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How to Choose the Best Investment Project - Multicriterial Approach

The choice of the best investment project is a typical problem which requires the use of multicriterial analysis. This paper presents one of the possible ways of such choice from the set of 15 investment projects mostly done for the so called "small enterprises". The final choice i.e. the final rank of the projects is carried out by the combination of the two methods for multicriterial decision making, the analytic hierarchy process and PROMETHEE method.

Key words: investment projects, multicriterial analysis, AHP, PROMETHEE.

1. Introduction

The selection of one or a group of the best (the most profitable) investment projects from a set of proposed or possible ones is a long-established task which is getting more relevant in Croatia after the introduction of new economic relations tending to be increasingly market-oriented.

Most frequently a "professional" analysis of such a task was reduced to the fact that the investor knew in advance what he wanted to do and then he looked for experts to justify such investment and present it as profitable or socially useful. Such analysis signed by professionals was a ticket for financial support provided by banks or the government. Such procedure need not be criticized in detail since we are surrounded by the consequences of such decisions.

Therefore let us consider a slightly different approach. No matter whether the investor is an individual, the government, or an institution willing to help (and to profit) financing some investment projects, the selection of the best project is a classical problem of multicriterial decision making. The questions posed by that problem emerge from the choice or relevant criteria, and finally from selection of suitable methods which can take into account all these criteria and provide us with a final result: the rank of all the proposed project and the selection of the best one. Thus encouraged by an expert analysis we shall be ready to invest into the best project with greater sequrity.

This paper will present a combination of methods in multicriterial decision making as one of the most suitable methodologies for such task. It is the combination of the analytical hierarchy process (AHP) and the PROMETHEE method. Both methods have been widely used in a series of multicriterial decision making problems, the AHP even more so, especially in the USA, while the PROMETHEE has been used mainly in Europe. In a way they represent mutually competitive "products" and each one has its own advantages. Each one has its weaknesses as well, but they will not be discussed here. We shall rather endeavor to put the advantages of both methods to food use in order to select the best project. Both methods have fairly strong and "user friendly" software support, Expert Choice program for the AHP and Promcalc for the PROMETHEE, which makes their use easier and provides a ermarkably good visual presentation and communication with the decision maker.

2. PROMETHEE and AHP

In this section we briefly outline the PROMETHEE method and the AHP which are used to rank all the proposed projects. The PROMETHEE method is appropriate to treat the multicriteria problem of the following type:

$$\text{Max}\ \{f_1(a), \ldots, f_n(a) | \varepsilon A\} \tag{1}$$

where K is a finite set of possible actions (here investment projects) and if, are n criteria to be maximized. For each action, if (a) is an evaluation of this action. When we compare two actions a, b, e K we must be able to express the result of this comparisons in terms of preference. We therefore consider a preference function P

$$P : K \chi K \rightarrow [0,1] \tag{2}$$

representing the intensity of action a with a regard to action b. In practice this preference function will be a function of the difference between the two evaluations d = f(a) - f(b), and it is monotonically increasing. Six possible types (for details see |1| and |2| of this preference function are proposed to the decision maker. The effective choice is made interactively be the decision maker and the analyst according to their feeling of the intensities of preference. In each case zero, one or two parameters have to be fixed:

- q is a threshold defining an indifference area;
- p is a threshold defining a strict preference area;
- s is parameter the value of which lies between *p* and *q*.

Now we can define a preference index

$$\Pi(a,b) = \Sigma_{j=1,n} w_j P_j(a,b) \quad (3)$$

where w_i are weights associated with each criteria.

Finally, for every a e K, let us consider no the two following outranking flows:

- leaving flow $F^+(a) = S_{beK} P(a,b)$ (4)

- entering flow $F^-(a) = S_{beK} P(a,b)$ (5)

The leaving flow F^+ (a) is the measure of the outranking character of a (how a dominates all the other actions of K). Symmetrically, the entering flow F^- (a) gives the outranked character of a (how a is dominated by all the other actions). The action is better if the leaving flow is higher, and the entering flow lower. the PROMETHEE I gives a partial preorder of the set of actions in which some actions are comparable and some others are not. When the decision maker is requesting a complete ranking, the net outranking flow may be considered:

$$F(a) = F^+(a) - F^-(a) \quad (6)$$

and the higher the net flow, the better is the action. All the actions of K are now completely ranked.

