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ADVANCED MANUFACTURING TECHNOLOGY AND DEMOGRAPHICAL FACTORS IN MANUFACTURING SMALL AND MEDIUM ENTERPRISES – AN EXPLORATORY STUDY

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Abstract: Purpose: The main focus of this study is to find out the level of implementation of AMT in manufacturing SMEs and its relationship with the various demographical factors. **Methodology/approach:** A survey methodology has been used for this research. The data collected through the structured questionnaire was analyzed to bring out the difference between SMEs with or without the Advanced Manufacturing Technology. **Findings:** The demographical factors like cost of the project, size of the firm, ISO certification and export are having relationship with the AMT adoption. **Social implications:** This paper brings out the important results of the research survey conducted on adoption of Advanced Manufacturing Technologies (AMT) in Indian Small and Medium Enterprises (SMEs).

Keywords: SMEs, Advanced Manufacturing Technology, demographical factor

INTRODUCTION

Small and Medium Enterprises (SMEs) are vibrant and fast growing sector of the Indian economy, which is significantly contributing towards the annual GDP, exports and employment. Over the years, SME sector in India has recorded an impressive performance in terms of range of items produced, contribution to value addition in the industrial sector, exports and employment, which is well documented in the literature.

According to one of the study, the Indian SME sector accounts for nearly 35% of the gross value of output in the manufacturing sector, and over 40% of the total exports from the country. In terms of value addition this sector accounts for about 40% of the value added in the manufacturing sector (Sebastian et al, 2001) [1].

Since 1990, there is lot of pressure on Indian SMEs, because of liberalization, globalization and deregulation, which resulted in increased competitive pressure on SMEs. It is well noted in the literature that, SMEs are constrained by various factors such as technological obsolescence, imperfect knowledge of market conditions, unorganized nature of operation, inadequate and irregular supply of raw materials, inadequate availability of credit, lack of organized market channels, constraint of infrastructure facilities including power deficient managerial and technical skills etc...[2].

Advanced Manufacturing Technology (AMT) can be broadly defined as “an automated production system of people, machines and tools for the planning and control of the production process, including the procurement of raw materials, parts and components and the shipment services of finished products”[3].

Advanced Manufacturing Technologies (AMT) supports SMEs to overcome the limitations of conventional technology, allowing them to develop economies of scale based on low volume and cost of production. Specifically, AMT facilitates customization through the production variety, frequent design changeovers, rapid processing of design, assembly, materials handling and market information [4]-[6]. AMT may be quickly adopted in SMEs compared to large firms because they have few layers of bureaucracy, tend to be less geographically dispersed, have shorter communication lines, informal nature of small business, leadership of owner/manager and less bounded by traditions [7]. Various studies on different AMT suggest that they can be successfully introduced in SMEs, but that they will be





implemented in a way that differs from large business [8] and [9], but adoption patterns may be influenced by characteristics and preferred abilities of SMEs [10].

The potential benefits which can accrue investment in AMTs, have become increasingly evident with growing global competition [11] and [12]. The benefits of AMT have been widely reported in literature that can be classified as tangible and intangible benefits [30]. The tangible benefits which are easily quantifiable include inventory savings, less floor space, improved return on equity, and reduced unit cost of production. The benefits which are difficult to quantify, includes competitive advantage, improved product quality, increased flexibility and quick response to customer demand [13].

ADVANCED MANUFACTURING TECHNOLOGY ADOPTION AND DEMOGRAPHICAL FACTORS

Demographic aspects such as gender, age and education have been extensively researched on different context in SME area [14]-[21]. Empirical studies commonly use three measures of enterprise size – Sales revenues, total employment, and total assets [14]. Certain characteristics like recent plant growth, plant size and age are used to represent the general competencies to absorb technologies [22]-[27]. There are numerous studies which relate firm size and technology adoption [28]-[30]. Some of the recent studies suggest that gender can play an important role in determining technology used [31]-[33]. Owner characteristics, planning orientation, and the existence of alliances/networks influence technology adoption by SMEs [34].

Some of the important studies related to these research areas are, Venkateshet. al [33] found gender difference in individual adoption and sustained usage of technology in the workplace, Jantan et al [35] in his study on advanced manufacturing technology adoption among SMEs found that, older CEO's of SMEs were more innovative than younger ones who promote AMT.

Sanchez [36], suggests that firms which exports large portion of their production adopt greater variety of AMT than domestic competitors. George et. al [28], supports the above argument and reveals that exporting is positively related to AMT adoption. Therefore it is expected that demographical factors may influence the ability of the SMEs to acquire AMT.

