td>
<td>4.0 (2) [+1]</td>
<td>5.0 (1) [+1]</td>
<td>4.3 (1) [+1]</td>
</tr>
<tr>
<td>Delivery</td>
<td>3.2 (6) [0]</td>
<td>3.3 (5) [0]</td>
<td>3.8 (6) [0]</td>
<td>4.5 (2) [+1]</td>
<td>4.2 (2) [+1]</td>
</tr>
<tr>
<td>Innovation</td>
<td>3.5 (5) [0]</td>
<td>4.2 (1) [+1]</td>
<td>3.0 (3) [+1]</td>
<td>4.0 (5) [0]</td>
<td>3.3 (6) [0]</td>
</tr>
<tr>
<td>Flexibility</td>
<td>2.8 (8) [-1]</td>
<td>3.2 (7) [0]</td>
<td>3.5 (7) [-1]</td>
<td>3.9 (6) [0]</td>
<td>2.9 (7) [-1]</td>
</tr>
<tr>
<td>Cost</td>
<td>4.5 (1) [+1]</td>
<td>2.5 (8) [-1]</td>
<td>3.5 (8) [-1]</td>
<td>3.2 (7) [-1]</td>
<td>2.9 (8) [-1]</td>
</tr>
<tr>
<td>Use of advanced manufacturing technology</td>
<td>3.5 (4) [0]</td>
<td>3.8 (4) [+1]</td>
<td>4.5 (1) [+1]</td>
<td>4.3 (4) [+1]</td>
<td>4.0 (4) [+1]</td>
</tr>
<tr>
<td>Alignment of manufacturing strategy and corporate strategy</td>
<td>2.5 (7) [-1]</td>
<td>3.3 (6) [0]</td>
<td>4.0 (5) [+1]</td>
<td>4.3 (3) [+1]</td>
<td>4.2 (3) [+1]</td>
</tr>
<tr>
<td>Exports</td>
<td>2.0 (9) [-1]</td>
<td>2.0 (9) [-1]</td>
<td>3.0 (9) [-1]</td>
<td>3.0 (8) [-1]</td>
<td>2.0 (9) [-1]</td>
</tr>
<tr>
<td>Profit trends</td>
<td>4.0 (3) [+1]</td>
<td>4.0 (3) [+1]</td>
<td>4.0 (4) [+1]</td>
<td>3.0 (9) [-1]</td>
<td>4.0 (5) [+1]</td>
</tr>
</tbody>
</table>

Manufacturing competence index:

\[
C_j = [W_i \log (K_i)]
\]

Table 11. Manufacturing competence index.
Profit trends: companies were asked to indicate trend in profits during last 3 years. Criteria for the scores are given in Table 13.

We have mapped the highest and lowest mean value for above strategic manufacturing issues for the companies under study into 100% and 0% respectively. For calculation of manufacturing competence index, we used a linear approximation method. Table 11 also shows the manufacturing competence index for each company.

\[
W_i = +1 \text{ (strength), when } > 60\%
\]
\[
= 0 \text{ (neutral), when between 40 and 60}\%
\]
\[
= -1 \text{ (weakness), when } < 40\%.
\]

### Table 12.

<table>
<thead>
<tr>
<th>Export (% of total sales)</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nil</td>
<td>1</td>
</tr>
<tr>
<td>Up to 10</td>
<td>2</td>
</tr>
<tr>
<td>10–20</td>
<td>3</td>
</tr>
<tr>
<td>20–30</td>
<td>4</td>
</tr>
<tr>
<td>&gt;30</td>
<td>5</td>
</tr>
</tbody>
</table>

### Table 13.

<table>
<thead>
<tr>
<th>Profit trend</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decrease more than 10%</td>
<td>1</td>
</tr>
<tr>
<td>Decrease up to 10%</td>
<td>2</td>
</tr>
<tr>
<td>Constant</td>
<td>3</td>
</tr>
<tr>
<td>Increase up to 10%</td>
<td>4</td>
</tr>
<tr>
<td>Increase more than 10%</td>
<td>5</td>
</tr>
</tbody>
</table>

7. A few remarks

Manufacturing competence index is a good measure of performance of a company. Table 11 shows the competence index values of companies A–E. The maximum competence index is quite high (3.40) for companies C and E, whereas lowest (1.92) for company A. One interesting observation from the cases is that company C is using the focused factory concept of Skinner (1969), in which he suggested to focus at a time on a particular market niche to achieve superior performance. It is reflected with the marketing strategy of the company C, in which it focuses at a time one market segment, develop capability and then move into the next segment, taking advantage of previous one. It is reflected with following facts:

- **1956–85**: devoted to development of heavy commercial vehicles (trucks and buses).

