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Forecasting the Implementation Success of AMT in SMEs using an Integrated AHP-TOPSIS Approach

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Abstract

The adoption of Advance Manufacturing Technology (AMT) requires careful planning at each level of organization due to large capital investments involved in newer technology. It has been seen in many cases that the AMTs have improved the firm's peformances, however according to recognized practitioners there is still a possibility of project failure due to adoption of this new technology. Hence it is always practiced to identify the major success factors that influence the adoption of AMTs. This study proposes a hybrid model for AMT justification which takes account thirteen factors and their relative importance in the justification phase. The justification phase comprises of three sub-phases: identification of critical factors; calculation of priority weights and ranking of critical factors and determination of possibility of successful adoption of the technology. The results showed that in order to have fruitful result from AMT investment, the strategic issues, technology transfer and continuous support of management should be properly organized to avoid the barriers in successful adoption of advance technologies.

Keywords: Advance Manufacturing Technologies (AMT), Analytical Hierarchical Process (AHP), Implementation, Small and Medium Enterprises (SMEs), Technique for order preference by Similarity to Ideal Solution (TOPSIS)

1. Introduction

The manufacturing sector plays a vital role in development of economy. In developing countries like India, Small and Medium Enterprises (SMEs) are the strength of manufacturing sector. In the past years, these enterprises have been excessively promoted due to its immense contribution to generate opportunity of employment. An important advantage of this sector is their high labor-capital ratio. Apart from providing the services to larger enterprises, SMEs also promotes the industrialization of rural and backward areas. Since it is well entrenched that SMEs significantly contributes to nation economy, hence survival of these enterprises in a global business environment is one of the most pressing matter for a nation. In the global business environment, complexity, uncertainty and dynamism are the dominant characteristics that ensued in a diversification of the today's market. To remain competitive, manufacturing organizations must update their technologies used for manufacturing processes. The decision for up gradation of technologies must justify the cost of implementation as well as the quality and responsiveness expectations of customers.

It is unquestioned that the adoption of Advance Manufacturing Technologies (AMTs) in manufacturing propels the globalization and innovation. When a production system uses computers not only for manufacturing operations but for planning and control, for procurement and inventory tasks and also for shipment and service of finished products, then such automation in technology is called Advanced manufacturing technology. The espousal of AMTs in SMEs would enhance quality, financial and organizational performances, operational capability, leads greater control of operations, effective coordination between different departments and shorter lead time. However, the high initial capital investment in AMTs seeks the wise decision from the top management about the enactment of this technology in low budged SMEs. The need of AMTs in SMEs arises due to increased competition in global market, rapid changes in the market, dynamism in product variety and shorter life span of products in market [Rosnah (2003)][25].

AMTs have widely accepted as valuable weapons to face challenges imposed by dynamic market, its high initial investment should justify an organizational survival in highly competitive market. Some previous studies on AMTs adoption in SMEs show

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that these computerized innovations are not always lucrative for an enterprise and it can only be successfully implemented if evaluation of technology would be done on the basis of critical analysis of tangible and intangible factors[Mechling et.al. (1996)[19], [Koc &Bozdag(2009)],Chung(2000)[7], Sohal(2000)][32].

In this paper an attempt is made to adopt an integrated approach that involves AHP-TOPSIS methods to critically evaluate thirteen factors that play a crucial role in decision making process of implementation of AMTs in SMEs.

AHP involves formulation of structure hierarchy, starting from the goal of decision and then through the intermediate levels that define the objectives to the lowest level that usually represents the set of alternatives. In AHP a pairwise comparison matrix is formed that compares the elements in intermediate level. The result of the comparison matrix depicts the weights assigned to these objectives. By continuing the procedure, final priorities of alternatives can be obtained. Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) developed by Yoon and Hang (1980) determines the euclidean distance from positive and negative ideal solution and thus provides the scoring of alternatives. The main aim is to provide ranking of alternatives. Over the past few decades, TOPSIS has found its applications in decision making process. It is particularly useful in scenarios in which hundreds of objectives or alternatives are considered. In AHP the use of pairwise comparison matrix restricts the number of objectives and alternatives to twenty. However, TOPSIS still requires weighting of criteria's. Thus it is usually combined with AHP.

The present paper is organized as follows: the second section provides research background of critical factors. The third section discusses the methodology. The paper is finally concluded with a discussion of limitations and future directions.