The Analytic Hierarchy Process (AHP) is one of the most outstanding multicriteria decision making approaches. It employs a method of multiple paired comparison of attributes (criteria) to rank order alternatives. In this paper we use AHP for ranking the criteria, e.g. for determining the weights of the criteria which we need for PROMETHEE procedure.

In AHP multiple paired comparisons is based on a standardized evaluation scheme (1 = equally important; 3 = slightly more important; 5 = much more important; 7 = ery much more important; 9 = absolutely more important). The result of the pairwise comparisons on *n* elements can be summarized in a (nxn) evaluation matrix A in which every element a_{ij} is the quotient of weights of the criteria, e.g. $a_{ij} = w_i / w_j$ whereby small errors in consistency of judgments are acceptable. In a further step the largest eigenvalue of the evaluation matrix has to be determined. If no errors in judgment exist, the relation Aw = nw, or (A-n/w = 0, holds, where *w* is the vector of *n* evaluation weights w_i. This is a system of homogenous linear equations which has a nontrivial solution if the determinant (A-nl) vanishes, thus indicating that *n* is eigenvalues of A except one are zero.Small errors in judgment lead to smallperturbations of the coefficients of the matrix A and its eigenvalues as well. The basic relation for the eigenvalue of the matrix $A'w' = l_{max} w'$, where l_{max} is the largest eigenvalue of the matrix A'. It can easily be seen that $l_{max} \geq n$ (see [8] Theorem 7.). The difference l_{max} - n can therefore be used as a consistency index, where consistency is defined by the relation between the entries of A : a_{ij} a $_{ik}$ = a_{ik}. If the average deviation (difference l_{max} - n) / (n-1) exceeds a predetermined value (e.g. 0.1) the evaluation procedure has to be repeated to improve consistency.

3. Problem formulation and solution

The selected methodology will be presented on the example of choice among 15 investment projects designed mainly for private enterprise. The choice could have been even wider, but we considered this group of projects to be sufficient for a valuable presentation of the selected methodology. The presented projects are heterogeneous, which can be seen from their evaluation in terms of the chose criteria, the size of investment, playback period, risk etc. The presented methodology will best display its advantages on such a "badly structured" set. We shall assume that all the proposed projects comply with legal and other regulations, and that it is possible to get a license for all of them including land or maritime concessions.

The chosen projects are:

P1 - Chain of small ice-houses,
P2 - School for foreign languages,
P3 - Production of synthetic cord,
P4 - Yachting services,
P5 - Production of perlit,
P6 - Production of Styrofoam sheets,
P7 - Sea - bass farm,
P8 - Fish market.
P9 - Production of vermiculite,
P10 - Production of gypsum,
P11 - Production of plastic bags,
P12 - Production of steel screws,
P13 - Tourist seaplane,
P14 - Production of plastic pipes,
P15 - Production of plastic goods,

Detailed descriptions of these projects will not be included in this paper. Each of these projects has been provided with a detailed financial analysis of costs and expected income i.e. that net capital glow necessary for the first group of criteria to be used in the selection of the best project. It is the financial criterion group comprising five basic most paybaack period (PP), profitability index (PI) return on assents (ROA) and internal rate of return (IRR).

Which of these indicators is to be used for further analysis and which ones are to be neglected, has been an everlasting issue. Numerous analyses made in USA in a number of large firms have not answered that question, nor have they stated which of these indicators is the best one, or when an individual indicator is to be used.

As it can be seen from the title of this paper, we have decided for multicriterial analysis and thus have taken all the five criteria into consideration. Naturally, another question is here immediately imposed: Are al these criteria equally important, and if not, what is their relative importance?

That is the point where we are helped by the AHP, one of the methods that has been particularly designed to answer that kind of questions. We chose a group of 20 experts, most of whom had taken part in the design of proposals for these projects, and we set off into painwise comparisons of these indicators. Each expert answered $\binom{5}{2}$ different questions like: How much more important is for you the.