RESEARCH OBJECTIVE AND METHODOLOGY

The main objective of the study is to examine the level of adoption of AMT and also to identify the relationship between demographical factors of the organizations with the AMT adoption. A survey methodology has been used for this research. The data collected through the structured questionnaire was analyzed to bring out the difference between SMEs with or without the Advanced Manufacturing Technology. The data was collected from the owners/managers of the SMEs with face to face interviews.

Questionnaire

Based on the review of the available literature and the research objectives a structured draft questionnaire was designed. The draft questionnaire was used for the pilot study. Based on the inputs given by the owners/managers of the firm and experts, the draft questionnaire was fine tuned. The final questionnaire contains close ended questions under the important section namely, 1) Firm general information 2) Technology related information 3) Training need information 4) Human resource practice related information.

There were 31 questions and 23 Advanced Manufacturing Technologies considered for this study, which were further analyzed with the seven demographical factors of the firms which are discussed later in this paper.

Research Sample

The information collected through the face to face interview with owners/managers from 657 participants, was randomly chosen from the directory of Small Scale Industries, Government of Karnataka, India. Of the 657 firms surveyed the responses of 217 participants were found to be valid and considered for further analysis and interpretation.

The table 1 shows the technologies considered for the study. If a firm has successfully adopted one or more of these technologies, then the firm is considered to be an Adopter of Advanced Technologies else Non Adoptive. Further the considered 23 AMT were divided into six major functional groups.

SURVEY RESULT AND ANALYSIS

The firms are classified with respect to those who Adopted Advanced Technology (ATA), and those who have Not Adopted Advanced Technology (ATNA) across the 217 SMEs and they are then compared against their demographic characteristics. From the 217 SMEs surveyed, 118 firms accounting for 54.37 percent of the sample have adopted advanced technology while 99 firms (45.63 percent) have not adopted advanced technology. An overwhelming number of SMEs (210) accounting for 97 percent of the sample had an opinion that Advanced Technology could be adopted in the SME sector, thereby





emphasizing its relevance to Indian context. Only seven SMEs (3 percent) are of the opinion that it is not relevant. This clearly shows the awareness about the importance and benefits of AMT adoption. From the 217 SMEs surveyed, the major functional groups for which the firms have adopted advanced technologies are namely Design and Engineering Group (147 firms), Network communications (84 firms), Processing Fabrication and Assembly (47 firms), Automated material handling (14 firms), Inspection (18 firms) Integration and control (37 firms).

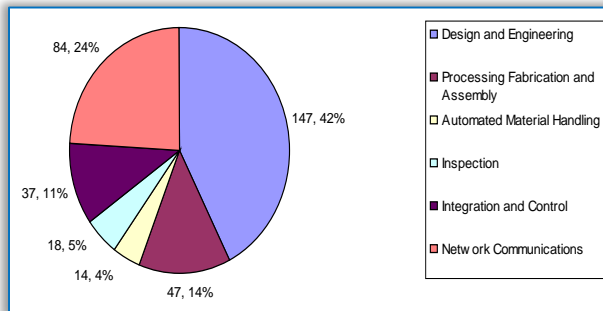


Figure1: Adoption of advanced technology among SMEs under different functional groups

Level of Advanced Technology Adoption

The level of Advanced Technology Adoption among ATA SMEs are classified in to three groups as shown Figure2.

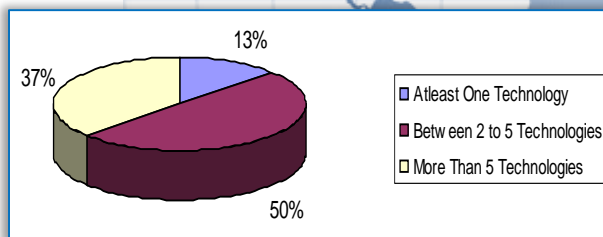


Figure 2: Level of advanced technology adoption among ATA firms

Among 118 advanced technology-adopted firms, 59 firms accounting for 50 percent have adopted between 2 to 5 technologies followed by 44 firms (37 percent); 15 firms accounting for only 13 percent have adopted at least one technology. From this it is clear that, 93 firms accounting for 87 percent have adopted more than one Technology.

AMT Adoption and Educational Background of Entrepreneurs

Educational background of the owner of ATA and ATNA is presented in the Figure 3.