2. Research background supporting Critical Factors

A limited budget of SMEs enforces enterprises to use a systematic selection model for making decisions on AMTs selection. A large number of selection models have employed for AMTs selection over the past years. Several models and approaches have proposed in the literature for evaluation and justification of advance technologies. Few of these are analytical hierarchal process [Yusuff et.al. (2001)[37], Tansel & Yurdakul(2013)][34]. Cone ratio data envelopment analysis (Talluri and Yoon (2000)), Financial evaluation techniques [Orr (2002)][23]. The justification of AMTs is the new field of study and till date several researches have been performed. Singh and Kumar (2011)[29] employed a two phase approach using AHP and VIKOR for effective utilization of AMTs. They considered seven factors which were weighed by AHP method and VIKOR technique was utilized to rank the final results. Kluczek and Gladysz(2015)[12] employed AHP and TOPSIS in an industrial case study where the goal was to determine the most suitable improvement option that prevents hazardous solvents and solid waste in painting process.

Chang and Wang (2009)[6] presented a comparison between AHP and Consistent fuzzy preference relations (CFPR) methods used for justification of AMTs. Authors compared seven attributes using these two methods and outcome was more chances in successful implementation of AMTs. Lee et.al. (2012)[16] implemented AHP and correlation analysis in their study on technology transfer adoption and how the factors influences the decision making process. Singh and Kumar (2013)[31] published a research paper on a hybrid method that uses AHP-TOPSIS-AHP in three phases. The authors carried out their research by selecting seven factors that assist in effective utilization of AMT. It was also reported by Zhou et. al.(2009)[38] that investments in AMTs were justified with firm performance in Swedon but not in Singapore and according to Koc & Bozdag(2009),failures in AMT results more often than their success especially in small and medium enterprises.

Most recently Kumar and Raj (2016)[15] have employed integrated AHP and modified gray rational analysis to take into account the vagueness in decision regarding selection of mobile robots for material handling in FMS environment.

The present study is based on Singh and Kumar (2013) method but we have considered thirteen factors that almost cover all the attributes that play a major role in making decision on AMTs justification in SMEs.

Following are the factors that may assist in justification of AMTs in SMEs of India.

2.1 Strategic Issues (ST)

Strategic issues address a series of decisions that provide the necessary support to achieve defined objectives of an organization. These issues deal decisions in structural and infrastructural areas in a time and market specific pattern. These strategies should take into account the manufacturing capabilities, competitive priorities and decision criteria. An effective strategy of an organization includes decisions involving capacity, inventory, plant size and location, quality control, work force management policies, organizational structure and financial and information system. [Efstathiades,et.al. (2002)][8,9],[Kreng et.al. (2011)].[14]

2.2 Technology selection and Transfer (TT)

These issues deal with how AMTs can improve productivity of a manufacturing system. The dynamic characteristics of market seek flexible manufacturing which integrates hardware with software technologies. The selection of hardware is carefully done on the basis of flexibility of machine tools, material handling and storage units. The hardware should be selected on the basis of maintenance requirement, skilled worker's requirement, capital requirement etc. (Sambasivarao and Deshmukh(1995))[27]. The software should be selected on the basis of capability to process huge amount of data and flexibility to incorporate further modifications. The software should be capable to integrate all the concerned department of organization such as engineering design, manufacturing, business, shop floor etc[Lee et.al. 2012].

2.3 Organizational changes & external consultants (OR)

To adapt a new technology, one needs to revise the organizational structure. A new technology calls integration of production planning and execution activities which were earlier considered as sequential and separate. Flexibility in structure enhances variety rather than volume and judgment rather than standard procedure. A flexible structure brings different disciplines under one umbrella that does not appreciate differentiation in task and authority. An advance manufacturing technology demands flexible, adaptive and multi skilled oriented organizational structure. [Nyori et.al. (2015)][22]

2.4 Continuous management & manufacturing support(CM)

Support of top management is of crucial importance to successful implementation of AMTs. Their support is desirable throughout the justification, transfer and implementation of technology. A continuous support of management has a positive influence on operation managers and technology operators [singh et.al. (2007)][30].

2.5 Human Factors (HF)

A new adaption of technology should be carefully done so that individuals and groups would be productive, efficient, flexible and motivated. Human factors refer to employee reactions on technological change. It is natural for psychological unprepared employees to resist technological change due to uncertainty, technological stress, job security and fear of losing identity. So it is the responsibility of management to make their people comfortable with the ongoing change by organizing workshops, expert's lectures that can motivate as well as enhance knowledge and skills of workers.Special emphasis should be given in involvement of workers in technology transfer and selection. [Bidanda & Cleland(1995)][1],[Bayo-Moriones & Cerio(2004)][2].

