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A FINANCIAL MULTI-ATTRIBUTE DECISION PROBLEM

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The purpose of this paper consists in modelling as a multi-attribute decision making problem the process of selecting the best financing alternative for the acquisition of a car out of the following financial alternatives: bank loan, financial leasing, rates or even paying cash, although mostly unlikely. The problem was then solved using the TOPSIS, ELECTRE I and ONICESCU methods and several conclusions were drawn from the analysis.

Keywords: multi-attribute decision making, financing, acquisition

1. Introduction

In the context of financial crisis, when searching for the best financial alternative is quite vital, it is really appropriate to optimize the decision process, while taking into consideration multiple

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conflicting attributes. That is why, in this paper we focus on a multi-attribute decision making (MADM) approach for the process of selecting the best financing method. For exemplification, we chose the case of an automobile acquisition, for which, the available financial alternatives are the following: to apply for a bank loan, to solicit a financial leasing or to pay rates. The alternative of paying cash was also considered, even though it is less likely to occur since in most cases the buyer of an expensive good does not have the entire amount of money to pay cash or does not want to spend the entire sum on the acquisition of that good. However, this financial alternative was also taken into discussion, mostly in order to highlight the amount of tax savings of the other financial methods in comparison to paying cash.

The paper is structured as follows. The MADM problem for selecting the best financing method for the acquisition of an automobile is modelled in section 2, followed by the results of the TOPSIS, ELECTRE I and ONICESCU methods in Section 3. Finally, the conclusions are presented in section 4.

2. Modelling the financial multi-attribute decision problem

In our analysis, we considered the case of a small or medium sized VAT payer company, searching for the best financial alternative in order to acquire a 15.000€ automobile, out of the following alternatives: applying for a bank loan or for a financial leasing, paying rates or paying cash. In order to have a common basis of comparison of the four financial methods, we assumed that both the bank loan, the leasing and the rates payment are carried on the same 3 year period, implying that the total costs of the three alternative funding sources have to be updated in order to be comparable to the cash payment alternative. For the same comparison purpose, we also decided that in the case of the leasing transaction the residual value should be included in the monthly rates, although choosing a residual value up to 20% of the contract value is usually one of the leasing

advantages, since this value is only payable by the end of the financial leasing contract, generating a lower level of monthly rates, but also a higher risk for the leasing companies.

The first step in modelling the financial decision problem of the small or medium sized firm consists in identifying the main features of the four financing alternatives. The characteristics were summarized in the following table.

Table 1. Main features of the financing methods

Main features	Financial Leasing	Bank loan	Rates	Cash
Payment in advance (%)	20%	20%	40%	100%
Interest	9,5%	7,5%	9,5%	0%
Duration	3 years	3 years	3 years	present
Commission	2%	1,5%	0%	0%
Feasibility study expenses	0	100 €	0	0
CASCO Insurance	4%	4%	4%	4%
Property Insurance	0%	0,05%*2*(Price-Payment in advance)	0,05%*2*(Price-Payment in advance)	0%
Insurance for no-payment	0%	0%	2,5%	0%

The second step consists in deciding upon the most relevant decision criteria for the financial problem. The following 6 criteria were selected to be most significant in the financing alternatives selection problem of an automobile buyer:

C1= Total Actualized Net Cost

C2= Difficulties in the financing process

C3= Payment in advance

C4= Extra facilities

C5= Ways of paying VAT

C6= Property rights

Out of them all, the financing cost criterion is by far the most important one in this decision process. However, since the classical consideration of the financing cost as being represented only by the purchasing price is too rudimentary, we decided to broaden the analysis, by also taking into consideration the different types of expenditures each financing method implies, such as commissions, Value Added Tax (VAT) and insurance costs, as well as the amount of tax savings. In order to do that, we made use of a more elaborated method for calculating the financing cost that is known as the Total Actualised Net Cost. [1]

The second criterion refers to the nature of the difficulties implied by each financial source. For instance, when applying for a bank loan, the process can often get very complicated, because of the banks requirements for funding guarantees and several creditworthiness proofs of the potential customers. However, in the case of a leasing contract or of rates payment, there are a few less documents solicited to be provided by the potential customer, making the financing process easier.