Indian auto sector has set to compete globally due to high innovation rate, faster new product development and continuous improvement. It is reflected in table 8.

The study depicts that manufacturing strategy of most companies participated in the survey are focused on improving product and process quality and delivering products on time. However competitive advantage can be obtained through fundamental changes in the way manufacturing is organized. Indian companies are giving less importance to flexibility (table 5), whereas companies from other countries (USA, Japan Korea, Singapore, etc.) are giving priority to flexibility (Kim and Arnold 1993, Ward et al. 1995). Swedish companies are introducing FMS, robotics and CAM as a part of strategic direction (Horte et al. 1991). Similarly competitive priorities for Brazilian companies are cost, delivery and flexibility (Rohr and Correa 1998). These companies have already qualified on the dimension quality. According to Chikan and Demeter (1994) Hungarian companies are now pursuing quality as top most competitive priority after transition from planned economy to market economy. Quality is most important competitive priority for Indian companies since most of the companies are engaged in ISO certification process. For them ISO 9000 is synonym for quality. Today ~5000 companies in India has obtained ISO 9000 certification. The competition from multinationals has made Indian companies quality conscious. Traditional quality control is now moving to preventative measures reflected in wide adoption of TQM practices, e.g. Sundaram Clayton (a medium-scale auto company) has won Deming award for quality. Indian companies perceive that survival of manufacturing is critically dependent on quality of design, quality of manufacturing and time of delivery.

The study also highlights that in general Indian automobile companies are investing in advance management systems (AMS) as an improvement activity, which is reflected from table 9. To compete globally they should invest more on AMT, research and development and other infrastructural issues like organization culture, information technology, etc. However few Indian companies (studied under case study) are moving slowly towards global competition, by investing in improvement activities such as advanced manufacturing technology (CAD, CAM, etc.).

8. A framework for manufacturing strategy

Based on the learning of the case study, a model framework is proposed depicted in figure 4:

- Based on the external and internal analysis, manufacturing mission is spelt out in line with corporate vision. To arrive at this, brainstorming session involving executives from marketing, design, R&D, finance, manufacturing, etc. need to be involved.
- Once mission is identified, manufacturing strategy is framed to address various structural (such as capacity, manufacturing capabilities, and Technology) and infrastructural issues (such as quality policies, human resource policies, etc.).
- Manufacturing strategy must provide direction for achieving that contribution:
  - it must support corporate strategy
  - it should describe allocation of resources to achieve the stated objectives
it will be reflected in patterns of actual decisions made by manufacturing function.

• plans are made in a holistic manner by jointly agreeing an internal capabilities and mapping them to market opportunities
• market requirements of cost, flexibility, delivery speed, innovation together with quality requirements are clearly understood by all and resources are allocated to meet these requirements
• decisions concerning manufacturing environment in terms of new process/ technology are made on long term manufacturing advantage
• focused strategy based on long-term holistic view

• Drawing up a detailed set of tactics carries out the implementation of manufacturing strategy. This would also involve a set of improvement activities in terms of
  • advanced manufacturing technology (such as CAD, CAE, robotics, FMS, etc.)
  • integrated information systems (such as MRP, ERP, ABC, etc.)
  • advanced management systems (such as TQM, BPR, JIT, benchmarking, etc.)

• Once tactics are deployed, organizational control is established through a set of performance measures (both finance and non-finance). Manufacturing competence index is a good measure. In our view corporate strategy, marketing strategy, and manufacturing strategy should be properly aligned to achieve corporate goals of survival and growth. These strategies must be properly synthesized as shown in figure 5.
9. Conclusion

This research has identified four types of manufacturing enterprises, namely reactive enterprise (RE), neutral enterprise (NE), active enterprise (AE) and proactive enterprise (PE). We tried to observe the practices in MS in automotive sector. As compared with earlier Indian MS researchers, we have got good response rate, i.e. 47.3%.