2.6 Vendor Selection(VS)

Vendor selection is another important factor in adoption of advance technology. A manufacturer planning to invest in AMTs should have prior information about vendors and the products. He should avoid group buying and technological packages offered by vendors. The selection of vendor should be done by the panel of experts on the basis of technical and business requirements of the organization. (Un and Asakawa, 2015)[35]

2.7 Implementation Practice (IP)

The implementation practices have substantial influence on results of AMTs implementation. Implementation practices involves working procedures, planning and control activities, quality methods, skill development etc. These practices largely influence total cycle time for a manufacturing process. Better implementation practices helps in reducing the bottlenecks of shop floor [Pintado et.al.(2015)][24].

2.8 Planning to Infrastructural Preparation (PTI)

Since advance technologies are solely depended on software, the basic infrastructure such as internet, power, and telephone lines should be 24/7 available at the facility location. The excessive use of information technologies in manufacturing unit demands this basic infrastructure to be in place. A proper plan can handle these infrastructural issues [Millen, & Sohal, 1998][20]

2.9 Social Issues (SI)

It deals with how the implementation of automation techniques affects those who are associated with the organization. The decision of adoption of new technology depends also on how the decision will proved to be beneficial for its people. The social issues include customer satisfaction, community development, ecological issues and working environment. The customer satisfaction can be calculated by keeping an eye on market fluctuations and the depletion of product demand. AMT implementation guarantees high quality products at reasonable prices that somehow help in raising standard of living of customers. Another important factor is working environment which if safe, fatigue proof, hygienic, properly illuminated and ventilated will improve worker's productivity. Also, organization must take care that adoption of these technology should not deplete or harm natural resources like water, air etc. [Elghany, 2015][10].

2.10 Hands on Training (HT)

Advance manufacturing technology supersedes the traditional manufacturing and it has increased the demand of skills requirement in manufacturing sector. Instead of searching skilled workers, advance manufactures should provide the necessary education and training that can anticipates and satisfies the training needed for manufacturing sector.

An adequate hand on training prepares the workers for shop floors and management's efforts in this direction help in gaining the trust and cooperation of workers. [Mital et.al.(1999)][21].

2.11 Setting of Interim Target (SOI)

To evaluate the process of implementation of flexible technologies, a number of intervening targets need to define. This would help the organization to achieve a speedy growth in market. [Efstathiades et.al. 2002].

2.12 Performance Measurement (PER)

This issue deals with how the adoption of AMTs technologies have supported the objectives and goals discussed in strategic planning process. Performance of AMTs can be evaluated on the basis of cost and efficiency. The criteria of performance should be well defined for excellent benefits to the company. There should be a clear vision on performance goals during pre-implementation and optimization stage [Lin& Nagalingam (1999)][17], [Boyer & Pagell (2000)][4].

2.13 Integrity of AMT (INT)

The greatest advantage of AMT is its ability to control all the activities starting with arrival of raw material to the transport of finished goods. The complete integration of activities can be achieved through excessive use of computers in marketing, engineering, production and maintenance. The available literature truly supports integration of technology over individual automation of the processes. [Cescon, 2012][5]

After reviewing the available literature, we have come down to thirteen factors for AMT selection. Also while searching for most suitable method for our problem; we agreed to use an integrated approach that employed both AHP and TOPSIS. Most of the multi attributes problems use AHP for decision making because of its ease of use and its ability to eliminate deadlock as it is centered on collaboration. However this method alone is not efficient enough when sub-objectives and alternatives are involved are large. In such situations, the multiple comparison matrices formed that increase the complexity in computation. Also a general drawback observed in AHP is that it form hierarchical structure first and then determines the priorities. So we need to validate the prioritization with some other model. Thus to assist in decision making we use TOPSIS method due to its ability to consider a non-limited number of alternatives and criteria in decision making process. The prioritization of AHP needs to validate by TOPSIS.