Among 118 ATA firms, 90 firms (76.27 percent) have their founders from a technical background when compared to 28 firms (23.72 percent) with their founders from a non-technical background. Among 99 ATNA firms, 65 firms (65.65 percent) have their founders from a technical background when compared to 34 firms (34.35 percent), which have their founders from a non-technical background.

Advanced Technology adoption and Cost of Project

Investment made on plant and machinery in ATA and ATNA SMEs is classified in to five groups as shown in Figure 4.

Table 1: Adoption of advanced technology among the Functional groups

Advanced Manufacturing Technology Functional Groups	Number of firms
Design & Engineering	
Computer Aided Design/Engineering (CAD/CAE)	95
Computer Aided Design/Manufacturing (CAD/CAM)	38
Modeling or Simulation Technologies	14
Processing Fabrication & Assembly	
Flexible Manufacturing Cells or Systems (FMC/FMS)	07
Programmable Logic Control (PLC) machine/s or process/es	12
Lasers used in Materials Processing (including Surface Modification)	02
Robot/s with sensing capabilities	01
Robot/s without sensing capabilities	01
High speed machining	24
Automated Material Handling	
Part identification for Manufacturing automation, like Bar coding	14
Automated Storage and Retrieval System (AS/RS)	00
Inspection	
Automated vision-based systems used for inspection/testing of inputs and/or final products	08
Other automated Sensor based systems used for inspection/testing of inputs and/or final products	10
Integration & Control	
Manufacturing Resource Planning (MRPII/Enterprise Resource Planning (ERP)	04
Computer/s used for control on the factory floor	15
Computer Integrated Manufacturing (CIM)	05
Supervisory Control and Data Acquisition (SCADA)	04
Use of Inspection data in Manufacturing Control	07
Digital remote controlled Process plant control, like Field bus	00
Knowledge based software	02
Network Communications	
Local Area Network (LAN) for Engineering/Production	61
Company-wide computer Networks (including Intranet and WAN)	13
Inter-company computer Networks (including Extranet and EDI)	10



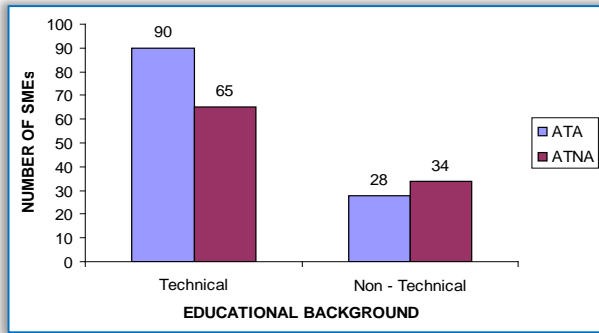


Figure 3: Educational Background of Entrepreneurs

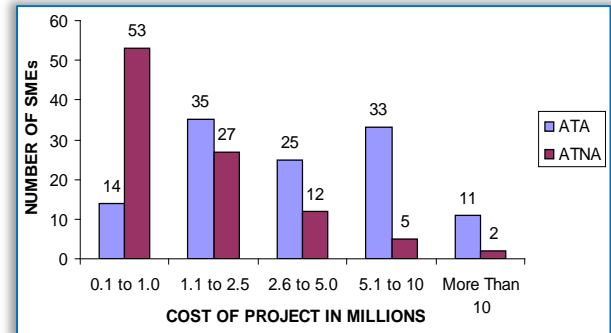


Figure 4: Cost of Project (Investment in INR)

Among 118 ATA firms, 107 SMEs accounting for 90.67 percent have their investment up to 10 Million whereas only 11 SMEs (9.33 percent) have their investment above 10.0 Million (Fig. 4). Among 99 ATNA firms, 97 firms accounting for 97.97 percent have their investment level in terms of investment up to Rs. 10 Million whereas only 2 firms (2.03 percent) have their investment above Rs. 10.0 Million. Overall, 13 SMEs (5.99 percent) have their investment level above Rs.10 Million which have been established between year 1997 and 1999. In this, 11 firms have adopted advanced technology and 2 firms have not adopted advanced technology. This period is significant because there has been a ceiling limit of Rs.30 Million for investment by SMEs.

