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Developing a Predictive Model for Identifying Key Enablers in Advanced Manufacturing Using AHP Approach

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Abstract: This research aims to comprehend the enablers of Advanced Manufacturing Technology (AMT) implementation within manufacturing organizations. The objectives include consolidating key AMT Enablers (AMTEs) from existing literature, providing a holistic approach to successful AMT implementation, understanding the dynamics among AMTEs, and utilizing Analytic Hierarchy Process (AHP) methodology to prioritize them for effective integration. This paper is to focused on enhance our understanding of the relationships among identified enablers through the utilization of Analytic Hierarchy Process and pairwise comparisons. By establishing these comparisons, priority weights can be derived. This study endeavors to pinpoint the significant and justifiable Advanced Manufacturing Technologies Enablers crucial for effective implementation of Advanced Manufacturing Technologies. The outcomes of this research can serve as a foundation for creating a confirmation-based ranking of AMTEs, thus refining the process of AMT implementation. Furthermore, utilize AHP to prioritize factors like Finance position, Top management commitment, Strategic planning etc. to forecast the success or failure of AMT implementation projects accurately.

Keywords: Analytical hierarchy method; Advanced manufacturing technology; AMT Enabler; Predictive Model; Prioritization

1. Introduction

Manufacturing has undergone significant evolution, driven by emerging needs and technologies. Today, advanced manufacturing technologies have emerged as crucial strategic tools for numerous industries, aimed at reducing manufacturing response time, enhancing quality, and cutting costs. These technologies enable the production of diverse or customized products with greater precision, speed, and efficiency Esan et al.[1)]. Specifically, computer-aided design (CAD) technology aids engineering departments in slashing design cycle times, thereby expediting the transition from design to full production. Additionally, CAD technology streamlines processes by eliminating manual tasks like modifying assembly drawings, assembly charts, and routing sheets Hutchison and Das[2)].

In recent years, there have been significant advancements in advanced manufacturing concepts, particularly in the realm of truly integrated systems Rehman et al.[3)]. AMTs encompass a wide array of modern manufacturing systems, predominantly computer-based, aimed at enhancing manufacturing operations. They offer numerous benefits across various domains, enabling manufacturers to uphold quality, operational efficiency, organizational performance, and financial viability to bolster technological competitiveness. Operational benefits of AMTs include enhanced coordination between departments, improved process control, reduced product design time, shorter lead times, and consistently high-quality outputs Small and Yasin[4)].

Efficient and cost-effective implementation of AMTs can aid small and medium enterprises (SMEs) in enhancing their performance in the global market by delivering timely production, high efficiency, high quality, and low costs. Successful implementation of AMTs necessitates support from complementary softer improvement programs, such as quality leadership, training, worker empowerment, and the utilization of small, cross-functional groups, alongside improvements in infrastructure. These AMT enablers (AMTEs) are theoretically derived from various literature sources and expert discussions.

AMTs are widely recognized as invaluable tools for meeting the challenges posed by evolving market dynamics in the manufacturing sector. Effective implementation of AMTs leads to increased customer satisfaction and reduced manufacturing operating costs Hottenstein and Casey[5)]. They empower firms to bridge the gap between low-cost dedicated production and high-variety differentiation. Therefore, AMTEs play a pivotal role in the successful implementation of AMTs, facilitating quality and flexibility. While different researchers may use varied terminologies to denote these AMTEs, they can be distilled into generic themes. Based on previous studies these are the objectives of the articles are: Prioritize Enablers, Support Decision-Making, Enhance Manufacturing Capabilities, Leverage Expert Knowledge, Promote Sustainable Development, Adapt to Specific Contexts etc. But we focused on Prioritize Enablers, Support Decision-Making mainly.

2. Literature review of AMT enablers

In today's volatile business environment, the survival and prosperity of any organization hinge increasingly on its adept utilization of available resources Costa et al.[6]. Consequently, competition no longer revolves solely around manufacturing technology but extends to how efficiently an organization manages this technology in comparison to industry best practices Khurana[7].

Manufacturing is in a constant state of evolution, adapting to emerging needs and technologies. This evolution has led to a wider array of products available to customers at more affordable prices. To enhance delivery, reduce costs, elevate quality, and increase flexibility, manufacturers are increasingly turning to Advanced Manufacturing Technologies (AMTs). These technologies are viewed as a novel avenue to attain a competitive edge in the market. Despite the huge investment, very few succeed in utilizing AMTs because of the complex implementation process.

