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OUTSOURCING PARTNER SELECTION FOR AIRCRAFT SERVICING MAINTENANCE REPAIR & OVERHAUL USING MULTIPLE CRITERIA DECISION MAKING MODEL – ELECTRE-III

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Abstract:

"With no boundaries 'unattainable', no location 'unreachable' and with every access to new and novel markets, increased law enforcement and regulations, and immense technological advances, Aircraft 'Servicing Maintenance Repair and Overhaul' (SMRO) partner selection in the contemporaneous circumstances has become more complex than what it was" [30]. The airline operators including defense sector demand for quickness in delivery, flexibility, cost efficiency and quality. In this situation, it has become very difficult for the industry to carry out and meet all the Manufacturing & Aircraft Servicing activities by themselves without ever having to integrate their auxiliary units and partnership industry suppliers into their achievement network. Such industrial partners need to be selected with caution and such selection can be predominant factor for the overall growth of the industry. "When the organizations are looking for new avenues through concentration on core-competencies, outsourcing the specific areas to the

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reliable partnership resources is found to be the best substitute".[16] But SMRO partner selection is the most critical issue with multiple criteria with a eye on cycle time reduction in 'Aircraft Servicing' and is the key factor, when the industry is concentrating on core-competencies. For such critical selection considering multiple criteria, a novel method, "which combines entropy weight with an improved ELECTRE-III" [9] method, is expected to provide better results while selecting the right partner for SMRO. The present study analyzed the multiple criteria with the help of the relative literature, the indicator systems are constructed and then corresponding objective weight of each indicator based on entropy is calculated. Based on these results, various limitations are confirmed and then harmoniousness-index and the in-harmoniousness-index have been calculated. Thereafter the ranking relations are calculated, evaluated and are ranked based on the net advantage value. Matrix Calculator and determinant finder on-line been used for this purpose.

Keywords: Indian Aircraft Industry, SMRO, Partner Selection, ELECTRE-III, Ranking of the Servicing Partner.

1. Introduction

"Indian Aircraft Industry (IAI)'s Aircraft 'Servicing, Maintenance, Repair and Overhaul' (SMRO) activity is one of the leading instance and the systems followed by IAI are paramount for any industry to achieve the goal of attaining growth with inclusion of suppliers across the globe, as 'partners' in their net working" [30]. The growing need for 'vendor or supplier or servicing agency' integration and coordination has been recognized as critical and key resulting area (KRA) by Indian Aircraft Industries (IAI) and IAI has been quick in understanding and assessing the need of business partner's satisfaction by maintaining win-win relationship.

IAI also recognized that, ever growing increase in customer demands for quickness in delivery, flexibility, cost efficiency and quality, it has become very difficult to carry out and meet the specified criteria without integrating their vendors into their supply chain at all levels. "The IAI supply chains concentrated on four qualities: First, IAI's supply chains are agile. They react quickly to sudden changes in demand or supply. Second, IAI adapt over time as market structures and strategies evolve. Third, IAI "align the interests of all the firms in the supply

network" [18] so that companies optimize the chain's performance when they maximize their interests. Fourth, considering the Suppliers, as their own partners and giving special attention on the 'vendor base' with transparency. IAI is successful in attaining this inclusive and sustainable growth along with the growth of their 'supply partners and SMRO partners' based on their selection with Multiple Criteria Decision Making systems and their policies towards the vendors." [15]

"Selection of partners using Multiple Criteria Decision Making methods has helped IAI in realizing the strengths of the partners and maintaining the relationship. Such selection is critical to IAI's strategic growth, particularly when the organization is depending on outsourcing partners to a large extent both for manufacture and servicing of Aircraft in general and SMRO in particular, enabling the organization to concentrate on design and development of aircraft especially by focusing attention on the core business activities. SMRO Stations in India have emerged as value-adding partners "[28] [5] for IAI. These values could be derived effectively in IAI by keeping long term strategic relationships with the suppliers." Long term business agreements and sustainable partnerships are the essence of the satisfied vendors" [19] at IAI in all their echelons. The win-win relationship between the giant Indian Aircraft Industry and its suppliers are to meet the challenges in the contemporary world, because of-

1. Rapid changes in technology & innovations
2. Reduced Product life cycle & Component obsolescence
3. Shrinking Lead time
4. Cost Pressure
5. Increased global participation
6. Real-time view of demand, supply, and capacity information
7. Supply chain optimization visibility
8. Supplier's solutions to innovative breakthrough

These all grouped into the sub-constructs as given in table 1.