3. Research Methodology

A group of experts from industry and academia were consulted to identify the factors and their relationships that need to considered while making the decision. All the factors that the experts have determined is shown in Figure 1. The AMT justification model proposed in this paper is an extension of Saaty's AHP. The extended model is comprised of AHP-TOPSIS approaches. In the first phase, a panel of experts has formed the decision factors whose weights influenced the utilization of AMT. The pair wise comparisons matrix formed using AHP technique determines the priority weights of sub-objectives. The results of AHP were verified by performing consistency ratio analysis. In the next phase, the procedure of TOPSIS approach has carried out that results in ranking the sub-objectives involved in problem. The significance of this step is to ensure that all the sub-objectives have been valued depending on their weights. The flow chart that describes the methodology opted in the paper is shown in Figure 2.

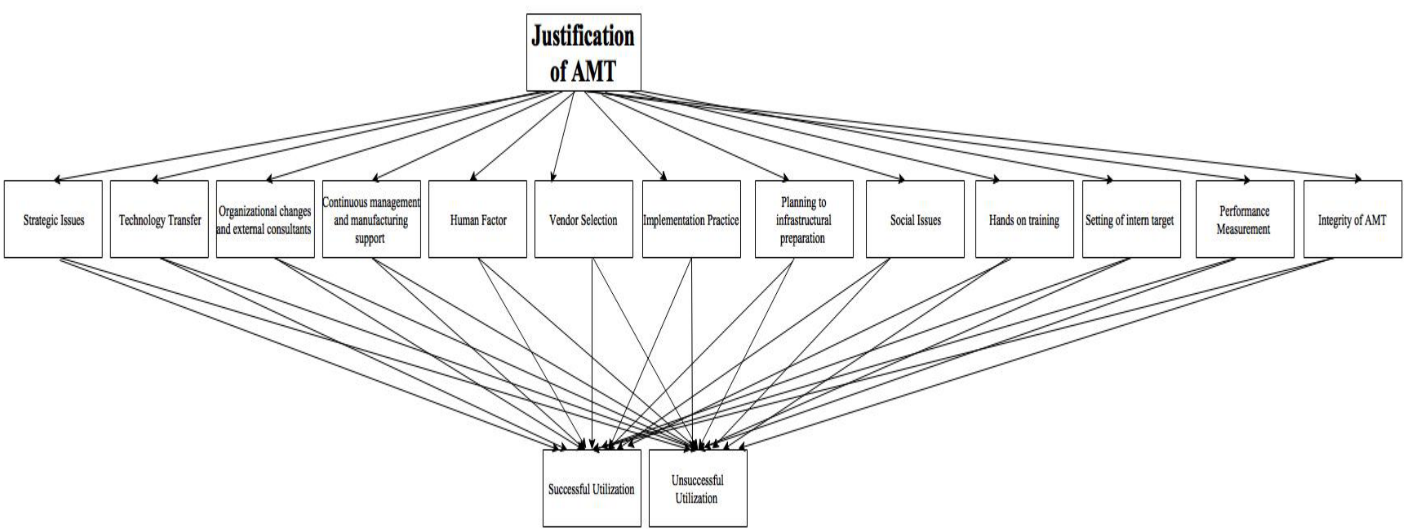

Figure 1. Hierarchy of AMT justification.