AMT epitomizes the seamless integration of technological capabilities with the challenges encountered in manufacturing. It encompasses manufacturing process technologies that leverage computer systems to store and manipulate data, Dean et al.[8].

Organizations recognize the criticality of all Advanced Manufacturing Technologies Enablers (AMTEs) yet often struggle with their effective implementation. AMTEs imbue Advanced Manufacturing Technologies (AMT) with essential significance by pinpointing core enablers crucial to successful implementation. Numerous authors (refer Table 1) have conducted direct research and provided insights into these AMTEs. A comprehensive review of diverse AMT literature was undertaken to formulate a framework for AMT implementation. This review revealed that several studies have identified key AMTEs essential for successful AMT implementation.

Table 1. Literature review of AMT and enablers.

Sr. No	AMT Enablers	References
1.	Finance position (E1)	Mohanty[22], Sambasivarao and Deshmukh[26], Sambasivarao et al.[27], Zhao and Co[32], Co et al.[34], Mohanty and Deshmukh[41], Efstathiades et al.[37], Monge et al.[21], Choudhury et al.[33], Singh et al.[29], Small[25], Cardoso et al.[17], Helal Uddin and Munim K Barai[55]
2.	Top management commitment (E2)	Voss[38], Mohanty[22], Sambasivarao and Deshmukh[26], Sambasivarao et al.[27], Zhao and Co[32], Udo and Ebiefung[47], Efstathiades et al.[37], Small[25], Singh et al.[29], Marri et al.[20], Singh and Kumar[39]
3.	Strategic planning (E3)	Ramamurthy[42], Sambasivarao and Deshmukh[26], Zhao and Co[32], Small and Yasin[4], Efstathiades et al.[37], Dangayach and Deshmukh[35], Monge et al.[21], Small[25], Singh et al.[29]
4.	Justification of AMT implementation (E4)	Chan and kumar[18], Singh et al.[29], Saberi et al.[28]
5.	Organizational structure (E5)	Yusuff et al.[52], Costa and Lima[16], Gao and Feng[15], Saberi et al.[28], Singh et al.[44], Saberi and Yusuff[45], Darbanhosseiniamirkhiz and Ismail[46], Cardoso et al.[17]
6.	Integration of departments (E6)	Udo and Ehie[31], Raymond[50], Singh et al.[29], Costa and Lima[16], Saberi et al.[28], Novandra et al.[56]
7.	Technical reliability (E7)	Sambasivarao and Deshmukh[26], Sambasivarao et al.[27], Choudhury et al.[33]
8.	Technical feasibility (E8)	Sambasivarao and Deshmukh[26], Sambasivarao et al[27] Tarek M. Mostafa and Dina S. Sarhan[54]
9.	Technical flexibility (E9)	Sambasivarao and Deshmukh[26], Choudhury et al.[33], Govindan K e al.[59]
10.	Technological compatibility (E10)	Sambasivarao et al.[27], Bagri et al., Sambasivarao and Deshmukh[26], Mohanty and Deshmukh[41], Saleh et al.[51]
11.	Shortening product life cycle (E11)	Mohanty and Deshmukh[41], Das and Jaya ram[36], Agarwal et al.[60]
12.	Reduction in lead time	Mohanty and Deshmukh[41], Boyer and Pagell[14], Singh et al.[29], Marri et al.[20]