We identified four clusters based on the importance attached to 12 competitive priorities and investment in 27 improvement activities. Reactive enterprises are adopting cost-driven strategies. Their dominant competitive priority is low cost. They follow traditional opportunistic approach to cope with competition. These companies stress on short-term gains. This MS is similar to stage I of Hayes and Wheelwright’s (1984) model. For NE conformance quality is the top preferred competitive priority. Companies adopting NE have moderate investment in TQM. In such companies MS is formulated at top level and manufacturing function is supposed to implement it. Human resource issues are given functional importance. In our view this type of reactive MS correspond to stage II of Hayes and Wheelwright’s (1984) model. In AE strategy functions are well coordinated. These companies invest more in improvement activities such as CAD, CNC, etc. A formal method of MS formulation in consultation with manufacturing is observed in AE. Companies having AE strategy keep active knowledge base in line with learning organizations. Such strategy is similar to stage III of Hayes and Wheelwright’s (1984) model. Companies with PE strategy place high emphasis on innovation and flexibility aspects. In such companies MS is properly aligned with BS. High emphasis is given on HR issues and continuous improvement and attempt is made to become a world class manufacturer. This strategy corresponds to stage IV of Hayes and Wheelwright’s (1984) model. In our study maximum 37% of the responded companies falls in AE group.

In our survey 27 companies responded to the questionnaire, which are distributed among four clusters, namely reactive enterprise (RE: 1), neutral enterprise (NE: 7), active enterprise (AE: 10) and proactive enterprise (PE: 9). Among these 27 companies 13 are listed in BT-1000 and ET-500 rankings. Business Today (BT) and Economic Times (ET) are two reputed business magazines of India like Fortune in USA. BT commissioned the Bombay-based Centre for Monitoring Indian Economy
<table>
<thead>
<tr>
<th>Issues</th>
<th>Company A</th>
<th>Company B</th>
<th>Company C</th>
<th>Company D</th>
<th>Company E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturing strategy formulation</td>
<td>• Informal</td>
<td>• Formal</td>
<td>• Formal</td>
<td>• Formal</td>
<td>• Formal</td>
</tr>
<tr>
<td></td>
<td>• By CEO and marketing managers</td>
<td>• By CEO, President and VPs (R&amp;D, marketing, finance, and manufacturing)</td>
<td>• VPs (manufacturing) are involved in manufacturing strategy formulation</td>
<td>• By MD and Directors finance, manufacturing and marketing</td>
<td>• Manufacturing managers are involved in formulation of plant level manufacturing strategy</td>
</tr>
<tr>
<td>Contents of manufacturing strategy</td>
<td>• Use of AMT such as CAD, CAM, etc.</td>
<td>• Use of CAD, CAM, etc.</td>
<td>• High investment in AMTs</td>
<td>• Emphasis on waste elimination</td>
<td>• Benchmarking</td>
</tr>
<tr>
<td></td>
<td>• Benchmarking</td>
<td>• Investments are consistent with business strategy</td>
<td>• Continuous improvement of manufacturing system</td>
<td>• Lean manufacturing</td>
<td>• Better human resource policies</td>
</tr>
<tr>
<td></td>
<td>• Faster new product development</td>
<td>• Well integrated functions</td>
<td>• High innovation rate</td>
<td>• Use of integrated information system such as ERP</td>
<td>• Use of AMTs</td>
</tr>
<tr>
<td>Key competitive priorities</td>
<td>• Low cost</td>
<td>• Prove high performance products</td>
<td>• Conformance quality</td>
<td>• Provide fast delivery</td>
<td>• Product reliability</td>
</tr>
<tr>
<td></td>
<td>• Product durability</td>
<td>• Conformance quality</td>
<td>• Product durability</td>
<td>• Dependable delivery</td>
<td>• Product durability</td>
</tr>
<tr>
<td></td>
<td>• Conformance quality</td>
<td>• Product reliability</td>
<td>• Provide high performance products</td>
<td>• Provide high performance products</td>
<td>• Provide high performance products</td>
</tr>
<tr>
<td>Order winners</td>
<td>• Brand image</td>
<td>• Excellent mileage</td>
<td>• User friendliness</td>
<td>• Product durability</td>
<td>• Dependable delivery</td>
</tr>
<tr>
<td></td>
<td>• Cost effectiveness</td>
<td>• User friendliness</td>
<td>• Cost effectiveness</td>
<td>• New product development</td>
<td>• Conformance quality</td>
</tr>
<tr>
<td></td>
<td>• After sales management</td>
<td>• New product development</td>
<td>• After sales management</td>
<td>• Brand image</td>
<td></td>
</tr>
<tr>
<td>Stage as per Hayes and Wheelright’s model</td>
<td>stage II Externally neutral</td>
<td>stage III internally supportive</td>
<td>stage IV Internally supportive</td>
<td>stage III Internally supportive</td>
<td>stage III Internally supportive</td>
</tr>
<tr>
<td>Manufacturing competence index</td>
<td>1.92</td>
<td>3.18</td>
<td>3.40</td>
<td>2.70</td>
<td>3.40</td>
</tr>
</tbody>
</table>