Table 1: Definitions for the Major Sub- Constructs

Sub-constructs	Definitions
Strategic supplier partnership	The long-term relationship between the organization and its suppliers. It is designed to leverage the strategic and operational capabilities of individual participating organizations to help them achieve significant ongoing benefits.
Customer relationship	The entire array of practices that are employed for the purpose of managing customer complaints, building long-term relationships with customers, and improving customer satisfaction.
Level of information sharing	The extent to which critical and proprietary information is communicated to one's supply chain partner.
Quality of information sharing	Refers to the accuracy, timeliness, adequacy, and credibility of information exchanged.
Postponement	The practice of moving forward one or more operations or activities (making, sourcing and delivering) to a much later point in the supply chain.

IAI finds itself under great pressure to cut the cost of its activities while improving the effectiveness of their performance to make budgetary room for the highest priorities including modernization, recapitalization, and carrying out core business. "Through optimized method of selection process, by interlacing the selected supply base into the growth operations of IAI, by taking the strength of the relationship with the satisfied vendors who are ready to be there with IAI for good long periods, IAI is progressing into new arena"[5].

2. Objective

The main aim of this study is to visualize 'what IAI has done' and how it followed the ELECTRE III [1] method to identify the right partnership company to go ahead with Long Term Business Agreements with multiple criteria decision making. Each of the IAI segments has programmes underway." A lot of work has been done already on all these platforms. Complete data is collected with the divisions of IAI, in relation to expertise & experience with vivid parameters, for short listing the Original Equipment Manufacturers (OEM), based on rankings. "Private sector majors will be selected as the strategic partners for each segment and they will in turn tie-up with the OEMs of international repute. The mechanism suggested for such rankings is ELECTRE III". [1] [20]

3. Supply Relationship Management Framework

A good supplier selection process is very important for efficient Aircraft Servicing and is a complicated process mainly for two reasons. First, suppliers' evaluation is not just based on single criteria. Second, each supplier got different capabilities and hence criteria for analysis differ from the others. "Additionally, there are two problems encountered in supplier selection". [2] "One is a single sourcing problem: the goal is to satisfy the buyer's needs with one supplier. In this case, the manager must decide which supplier is the best. The other problem is a multiple sourcing problem in which it is not possible to satisfy the buyer's needs with one supplier. In this case, the manager has to choose multiple suppliers and, in turn, allocate supplies to them". [21] [3].

The most important criteria that are considered important in selecting a right SMRO partner for Aircraft Maintenance are -

1. Product Quality/ Service Quality with the acceptance and approval of oversight authorities as a part of Quality Control & Production Management.
2. Price/ affordability which should be in-line with competitive market through Cost Analysis & Spend Analysis.
3. Service/ Reliability through Performance Measurement and contract Management.
4. Accessibility and geographical location/position under Evaluation Criteria for Suppliers/partners.
5. Technology lever and Innovation with Performance Management parametric..
6. Supply/ Service capacity and capability assessment through Contract Management.
7. Economic benefits and Productivity measurement through Administrative Compliance.
8. Regularity in delivery assessment through Performance Measurement and
9. Market effect degree with reliability under Production Control.