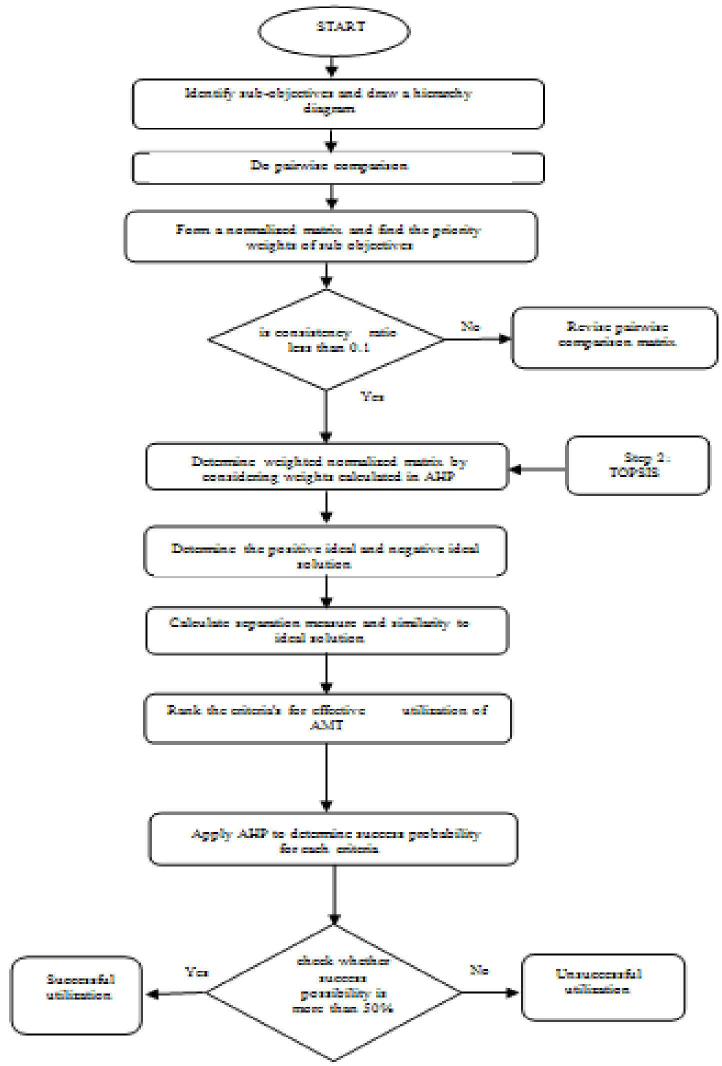

Figure 2. Flow chart of integrated approach.

3.1 Phase 1: AHP

The analytical hierarchal process also known as Satty method (1980) is a systematic approach of summarizing information about alternatives using multi-criteria. It is used for weighing qualitative and quantitative data.

In the first step, a complex multi-attribute decision making problem is breakdown into hierarchy of interrelated data that comprises of attributes and alternatives. Once the hierarchy is formed, the next step is prioritization of attributes which is carried out by forming comparison matrices. The attributes are compared pairwise depending on their influence and importance in decision making process. These comparisons are based on Satty's nine point scale of rating a criteria as shown in Table 1.

Table 1. Gradation scale for comparison of attributes as per Satty

Option	Numeric Value
Equal	1
Marginally Strong	3
Strong	5
Very Strong	7
Extremely Strong	9
Intermediate Values	2,4,6,8

The pairwise comparison matrix has been formed under the supervision of experts from academics and industries. The available literature on SMEs also justifies the importance of strategic issues over technology transfer. With all these attributes a total of seventy eight comparisons have performed by the AHP software. The final comparison matrix is shown in Table 2 .

The next step is to obtain a normalized matrix by dividing each cell of a column to sum of all cells of that column. Once the final normalized pairwise comparison matrix is formed the further step is to check the consistency of the matrix. the comparison ratio is obtained by using following formula :

$$CR = \frac{CI}{RI}$$

where $Consistency\ Index(CI) = (\lambda_{max} - n)/(n-1)$

Random index is taken from Satty's random index table based on matrix size.

If the consistency ratio (CR) is found out to be less than or equal to 0.1 , the result is acceptable else there is need to revise the pairwise comparison of attributes.

The average of each row of a normalized matrix gives the weights assigned to each criterion. The consistency ratio of comparison is found out to be 0.062 which is less than 0.1. Hence consistency is within the acceptable limit. The principal Eigen value is 14.160. The result of Phase 1 i.e. weighing of criteria is shown in Table 3.

3.2 Phase 2: TOPSIS

Technique For Order Preference By Similarity To Ideal Solution (TOPSIS) is a simple ranking method which was developed by Hwang and Yoon in 1981 and is used for conception and application. The idea for its development was to choose the alternatives such that they have shortest distance from positive ideal solution which would maximize the benefit criteria and longest distance from negative ideal solution that would minimize the benefit criteria. However the limitation of this method is it requires numeric data for attributes (Hwang and Yoon (1995))[36]. Like AHP, it also requires expert's perception in forming initial decision matrix. Once the decision matrix is obtained, the next step is to form a weighted normalized matrix (as shown in Figure 3) by multiplying the priority weights to normalized matrix.