	(E12)	
13.	Improvement in product quality (E13)	Udo and Ehie[31], Lin and berg[30], Singh et al.[29], Marri et al.[20], Spanos and Voudouris[43], Rahman et al.[23], Gao and Feng[15], Bagri et al.[58], Percival and Cozzarin[40], Singh et al.[44]
14.	Organizational culture (E14)	Lin and berg[30], Lewis and Boyer[19], Singh et al.[29], Gao and Feng[15], Saberi et al.[28], Bagri et al., Singh et al[44], Saberi and Yusuff[45], garg and Agarwal et al., Darbanhosseiniamirkhiz and Ismail[46], Andhika and Latief[53]
15.	Employee Involvement (E15)	Gunasekaran et al.[49], Chunget al.[24], Saberi et al.[28], Mohanty[22], Sambasivarao and Deshmukh[26]
16.	Employee Empowerment (E16)	Siegel et al.[48], Sambasivarao and Deshmukh[26], Bagri et al.[58] , Jagdish et al.[57]
17.	Employee motivation/Morale (E17)	Sambasivarao et al.[27], Sambasivarao and Deshmukh[26], Chung et al.[24], Udo and Ehie[31], Udo and Ebiefung[47], Luthra et al.[61], Bagri et al[58]., Marri et al.[20]
18.	Employee training (E18)	Zhao and Co[32], Co et al.[34], Das and Jaya ram[36], Yusuff et al.[52], Singh et al.[29], Marri et al.[20], Luthra et al.[61]), Singh and Kumar[39]

These Advanced Manufacturing Technologies Enablers (AMTEs) are derived from theoretical frameworks found in various literature sources and discussions with experts. Some AMTEs are drawn from broader studies exploring AMT in general or focusing on specific enablers in detail. Despite variations in terminology used by different researchers, these AMTEs can be categorized into generic themes. Moreover, literature coverage and emphasis on these AMTEs vary. In this study, eighteen AMTEs (refer Table 1) have been selected for implementing the Analytic Hierarchy Process (AHP) methodology.

Bhadu et al.[9] "This paper refines the Analytic Hierarchy Process (AHP) for prioritizing Industry 4.0 Technologies. By improving clarity and effectiveness, we offer decision-makers a robust framework. Through literature review and empirical analysis, we optimize AHP, addressing limitations and enhancing usability. Our refined methodology aids in systematic I 4.0 T selection, contributing to strategic decision-making**".**

Sakataven et al.[10] explores barriers to Lean implementation in contract manufacturing machining companies. Through empirical investigation, it identifies and examines contextual relationships among these barriers. The study sheds light on challenges hindering Lean adoption and their interconnectedness within the specific context of contract manufacturing machining. Findings offer insights into overcoming barriers and enhancing Lean implementation effectiveness in this industry".

Khan et al.[11] offers a perspective on the evolving landscape of cloud-based additive manufacturing. It explores recent advancements in technology, emphasizing their impact on the additive manufacturing process. By analyzing trends and innovations, the paper highlights the potential benefits and challenges associated with cloud-based approaches. Insights provided aim to inform stakeholders about the transformative possibilities and considerations in adopting cloud-based solutions for additive manufacturing.

V. Gupta and A. Jayant[12] presents a novel hybrid Multiple Criteria Decision Making (MCDM) approach integrating Fuzzy Decision-Making Trial and Evaluation Laboratory (DEMATEL), Analytic Network Process (ANP), and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS). The methodology aims to assess low carbon suppliers effectively. By combining fuzzy logic and decision-making techniques, it offers a comprehensive evaluation framework. The approach enhances decision-makers' ability to prioritize and select suppliers based on their low carbon performance, contributing to sustainable supply chain management.

S. Sunaryo and M A Aidane[13], by leveraging AHP, the research provides decisionmakers with a structured framework for identifying and prioritizing key factors, facilitating the establishment of an eco-friendly ship recycling industrial park".

Group of decision makers participated in the study are assistant professors in different reputed organizations, research scholars, and some industrial persons. For making it effective google forms are sent to concerned persons and telephonic conversations are also performed.

3. AHP Method and Process

The Analytic Hierarchy Process (AHP) is a structured decision-making technique pioneered by Saaty in the 1970s. It's designed to handle complex decision scenarios involving multiple criteria and alternatives. The process involves breaking down a decision problem into a hierarchy of criteria and alternatives, allowing decision-makers to systematically evaluate and prioritize them.