"A positive, supportive relationship with partner suppliers/ service agencies are aimed to meet specified goals in the Supply Chain Management function through IAI's Supplier Relationship Strategy"[30] with the specified principle as given below-

- Affirmed commitment to the visions
- Open and honest communication
- Mutual trust

- Incentives beyond complying with the contract
- Self-directed team with Boeing leadership
- Decisions made at the lowest possible level

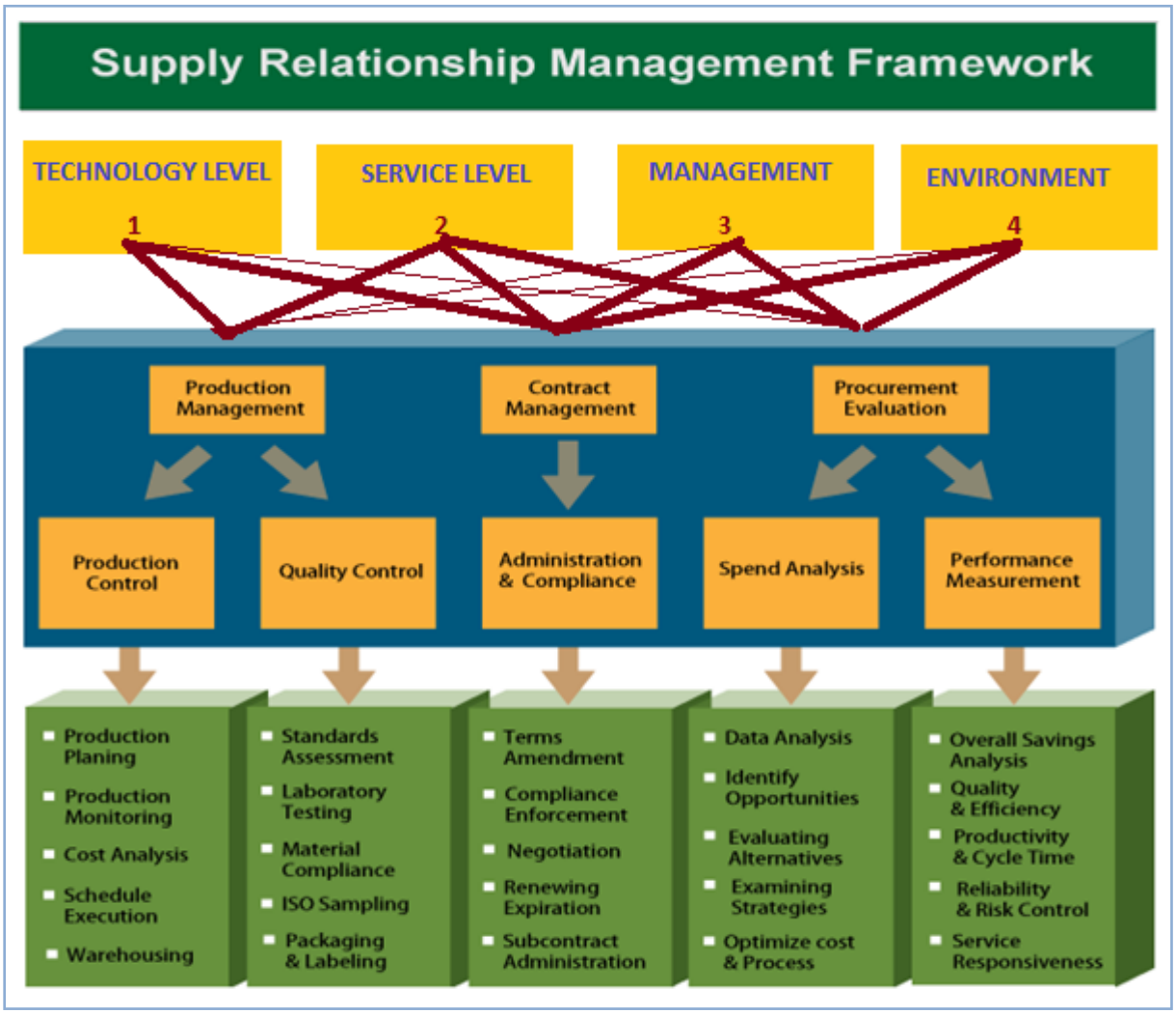

Figure 1: Supplier Relationship Framework at IAI

As per the foregoing, the right partner for 'supply and servicing' selection is the key factor to improve the whole competitive power and viability of the organization and for this ELECTRE III sorting system is found to be extremely useful. For this, the system considers the index system and the evaluation method.

