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MULTIPLE-DECISIONS DECISION-MAKING APPLIED TO THE SUPPLIER SELECTION FOR ASSEMBLY LINE EQUIPMENTS IN AN AUTOMOTIVE INDUSTRY

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Summary*: The Multiple-decisions decision-making (MDDM) subject was proposed by Thomas L. Saaty in the 8th International Symposium on the Analytic Hierarchy Process (ISAHP). This work presents the Multiple-criteria decision-making (MCDM) modeling for the selection of equipments supplier in an automotive plant located in the Sao Paulo State, Brazil. There were two new assembly lines for which equipments must be purchased by the factory. The AHP was applied with the same set of criteria for both lines. There were four potential suppliers involved, but only one competing, simultaneously, in the two selection processes. At first, this was a case of MCDM, but, some aspects of MDDM were taken into consideration. One of them was the use of ratings to decrease the necessary number of judgments.*

1. Introduction

The supplier selection is an important process of Industrial Engineering, according to Verma & Pullman (1998). After all, this process results the way companies will satisfy their needs of raw-materials, parts that were produced by other companies, operational equipments, supplies and even the services those are needed for the company works, but performed by third part. The Multiple-criteria decision-making (MCDM) has been successfully used to support the supplier selection (Salomon & Shimizu, 2006). The Multiple-decisions decision-making (MDDM) was proposed by Saaty (2005).

This work presents the MCDM modeling for the selection of equipments supplier in an automotive plant located in the Sao Paulo State, Brazil. The Analytic Hierarchy Process (AHP) was considered a proper MCDM method, because it seems that the number of criteria and alternatives would be lower than 9. Salomon & Montevechi (2001) suggest the use of the AHP if there will be no more than nine alternatives, and if these alternatives and the criteria of decision were totally independent.

At first, the problem consisted in the supplier selection for two different sets of equipments, named in this work as Line A and Line B. So, this was a case of MCDM, but, some aspects of MDDM were taken into consideration. One of them was the use of ratings, or absolute measurement, as defined by Saaty (2006). The use of ratings has allowed the decreasing on the necessary number of judgments.

2. The Supplier Selection Problem

In the beginning of 2006, a Brazilian automotive plant, located in the Sao Paulo State, was facing a good problem. It will need to export one of its main products to the United States. But, this new contract of supplying forces the plant to increase its production capacity. So, as previously mentioned, in Section 1, the company needed to select equipments suppliers for two assembly lines: Line A and Line B.

The AHP was considered a proper method to solve the problem with MCDM. After several group discussions, leaded by the Production Manager, the hierarchical structure presented in Figure 1 was obtained. There was determined that the same criteria would be used to the supplier selection for both lines. They are: *cost*, *lead time* (LT), *maintenance easiness* (ME), *expected index of rejected products* (RJ), *yield* and *contamination* (CONT).

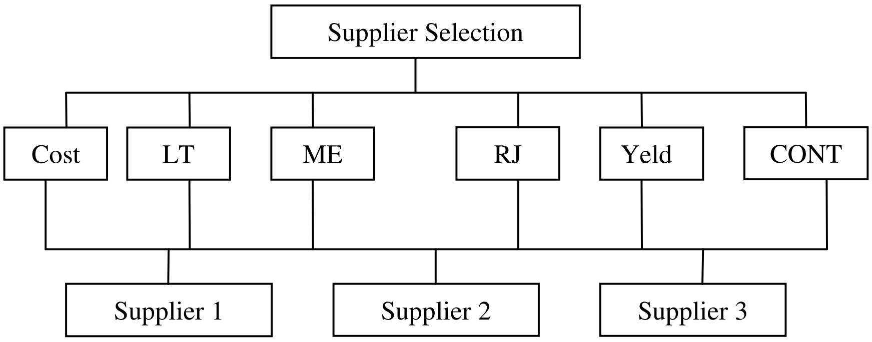

Figure 1. Hierarchical structure to the supplier selection of Line A.

Although they use the same set of criteria, the supplier selection for Line A and Line B differ each other regarding the suppliers, as presented in Figure 2. It can be noted that Supplier 2 is the only supplier simultaneously competing for both lines.

Line A	Line B
Supplier 1 Supplier 2 Supplier 3	Supplier 2 Supplier 4

Figure 2. Suppliers to be selected.

The next step consists in the determination of values for the weights of the criteria and values for the performance of the suppliers according to each criterion. Table 1 presents the judgments on the weights of the criteria. For these judgments, the Fundamental Scale (Saaty, 1980) was initially adopted, although intermediate values as “2” and “6” was preferred in some judgments. The Consistency Ratio (CR) for the judgments matrix presented in Table 1 is equal to 0.18, which is still acceptable according to Saaty (2001). The vector of weights was obtained with the normalization of the geometrical means of the judgment matrix rows, as proposed by Saaty (2001). As one can see, *contamination* was considered as the most important criterion, with a weight of almost 50%.

Table 1. Judgments on weights of the criteria to supplier selection.

Criteria	Cost	LT	ME	RJ	Yield	CONT	Weights
Cost	1	2	2	3	1/5	1/6	9.3%
Lead time (LT)		1	3	1/6	1/7	1/9	3.9%
Maintenance easiness (ME)			1	1/7	1/8	1/9	2.7%
Index of rejection (RJ)				1	1/5	1/5	9.9%
Yield					1	1/5	25.6%
Contamination (CONT)						1	48.6%

In order to obtain the values of the suppliers' performance for the criteria *cost* and *lead time*, it was possible to use numeric data. The performance values presented in Tables 2 and 3 were obtained with the idealization of the performance data, as commented by Saaty (2006).

