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Research Paper

Application of Fuzzy Logic to Capital Budgeting Decisions; Case Study Research

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ABSTRACT: *This paper presents a model for capital budgeting decisions made by corporations.Capital budg eting decisions are based on various methods: NPV, IRR, MIRR, payback period, discounted payback period, et c. There hasn't been any model in capital budgeting decisions which takes multiple methods into consideration until now. Fuzzy logic is a superset of Aristotle's logicwhich has been enlarged to manage the concept of partia l truth-truth values between "completely true" and "completely false". As its name expresses, it is the logic bas ed onway of reasoning which are approximate rather than exact. In the research, we have defined one fuzzy out put (quality of investment) and three fuzzy inputs: net present value, internal rate of return, modified internal rat e of return.*

Keywords: *NPV, IRR, MIRR, fuzzy input, fuzzy output.*

I. INTRODUCTION

Capital budgeting is the process by which the businesses define how to invest their capital. The differen t methods are used in capital budgeting decisions. They are divided into two groups: discounted cash flow based methods and non-discounted cash flow based methods. The NPV, MIRR, IRR and discounted payback period a re most frequently employed in the evaluation of investment projects. Actually, the decisions made by businesse s are based on a single indicator. However, there are some situations where conflict of NPV and IRR, NPV and MIRR, MIRR and IRR methods occurs when they produce opposite results. We have applied fuzzy logic into ca pital budgeting decisions to join the methods into a single IRR_MIRR_NPV method. NPV is the value which is calculated by the difference between discounted cash inflows and outflows at given cost of capital. If the NPV is greater than or equal to 0, this investment project should be accepted. IRR is the rate in which net present value of investment is equal to 0. If IRR is greater than the given cost of capital, the investment project should be acce pted. MIRR is the rate which makes future value of cash flows equal to the present value of cash flows where ca sh inflows are reinvested.

II. LITERATURE REVIEW

Fuzzy Logic was introduced in 1965 by Lotfi A. Zadeh, professor at the University of California in Ber keley. Fuzzy Logic is a logic which allows intermediate values to be defined between conventional evaluations l ike true/false, good/bad, etc. Concepts like bad or very good can be quantified mathematically and processed by smart computers, for applying human-like way of thinking in the programming.

In capital budgeting decision making, the methods sometimes produces opposite results. These types of problems have been investigated by many researchers including: Brealey, Myers, Marcus, Blank, and Brigham. However, it has not been studied effectively yet.

III. ANALYSIS OF CAPITAL BUDGETING METHODS

3.1 Comparison Of The Methods

Hypothetically, the Mati Company has 5 different capital projects. All the projects require initial invest ment which is in range from $8933 to $11744. In table 1, the values at time t_0 represents the initial investment. It is presupposed that all projects will generate some revenues in next 9 years. All the values related to cash flows were randomly generated via Excel's "randbetween" function. Intentionally, the values have been manipulated t o create the case in which NPV, IRR, and MIRR results are relevant to our decision. The given table represents t he data on cash flows for five individual projects.

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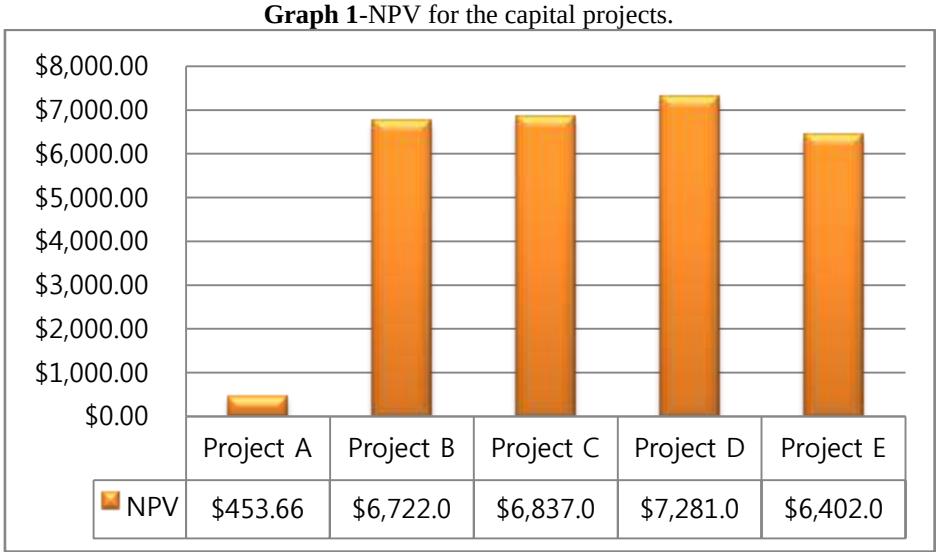
Table 1-Cash flows from the capital projects