Table 2. Pairwise comparison matrix of sub-objectives

Factors	ST	TT	OR	CM	HF	VS	IP	PTI	SI	HT	SOI	PER	INT
ST	1	2.00	7.00	3.00	8.00	5.00	9.00	6.00	4.00	8.00	6.00	9.00	6.00
TT	0.50	1	6.00	2.00	7.00	4.00	8.00	5.00	3.00	7.00	5.00	8.00	5.00
OR	0.14	0.17	1	0.20	2.00	0.33	3.00	0.50	0.25	2.00	0.50	3.00	0.50
CM	0.33	0.50	5.00	1	6.00	3.00	7.00	4.00	2.00	6.00	4.00	7.00	4.00
HF	0.12	0.14	0.50	0.17	1	0.25	2.00	0.33	0.20	1.00	0.33	2.00	0.33
VS	0.20	0.25	3.00	0.33	4.00	1	5.00	2.00	0.50	4.00	2.00	5.00	2.00
IP	0.11	0.12	0.33	0.14	0.50	0.20	1	0.25	0.17	0.50	0.25	1.00	0.25
PTI	0.17	0.20	2.00	0.25	3.00	0.50	4.00	1	0.33	3.00	1.00	4.00	1.00
SI	0.25	0.33	4.00	0.50	5.00	2.00	6.00	3.00	1	5.00	3.00	6.00	3.00
HT	0.12	0.14	0.50	0.17	1.00	0.25	2.00	0.33	0.20	1	0.33	2.00	0.33
SOI	0.17	0.20	2.00	0.25	3.00	0.50	4.00	1.00	0.33	3.00	1	0.25	1.00
PER	0.11	0.12	0.33	0.14	0.50	0.20	1.00	0.25	0.17	0.50	4.00	1	0.25
INT	0.17	0.20	2.00	0.25	3.00	0.50	4.00	1.00	0.33	3.00	1.00	4.00	1

Table 3. weights of criteria influencing justification of AMT

Factors	ST	TT	OR	CM	HF	VS	IP
Weights	0.25	0.188	0.032	0.139	0.021	0.071	0.015
Factors	**PTI**	**SI**	**HT**	**SOI**	**PER**	**INT**	
Weights	0.047	0.101	0.021	0.041	0.025	0.047	

The next step in TOPSIS is to determine positive ideal and negative ideal solution according to formulas given below:

$$A^{+} = \left\{ \left(\sum_{i}^{max} A_{ij} \quad j \epsilon J \right), \left(\sum_{i}^{min} A_{ij} \quad j \epsilon J' \right) \right\}$$

$$A^{-} = \left\{ \left(\sum_{i}^{min} A_{ij} \quad j \epsilon J \right), \left(\sum_{i}^{max} A_{ij} \quad j \epsilon J' \right) \right\}$$

where J is associated with beneficial attributes and J' is associated with non-beneficial attributes. The positive (PIS) and negative ideal solution (NIS) are shown in Table 3.

After finding the best and worst ideal solution, the separation measure is calculated and is shown in Table 4.

$$E^{+} = \left\{ \sum_{J-1}^{M} \left(A_{ij} - A_{j}^{+} \right)^{2} \right\}^{\frac{1}{2}}$$

$$E^{-} = \left\{ \sum_{J-1}^{M} \left(A_{ij} - A_{j}^{-} \right)^{2} \right\}^{\frac{1}{2}}$$

After the ideal solution, calculate relative closeness which is the measure of ranking the criteria. The similarity to ideal solu-

FACTORS	ST	TT	OR	CM	HF	VS	IP	PTI	SI	HT	SOI	PER	INT
ST	0.1964	0.1583	0.0184	0.1088	0.0112	0.0474	0.0075	0.0291	0.0728	0.0112	0.0235	0.0129	0.0291
TT	0.0982	0.0792	0.0157	0.0725	0.0098	0.0379	0.0067	0.0243	0.0546	0.0098	0.0196	0.0114	0.0243
OR	0.0275	0.0135	0.0026	0.0073	0.0028	0.0031	0.0025	0.0024	0.0046	0.0028	0.0020	0.0043	0.0024
CM	0.0648	0.0396	0.0131	0.0363	0.0084	0.0284	0.0059	0.0194	0.0364	0.0084	0.0157	0.0100	0.0194
HF	0.0236	0.0111	0.0013	0.0062	0.0014	0.0024	0.0017	0.0016	0.0036	0.0014	0.0013	0.0029	0.0016
VS	0.0393	0.0198	0.0079	0.0120	0.0056	0.0095	0.0042	0.0097	0.0091	0.0056	0.0078	0.0071	0.0097
IP	0.0216	0.0095	0.0009	0.0051	0.0007	0.0019	0.0008	0.0012	0.0031	0.0007	0.0010	0.0014	0.0012
PTI	0.0334	0.0158	0.0052	0.0091	0.0042	0.0047	0.0033	0.0049	0.0060	0.0042	0.0039	0.0057	0.0049
SI	0.0491	0.0261	0.0105	0.0181	0.0070	0.0190	0.0050	0.0146	0.0182	0.0070	0.0118	0.0086	0.0146
HT	0.0236	0.0111	0.0013	0.0062	0.0014	0.0024	0.0017	0.0016	0.0036	0.0014	0.0013	0.0029	0.0016
SOI	0.0334	0.0158	0.0052	0.0091	0.0042	0.0047	0.0033	0.0049	0.0060	0.0042	0.0039	0.0004	0.0049
PER	0.0216	0.0095	0.0009	0.0051	0.0007	0.0019	0.0008	0.0012	0.0031	0.0007	0.0157	0.0014	0.0012
INT	0.0334	0.0158	0.0052	0.0091	0.0042	0.0047	0.0033	0.0049	0.0060	0.0042	0.0039	0.0057	0.0049