Aspect of index system:

Che and Wang, [9] stated that "organizations are to make an critical and crucial decision regarding the partner selection and evaluation in order to collaborate with qualified selective suppliers and eliminate those unqualified ones, who will be the real associates with the organization with long term relationships"[9]. Lin et.al., mentioned that "performance of out-sourcing operations is greatly affected by vendor selection activities" [22]. Mafakheri et. al., pointed out that "costs reduction and quality improvement of end products is highly dependent on choosing the appropriate supplier. Consequently, considerable amount of interests exist in development of suitable frame-works to evaluate and select suppliers[22]. He et. al., suggested that "selecting the suitable suppliers based on the characteristics of market and product features is a key factor in achieving good supply-chain management"[14]. The literature review of Weber et al. (1991) [14] [23] summarized the 'research accomplishments of the supplier selection criteria'[23]. This is re-emphasized in the work of Dickson (Dickson 1966) [14] and revealed that Quality, Price and delivery along with ability are the most important criteria for supplier selection. Johnson (1995) [24] adopted an "enterprise performance evaluation method to consider that time, quality, cost and service were the key factors of success of the factors affecting supplier selection" [24]. Ma et al. (2000) [26] [27] proposed a "synthetic evaluation index system in the environment of supply chain management, and classified the main factors into four kinds: enterprise performance, professional structure and produce ability, quality system, and enterprise environment."

Qian et al. (2000) [25] pointed out that "time, quality, cost and service were the key factors of success when selecting a supplier in an agile enterprise". Ma (2002) proposed that "the criteria of supplier selection are composed of nine evaluation indices: quality, price, service, geographical position, [29] technology lever, supply capacity, economic benefits, delivery, and market effect degree". Therefore these Nine factors were considered for evaluation and are are in line with the requirements of IAI.

Aspect of evaluation methods: The literature reveals new aspects. Zhu (2004) [6] utilized "the buyer and seller two-phase game model to simplify DEA and constructed an efficiency interval to evaluate suppliers" [6]. Kumar et al. (2006) used "fuzzy optimization theory to evaluate

suppliers". Wang et al. (2002) proposed a "Euclid norm evaluation method based on the relative inferior membership degree". Ma and Wang (2002) proposed a "grey relation model to solve the evaluation index weight"[6].

"Multi criteria decision-making (MCDM) is involved with the process of supplier selection. This process is mainly influenced by different intangible and tangible criteria such as price, quality, technical capability, delivery performance, etc. Many researchers solved the problem of supplier selection by different approaches which include linear programming (LP), integer non-linear programming, mixed-integer linear programming (MILP), analytic network process (ANP), multiple-objective programming, neural networks (NN), goal programming, data envelopment analysis (DEA), simple multi-attribute rating technique (SMART), analytic hierarchy process (AHP), cost-based methods (CBM), genetic algorithm, techniques for order preference by similarity to ideal solution (TOPSIS) and Elimination and Choice Expressing Reality (ELECTRE) methods" [11][14][30].

Bai and Cui (2006) [4] proposed "supplier evaluation based on TOPSIS". "These all methods considered the compensating accumulation principle, that is, the weakness of a certain index can be compensated by another index, such as the weakness of price can be compensated by service, but in practice, the compensation of weakness is only up to a certain range. When the attribute is very weak, it is not compensated, such as the price of a certain supplier exceeds other suppliers heavily", [4] (for example, over double), the supplier may not be considered; on the other hand, if the difference in the price is small, one can consider that the suppliers & ignore the difference in the attribute of price.

"ELECTRE-III is a decision evaluation method based on a precedence relation; it can satisfy different evaluation requirements by defining undifferentiated threshold", [8] strict superior threshold and rejection threshold. ELECTRE-III has strong flexibility and can satisfy the requirement of supplier selection. Based on the above reasons, this paper proposes an improved ELECTRE-III method based on a precedence relation to evaluate suppliers. Firstly, the corresponding objective weight of each index based on entropy is calculated; then the threshold is confirmed and the harmoniousness-index and the in-harmoniousness-index are calculated, and

the outranking relation is calculated and evaluated; and last, the suppliers are ranked based on the net advantage value of each project.