Here's how AHP typically works

a) Hierarchy Formation

The decision problem is systematically broken down into a hierarchical structure comprising criteria, sub-criteria, and alternatives. Criteria represent the main objectives or attributes of the decision, sub-criteria are the components of criteria, and alternatives are the options being evaluated.

b) Pairwise Comparisons

Decision-makers compare each element in the hierarchy to every other element, establishing their relative importance. This is typically done using a scale where each pairwise comparison receives a numerical value based on the decision-maker's judgment of their relative importance.

c) Consistency Check

AHP employs a consistency check to ensure that the judgments provided by the decision-maker are coherent and free from inconsistency. If inconsistencies are detected, decision-makers may need to revise their judgments.

d) Weight Calculation

The pairwise comparison results are aggregated to calculate weights for each criterion and alternative. These weights represent the relative importance of each element in the hierarchy.

e) Priority Calculation

Priorities are calculated for each alternative by combining the weights of the criteria with the performance of the alternatives against each criterion.

f) Decision Making

Finally, decisions can be made based on the priorities assigned to the alternatives.

AHP is valued for its ability to handle complex decision scenarios, its intuitive nature, and its ability to incorporate subjective judgments of decision-makers. However, it does rely heavily on the judgment of decision-makers, which can introduce bias or inconsistency if not carefully managed. Additionally, constructing the hierarchy and performing pairwise comparisons can be time-consuming and require significant effort.

This model operates under the assumption of the independence of each module once the determinants of each module are identified from existing literature, pairwise comparisons of the Advanced Manufacturing Technologies Enablers (AMTEs) can be conducted. These comparisons aim to establish the relative dominance of one AMTE over another concerning a higher-level element. The preference degree for each pairwise comparison is quantified on a scale ranging from one to five. This scaling methodology facilitates the translation of preferences into priority weights for evaluating alternatives.

Table 2. presents the preference degrees between pairs of AMTEs.

When comparing AMTE "a" with AMTE "b,"	Assigned value
If AMTE "a" and AMTE "b" are considered to have equal importance	1
If AMTE "a" is slightly more important than AMTE "b,"	2
If AMTE "a" is significantly more important than AMTE "b,	3
If AMTE "a" is considerably more important than AMTE "b,"	4
If AMTE "a" is unquestionably more important than AMTE "b,"	5

The utilization of the Analytic Hierarchy Process (AHP) method to evaluate the success or failure of AMT implementation within the Initiation module is illustrated. This methodological approach is systematically implemented across all modules, facilitating the determination of predictive weights for each module. Figure 1, illustrates the potential outcomes of implementation and relevant attributes associated with the initiation module, structured within a hierarchical framework spanning three levels.