Figure 3. Weighted normalized matrix.

Table 4. Ideal Solutions

Ideal solution	ST	TT	OR	CM	HF	VS	IP
PIS(A^+)	0.1964	0.1583	0.0184	0.1088	0.0112	0.0474	0.0075
NIS(A^-)	0.0216	0.0095	0.0009	0.0051	0.0007	0.0019	0.0008
	PTI	**SI**	**HT**	**SOI**	**PER**	**INT**	
PIS(A^+)	0.0291	0.0728	0.0112	0.0235	0.0129	0.0291	
NIS(A^-)	0.0012	0.0031	0.0007	0.0010	0.0004	0.0012	

Table 5. Separation measure of sub-objectives

Separation Measure	ST	TT	OR	CM	HF	VS	IP
E^+	0	0.1331	0.2624	0.1966	0.2675	0.2449	0.2705
E^-	0.2705	0.1455	0.0096	0.0826	0.0041	0.0301	0.0011
Separation Measure	**PTI**	**SI**	**HT**	**SOI**	**PER**	**INT**	
E^+	0.2550	0.2778	0.2675	0.2552	0.2697	0.2550	
E^-	0.0180	0.0495	0.0041	0.2552	0.0147	0.0180	

tion and rank are shown in Table 5 & Table 6 respectively. For better visualization of ranking of criteria's the bar chart is shown in Figure 4.

3.3 Prediction of success possibility of AMTs

To calculate the chances of successful utilization of AMTs, again AHP is applied for finding out the chances of success and fail-

Table 6. Similarity To Ideal Solution

ST	TT	OR	CM	HF	VS	IP	PTI	SI
1	0.5233	0.0354	0.2959	0.0150	0.0039	0.0661	0.1786	0.0150
HT	**SOI**	**PER**	**INT**					
0.0632	0.0518	0.0661						

Table 7. Ranking Of Sub-Objectives

	Criteria	Ranking As per TOPSIS	Ranking As per AHP
1	Strategic Issues(ST)	1	1
2	Technology selection and Transfer(TT)	2	2
3	Organizational changes & external consultants(OR)	9	9
4	Continuous management & manufacturing support(CM)	3	3
5	Human Factors(HF)	10	11
6	Vendor Selection(VS)	5	5
7	Implementation Practice(IP)	11	13
8	Planning to infrastructural preparation(PTI)	6	6
9	Social issues(SI)	4	4
10	Hands on training (HT)	10	11
11	Setting of intern target(SOI)	7	8
12	Performance measurement(PER)	8	10
13	Integrity of AMT(INT)	6	6

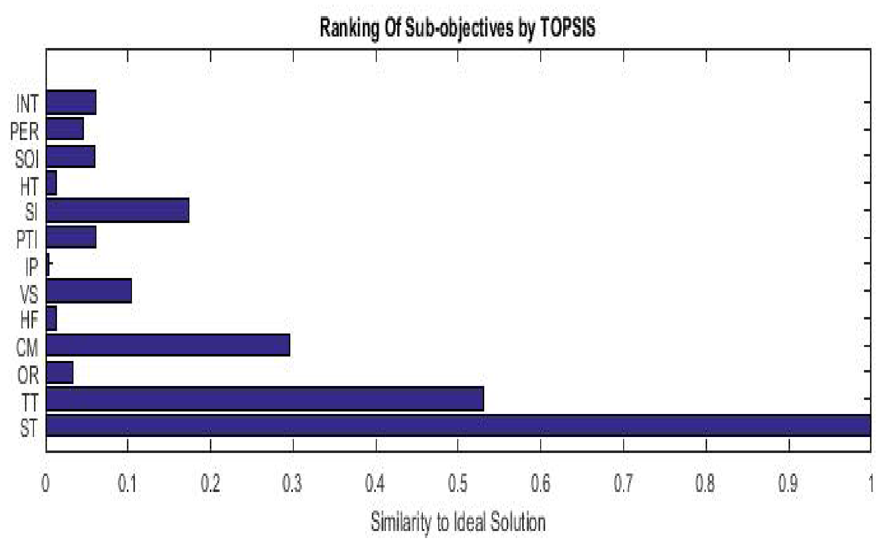

Figure 4. Bar chart of ranking.