Evaluation index system

Based on the foregoing analysis and after combining the practical aspects of Aircraft SMRO management, it is considered that constructing an evaluation index system for supplier selection should follow primarily six principles: comparability, objectivity, comprehension, reliability, flexibility, and easy operation. This further will be helpful in minimizing the evaluation index to make the evaluation process financially feasible and definition definite. Upon considering the nine specific criteria, taking four of the Major contents, an Evaluation Index is drawn and is shown in **Table 2**.

Table 2. Evaluation Index

	CONTENT		**INDEX**
A1	**Technology level**	B1	Production development ability
		B2	Production quality
		B3	Production reliability
		B4	Production Quality certification system
A2	**Service level**	B5	Price
		B6	Delivery
		B7	Credit degree
		B8	The satisfaction degree of after service
A3	**Managing ability**	B9	Finance status
		B10	Supply ability
		B11	Collaboration ability
		B12	Management ability
		B13	Development ability
A4	**Enterprise environment**	B14	Politics and law environment
		B15	Economic and technical environment
		B16	Natural geographical environment

		B17	Social and cultural environment
		B18	The compatibility of enterprise culture
		B19	The compatibility of management system
		B20	Innovation & Knowledge administration

Improved ELECTRE-III method based on entropy weight

"The ELECTRE **(*ELimination Et Choix Traduisant la Realite – elimination and choice translation reality*)** method was first coined and put forward by Benayoun, Roy and Sussman in the 1960s (Benayoun et al. 1966)". [7] Then Roy (1968, 1978) and Rey and Bertier (1971, 1973) [10] developed the method to form the ELECTRE family which have different varieties. Among them said family, the ELECTRE-III method is expected to solve the ranking problem of the alternatives whose data is certainty data with multiple degrees of weights.

- **The determination of index weight**

Suppose that there are m evaluation objects (suppliers)

$A = (a_1, a_2, ..., a_m)$,

n evaluation indices

$C = (c_1, c_2, ..., c_n)$,

the evaluation index values of each supplier form matrix X, where x_{ij} represents the j^{th} index evaluation value of the i^{th} supplier.

(1) Data normalization

$$r_{ij} = \tilde{x}_{ij} / \sqrt{\sum_{i=1}^{m} \tilde{x}_{ij}^2}, \quad 1 \le i \le m,\ 1 \le j \le n.$$

$$\tilde{x}_{ij} = \begin{cases} x_{ij}, & \text{if } x_{ij} \text{ is a benifit index} \\ 1/x_{ij}, & \text{if } x_{ij} \text{ is a cost index} \end{cases}.$$

..... (a)

(2) Decision information entropy value calculation

"There are many methods to determine the index weight, such as expert opinion survey method or AHP, but these methods have very large subjective factors when determining the evaluation

index weight. This paper adopts information entropy to determine the weight to avoid the effect of subjective factors"[11]. "Entropy is a measure that uses probability theory to measure the uncertainty of information. It shows that the more dispersive the data, the bigger the uncertainty'[12]. The decision information of each index can be expressed by entropy value $\mathbf{E_j}$.

$$E_j = -K\sum_{i=1}^{m} r_{ij}\ln r_{ij}, \quad 1 \le i \le m,\ 1 \le j \le n,\ 0\ln 0 \equiv 0.$$

Here, m is the number of evaluation objects, and $K = 1/\ln m$. …….. (b)

(3) Difference degree calculation

The difference degree can be calculated as follows:

$$G_j = 1 - E_j, \quad 1 \le j \le n.$$

……

(c)

(4) Calculate entropy weight '$\mathbf{w_j}$,

$$w_j = G_j / \sum_{j=1}^{n} G_j \quad 1 \le j \le n$$

……(d)

➢ **The evaluation steps of ELECTRE-III method**

(1) Construct threshold.

