Advanced Manufacturing Technologies: Evidences from Indian Automobile Companies

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Abstract

This research reports the findings of a exploratory survey on Advanced Manufacturing Technologies (AMT) administered in Indian automobile companies. The objective of the survey is to assess the status of advanced manufacturing technologies, Identify advanced manufacturing technologies relevant to Indian automobile sector companies, Identify competitive priorities, assess the degree of investment in advanced manufacturing technologies. Responses from 68 companies are analyzed and presented.

INTRODUCTION

Manufacturing has been evolving over the years as different needs and technologies arise. The customer of the twenty first century, demands products and services that are fast, right, cheap and easy (Dangayach & Deshmukh 2001). The rapid growth in applications of information technology has resulted in intensive use of advanced manufacturing technologies. Advanced manufacturing technologies have been heralded as a new way for manufacturing companies to gain a competitive advantage (Pagell et al. 2000).

Evaluating capital investments for the Installation of advanced manufacturing technologies is a critical task faced by manufacturing management due to the high capital investment and the high degree of uncertainty involved in these investments. What makes the justification process challenging is the lack of frameworks that incorporate both tangible and intangible benefits expected from such investments.

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 advanced manufacturing technologies 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 the 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 (Kumar 1998).

Due to the robust growth of rural market, Indian automobile sector is experiencing a growth. A series of favorable climatic conditions for agricultural commodities have increased the purchasing power of rural customers. Today the rural market of over six lakhs Indian villages contributes about 35% of two wheeler sales (Kumar 1998).

The objective of this research is to assess the status of advanced manufacturing technologies, Identify advanced manufacturing technologies relevant to Indian automobile sector companies, Identify competitive priorities, and assess the degree of investment in advanced manufacturing technologies.

ADVANCED MANUFACTURING TECHNOLOGIES

Advanced manufacturing technologies (AMT) is a term that covers a broad spectrum of computer-controlled automated process technologies. AMT is an umbrella term used to describe a wide range of automation and related technologies, which have emerged during the past two decades as a consequence of developments in information technology (Bessant 1991). More specifically, AMT can be described as a group of computer-based technologies, including computer-aided design (CAD), computer numerical control (CNC) machines, direct numerical control (DNC) machines, robotics (RO), flexible manufacturing systems (FMS), automated storage and retrieval system (AS/RS), automated material handling systems (AMHS), automated guided vehicles (AGV), bar coding (BC), rapid prototyping (RP), material requirement planning (MRP), statistical process control (SPC), manufacturing resource planning (MRPII), enterprise resource planning (ERP), activity based costing (ABC), and office automation (OA) (Beaumont et al. 2002). Figure 1 shows evolution of various technologies according time. In this paper we categorize AMT in three types i.e. direct, indirect, and administrative AMT.

- Direct AMT: Technology used on the factory floor to cut, join, reshape, transport, store or modify materials e.g. CNC, DNC, robotics, FMS, AS/RS, AMHS, AGV, RP etc.
- Indirect AMT: Technology used to design products and schedule production e.g. CAD, MRP, SPC, BC, MRPII etc.
- Administrative AMT: Technology used to give administrative support to the factory and integrate its operations with the rest of the organization e.g. ERP, ABC, OA etc.

METHODOLOGY

The “Survey on Advanced Manufacturing Technologies” questionnaire was distributed in 314 Indian automobile companies (manufacturing two wheeler, four wheeler vehicles and automotive components) through postal mail in the first quarter of 2002. A database of these 314 companies was created from "Confederation of Indian Industry (*CII*) Directory-2001". The questionnaire included questions on details of companies, AMT investment, planning, and implementation issues on five point Likert scale.

To assess content validity few questionnaires were pilot tested with 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 314 Indian automobile manufacturing companies. 68 valid responses in the form of filled questionnaire have been received. The response rate is 21.7%, which seems good in Indian context. Figure 2 shows distribution of companies as per employees.