ure of each attribute. The pair wise comparison matrix for each attribute is prepared that determines the priority weight of success and failure of each sub-objective. The predication of success is based on the user's perspective for each attribute in the organization which is as follows:

ST=5(Extremely Good); TT=3(Very Good) ;OR=5(Extremely Good); CM=5(Extremely Good); HF=3(Very Good); VS=3(Very Good); IP=3(Very Good); PTI=3(Very Good); SI=2(Very Good); HT=3(Very Good); SOI=1(Fair);PER=1(Fair);INT=2(Between Fair and Very Good).

the prediction of success or failure has been determined by multiplying the priority weights of success or failure by the priority weights of alternatives from step 1.

Probability of successful utilization is found to be:

0.833*0.25+0.75*0.188+0.833*0.032+0.833*0.139+0.75*0.021+0.75*0.071+0.75*0.015+0.75*0.047+0.667*0.101+0.75*0.021+0.5*0.041+0.5*0.025+0.667*0.047=0.708011

Probability of unsuccessful utilization is found to be

0.167*0.25+0.25*0.188+0.167*0.032+0.167*0.139+0.25*0.021+0.25*0.071+0.25*0.015+0.25*0.047+0.333*0.101+0.25*0.021+0.5*0.041+0.5*0.025+0.333*0.047=0.243341

The above calculation shows that the chances of successful utilization of AMTs is about 2.9 times more than that of unsuccessful utilization if the above thirteen factors are prioritized according to the author's prediction.

Table 8. Prediction of possible outcome for each criteria

Alternatives	Success	Failure	Priority weight
Strategic Issues(ST)			
Success	1	5	0.833
Failure	1/5	1	0.167
Technology selection and Transfer(TT)			
Success	1	3	0.75
Failure	1/3	11	0.25
Organizational changes & external consultants(OR)			
Success	1	5	0.833
Failure	1/5	1	0.167
Continuous management & manufacturing support(CM)			
Success	1	5	0.833
Failure	1/5	1	0.167
Human Factors(HF)			
Success	1	3	0.75
Failure	1/3	1	0.25
Vendor Selection(VS)			
Success	1	3	0.75
Failure	1/3	1	0.25
Implementation Practice(IP)			
Success	1	3	0.75
Failure	1/3	1	0.25
Planning to infrastructural preparation(PTI)			
Success	1	3	0.75
Failure	1/3	1	0.25
Social issues(SI)			
Success	1	2	0.667
Failure	1/2	1	0.333
Hands on training (HT)			
Success	1	3	0.75
Failure	1/3	1	0.25
Setting of intern target(SOI)			
Success	1	1	0.5
Failure	1	1	0.5
Performance measurement(PER)			
Success	1	1	0.5
Failure	1	1	0.5
Integrity of AMT(INT)			
Success	1	2	0.667
Failure	1/2	1	0.333

4. Conclusion

In this research study, after critically reviewing the available literature the authors have identified thirteen factors that play significant role in adoption procedure of Advance technologies in manufacturing firms especially in small and medium enterprises of India. The decision making becomes critical when an enterprise has a limited budget. A relationship between these 13 critical factors has established by AHP -TOPSIS integrated approach. Through this approach the most driving factor has identified. It can be concluded from the research that an effective implementation of available advance technology in SMEs could be observed if the management considers strategic issues and technology selection and transfer as major driving factors in the planning phase of AMTs implementation. Since decision on implementation practices is taken afterwards the installation of new technology hence it has least importance in planning phase. This research also suggests that management should not ignore the ranking of these factors. If priorities of critical factors are taken in same order as evaluated by authors then the enterprise shows successful results 71 percent of the times.

The limitation of the model is the subjective nature of priorities weights and rank. The vagueness of the results can be eliminated if Fuzzy perception will be incorporated. The authors are hopeful that these findings will help the industrial professionals in developing strategies for effective adoption of AMTs.

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