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Selection of Optimal Supplier in Supply Chain Using A Multi-Criteria Decision Making Method

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Abstract: *The supplier selection problem is one of the strategic decisions that have a significant impact on the performance of the supply chain. In this study, supplier selection problem of an automotive company is investigated and a comprehensive methodology is used to select the best supplier providing the most customer satisfaction for the criteria determined. The proposed methodology consists of Analytic Network Process (ANP), the criteria which are relevant in the supplier selection, have been used to construct an ANP model.*

Keywords: *Supplier Selection, ANP,*

I. INTRODUCTION

Since 1960s, supplier selection criteria and suppliers performance have been a focal point of many researchers. As a pioneer in supplier selection problem, Dickson (1966) identified 23 different criteria for this problem including quality, delivery, performance history, warranties, price, technical capability and financial position. Weber et al. (1991) analyzed 74 articles published between 1966 and 1990 dealing with this problem.

Extensive multi-criteria decision making approaches have been proposed for supplier selection, such as the analytic hierarchy process (AHP), Analytic Network Process (ANP), Case-Based Reasoning (CBR), mathematical programming, Data Envelopment Analysis (DEA), Genetic Algorithm (GA)… Many decision problems cannot be building ad hierarchical because of dependencies, influences between and within clusters (criteria, alternatives). ANP (Saaty, 2001) is very useful to solve this kind of problems.

Analytic Network Process (ANP) is a generalization of the (AHP), it considers the dependence between the elements of the hierarchy. The ANP feedback approach replaces hierarchies with networks, and emphasizes interdependent relationships among various decision-making, also interdependencies among the decision criteria and permit more systematic analysis.

II. THE PROPOSED MODEL IN SUPPLIER SELECTION

The automotive company is in a decision-making situation for purchasing one of the main items for assembling the components of cars. A committee of decision-makers wants to select the most promising vendor for supplying the item. After a preliminary screening, three alternatives {*S1*, *S2*, *S3*} remain for further evaluations. The network structure of this problem is depicted in Figure 1.

Several techniques have been developed to solve the supplier selection problem, and all techniques have to use criteria and sub-criteria to rate suppliers. The main goal of the supplier selection is selecting the best supplier that meets the requirements or criteria. For the proposed supplier selection model, overall criteria are determined under two main criteria clusters mentioned below:

- Selectivity criteria;
- Rejectability criteria

All criteria and sub-criteria are given in the following model:

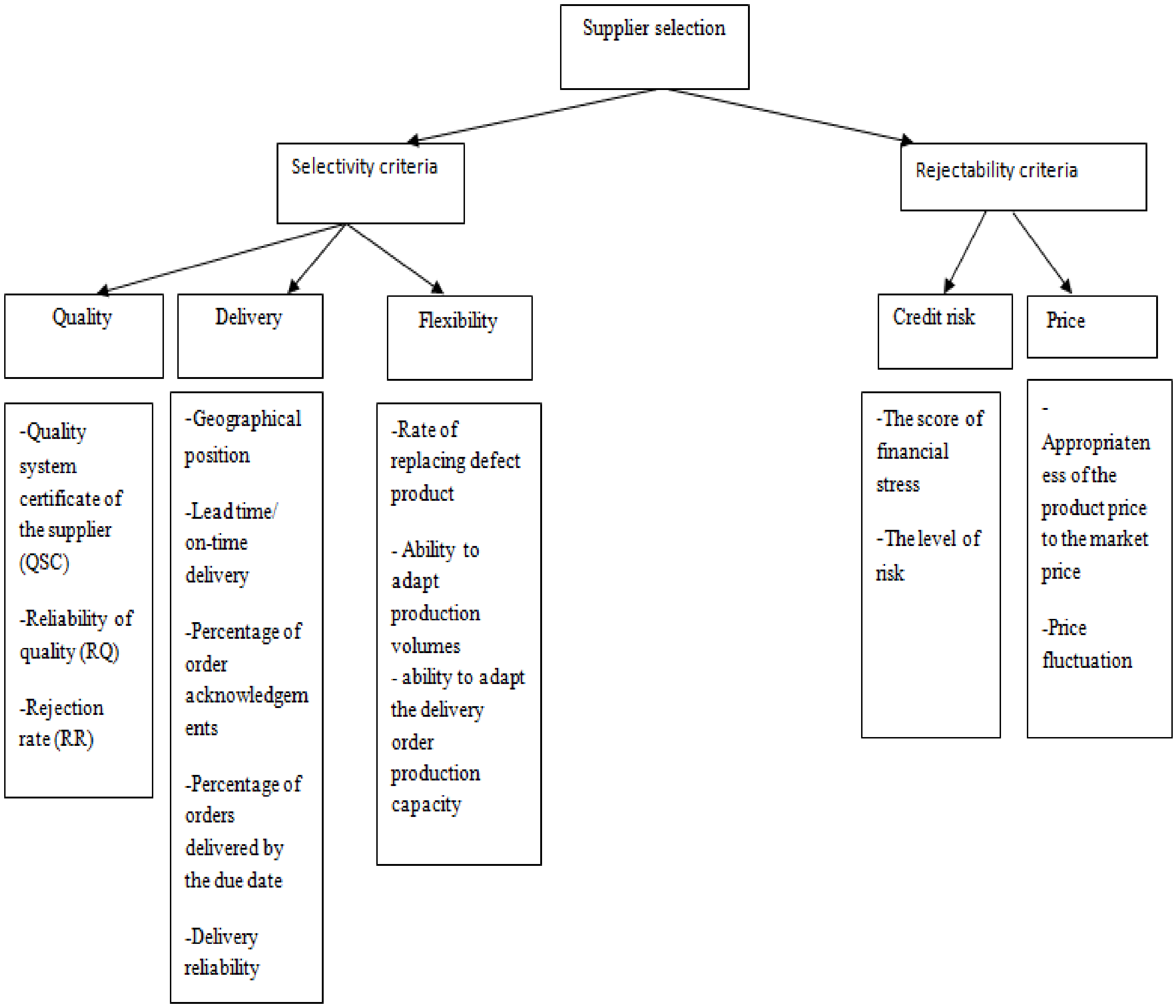

Figure 1: ANP-base d mode l for supplier selection

As shown in Figure1, the problem is composed into a network. There are five criteria, each of which has several sub-criteria

III. APPLICATION OF SUPPLIER SELECTION

Step1: pairewise comparison of clusters:

In this step, a series of pairwise comparisons are made to establish the relative importance of clusters in achieving the objective. In such comparisons, a ratio scale of 1_9 is used to compare any two elements. A score of 1 indicates equal importance of the two elements whereas a score of 9 indicates overwhelming dominance of the elements under consideration (row component) over the comparison element (column component).

The matrix showing the pairwise comparison of clusters along with the derived local priority vectors (also known as e-vectors (eigen vectors)) is shown in table 1

Table 1: paire wise comparisons of clus te rs:

	Selectivity criteria	Rejectability criteria	e-vectors
Selectivity criteria	1	8	0.888
Rejectability criteria	1/8	1	0.111

Step 2: Pairwise Comparison of criteria

In this step, the relative importance of each criterion for cluster 1 (selectivity criteria) is obtained through a pairwise comparison matrix. Two such matrices would be formed in the present case. One each for the two clusters.

The matrix for selectivity criteria cluster is shown in table 2.

Table 2: pairewise comparison of criteria for cluster 1

	Quality	Delivery	Flexibility	E vectors
Quality	1	4	2	0,552
Delivery	1/4	1	3	0,277
Flexibility	1/2	1/3	1	0,172

The matrix for rejectability criteria cluster is shown in table 3

Table 3: pairewise comparison of criteria for cluster 2

	Credit risk	Price	e-vectors
Credit risk	1	1/3	0,245
Price	3	1	0,754

Step 3: Pairwise Comparison of subcriteria:

In this step, the pairwise comparison of elements at each level is conducted with respect to their relative influence towards their control criterion. One such pairwise comparison matrix for quality under the selectivity criteria cluster is shown in table 4:

Table 4: The pairwise comparison matrix for quality under the selectivity criteria cluster

	(QSC)	(RQ)	(RR)	e-vectors
(QSC)	1	4	1/3	0,352
(RQ)	1/4	1	5	0,347
(RR)	3	1/5	1	0,301

It is observed from table 4 that QSC has the maximum influence on quality under selectivity criteria

Step 4: Pairwise Comparison for interdependencies:

In this step, pairwise comparisons are made to capture interdependencies among the criteria. The pairwise comparison matrix and relative importance weight results for other criteria and impact on quality criterion is shown in table 5:

Table 5: The pairwise comparison matrix and relative importance weight results for other criteria and impact

on quality criterion

Quality	Delivery	Flexibility	Credit risk	Price	W
Delivery	1	3	4	6	0,536
Flexibility	1/3	1	2	3	0,218
Credit risk	1/4	1/2	1	5	0,179
Price	1/6	1/3	1/5	1	0,064

Step 5: Evaluation of suppliers

The final set of pairwise comparaison is made of the relative impact of each of the alternatives (S 1, S2et S3) on the subcriteria in influencing the clusters. The number of such pairwise comparison matrices is dependent on the number of subcriteria that are included in each cluster. In the present case 11 subcriteria for the selectivity criteria cluster and 6 subcriteria for the rejectability criteria, this leads to the formation of 17 such pairwise comparaison matrices.

Matrix for alternatives impact on subcriterion (DR) in influencing the selectivity criteria:

Table 6: Matrix for alternatives impact on subcriterion (DR) in influencing the selectivity criteria

	S 1	S 2	S 3	e-vectors
S1	1	2	3	0,512
S2	1/2	1	4	0,36
S 3	1/3	1/4	1	0,128

Step6: super-matrix formation:

After we have all the pairwise comparisons completed, we go to the next step, to evaluate those criteria with interdependencies using super-matrix analysis. The super matrix as shown in table 7, presents the results of the criteria.