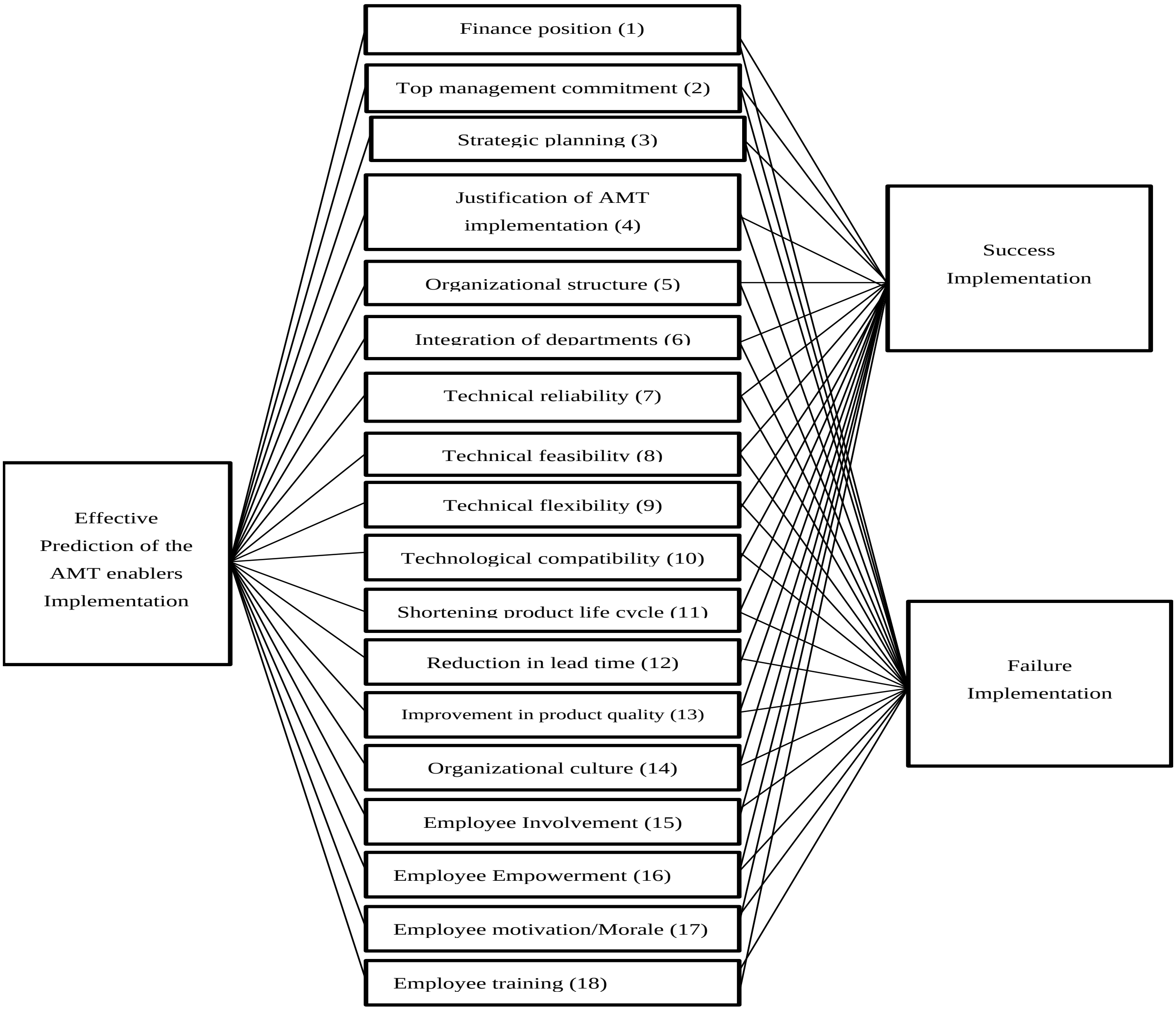

Fig. 1: Hierarchical diagram of the of AMT enablers implementation.

4. Priority weights of attributes

For each module, the relative importance among the enablers was determined based on insights from various literature sources. In the case of the AMT implementation initiation module, eighteen attributes were identified. Using the suggested numbers to express degrees of preference between two elements, the pairwise comparison matrix in Table 3 was formulated. Subsequently, after conducting the pairwise comparisons, a normalized matrix was created in Table 4. This normalization process involved dividing each element by the sum of its respective column.

Table 3. Presents the matrix of paired comparisons for advanced manufacturing technologies enablers (AMTEs).

	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	E11	E12	E13	E14	E15	E16	E17	E18
E1	1	1/4	1/3	¼	½	1/3	½	1/3	1/3	½	2	3	2	1/3	½	2	2	2
E2	4	1	3	¼	3	4	3	3	3	3	3	5	3	3	3	4	4	4
E3	3	1/3	1	1/5	3	4	3	3	3	3	4	5	4	2	4	3	4	4
E4	4	4	5	1	2	5	4	4	4	4	4	4	4	3	4	4	4	4
E5	2	1/3	1/3	½	1	3	2	2	2	2	3	3	3	2	3	3	3	3
E6	3	¼	¼	1/5	1/3	1	1/3	1/3	1/3	1/3	2	3	3	¼	2	2	2	2
E7	2	1/3	1/3	¼	½	3	1	2	½	2	2	2	2	¼	2	2	2	2
E8	3	1/3	1/3	¼	½	3	½	1	2	2	2	2	2	¼	2	3	2	2
E9	3	1/3	1/3	¼	½	3	2	½	1	2	2	2	2	¼	2	3	3	3
E10	2	1/3	1/3	¼	½	3	½	½	½	1	2	2	2	¼	2	2	2	2
E11	2	1/3	¼	¼	1/3	½	½	½	½	½	1	3	3	1/3	3	3	3	3
E12	1/3	1/5	1/5	¼	1/3	1/3	½	½	½	½	1/3	1	2	¼	½	1/3	2	2
E13	½	1/3	¼	¼	1/3	1/3	½	1/2	½	½	1/3	½	1	¼	2	1/3	2	2
E14	3	1/3	½	1/3	½	4	4	4	4	4	3	4	4	1	4	4	4	4
E15	2	1/3	¼	¼	1/3	½	½	1/2	½	½	1/3	2	½	¼	1	1/3	2	2
E16	½	¼	1/3	¼	1/3	½	½	1/3	1/3	½	1/3	3	3	¼	3	1	3	3
E17	½	¼	¼	¼	1/3	½	½	½	1/3	½	1/3	½	½	¼	½	1/3	1	½
E18	½	1/4	¼	¼	1/3	½	½	½	1/3	½	1/3	½	½	¼	½	1/3	2	1
Total	36.3	9.75	13.51	5.48	14.64	36.49	24.33	23.99	23.65	27.33	31.98	45.5	41.5	14.41	39	37.65	47	45.5