As for the third criterion, the amount of money that has to be paid in advance might imply a too high financial effort for the potential buyer in case the buyer does not have that sum of money.

Moreover, a potential buyer should also take into account if any extra facilities are being offered by a particular financing source. For instance, unlike other methods of financing, a financial leasing contract actually offers a package of integrated services, consisting in the fact that after contracting, the leasing companies take full responsibility on insurance services, import operations as well as registration of the vehicles.

The fifth criterion highlights the benefits of paying the VAT in stages. Unlike a bank loan financing or cash payment, that requires a full VAT payment at the moment of automobile acquisition, leasing operations, as well as rates payment allow deferred payment of VAT

together with the monthly rates, implying less financial effort when starting the lease contract or the rates payment.

However, the buyer should also be aware of the fact that when contracting a financial leasing, the property rights are only given at the end of the contract, right after the payment of the residual value, in comparison to the rest of the financing methods, in which the change of property rights from the supplier to the buyer coincides with the moment of asset acquisition.

The third step in modelling the financial decision problem as a MADM problem consists in building the consequences matrix that can be summarized in the form of a matrix, in which there are m rows, representing different alternatives and n columns, representing the criteria specifying the properties of the alternatives. Using the 4 financing methods, as well as the 6 decision criteria, we were able to build the consequences matrix presented below.

Table 2. The initial consequences matrix of the MADM problem

	C1	C2	C3	C4	C5	C6
Financial Leasing	16.583	high	20%	YES	Monthly	postponed
Bank loan	16.615	very high	20%	No	Integral at start	instant
Rates	17.156	high	40%	No	monthly	instant
Cash	17.040	none	100%	No	Integral at start	instant

We first notice that the attributes of the second, the forth, the fifth and the sixth decision criteria are all qualitative. In order to be transformed to quantitative attributes according to each cost or benefit criteria, different numerical scales were used. Thus, the consequences matrix has been rewritten in the following form:

Table 3. The final consequences matrix of the MADM problem

	C1 (min)	C2 (min)	C3 (min)	C4 (max)	C5 (max)	C6 (max)
Financial Leasing	16.583	2	20%	1	1	0
Bank loan	16.615	3	20%	0	0	1
Rates	17.156	2	40%	0	1	1
Cash	17.040	0	100%	0	0	1

The forth step consists in deciding upon the degree of importance of each decision criterion. Since in most cases it is quite difficult to determine precisely the exact value of the degrees of importance of each criterion under incomplete information and uncertainty, their values were treated as triangular fuzzy numbers [2,4], for which different membership functions transformations were used. We considered five degrees of importance, described by membership functions belonging to various intervals of length of 0.25 or 0.3. For example, the fuzzy variable expressing a very low importance of the criteria was assigned a triangular fuzzy number with minimum value 0, maximum value of 0.25 and a 0.1 mode. The triangular numbers are presented in the following table:

Table 4. The triangular numbers

Degree of importance	Code	Mark	Membership function
<i>Very low importance</i>	(FS)	1	(0.0;0.1;0.25)
<i>Low importance</i>	(S)	2	(0.15;0.3;0.45)
<i>Medium importance</i>	(M)	3	(0.35;0.5;0.65)
<i>High importance</i>	(R)	4	(0.55;0.7;0.85)
<i>Very hih importance</i>	(FR)	5	(0.75; 0.9; 1.0)

The membership functions of the triangular fuzzy numbers used for determining the importance of the criteria are shown in the figure below.