Table 7: super matrix before convergence

	Quality	Delivery	Flexibility	Credit risk	Price
Quality	1	0,327	0,351	0,298726	0,322
Delivery	0,536	1	0,27233	0,211855	0,209
Flexibility	0,218	0,257511	1	0,181249	0,224
Credit risk	0,179	0,177165	0,110496	1	0,052
Price	0,064	0,233	0,221	0,223	1

These converged values turn out to be Wf= 0.240, 0.203, 0.165, 0.110, 0.235 for quality, delivery, flexibility, credit risk, price

Step7: selection of the best supplier:

The selection of the best supplier depends on the values of various desirability indices. The final step of the process is to aggregate the values to arrive at the final scores for each supplier. This aggregation is a weighted average sum calculation defined by expression.

Provider r_i =

$$\sum_{i=1}^{2} \sum_{k=1}^{Kl} \sum_{j=1}^{Jl} Aijkl * SSjkl * FIkl * FDkl * Cl$$

- **Provider r_i** is the overall desirability index score for supplier i.
- **Jk** is the index for the number of selected subcriteria for a criterion k.
- **Kl** the index for the number of selected criteria for a Cluster l.
- **Cl** the relative importance score of a Cluster l at the top level (e.g. a score for the selectivity criteria cluster).
- $\mathbf{F^{D}kl}$ the direct (dependent) relative importance score of criterion k within a Cluster l. (e.g. a score for quality criterion which appears within the selectivity criteria cluster).
- $\mathbf{F^{I}kl}$ the interdependent relative importance score of criterion k within the Cluster l as determined by the super-

matrix results.

- **SSjkl** the relative importance score for a subcriterion j controlled by criterion k within Cluster l (e.g. a score of Reliability of quality under the quality criterion within the selectivity criterion cluster).

- **Aijkl** the relative importance score of a supplier i for subcriterion j under criterion k within the Cluster l.

Desirability index calculations for supplier selection:

Table 5: Desirability index calculations for supplier selection

Cluster	cl	factors	attributes	$F^D kl$	SSjkl	$F^I kl$	A1jkl (A)	A2jkl (B)	A3jkl ©	1	2	3
Selectivity criteria	0,888	Quality	QSC	0,552	0,352	0.240	0,512	0,36	0,128	0,002	0,017	0,0068
	0,888		RQ	0,552	0,346	0.240	0,139	0,573	0,286	0,003	0,015	0,007
	0,888		RR	0,552	0,300	0.240	0,095	0,650	0,254	0,002	0,014	0,005
	0,888	Delivery	GP	0,277	0,158	0.203	0,331	0,119	0,549	0,001	0,0006	0,002
	0,888		LT	0,277	0,211	0.203	0,259	0,065	0,675	0,001	0,0004	0,004
	0,888		PA	0,277	0,255	0.203	0,267	0,063	0,668	0,002	0,001	0,005
	0,888		PD	0,277	0,215	0.203	0,273	0,089	0,637	0,001	0,001	0,004
	0,888		DR	0,277	0,158	0.203	0,231	0,071	0,696	0,001	0,001	0,003
	0,888	Flexibility	RRD	0,172	0,557	0.165	0,303	0,089	0,607	0,0039	0,0011	0,007
	0,888		APV	0,172	0,320	0.165	0,303	0,089	0,607	0,0022	0,0006	0,004
	0,888		ADC	0,172	0,122	0.165	0,303	0,089	0,607	0,0008	0,0002	0,001
Rejectability criteria	0,111	Credit risk	SFS	0,245	0,557	0.110	0,2	0,6	0,2	0,0051	0,0153	0,0051
	0,111		ORS	0,245	0,320	0.110	0,157	0,655	0,186	0,0003	0,0014	0,0004
	0,111		LR	0,245	0,122	0.110	0,157	0,655	0,186	0,0001	0,0005	0,0001
	0,111	Price	APM	0,754	0,621	0.235	0,134	0,745	0,120	0,0012	0,007	0,0011
	0,111		FP	0,754	0,096	0.235	0,111	0,777	0,111	0,0001	0,001	0,0001
	0,111		FS	0,754	0,281	0.235	0,096	0,797	0,1053	0,0004	0,003	0,0004
Desirability indices										**0,0399**	**0,0854**	**0,0655**

IV. CONCLUSION

Supplier selection is difficult given the qualitative and quantitative criteria. Since selecting the best supplier involves complex decision variables, it is considered to be a multicriteria decision problem. The ANP approach, as a methodology used to select the best supplier, not only leads to a logical result but also enables the decision-makers to visualize the impact of various criteria in the final result. Further, we have demonstrated that the interdependencies among various criteria can be effectively captured using the ANP technique. The ANP approach is capable of taking into consideration both qualitative and quantitative criteria

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