Advanced Technology adoption and Firm Size

Firm size in terms of number of employee in SMEs is classified in to five groups as shown in Figure 5. Among 118 ATA firms, 72 firms accounting for 61.10 percent have employed up to 25 employees while only 39 firms (33.05 percent) have 25 to 100 employees. Only 7 firms (5.93 percent) have employed more than 100 employees. All the 99 ATNA firms accounting for (100 percent) have employed less than 50 employees (Figure 5)

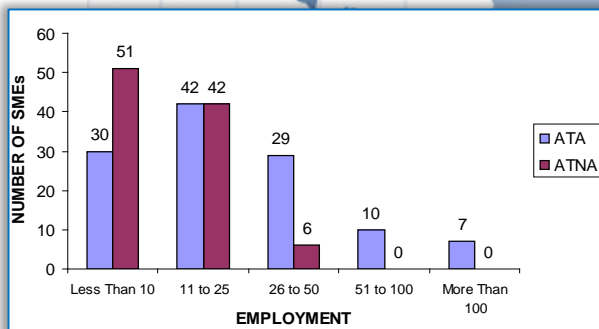


Figure 5: Firm Size (In terms of number of employees)

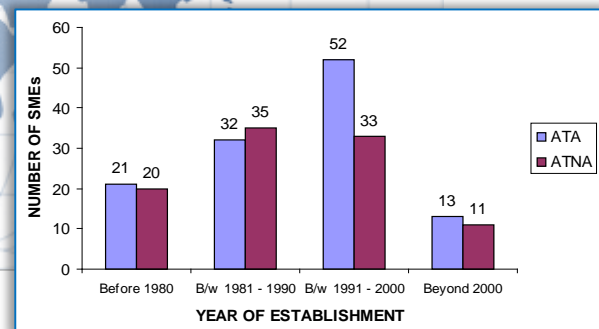


Figure 6: Year of Establishment of Firms

ATA and Year of Establishment of the firms

Age of the SMEs is classified into four groups as shown in Figure 6. Among ATA firms 65 firms were established after 1991 and the rest were established before 1991. Liberalization of the economy started from 1991. Hence the ATA firms which were started after 1991 realized the need to adopt advanced technology so as to compete in global competition. Among 99 ATNA firms, almost 55 firms (56.12 percent) were established before 1990 whereas 43 firms (43.87 percent) were established after 1991 (Figure 6).

Advanced Manufacturing Technology adoption and age of the firms

Age of the SMEs was classified into six groups as shown in the figure 7. Among ATA firm 54 firms (45.76%) are having more than 15 years of existence. 64 firms (54.23%) are having age less than 15 years of age. Among ATNA firms 34 firms (34.34%) are having more than 15 years of existence. 45 firms (45.45%) are having age less than 15 years of age.

ATA and Usage of Information Technology

Usage of information technology in ATA and ATNA firms is as shown in Figure 8. Among 118 ATA firms, 59 firms (49.57 percent) have only e-mail, 18 firms (15.12 percent) had both E-mail and Web Page facilities whereas 41 firms (34.74 percent) do not have either E-mail or Web page facilities. Among 99 ATNA firms, 23 firms (23.46 percent) have only E-mail, 5 firms (5.10 percent) had both E-mail and Web Page facilities. A Majority of firms (71) accounting for 71.71 percent do not have E-mail or Web page facilities. This factor indicates that the firms, which have not adopted advanced





technology, have not embraced information technology revolution and are lagging behind in technology adoption. (Figure8)