NPV than IR within the group of financial criteria in terms of the best project selection. Taking the geometric means of these evaluations, we employed Expert Choice, or rather, a part of it, and we got the following relation of importance of financial criteria, i.e. the appropriate wight of these criteria (the sum of weights equals 1):

NPV - 0,256,
PI - 0,338,
IRR - 0,187,
PP - 0,132,
ROA - 0,088.

The great importance of profitability index was surprising even for us, while the fairly big weight of NPV was expected due to the popularity this indicator enjoys with financial theoreticians. However, in this paper we shall not go into more detailed explanation of these evaluations.

The procedure of multicriterial analysis has thus begun. However, induced by some experts dealing with investment projects, we concluded that some other criteria have to be taken into consideration as wall. Consequently we got the following two groups: criteria of reject risking and environmental criteria. The question of project risk would require further work on evaluation of possible economic situations and an extraordinary detailed analysis of each project in every one of these possible situations. therefore we decided to focus on only one, the risk indicator most frequently used, the so called sensitivity analysis (i.e. on investment cost change and anticipated income chante). In that way we got them into five risk groups: very stable, stable, average risky, risky and extremely risky. The importance of these two indicators within the risk group remained identical, i.e. each indicator got an equal weight.

The group of ecological criteria has attracted our special attention. Namely all the proposed projects comply with necessary environmental minimums and we were wondering whether to consider that group of criteria al all. Still, due to the basicpurpose of this paper, and that is methodology presentation, we decided to include these criteria as well, because an investor, who is not necessarily an individual, but possibly a community, may want to favor those projects which endanger human environment to a lesser degree. In agreement with experts we chose two criteria (with equal weight): threat to air and water quality (ECO1), and threat to floral and animal species (ECO2). In terms of these criteria the projects were subdivided into four groups: not threatening, mildy threatening, threatening and very threatening.

In that way the decision matrix was provided, i.e. the initial set of 15 projects evaluated according to 9 different criteria. It is obvious that the application of any of the method requires the relative importance of these three criterion groups, i.e. the weight by which they contribute to the basic objective - the selection of the best investment project. Here the financial criterion group outweighed the rest and we got the following results:

financial criteria	- 0.663,
risk criteria	- 0.207,
ecological criteria	- 0.129.

Normalizing these weights we got the final set of weight for all the nine criteria:

NPV - 0.170, PI - 0.224, IRR - 0.124, SA-C - 0.104
PP - 0.087, ROA - 0.058, SAI - 0.104, ECO1 - 0.065,
ECO2 - 0.065

In that way we formed a comlete decision matrix and weights for all criteria. The next question was only whether to go on using the AHP or take another course of action. The tedious procedure required by the AHP for further comparisons, i.e. judgment of project pairs according to all the 9 criteria and asking each expert $\binom{15}{2}$ questions in terms of each criterion, i.e. $105 \cdot 9 = 945$ for all the nine criteria, made us decide for the PROMETHEE method. We remark that within the Expert Choice program there was still possibility to use the so called "ratings" option, but we estimated that the PROMETHEE could also answer the question about the best project class.
programe there was still the possibility to use the so called "ratings" option, but we estimated that the PROMETHEE could also answer the question about the best project class.

Naturally, this decision required an additional activity, the choice of one among the 6 criterion types proposed by the PROMETHEE method and selection of indifference and preference thresholds for each of these criteria. In agreement with experts we defined the parameters as well and got the final input table for the PROMETHEE method. Let us state that we naturally had to transform the last four qualitative criteria into numerical indicators as well, so we did it too, giving them marks from 1 to 5 in the sense "the lesser, the better". The input data for the PROMETHEE method are shown in the table 1.

The output results shown in figure 1. displaying the partial preorder for the best 12 investment projects. It is obvious that three projects P3-cords, P12-screws and P5-perlit represent class of the most desirable projects in terms of the PROMETHEE I method), and they represent a group of profitable projects which in any case should be supported and realized.