Inter-item analysis is used to check the scales for internal consistency or reliability. Chronbach's coefficient alpha is calculated for each scale, as recommended for empirical research in operations management (Flynn et al. 1990, Malhotra and Grover 1998, Forza 2002). Table 1 shows Cronbach's Alpha values calculated for scales used. Cronbach's alpha values for each scale is more than 0.5, which is considered adequate for exploratory research (Nunally 1978).

Table 1. Cronbach's Alpha for Scales Used

Scales Used	Cronbach's Alpha
Competitive Priorities	0.70
AMT implementation Steps	0.89
Direct AMT	0.86
Indirect AMT	0.80
Administrative AMT	0.82

Area wise distribution of 68 respondent companies is observed as under (Figure 3) and Figure 4 gives the distribution of companies according to annual sales

Region	Number of respondents (%)
Northern India	51 (75)
Southern India	9 (13)
Western India	5 (7)
Eastern India	3 (5)
Total	68 (100)

MEASURES

Competitive Priorities

In the survey companies were asked to indicate the importance given to four competitive priorities i.e. quality, delivery, flexibility, and cost on five point Likert scale. Table 2 gives mean, standard error, F-statistic and p-values of above four competitive priorities. It is observed that top most competitive priority for the Indian automobile companies is quality, followed by delivery, cost, and flexibility.

Table 2. Competitive Priorities

Competitive priority	Mean (Rank)	Standard error (S.E.)	F-statistic	p-value
Quality	4.64 (1)	0.11	6.141	0.001
Delivery	4.42 (2)	0.11	7.560	0.000
Flexibility	**3.93 (4)**	0.12	4.384	0.007
Cost	4.35 (3)	0.09	3.420	0.014

On five point Likert scale (Interval scale 1-5: 1 - least important and 5 - most important)
The observed F-statistics were derived from one-way ANOVAs and the p-values are associated with the observed F-statistics.

AMT Implementation Steps

Based on literature eight steps are identified for effective AMT implementation. Respondents were asked to give importance to these eight implementation steps on five point Likert scale. Table 3 gives the various steps their mean, standard errors, F-statistic and p-values.

Table 3. AMT Implementation Steps

AMT implementation steps	Mean Rank)	Standard error	F-statistic	p-value
Planning	4.18 (2)	0.11	6.293	0.000
Concept development	3.90 (7)	0.12	20.60	0.000

Requirement analysis	3.90 (8)	0.12	10.88	0.000
Cost/Benefit analysis	4.21 (1)	0.10	5.03	0.004
Technology assessment	4.18 (3)	0.10	4.84	0.004
Development & Implementation	4.18 (4)	0.11	5.79	0.002
Training	4.12 (5)	0.11	6.61	0.001
Post-implementation evaluation	3.92 (6)	0.13	6.24	0.001

On five point Likert scale (Interval scale 1-5: 1 - least important and 5 - most important)
The observed F-statistics were derived from one-way ANOVAs and the p-values are associated with the observed F-statistics.

Investment in AMT

Respondents were asked to indicate degree of investment in direct AMT (eight items), indirect AMT (five items), and administrative AMT (three items) in their companies on five point Likert scale (where 1- No investment and 5 – Heavy investment). Table 4 shows mean, standard error, F-statistics, and p-values of all three AMT.

Table 4. Investment in AMT

AMT	Mean (Rank)	Standard error	F-statistic	p-value
Direct AMT				
CNC	3.36 (1)	0.18	4.19	0.005
DNC	2.55 (3)	0.18	3.44	0.014
RO	1.89 (8)	0.16	3.36	0.015
FMS	2.58 (2)	0.16	2.02	0.103
AMHS	2.40 (4)	0.17	2.42	0.058
AGV	1.96 (7)	0.15	2.30	0.069
AS/RS	1.98 (6)	0.15	2.49	0.053
RP	2.03 (5)	0.15	1.57	0.193
Overall mean	**2.34**			
Indirect AMT				
CAD	3.44 (2)	0.14	4.30	0.004
MRP	3.30 (3)	0.17	24.02	0.000
SPC	3.71 (1)	0.12	0.53	0.715
BC	2.31 (5)	0.17	2.72	0.038
MRPII	3.22 (4)	0.18	20.94	0.000
Overall mean	**3.19**			
Administrative AMT				
ERP	2.95 (2)	0.19	6.51	0.000
ABC	2.78 (3)	0.17	2.63	0.043
OA	3.43 (1)	0.15	4.09	0.005
Overall mean	**3.05**			