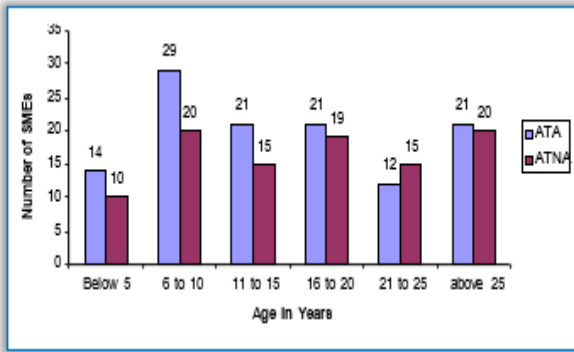


Figure 7: Technology adoption and age of the Firm

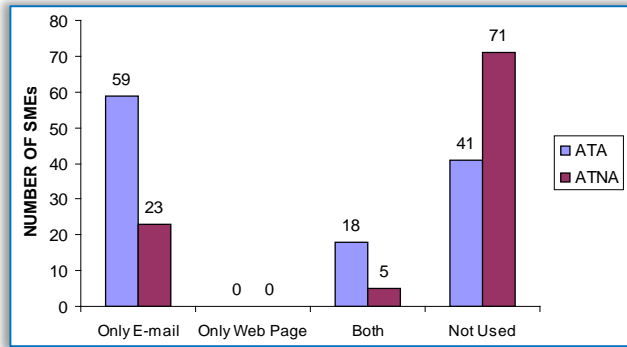


Figure 8: Usage of Information Technology in SMEs

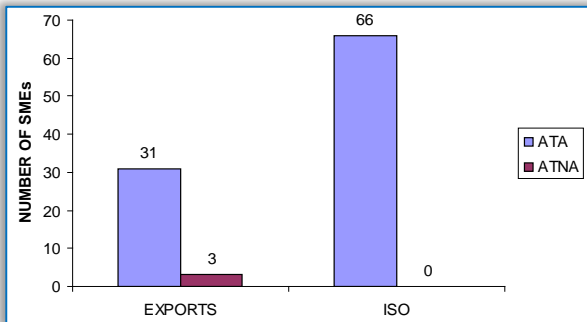


Figure 9: ISO Certification and Export SMEs

ATA, ISO certification and Export Activity

ISO Certification and Export activity in ATA and ATNA firms are as shown in Figure 9.

Among 118 ATA Firms, 66 firms accounting for 55.93 percent are ISO Certified while 28 firms 28.70 percent are Export Oriented Units. Among 99 ATNA firms, None of the firm is ISO Certified while 6 firms (6.06 percent) are Export-Oriented. It is very clear from the above observation that SMEs which have adopted some of the advanced technologies, have placed more emphasis on ISO certification and are Export units striving to remain competitive globally

whereas SMEs which have not adopted technology are clearly lagging behind and need some catching up to remain competitive and sustain themselves in the global economy (Figure 9).

Demographical Factors and Technology Adoption in SMEs

The SMEs are classified into ATA and ATNA firms for all the demographical characteristics and are presented in Table 2. Also presented are the values of χ^2 and their significance levels (if significant) for testing the association between Technology Adoption and demographic characteristics studied.

Table 2: Demographical Factors and Technology Adoption in SMEs

Sl. No	Demographical factor	ATA	ATNA	χ^2 value	Significance level	
1.	Educational Background	Technical	90	65	29.72	NS
		Non-technical	28	34		
2.	Cost of Project	0.1 to 1 million	14	53	36.172	1%
		1.1 to 2.5 million	35	27		
		2.6 to 5 million	25	12		
		5.1 to 10 million	33	05		
		Above 10 million	11	02		
3.	Size of the firm	Less than 10	30	51	36.172	1%
		11 to 25	42	42		
		26 to 50	29	06		
		51 to 100	10	00		
4.	Age of the firm	Above 100	07	00	2.972	NS
		Below 5 years	14	10		
		6 to 10 years	29	20		
		11 to 15 years	21	15		
		16 to 20 years	21	19		
5.	ISO Certification	21 to 25 years	12	15	79.576	1%
		Above 25 years	21	20		
6.	Export	ISO firm	66	00	22.007	1%
		Non-ISO firm	52	99		
7.	Nature of activity	Export firm	31	03	2.789	NS
		Non-export firm	87	96		
		Production	101	76		
		Job work	17	23		
		Both	59	66		
			59	33	6.123	1%
			43	45		
			75	54	1.814	NS





The firm size and cost of investment were significant association with the firm being ATA or ATNA. The larger size firms had higher cost of investment were found to have adopted advanced technology. Technology Adoption is independent of the age of the firm. Nature of the activity of the firm is independent of Technology Adoption. ISO Certification of the firm is significantly dependent on Technology Adoption. i.e., ATA firms tend to get ISO certification over ATNA firms. The export activities are significantly dependent on whether the firm is ATA or ATNA. i.e., larger numbers of ATA firms take up export activities as compared to ATNA firms.

Reason for Adopting Advanced Manufacturing Technologies

Table 3 presents various reasons for Adopting Advanced Manufacturing Technologies along with the χ^2 statistics and their significance for testing the association between the AMT adoption and each of the reason for adoption considered in the study.

Table 3: Reasons for AMT Adoption

Sl. No.	Reason		ATA	ATNA	χ^2 value	Significance level
1.	Competition	Yes	33	28	0.003	NS
		No	85	71		
2.	Customer Demand	Yes	38	31	0.020	NS
		No	80	68		
3.	Self-Motivation	Yes	37	27	0.432	NS
		No	81	72		
4.	Advice From Expert	Yes	05	01	2.085	NS
		No	113	98		

Competition is not significantly associated with AMT adoption. That is, both ATA and ATNA firms clearly expressed that competition is not a reason for adoption of AMT. Self-motivation of the entrepreneur, Customer

demand or pressure and Advice from experts or well-wishers are not significantly associated with the AMT Adoption.