The table 2. displays positive and negative flows from the PROMETHEE method, and here we have to remark that the alternative is the better the higher its leaving flow is, or respectivelly the lower its entering flow is. the last column of the table shows the complete preorder of all the projects based on the difference between the positive and the negative flows. It can be seen that the minimal advantage between the three best projects belongs to project P3- cord, P12.screws holds the second position, and P5-perlit holds the third position.

Table 1.: Input data for PROMETHEE

The PROMCALC Spreadsheet

Criteria	C 1	C 2	C 3	C 4	C 5
Name	NPV	PP	PI	ROA	IRR
Min/Max	max	min	max	max	max
Type	5	3	3	5	5
Weight	17.00	8.70	22.40	5.80	12.40
Actions					
A 1 ICE-HOUSES	562.21	1.69	4.02	52.26	60.03
A 2 LAN.SCHOOL	43.10	3.12	1.70	20.12	26.45
A 3 SYNTH.CORD	2146.53	1.16	5.68	100.25	99.50
A 4 YAHT.SERV.	237.05	2.64	2.14	29.20	35.00
A 5 PERLIT PR.	10253.00	0.94	4.23	89.10	104.00
A 6 STYROFOAM	778.80	2.86	1.44	17.50	24.10
A 7 BASS FARM	437.50	4.68	1.46	17.60	16.40
A 8 FISHMARKET	6419.50	2.27	4.76	30.80	40.10
A 9 VERMICULIT	672.70	2.66	1.60	21.90	28.70
A10 GYPSUM PR.	1747.30	3.28	1.18	11.40	16.90
A11 PLAST.BAGS	2994.60	1.77	4.15	64.30	64.10
A12 ST. SCREWS	726.80	1.27	7.45	125.80	103.50
A13 T.SEAPLANE	223.80	4.55	1.22	9.50	14.60
A14 PLAS.PIPES	2416.90	2.73	3.85	59.30	54.70
A15 PLAS.GOODS	162.60	2.76	1.82	23.70	32.30

Criteria	C 6	C 7	C 8	C 9
Name	SA-T	SA-C	ECO1	ECO2
Min/Max	min	min	min	min
Type	4	4	3	3
Weight	10.40	10.40	6.50	6.50
Actions				
A 1 ICE-HOUSES	2.00	3.00	2.00	1.00
A 2 LAN.SCHOOL	5.00	5.00	1.00	1.00
A 3 SYNTH.CORD	1.00	1.00	3.00	2.00
A 4 YAHT.SERV.	4.00	4.00	4.00	3.00
A 5 PERLIT PR.	1.00	3.00	3.00	2.00
A 6 STYROFOAM	4.00	4.00	2.00	3.00
A 7 BASS FARM	4.00	5.00	2.00	2.00
A 8 FISHMARKET	2.00	4.00	4.00	2.00
A 9 VERMICULIT	4.00	3.00	3.00	2.00
A10 GYPSUM PR.	5.00	5.00	4.00	4.00
A11 PLAST.BAGS	2.00	2.00	3.00	2.00
A12 ST. SCREWS	2.00	2.00	2.00	1.00
A13 T.SEAPLANE	5.00	5.00	2.00	2.00
A14 PLAS.PIPES	4.00	2.00	3.00	3.00
A15 PLAS.GOODS	4.00	4.00	3.00	3.00