Here N =18, λmax = 20.172, C.I = 0.127764. Random Index (R.I) for Matrix size 18X18 is 1.81.
Thus C.R = 0.0705878. The Consistency Ratio should ideally be less than or equal to 0.1 to indicate an acceptable level of consistency in the pairwise comparisons.

5. Priority weights for prediction

The likelihood of a successful AMT implementation significantly improves when the attributes or enablers are robust. Priority weights assigned to alternatives (success or failure) serve as a metric indicating the preference of the alternative concerning an attributes/enabler. Therefore, if an attribute or enabler is strongly present within the organization, it is more inclined towards success compared to an attribute with weaker presence.

To determine the priority weights for alternatives, the strength of each attribute present in the organization was assessed based on five options:

- very good (5)
- Good (3)
- Fair (1)
- Weak (1/3)
- Poor (1/5)

As a rating of 3 or 5 indicates a high chance of success. For instance, if the user perceives that the justification of AMT implementation is strong, they would rate the attribute as very good (5), indicating that successful implementation is five times more likely compared to failure.

Table 5 outlines the pairwise comparison of possible outcomes concerning the attribute of justification of AMT implementation.

Now, the prediction weight is calculated by multiplying the attribute weights by the success values, and then summing all these values. This suggests that for this module, the likelihood of success is approximately four times greater than that of failure.

Table 4. displays the normalized matrix of paired comparisons along with the calculation of priority weights.

	E1	**E2**	**E3**	**E4**	**E5**	**E6**	**E7**	**E8**	**E9**	**E10**	**E11**	**E12**	**E13**	**E14**	**E15**	**E16**	**E17**	**E18**	**Row sum**	**Average**
E1	0.028	0.026	0.024	0.046	0.034	0.009	0.021	0.014	0.014	0.018	0.063	0.066	0.048	0.023	0.013	0.053	0.043	0.044	0.585	0.032
E2	0.110	0.103	0.222	0.046	0.205	0.110	0.123	0.125	0.127	0.110	0.094	0.110	0.072	0.208	0.077	0.106	0.085	0.088	2.120	0.118
E3	0.083	0.034	0.074	0.036	0.205	0.110	0.123	0.125	0.127	0.110	0.125	0.110	0.096	0.139	0.103	0.080	0.085	0.088	1.852	0.103
E4	0.110	0.410	0.370	0.182	0.137	0.137	0.164	0.167	0.169	0.146	0.125	0.088	0.096	0.208	0.103	0.106	0.085	0.088	2.893	0.161
E5	0.055	0.034	0.024	0.091	0.068	0.082	0.082	0.083	0.085	0.073	0.094	0.066	0.072	0.139	0.077	0.080	0.064	0.066	1.336	0.074
E6	0.083	0.026	0.019	0.036	0.023	0.027	0.014	0.014	0.014	0.012	0.063	0.066	0.072	0.017	0.051	0.053	0.043	0.044	0.676	0.038
E7	0.055	0.034	0.024	0.046	0.034	0.082	0.041	0.083	0.021	0.073	0.063	0.044	0.048	0.017	0.051	0.053	0.043	0.044	0.857	0.048
E8	0.083	0.034	0.024	0.046	0.034	0.082	0.021	0.042	0.085	0.073	0.063	0.044	0.048	0.017	0.051	0.080	0.043	0.044	0.912	0.051
E9	0.083	0.034	0.024	0.046	0.034	0.082	0.082	0.021	0.042	0.073	0.063	0.044	0.048	0.017	0.051	0.080	0.064	0.066	0.954	0.053
E10	0.055	0.034	0.024	0.046	0.034	0.082	0.021	0.021	0.021	0.037	0.063	0.044	0.048	0.017	0.051	0.053	0.043	0.044	0.737	0.041
E11	0.055	0.034	0.019	0.046	0.023	0.014	0.021	0.021	0.021	0.018	0.031	0.066	0.072	0.023	0.077	0.080	0.064	0.066	0.749	0.042
E12	0.009	0.021	0.015	0.046	0.023	0.009	0.021	0.021	0.021	0.018	0.010	0.022	0.048	0.017	0.013	0.009	0.043	0.044	0.408	0.023
E13	0.014	0.034	0.019	0.046	0.023	0.009	0.021	0.021	0.021	0.018	0.010	0.011	0.024	0.017	0.051	0.009	0.043	0.044	0.433	0.024
E14	0.083	0.034	0.037	0.060	0.034	0.110	0.164	0.167	0.169	0.146	0.094	0.088	0.096	0.069	0.103	0.106	0.085	0.088	1.733	0.096
E15	0.055	0.034	0.019	0.046	0.023	0.014	0.021	0.021	0.021	0.018	0.010	0.044	0.012	0.017	0.026	0.009	0.043	0.044	0.475	0.026
E16	0.014	0.026	0.024	0.046	0.023	0.014	0.021	0.014	0.014	0.018	0.010	0.066	0.072	0.017	0.077	0.027	0.064	0.066	0.611	0.034
E17	0.014	0.026	0.019	0.046	0.023	0.014	0.021	0.021	0.014	0.018	0.010	0.011	0.012	0.017	0.013	0.009	0.021	0.011	0.318	0.018
E18	0.014	0.026	0.019	0.046	0.023	0.014	0.021	0.021	0.014	0.018	0.010	0.011	0.012	0.017	0.013	0.009	0.043	0.022	0.350	0.019
Total	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000		