None of the reasons studied are not significantly associated with the Advanced Manufacturing Technology Adoption.

Discouraging Factors for not adopting AMT

Table 4 presents, the discouraging factors for not adopting AMT with respect to ATA and ATNA firms. Also the values of χ^2 Statistics and their significance for testing the association between the Technology Adoption and each of the discouraging factors considered in the study given in the Table 4

Small market size is a notable/ remarkable discouraging factor for firms to adopt Advanced Manufacturing Technology. Most of the SMEs target small markets and hence confine themselves with the existing manufacturing technology to satisfy the needs of small markets, and therefore, do not opt for AMT. High cost of equipment / technology is a significant discouraging factor for adopting AMT. Shortage of skills is significantly associated with Technology Adoption. Higher the shortages of skills, lower are the Technology Adoption. Worker resistance is not significantly associated with Technology Adoption. Both ATA and ATNA have expressed that there is no resistance from the workers towards AMT adoption.

Ability to evaluate Technology is significantly associated with Technology Adoption. Inability to evaluate technology among SMEs lead to non-adoption of AMT. Lack of technical support is not significantly associated with the Technology Adoption. Both ATA and ATNA firms have clearly expressed that lack

Table 4: Discouraging Factors for not adopting AMT

Sl. No	Discouraging factor		ATA	ATNA	χ^2 value	Significance level
1.	Small Market Size	Yes	08	59	70.363	1%
		No	110	40		
2.	High Cost of Equipment	Yes	11	52	48.769	1%
		No	107	47		
3.	Shortage of Skills	Yes	06	21	12.852	1%
		No	112	78		
4.	Worker Resistance	Yes	00	01	1.197	NS
		No	118	98		
5.	Inability to Evaluate Technology	Yes	03	21	19.076	1%
		No	115	78		
6.	Lack of technical support /service (from consultant/ vendor)	Yes	02	02	0.031	NS
		No	116	97		

of technology support is not a discouraging factor at all for adopting AMT.

Benefits of AMT adoption

In this study, thirteen different factors were considered as potential benefits when the SMEs adopt AMT. Table 5 present all the different potential benefits and their association with the AMT adoption.





Table 5: Benefits of AMT adoption and Technology Adoption

Sl. No.	Type of Benefit		ATA	ATNA	χ^2 value	Significance level
1.	Reduces labour requirement	Yes	60	44	0.884	NS
		No	58	55		
2.	Reduces materials consumption	Yes	40	15	9.999	1%
		No	78	84		
3.	Reduces set up time	Yes	63	30	11.717	1%
		No	55	69		
4.	Reduces rejection rate	Yes	76	43	9.561	1%
		No	42	56		
5.	Reduces time to market	Yes	42	18	8.158	1%
		No	76	81		
6.	Increases product quality	Yes	84	56	5.027	NS
		No	34	43		
7.	Increases production flexibility	Yes	48	21	9.406	1%
		No	70	78		
8.	Increases skill level	Yes	72	45	5.247	1%
		No	46	54		
9.	Increases equipment utilization rate	Yes	38	11	13.70	1%
		No	80	88		
10.	Increases market share	Yes	67	45	2.765	NS
		No	51	54		
11.	Increases profitability	Yes	83	54	5.769	1%
		No	35	45		
12.	Overcome competition	Yes	67	47	1.869	NS
		No	51	52		

The factors that are not significantly associated with AMT adoption are: Reduction in labor requirement / unit of output, Reduction in material consumption / unit of output, Market share and overcome competition

The factors that are significantly associated with AMT adoption are set up time during the production, rejection rate during the manufacturing, time to market, technology and product quality, Production flexibility, equipment utilization, profitability.

CONCLUSION

The findings of this research indicate that the technologies like computer aided design/ engineering, Local area network for engineering/ production and computer aided design/ manufacturing are extensively used AMT in the SMEs. The demographical factors like cost of the project, size of the firm, ISO certification and export are having relationship with the AMT adoption. The perceived benefits for the adoption like, reduces material consumption, set up time during the production, lower rejection rate during the manufacturing, shorter time to market, technology and product quality, production flexibility, increases skill level, maximum equipment utilization and increase profitability are having relationship with the AMT adoption. The discouraging factors for the AMT adoption like, small market size, high cost of the equipment, availability of skilled manpower, and inability to evaluate the technology are significant relationship between the AMT adoptions.

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