In order to construct the fuzzy outranking relation, the ELECTRE-III method brings in three thresholds (Zhang et al. 2006):

(a) Un-differentiated threshold, q_j;

(b) Strict superior threshold, p_j; and

(c) Rejection threshold, v_j.

Their meanings are as follows:

Undifferentiated threshold $\mathbf{q_j}$: when the difference between attribute values of alternative a_i and alternative a_k in criterion c_j is not more than q_j, that is, when $\mathbf{r_{ij} + q_j \ge r_{kj}}$ and $\mathbf{rk_j + q_j \ge r_{ij}}$, alternative a_i and alternative a_k are considered to be undifferentiated in criterion c_j.

Strict superior threshold p_j: when the difference between attribute values of alternative a_i and alternative a_k in criterion c_j is more than p_j, that is, when $\mathbf{r_{ij} \geq rk_j + p_j}$, alternative a_i is considered to be a strict superior to alternative a_k. If $\mathbf{r_{kj} + qj < r_{ij} \leq r_{kj} + pj}$, then alternative a_i is considered to be a weak superior to alternative a_k.

Rejection threshold vj: when the difference between attribute values of alternative a_k and alternative ai in criterion c_j is no less than v_j, that is, when $\mathbf{r_{kj} \geq r_{ij} + v_j}$, alternative a_i is not considered to be superior to alternative a_k on the whole.

For given random criterion cj, $\mathbf{0<q_j <p_j <v_j}$. The thresholds q_j, p_j and v_j, need to be determined according to the practice of concrete problems and the risk attitude of the decision-maker. The following principles are advised in this paper:

(a) Undifferentiated threshold q_j:

Undifferentiated threshold q_j = (the max attributes value - the min attributes value)*certain percent, the percent is usually: 5–10%. Of course, it can be regulated appropriately according to the risk attitude of the decision-maker. In this paper, the percent is taken as 10%.

(b) Strict superior threshold p_j:

Strict superior threshold p_j = undifferentiated threshold q_j *certain multiple, the multiple is usually 3–10. In this paper, the multiple is taken as 3.

(c) Rejection threshold v_j:

Rejection threshold v_j =(the max attribute value - the min attribute criterion value)*certain multiple. The multiple is usually 3–5. In this paper, the multiple is taken as 3.

(2) Calculate the harmoniousness index and the inharmoniousness-index.

$$SD_j(i,k) = \begin{cases} 1, & \text{if } r_{ij} + q_j \geq r_{kj} \\ 0, & \text{if } r_{ij} + p_j \leq r_{kj}, \\ (r_{kj} - (r_{ij} + p_j))/(q_j - p_j), & \text{otherwise} \end{cases} \quad \text{..... (1)}$$

$$D_j(i,k) = \begin{cases} 0, & \text{if } r_{ij} + p_j \geq r_{kj} \\ 1, & \text{if } r_{ij} + v_j \leq r_{kj} \\ (r_{kj} - (r_{ij} + p_j))/(v_j - p_j), & \text{otherwise} \end{cases}, \quad \text{..... (2)}$$

$$C(i,k) = \frac{\sum_{j=1}^{n} w_j SD_j(i,k)}{\sum_{j=1}^{n} w_j} = \sum_{j=1}^{n} w_j SD_j(i,k), \quad i,k = 1,2,\ldots,m. \quad \text{..... (3)}$$

$$S(i,k) = \begin{cases} C(i,k), & \text{if } D_j(i,k) \leq C(i,k), \forall j \\ C(i,k) \prod_{\{j \in J: D_j(i,k) > C(i,k)\}} \frac{1-D_j(i,k)}{1-C(i,k)}, & \text{otherwise} \end{cases}, \quad \text{..... (4)}$$

Where

1. SDj (i, k) represents the degree of supporting the judgment that alternative a_i is superior to alternative a_k in index c_j.
2. D_j (i, k) represents the measure which rejecting the judgment that alternative ai is superior to alternative a_k in index c_j
3. C (i,k) Overall harmoniousness relation
4. S(I, k) represents the measure which supports the judgment that alternative a_i is superior to alternative a_k in the whole level.