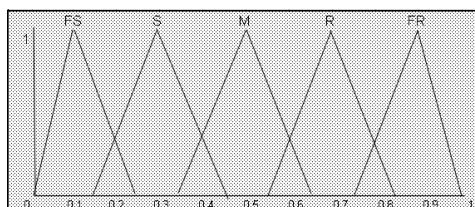


Fig.1. Membership functions of triangular fuzzy numbers

Using these fuzzy transformations, we attached the following degrees of importance to the 6 criteria of the MADM problem, that were later on defuzzified and normalized and presented in the next table.

Table 5. The importance coefficients

	C1	C2	C3	C4	C5	C6
Importance coefficients	FR	M	FR	S	S	M
Importance coefficients after defuzzification	0.88	0.5	0.7	0.3	0.12	0.3
Importance coefficients after normalization	0.31	0.18	0.25	0.11	0.04	0.11

3. Results of the analysis

After allowing the presence of uncertainty in the decision process, by attaching the normalized defuzzified importance coefficients of the criteria to the consequences matrix presented in table 3, we then solved the buyers' financing selection problem based on 3 most adequate MADM methods. We therefore applied the TOPSIS, ELECTRE I and the ONICESCU methods [3] for which we shortly summarize the main steps.

In case of the **TOPSIS** method we had to:

- build the weighted normalized matrix $V = (v_{ij})$
- identify the ideal positive V^* and negative V^- solutions
- calculate the distance between the alternatives and the V^* and V^- using Euclidian distance
- calculate the closeness coefficient from the ideal solution C_i^* , based on which the final ranking was determined.

When using the **ELECTRE I** method we:

- built the weighted normalized matrix $V = (v_{ij})$
- identified the concordance and discordance matrix
- identified the best solution based on the number of dominated alternatives by each alternative

In case of using the second version of **ONICESCU** method we:

- calculated the importance criteria based on the formula $p[j] = \frac{1}{2^k}$, in which: $k=1$, for the most important criterion;

$k=2$, for the second most important criterion and so on, reaching the following vector:

$$p = \left(\frac{1}{2^1}, \frac{1}{2^3}, \frac{1}{2^2}, \frac{1}{2^4}, \frac{1}{2^5}, \frac{1}{2^4} \right)$$

- calculated the function $f(F_i) = \sum_{j=1}^6 p[j] \cdot 2^{-loc(oa_{ij}, C_j)}$ for each alternative, in which $loc(oa_{ij}, C_j)$ represents the ranking value of alternative oa_{ij} relative to criterion C_j .
- ordered the alternatives based on the function values.

Based on the 3 MADM methods we obtained the following rankings of the alternatives, as presented in table 6, in which between brackets are the closeness coefficients in case of TOPSIS method and the function values in case of ONICESCU method.

Table 6. Ranking of the financing sources

	TOPSIS	ELECTRE I	ONICESCU
Rank 1	A1 (0,67)	A1	A1 (0,47)
Rank 2	A2 (0,53)	A4 or A3 or A2	A2 (0,32)
Rank 3	A3 (0,52)	A4 or A3 or A2	A4 (0,21)
Rank 4	A4 (0,40)	A4 or A3 or A2	A3 (0,19)

As we can simply see, all three methods of MADM problems with fuzzy importance coefficients indicated that the unique best solution to the financing selection problem of a potential buyer of an automobile consists in purchasing the car through a financial leasing transaction. Both TOPSIS and the ONICESCU methods further identifies the bank loan alternative as the second best one, while the ELECTRE I method finds it indifferent between the remaining alternatives, indicating that there is less variance between each other.

4. Conclusions

The study indicates that most expensive financial means from the total actualized net cost perspective are cash and rates payment, since they offer less tax savings and most financial effort based on large

amount of money payable in advance. At the other pole one can find the leasing transaction and the bank loan. Although the best financing alternative for the automobile acquisition seems to be the leasing transaction for this study when judging from a multi-attribute perspective, we can still say that the advantage of leasing over all the other forms of car acquisition consists not so much in its cost, which is very similar to the bank loan, but mostly in the additional services that are offered in a lease transaction, although the property rights are only obtained by the end of the contract.

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