Table 5. presents the matrix of paired comparison results for possible outcomes, as well as the normalized matrix and priority weights of these outcomes.

	justification of AMT implementation		Normalized Matrix value			
	Success(S)	**Failure(F)**	**S value**	**F value**	**Row total value**	**Average value**
Success	1	5	1/1.20 = 0.83	5/6 = 0.833	1.666	0.833
Failure	1/5	1	(1/5)/1.20 = 0.16	1/6 = 0.166	0.332	0.166
Total	1.20	6	1	1	2	1

Similar to other AMT enablers, the success or failure is calculated, as shown in Table 6.

Table 6. Presents a comprehensive summary of all paired comparisons and the resulting priority weight for possible outcomes with respect to each attribute.

Enablers serial No.		success	failure	Priority Weights value
E1	Success	1	3	0.75
	Failure	1/3	1	0.25
E2	Success	1	5	0.833
	Failure	1/5	1	0.167
E3	Success	1	5	0.833
	Failure	1/5	1	0.167
E4	Success	1	5	0.833
	Failure	1/5	1	0.167
E5	Success	1	5	0.833
	Failure	1/5	1	0.167
E6	Success	1	3	0.75
	Failure	1/3	1	0.25
E7	Success	1	5	0.833
	Failure	1/5	1	0.167
E8	Success	1	5	0.833
	Failure	1/5	1	0.167
E9	Success	1	5	0.833
	Failure	1/5	1	0.167
E10	Success	1	3	0.75
	Failure	1/3	1	0.25
E11	success	1	3	0.75
	failure	1/3	1	0.25
E12	success	1	3	0.75
	failure	1/3	1	0.25
E13	success	1	3	0.75
	failure	1/3	1	0.25
E14	success	1	5	0.833
	failure	1/5	1	0.167
E15	success	1	3	0.75
	failure	1/3	1	0.25
E16	success	1	3	0.75
	failure	1/3	1	0.25
E17	success	1	3	0.75
	failure	1/3	1	0.25
E18	success	1	3	0.75
	failure	1/3	1	0.25

Table 7. provides a concise summary of all priority weights, facilitating the calculation of the final result, which is the priority weights of respective outcomes.