(3) Calculate the total score, and determine the ranking relation of each alternative.

For all the alternative pairs in alternative sets, consider the outranking relations which satisfy the above conditions. In these relations, measure the good and bad of alternative ai according to the difference between the number of direction arca flowing from ai and the number of direction arcs flowing into ai, by classifying and comparing many times to finally determine the ranking. In this paper, the net advantage value in the literature (Zhang et al. 2006) is used as the basis of judging the score of alternatives. The formula of the net advantage value is as follows:

$$\delta_k = \sum_{\substack{i=1 \\ i \neq k}}^{m} S(i,k) - \sum_{\substack{i=1 \\ i \neq k}}^{m} S(k,i), \quad k = 1, 2, \ldots, m,$$

……(5)

Where δ_k represents the satisfaction scores of alternatives. The more the scores, the higher the satisfaction degree.

4. Application case

"For SMRO development, IAI has chosen primarily six suppliers at a specified station for the specific aircraft. Servicing quality, price, after MRO service, geographical position, technology level, supply ability, economic benefits, delivery, and market effect degree"[13,17] as stated earlier with detailed descriptions have been chosen as the nine evaluation criteria. Among them, product quality, technology level, supply ability, economic benefits, delivery, and market effect degree are benefit indexes, the bigger, the better; product price, service, geographical position are cost indexes, the smaller, the better. The evaluation values of each index are shown in Table 3.

Table 3: Supplier Evaluation Calculated Values

Supplier	Product quality	Product price (Rs thousands)	Service (hour)	Geo-graphical position (km)	Techn-ology level	Supply ability (pieces)	Economic benefits	Delivery	Market effect degree
1	0.785	335	3.21	15	0.121	250	0.122	0.832	0.132
2	0.912	268	1.42	35	0.251	150	0.082	0.961	0.152
3	0.981	304	1.92	20	0.092	200	0.139	0.989	0.201
4	0.968	270	2.02	20	0.332	180	0.091	0.869	0.211
5	0.861	310	0.81	25	0.199	150	0.152	0.801	0.124
6	0.952	303	2.69	10	0.192	200	0.169	0.911	0.189

(1) The decision steps

(i) The Initial Evaluation Matrix - **X**

$$\mathbf{X} = \begin{pmatrix} 0.785 & 335 & 3.21 & 15 & 0.121 & 250 & 0.122 & 0.832 & 0.132 \\ 0.912 & 268 & 1.42 & 35 & 0.251 & 150 & 0.082 & 0.961 & 0.152 \\ 0.981 & 304 & 1.92 & 20 & 0.092 & 200 & 0.139 & 0.989 & 0.201 \\ 0.968 & 270 & 2.02 & 20 & 0.332 & 180 & 0.091 & 0.869 & 0.211 \\ 0.861 & 310 & 0.81 & 25 & 0.199 & 150 & 0.152 & 0.801 & 0.124 \\ 0.952 & 303 & 2.69 & 10 & 0.192 & 200 & 0.169 & 0.911 & 0.189 \end{pmatrix}$$

(ii) According to Formula (a), the normalized matrix is:

$$R = \begin{bmatrix} 0.353 & 0.360 & 0.186 & 0.405 & 0.231 & 0.523 & 0.380 & 0.378 & 0.312 \\ 0.406 & 0.450 & 0.424 & 0.164 & 0.481 & 0.295 & 0.253 & 0.437 & 0.360 \\ 0.442 & 0.397 & 0.313 & 0.276 & 0.173 & 0.455 & 0.443 & 0.451 & 0.479 \\ 0.433 & 0.447 & 0.297 & 0.320 & 0.635 & 0.409 & 0.285 & 0.396 & 0.503 \\ 0.384 & 0.389 & 0.742 & 0.234 & 0.385 & 0.341 & 0.475 & 0.365 & 0.288 \\ 0.424 & 0.398 & 0.220 & 0.759 & 0.366 & 0.386 & 0.538 & 0.415 & 0.455 \end{bmatrix}$$