Table 14. Various issues of manufacturing strategy in the companies.
(CMIE), which has built the country’s most comprehensive databases, to identify India’s most valuable companies in line with *Fortune-500*. BT-1000 rankings are based on company’s financial performance in 1998–99. Similarly ET and Investment Research and Information Services (IRIS) identified top 500 Indian companies. They had culled financial information from the IRIS database. Companies of BT-1000 and ET-500 were taken from the universe of 9432 companies listed on the India’s two premier stock exchanges: Bombay stock exchange (BSE) and National stock exchange (NSE).

In our study we have tried to map the companies A–E (where companies A–C are the automobile (four- and two-wheelers) manufacturers and companies D and E are auto component manufacturers) in various manufacturing strategy-related issues based on the following frameworks (table 14):

- Competitive priorities.
- Manufacturing strategy formulation.
- Order qualifiers/order winners.
- Relative position of the firms in Hayes and Wheelwright’s framework.
- Investment in improvement activities.
- Manufacturing competence index.

It is observed that manufacturing strategy seems to be linked to firms overall business strategy. Manufacturing managers are involved in the strategic formulation process.

Manufacturing strategy role is significant in providing a ‘strategic fit’ in focussing efforts and resources, so that manufacturing strategy is consistent with, and helps to support the business strategy.

Manufacturing strategy can be indeed used in a proactive manner (as evident from case C). The manufacturing comparisons are exploited to create new opportunities and markets.

The study has highlighted a number of interesting aspects of manufacturing function and strategy. The overall results are encouraging with 47.3% response rate in the survey, in Indian scenario and underline the need for more such studies of Indian companies. Based on the experiences of case companies a framework for manufacturing strategy is also proposed. Viewing the challenges to Indian companies in an integrated framework, one needs to put the strategic issues in proper perspective. The manufacturing competence index and relative position reflected in Hayes and Wheelwright’s framework is pointers in this direction.

**Appendix A:** Questionnaire and Cronbach’s $\alpha$

1. Please indicate the degree of importance given to following competitive priorities by your organization (on a five-point Likert scale: 1, least important; 5, most important) (Cronbach’s $\alpha = 0.7922$):

   (1) Conformance quality (CQ).
   (2) Product durability (PD).
   (3) Product reliability (PR).
   (4) Product performance (PP).
   (5) Delivery speed (DS).
   (6) Dependable delivery (DD).
2. Please indicate the degree of investment in following improvement activities (on a five-point Likert scale: 1, no investment; 5, heavy investment) (Cronbach’s $\alpha = 0.9079$):

(1) Computer-aided design (CAD).
(2) Computer-aided engineering (CAE).
(3) Computer-aided process planning (CAPP).
(4) Computer numerical control (CNC).
(5) Direct numerical control (DNC).
(6) Robotics (RO).
(7) Group technology (GT).
(8) Flexible manufacturing systems (FMS).
(9) Automated material handling systems (AMHS).
(10) Automated guided vehicles (AGVs).
(11) Bar coding (BC).
(12) Automated storage and retrieval system (AS/RS).
(13) Material requirement planning (MRP).
(14) Manufacturing resource planning (MRPII).
(15) Enterprise resource planning (ERP).
(16) Activity-based costing (ABC).
(17) Office automation (OA).
(18) Customer relations (CR).
(19) Total quality management (TQM).
(20) Recycling (RC).
(21) Business process reengineering (BPR).
(22) Statistical process control (SPC).
(23) Just-in-time (JIT).
(24) Benchmarking (BM).
(25) Workforce involvement (WI).
(26) Employee empowerment (EE).
(27) Management training (MT).