Enablers serial No.	Enablers name	Attribute/ Enablers Weight	Success	Failure
E1	Finance position	0.032	0.75	0.25
E2	Top management commitment	0.118	0.833	0.167
E3	Strategic planning	0.103	0.833	0.167
E4	Justification of AMT implementation	0.161	0.833	0.167
E5	Organizational structure	0.074	0.833	0.167
E6	Integration of departments	0.038	0.75	0.25
E7	Technical reliability	0.048	0.833	0.167
E8	Technical feasibility	0.051	0.833	0.167
E9	Technical flexibility	0.053	0.833	0.167
E10	Technological compatibility	0.041	0.75	0.25
E11	Shortening product life cycle	0.042	0.75	0.25
E12	Reduction in lead time	0.023	0.75	0.25
E13	Improvement in product quality	0.024	0.75	0.25
E14	Organizational culture	0.096	0.833	0.167
E15	Employee Involvement	0.026	0.75	0.25
E16	Employee Empowerment	0.034	0.75	0.25
E17	Employee motivation/Morale	0.018	0.75	0.25
E18	Employee training	0.019	0.75	0.25
Prediction Weight			**0.809182**	**0.191818**

6. Result and discussion

In the study of AMT implementation involves the various enablers which are useful for the predicting the successful implementation of AMT. These enablers are grouped in hierarchy-based model to support the successful implementation of AMT. In the study of AMT implementation various enablers/critical factors are found based on the literature and discussion through the academicians and practitioner. Then all the AMTEs are conducted to priorities through the opinion of expert. From above the result justification of AMT implementation are the most predominant enablers for the implementation of AMT followed by top management, strategic planning, organizational culture and organizational structure. Other attributes of weight are shown in Table 7**.** Further this study shows that the effective application of AMT in different area and provides the benefits. This model enables to engage diverse experts in executing proposed procedures and selecting optimal alternatives. Through the hierarchical method, it can forecast the likelihood of success or failure in AMT implementation projects, facilitating informed decision-making processes and improving overall project outcomes. As per result listed in Table 7, Indicates that Justification of AMT implementation enabler is having highest priority weights (0.161) in among other AMT enablers that means it is awarded rank one with success rate 0.833 and failure is 0.167. so, Justification of AMT implementation is more important factors for AMT implementation and top management commitment AMT enabler is having priority weight 0.118 which indicates second highest important enabler for implementation with success and failure value 0.833 and 0.167 respectively. Similar way other AMT enablers are having priority weight and their success or failure value (see Table 7). The value of priority weights is indicated their rank of AMT enablers (Table7). Within AMT implementation studies, its widespread adoption in manufacturing organizations is noted as a strategic response to market competition and a means to establish a stable global presence. This study aims to identify the key enablers of AMT and assess their role in ensuring successful implementation.

7. Conclusion

The model is designed for a broad spectrum of AMT implementations, with crucial AMTEs identified through a comprehensive literature review. However, for specific AMT implementations, it's essential to identify the pertinent determinants, which may differ from those used in the general model.

The model serves as a decision-support tool for stakeholders such as policymakers, manufacturing firms, and researchers. It can guide resource allocation, strategy formulation, and policy development to enhance manufacturing capabilities. Furthermore, relative priority weights must be assigned appropriately to these determinants in comparison to others. AHP proved effective for prioritizing enablers by structuring complex decisions into a hierarchy and systematically analyzing expert inputs. This approach ensures transparency and consistency in decision-making.

8. Limitation

This model has inherent limitations due to the subjectivity of priority weightings and evaluation ratings. However, the utilization of the Analytic Hierarchy Process (AHP) holds significant promise in predicting the degree of success in AMT implementation. AHP's capability to address multi-attribute problems aligns well with the complexities inherent in AMT implementation. It not only aids in identifying crucial AMTEs but also enables organizations to concentrate their efforts on these key determinants. By assessing the potency and assigning priority to each AMTE, AHP facilitates informed decision-making and proactive measures to mitigate potential drawbacks in AMT implementation. Future research could explore integrating other multi-criteria decision-making techniques like ELECTRE or PROMETHEE or incorporate real-time data for dynamic analysis.

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Nomenclature

AMT	Advanced Manufacturing Technology
AMTE	Advanced Manufacturing Technology Enabler
AHP	AHP stands for Analytical Hierarchy Process
C.I	Consistency Index
C.R	Consistency Ratio
R.I.	Random Index
N	Order of matrix
S	Success
F	Failure

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