Table 2. Suppliers' performance for cost and lead time (Line A).

Supplier	Cost (US$)	Performance for cost	Lead time (min)	Performance for lead time
1	619,000	10	20	8.0
2	1,001,000	6.3	16	10
3	1,127,000	5.4	17	9.4

Table 3. Suppliers' performance for cost and lead time (Line B).

Supplier	Cost (US$)	Performance for cost	Lead time (min)	Performance for lead time
2	1,037,000	10	16	10
4	1,017,000	9.8	18	8.9

For the others criteria (*lead time*, *maintenance easiness*, *index of rejection*, *yield* and *contamination*) it was chosen to make ratings, or absolute judgments, instead the relative judgments. This comes from the need to avoid that subject factors, as the tradition of a supplier, does not make any influence in the decision. So, at first, some levels for the performance were identified. The levels of performance were compared and performance vectors can be obtained with the idealization of the geometrical means of the judgment matrix rows presented in Tables 4.

Table 4. Judgments on the performance levels for non quantitative criteria (CR = 0.10).

Level	E+	E-	G+	G-	g	p	Performance
Excellent (E+)	1	2	3	5	7	9	10
Between Excellent and Very Good (E-)		1	3	4	7	8	7.5
Very Good (G+)			1	5	6	8	4.9
Between Very Good and Good (G-)				1	6	8	2.5
Good (g)					1	3	1.0
Poor (p)						1	0.6

Tables 5 and 6 present the decision matrices, with the associate performance for each supplier according to each criterion. This association was obtained with the responses provided by the suppliers to a questionnaire and with the confirmation of the responses based in personnel contacts.

Table 5. Suppliers' performance (Line A).

Supplier	Cost	LT	ME	RJ	Yield	CONT
1	10	8.0	10	10	10	10
2	5.3	10	10	10	10	10
3	5.4	9.4	10	10	2.5	10

Table 6. Suppliers' performance (Line B).

Supplier	Cost	LT	ME	RJ	Yield	CONT
2	10	10	10	10	10	10
4	9.8	8.9	10	10	2.5	7.5

With the multiplication of the decision matrices by the vectors of criteria weights (Table 1) we can obtain the decision vectors presented in Tables 7 and 8.

Table 7. Suppliers' global performance (Line A).

Supplier	Global performance
1	9.9
2	9.7
3	7.6

Table 8. Suppliers' global performance (Line B).

Supplier	Global performance
2	10
4	6.1

The result with the AHP application is that we must select Supplier 1 for Line A and Supplier 2 for Line B. In the next section, it is presented how aspects of MDDM changed this decision for the selection of Supplier 2 for both lines.

3. Multiple-decision Decision-making

According to Saaty (2005), "Unlike in MCDM, the broader advocacy by the diverse people affected by the decisions, the politics involved, the timing, sequencing and scheduling need to be part of our considerations in MDDM". From Table 7, it can be seen that a difference of 0.2 points between the suppliers' global performance indicates the selection of Supplier 1 for Line A. From Table 8 it can see that for Line B the selection of Supplier 2 has been indicated by a difference of almost 4 points. So the reasons to select Supplier 2 for Line B appears more clear than the reasons to select Supplier 1, instead Supplier 2, for Line A.

With the results from Tables 7 and 8, it has started a discussion about "why not select the same supplier for both lines?". There were some advantages for this. The first one to be mentioned is that, with only one supplier, the both lines will have similar equipments, from the same manufacturer. Consequently, a number of procedures, as inspection and maintenance for example, could be standardized. The second advantage to choose the same supplier is the beginning of a partnership relationship. The chosen supplier can give better services after the purchase than if it has chosen for one line.

Just before the change of the decision for the selection of Supplier 2, one more point could be noted from Table 5. The Suppliers 1 and 2 were tied according to four of the six criteria. Supplier 1 was better in cost and Supplier 2 was better in lead time. But, the higher investment in a fast assembly line will be paid-off in few months. So, the selection of more expensive supplier will result higher profits for the company. This way, Supplier 2 was the chosen one for supply equipments for both Lines A and B.

4. Final Comments

This work presented the MCDM modeling for the selection of equipments supplier in an automotive plant. There were two new assembly lines for which equipments must be purchased. The AHP was applied with the same set of criteria for both lines. Two unusual procedures in the applications were adopted: the use of ratings (there was conducted absolute judgments instead the relative judgments) and the idealization of the performance values (instead the normalization). With the absolute judgments it was possible to avoid that subject factors have influence in the decision.

The use of ratings and the same set of criteria have extremely decreased the number of necessary judgments. Within Tables 1 and 4 we have 30 judgments. If we have considered 6 different criteria for both supplier selection process, more relative judgments for the suppliers' performance according to the non quantitative criteria (*lead time*, *maintenance easiness*, *index of rejection*, *yield* and *contamination*) we would need 30 judgments for Line A and more 20 judgments for Line B. So, the total number of judgment was decreased in 20 judgments or 40%.

As discussed in Section 3, the MDDM change the decision of the MCDM for the supplier selection for Line A. Finally, it is important to mention that the selection of the Supplier 2 for both lines was the decision adopted by the company, which, by the way is very happy with the results of these decisions.

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