F1 : Help - F7,F9 : Actions - F8,F10 : Criteria - Ins - ESC : Stop

Figure 1.: PROMETHEE I partical ranking

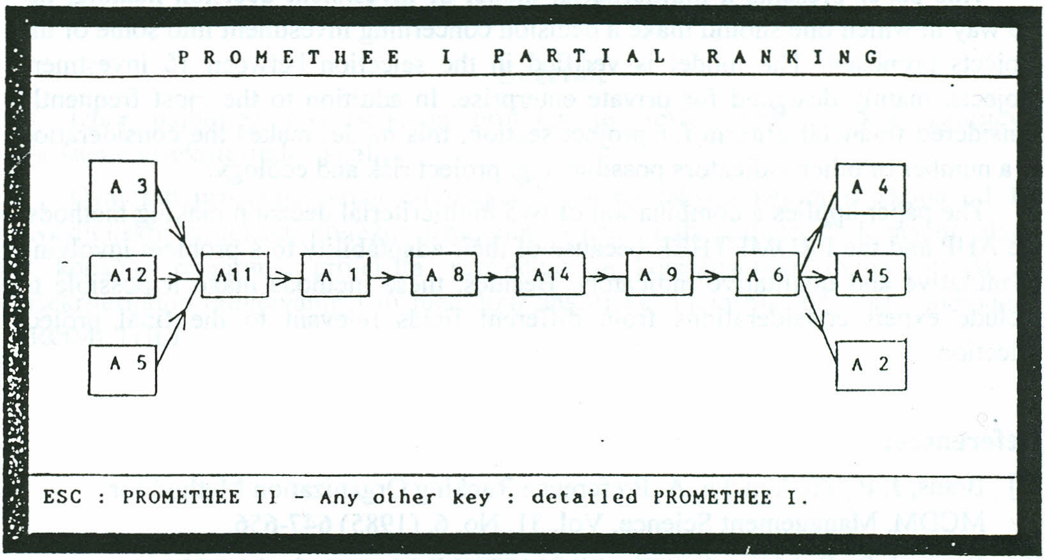

Table 2: PROMETHEE flows

P R O M E T H E E   F L O W S

Action		Phi+	Rank	Phi-	Rank	Phi	Rank
A 1	ICE-HOUSES	0.511	5.0	0.202	5.0	0.309	5.0
A 2	LAN.SCHOOL	0.122	11.0	0.533	12.0	-0.411	12.0
A 3	SYNTH.CORD	0.723	1.0	0.085	2.0	0.639	1.0
A 4	YAHT.SERV.	0.142	10.0	0.485	11.0	-0.343	10.0
A 5	PERLIT PR.	0.672	3.0	0.076	1.0	0.596	3.0
A 6	STYROFOAM	0.149	9.0	0.443	9.0	-0.294	9.0
A 7	BASS FARM	0.088	14.0	0.555	13.0	-0.467	13.0
A 8	FISHMARKET	0.501	6.0	0.220	6.0	0.282	6.0
A 9	VERMICULIT	0.184	8.0	0.389	8.0	-0.205	8.0
A10	GYPSUM PR.	0.120	12.0	0.592	14.0	-0.472	14.0
A11	PLAST.BAGS	0.601	4.0	0.135	4.0	0.466	4.0
A12	ST. SCREWS	0.705	2.0	0.088	3.0	0.618	2.0
A13	T.SEAPLANE	0.040	15.0	0.626	15.0	-0.586	15.0
A14	PLAS.PIPES	0.481	7.0	0.239	7.0	0.242	7.0
A15	PLAS.GOODS	0.108	13.0	0.481	10.0	-0.372	11.0

4. Conclusion

This paper presents a multicriterial model of investment decision making, i.e. the way in which one should make a decision concerning investment into some of the projects proposed. The model is verified in the selection between 15 investment projects, mainly designed for private enterprise. In addition to the most frequently considered financial criteria for project section, this model makes the consideration of a number of other indicators possible, e.g. project risk and ecology.

The paper applies a combination of two multicriterial decision making methods: the AHP and the PROMETHEE because of their adaptability to a problem involving quantitative and qualitative indicators. Besides, these methods make it possible to include expert considerations from different fields relevant to the final project selection.

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Plazibat N., Babić Z. Kako odabrati najbolji investicijski projekt
- višekriterijalni pristup

Sažetak

Izbor najboljeg investicijskog projekta je tipičan problem koji zahtijeva korištenje višekriterijalne analize.

Ovaj rad prikazuje jedan od mogućih načina takvog izbora iz skupa od 15 investicijskhi projekata, pretežno izrađenih za tzv. "mala poduzeća". Konačni izbor, tj. konačno rangiranje projekata, provedeno je kombinacijom dviju metoda za višekriterijalno odlučivanje i to metodom analitičke hijerarhije procesa i metodom PROMETHEE.