3. Manufacturing strategy (MS) – business strategy (BS) linkage (on a five-point Likert scale: 1, totally disagree; 5, totally agree) (Cronbach’s $\alpha = 0.5534$):

(1) We have a manufacturing strategy that is actively pursued.
(2) Our business strategy is translated into manufacturing terms.
(3) Manufacturing managers are only informed about strategic decisions.
(4) At our plant, manufacturing is kept in line with our business strategy.
(5) Manufacturing management is not aware of business strategy.

4. Which of the following attributes are there in your organization (Cronbach’s $\alpha = 0.7525$):

(1) Minimize manufacturing’s negative potential.
We use internal control systems to control manufacturing.
Fire fighting is common at our plant.
Short-term performance is emphasized.
Outside experts are called in, to make decisions about strategic manufacturing issues.
Manufacturing is kept reactive and unfocused.
Industry practice is followed.
Capital investment is the primary means for catching up with competition.
Aim is to achieve parity with competitors.
Manufacturing investments are screened for consistency with the business strategy.
Manufacturing strategy is formulated and pursued.
The functions of our firm are well integrated.
We actively develop proprietary equipments.
Manufacturing function provides credible support to the business strategy.
Manufacturing is involved up front in major marketing and engineering decisions.
Long-range programmes are pursued in order to acquire manufacturing capabilities in advance.
Aim is to pursue a manufacturing-based competitive advantage.
Efforts are made to anticipate the potential of new manufacturing policies and technologies.
Target is to achieve superior position than competition.

5. Order winning criteria for my organization is (on a five-point Likert scale: 1, totally disagree; 5, totally agree) (Cronbach’s \( \alpha = 0.7715 \)):

(1) Product durability.
(2) Conformance quality.
(3) Efficiency.
(4) Product range.
(5) Speed of new product development.
(6) Variety in design.
(7) After sales service.
(8) Versatility of product.
(9) Competitive price.
(10) Attractive packaging.

Appendix B: Quick cluster K-mean algorithm
We have used SPSS quick cluster procedure to evolve different strategic groups. Cluster analysis is a technique used for combining observations into groups such that each group is homogeneous with respect to certain characteristics/classifying criteria (Sharma 1996). In our research we classified 27 manufacturing companies on the basis of two criteria:

- Importance given to 12 competitive priorities (on five-point Likert scale: 1, least important; 5, most important).
- Degree of investment in 27 improvement activities (on five-point Likert scale: 1, no investment; 5, heavy investment).
We used non-hierarchical clustering method with K-mean algorithm (K = number of clusters). In non-hierarchical cluster analysis number of clusters/groups are known as a priori. To determine number of clusters, we sought managerial interpretability of the clusters on the defining variables (12 competitive priorities and 27 improvement activities) using ANOVA and the Scheffe pair wise comparison tests of mean differences (Harrigan 1985). The four cluster model best satisfied these criteria. The interpretation of the four manufacturing strategic groups, which we have named reactive enterprise, neutral enterprise, active enterprise and proactive enterprise. Various steps in K-mean algorithm are as under:

- Select K initial cluster seeds, in our case K = 4.
- Compute the squared Euclidean distance and mean of each observation and assign subjects to the cluster where mean is nearest.
- Compute mean of each cluster and change in cluster means
- If change in cluster mean is greater than the convergence criterion of 0.02, a reallocation of subjects is done in the next iterations and computing the distance of each observation from the mean reassigns subjects.
- When change in cluster mean is zero, none of the observations are reassigned and the final cluster solution will come.

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References


Industrial directory, 1999 (New Delhi: Balit).