On five point Likert scale (Interval scale 1-5: 1 - least important and 5 - most important)
The observed F-statistics were derived from one-way ANOVAs and the p-values are associated with the observed F-statistics.

CONCLUDING REMARKS

AMT appeared to represent a perfect marriage between technological potential and the manufacturing challenges of 21st century. AMT are a source of strategic competitive benefits, such as improved quality, greater flexibility, and cost reduction. To achieve those benefits, companies carefully manage the implementation of these technologies.

It is observed from Table 2 that Indian companies are giving highest priority to quality and the least priority to flexibility. Flexibility is the competitive priority, which is realized by adoption of AMT. This reflects that Indian automobile manufacturing companies are not emphasizing adequately on AMT, whereas companies from USA and Japan are giving highest priority to flexibility dimension. Table 3 depicts that 'concept development' and 'requirement analysis' AMT implementation steps have attracted least attention from Indian managers, which are rather more important to get more yield from AMT investment. It can be observed form Table 4 that Indian companies are investing more in 'indirect AMT' as compared to other two 'administrative AMT' and 'direct AMT'. Investment in the 'direct AMT' is the least as its mean value is 2.34 on a five point Likert scale. However it is the direct AMT which provide maximum flexibility to the manufacturing system.

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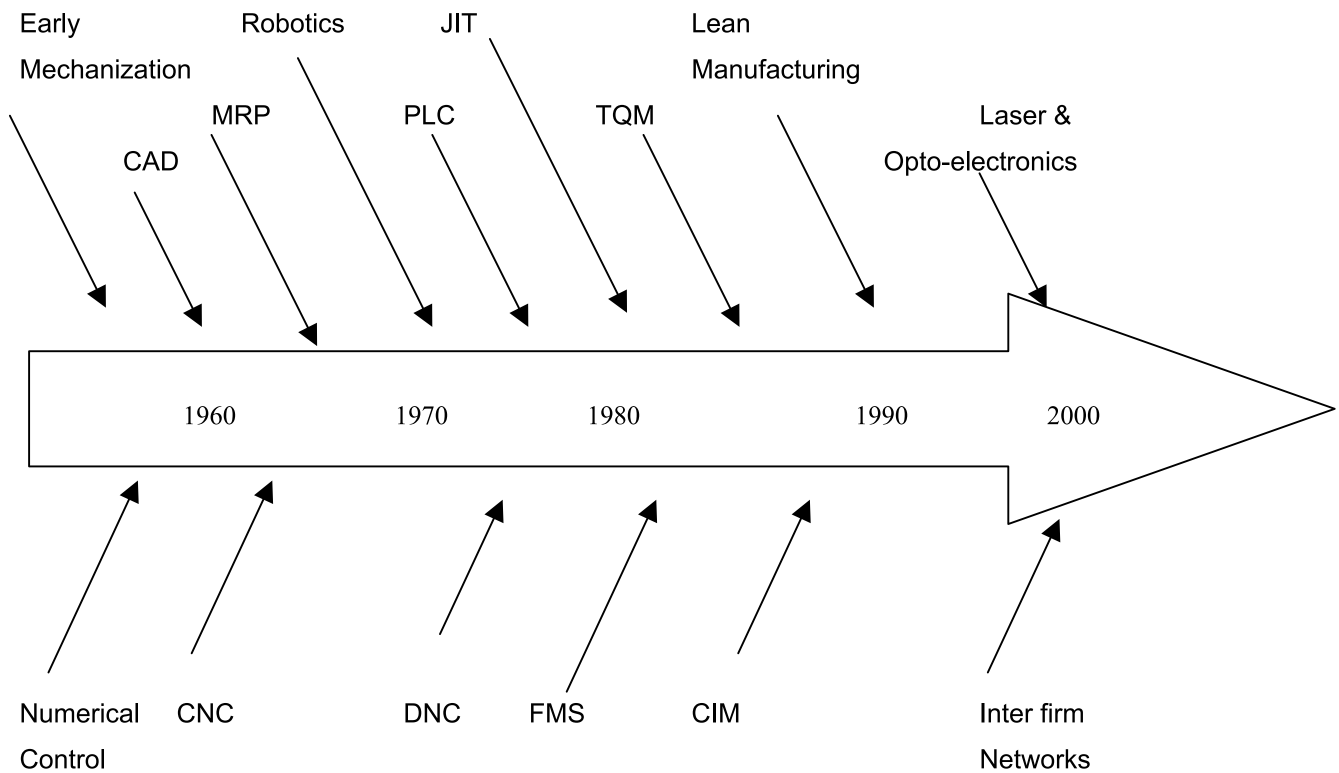