(iii) According to Formulae (b), (c), and (d), the entropy weight of each index is calculated as:

$$\mathbf{W} = \begin{pmatrix} 0.142 & 0.143 & 0.058 & 0{:}051 & 0{:}084 & 0.131 & 0.118 & 0.142 & 0.127 \end{pmatrix}$$

$$\mathbf{q} = \begin{pmatrix} 0.0201 & 0.0001 & 0.0935 & 0.0097 & 0.0241 & 10.000 & 0.0091 & 0.0192 & 0.0092 \end{pmatrix}$$

$$\mathbf{p} = \begin{pmatrix} 0.0608 & 0.0002 & 0.2815 & 0.0293 & 0.0719 & 30.0000 & 0.0272 & 0.0574 & 0.0273 \end{pmatrix}$$

$$\mathbf{v} = \begin{pmatrix} 0.6000 & 0.0021 & 2.8124 & 0.2937 & 0.7201 & 300.000 & 0.2704 & 0.5703 & 0.2703 \end{pmatrix}$$

(iv) The overall harmoniousness index is: **C**

$$\mathbf{C} = \begin{pmatrix} 1.00 & 0.35 & 0.33 & 0.40 & 0.45 & 0.20 \\ 0.70 & 1.00 & 0.42 & 0.47 & 0.75 & 0.50 \\ 0.83 & 0.75 & 1.00 & 0.78 & 0.86 & 0.75 \\ 0.74 & 0.82 & 0.67 & 1.00 & 0.82 & 0.75 \\ 0.78 & 0.43 & 0.45 & 0.22 & 1.00 & 0.40 \\ 0.87 & 0.62 & 0.63 & 0.69 & 0.94 & 1.00 \end{pmatrix}$$

The credit Index is- **S**

$$S = \begin{pmatrix} 1.00 & 0.35 & 0.33 & 0.40 & 0.45 & 0.20 \\ 0.70 & 1.00 & 0.42 & 0.47 & 0.75 & 0.50 \\ 0.83 & 0.75 & 1.00 & 0.78 & 0.86 & 0.75 \\ 0.74 & 0.82 & 0.67 & 1.00 & 0.82 & 0.75 \\ 0.78 & 0.43 & 0.45 & 0.22 & 1.00 & 0.40 \\ 0.87 & 0.62 & 0.63 & 0.69 & 0.94 & 1.00 \end{pmatrix}$$

The net advantage value is - **δ**

$$\delta = \{ -2.188 \quad -0.138 \quad 1.277 \quad 1.445 \quad -1.556 \quad 1.271 \}$$

So the ranking of the six suppliers is: **4, 3, 6, 2, 5, 1**.

P4, P3, P6,P2,P5 and P1 is the preferential order for the partners selection.

(2) Result analysis

The TOPSIS method is used to rank the supplier, and get the ranking result: 4, 3,6, 2,5, 1. It is the same as the result in the above method, indicating the validity of the above method.

5. Conclusion

SMRO partner selection is the basis of supply chain collaboration and outsourcing. The method used for such partner selection is the improved ELECTRE-III method and is based on entropy weights and formulated into the SMRO Center selection model for long term collaboration. The objective weight was calculated based on information entropy to avoid the subjectivity of weight determined and to make the evaluation result more objective and more practicable. In this method the alternatives are undifferentiated, compensated or rejected in a certain range to remedy the defects of the complete compensated evaluation method. The harmoniousness-index, the inharmoniousness-index and the outranking relation were calculated for clarity and clear decision making. The SMRO centers for collaboration were ranked based on the net advantage value. This system and methodology can be applied for any number of criteria with any number of possible sources and is helpful for any industry. The existing policy with Defense Procurement is cumbersome and hence is expected to be replaced by the new ranking scheme

ELECTRE III.

Note: The Views and opinions expressed, conclusions drawn and critical analysis arrived at or any other ideas/ strategies in the above paper are of our own and do not reflect or represent the views of any of the organization.

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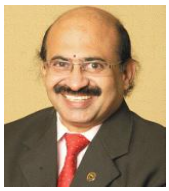

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