Figure 1. Convergent Streams in AMT

Figure 2. Distribution of Companies according to Number of Employees

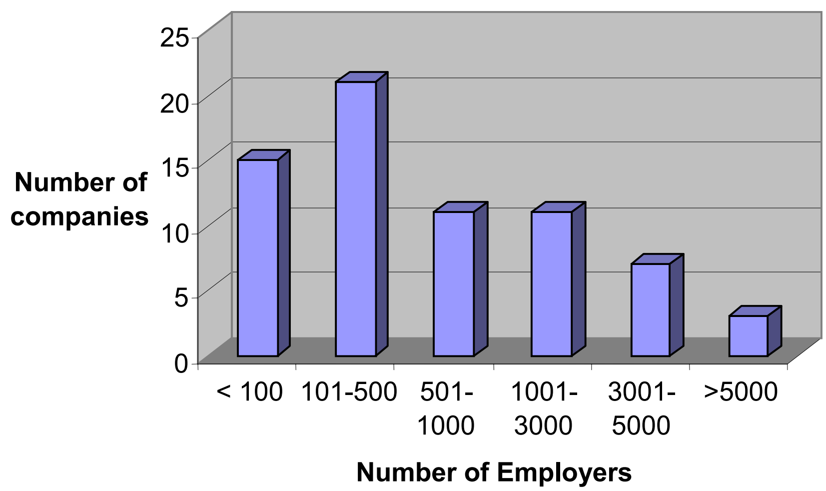

Figure 3. Area wise distribution of companies

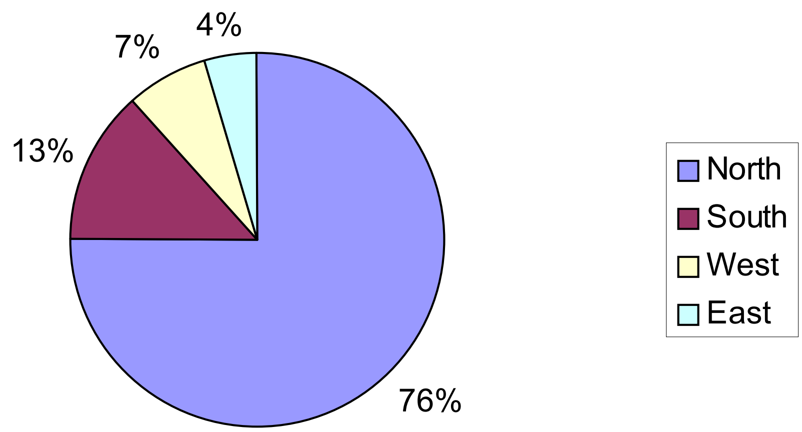

Figure 4. Distribution of Companies according to Annual Sales