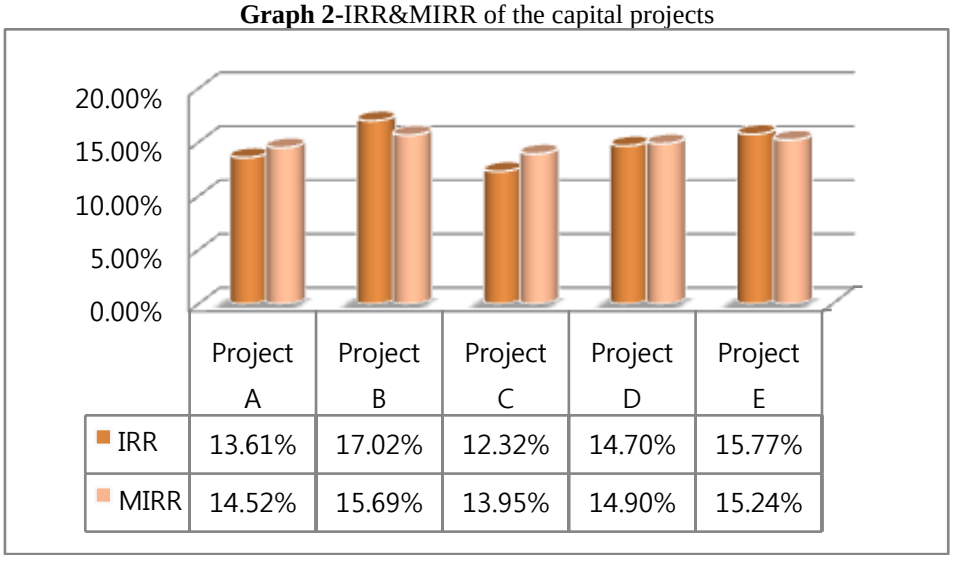
Years/Projects	Project A	Project B	Project C	Project D	Project E
0	-11081.00	-8933.00	-11744.00	-11559.00	-10878.00
1	4352.00	4769.00	3190.00	4724.00	5441.00
2	3039.00	1606.00	2671.00	3232.00	3066.00
3	2010.00	1080.00	2876.00	1505.00	1462.00
4	1015.00	1149.00	1932.00	1545.00	1165.00
5	1721.00	1459.00	1709.00	1795.00	1461.00
6	1145.00	1003.00	1388.00	1658.00	1259.00
7	1378.00	1895.00	1468.00	1340.00	1212.00
8	1537.00	1398.00	1598.00	1495.00	1115.00
9	1121.00	1296.00	1749.00	1546.00	1099.00

Accepting the cost of capital as 12%, and reinvestment rate as 10%, we have calculated the net present values, I RR and MIRR of the projects. According to the graph 1, all the projects have positive net present values. In addi tion, IRR of all the projects is greater than cost of capital. Modified internal rate of return is also greater than the cost of capital for all projects.

Graph 1-NPV for the capital projects.



Graph 2-IRR&MIRR of the capital projects



3.2 Defining fuzzy variables

In the model, we have defined "quality of investment" as an output variable. Input variables are net pre sent value (NPV), internal rate of return (IRR), and modified internal rate of return (MIRR). Fuzzy output variab le assesses the level of quality of investment decision for the projects. It is supposed that quality of investment c an be "Low", "Normal" and "Good". Quantification of the scores for output variable is in range from 0 to 10. Fi rst fuzzy input variable is the net present value of projects which is the most common method used by finance m

anagers when evaluating the capital budgeting decisions. It is supposed that NPV can be "Small", "Medium" an d "Large". Quantification of the scores for input variable, NPV is in range from $0 to $7300. Second fuzzy input variable is the internal rate of return for the projects. It is supposed that IRR can be "Small", "Medium" and "La rge". Quantification of the scores for input variable, IRR is in range from 0% to 18%. Third fuzzy input variable is the modified internal rate of return for the projects. It is supposed that MIRR can be "Small", "Medium" and "Large". Quantification of the scores for input variable, MIRR is in range from 0% to 11%.

3.3 Fuzzy Logic

Fuzzy logic is based on fuzzy sets. It enables making decision based on incomplete information, and m odels are based on "if-and-then" rules. When we assume that a = [a*1*, a*2*. . .a*n*] is a vector of features describing any object or state and b = [b*1*, b*2*. . . b*n*] is the vector of output values of a system, the rules are represented in the form: *IF* a_1*is* A_{r1}*AND* a_2*is* A_{r2}*AND...AND* a_n*is* A_{rn}*THEN b1 is* B_{r1},b_2*is* B_{r2}...b_m*is* B_{rm} *where:* $a \in A = a1 \times a2 \times ... \times an$, $b \in B = b1 \times b2 \times ... \times b_m$ *and* $Ar = Ar1 \times Ar2 \times ... \times Arn \subseteq A$, $Br = Br1 \times Br2 \times ... \times Brm \subseteq B$ *are the fuzzy.*

We define algorithms for approximate reasoning in fuzzy logic. Approximate algorithms for proj ects in this paper consists the following rules:

1. NPV is small: if the IRR is low, and MIRR is low, then quality of investment is low.
2. NPV is small: if the IRR is low, and MIRR is medium, then quality of investment is low.
3. NPV is small: if the IRR is low, and MIRR is high, then quality of investment is low.
4. NPV is small: if the IRR is medium, and MIRR is low, then quality of investment is low.
5. NPV is small: if the IRR is medium, and MIRR is medium, then quality of investment is normal.
6. NPV is small: if the IRR is medium, and MIRR is high, then quality of investment is normal.
7. NPV is small: if the IRR is high, and MIRR is low, then quality of investment is low.
8. NPV is small: if the IRR is high, and MIRR is medium, then quality of investment is normal.
9. NPV is small: if the IRR is high, and MIRR is high, then quality of investment is high.
10. NPV is medium: if the IRR is low, and MIRR is low, then quality of investment is low.
11. NPV is medium: if the IRR is low, and MIRR is medium, then quality of investment is normal.
12. NPV is medium: if the IRR is low, and MIRR is high, then quality of investment is normal.
13. NPV is medium: if the IRR is medium, and MIRR is low, then quality of investment is normal.
14. NPV is medium: if the IRR is medium, and MIRR is medium, then quality of investment is normal.
15. NPV is medium: if the IRR is medium, and MIRR is high, then quality of investment is normal.
16. NPV is medium: if the IRR is high, and MIRR is low, then quality of investment is normal.
17. NPV is medium: if the IRR is high, and MIRR is medium, then quality of investment is normal.
18. NPV is medium: if the IRR is high, and MIRR is high, then quality of investment is high.
19. NPV is large: if the IRR is low, and MIRR is low, then quality of investment is low.
20. NPV is large: if the IRR is low, and MIRR is medium, then quality of investment is normal.
21. NPV is large: if the IRR is low, and MIRR is high, then quality of investment is high.
22. NPV is large: if the IRR is medium, and MIRR is low, then quality of investment is normal.
23. NPV is large: if the IRR is medium, and MIRR is medium, then quality of investment is normal.
24. NPV is large: if the IRR is medium, and MIRR is high, then quality of investment is high.
25. NPV is large: if the IRR is high, and MIRR is low, then quality of investment is high.
26. NPV is large: if the IRR is high, and MIRR is medium, then quality of investment is high.
27. NPV is large: if the IRR is high, and MIRR is high, then quality of investment is high.

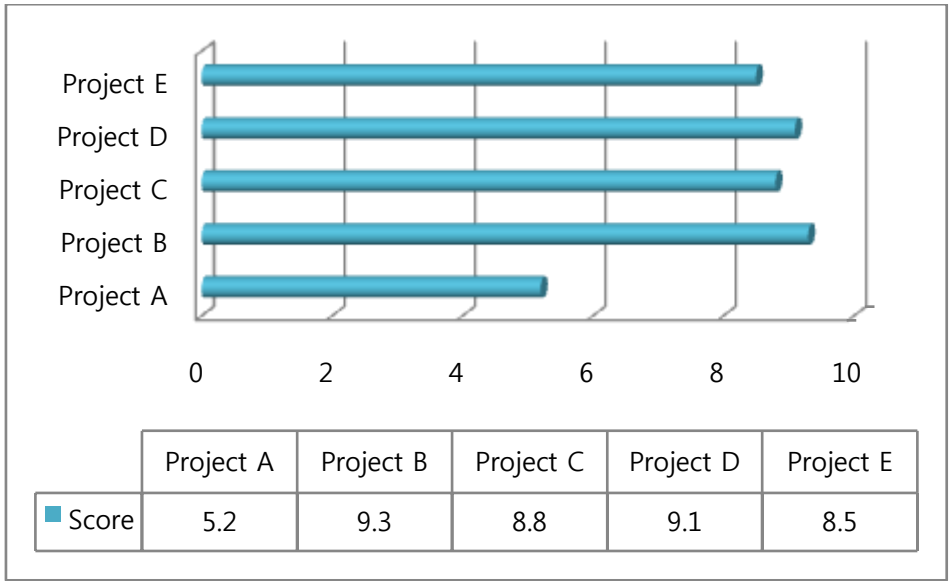
3.4 Defuzzification and results

We have used MATLAB in this project for defuzzification purposes. This is last step in fuzzy logic, wh ich allows formulating aggregation of results from fuzzy sets to a single decision. There are many methods of def uzzification. The most frequently used methods includes: bisector of area, first of maximum, fuzzy clustering def uzzification, random choice of maximum, center of gravity. We have applied COG (center of gravity). It calculat es area under the membership function. The value x^* of the output, which is resulting from the COG method, is given in the following equation. Where the $\mu(xi)$ is membership function. The formula shows that COG calculates the expected value when it is considered to be probability distribution.

$$x^* = \sum_{i=x_{min}}^{x_{max}} x_i \cdot \mu(x_i) \Big/ \sum_{i=x_{min}}^{x_{max}} \mu(x_i)$$

Intentionally, we don't include all the steps in our article. The results of the assessment of the investment quality of the capital projects are shown in the Graph 3.

Graph 3-Final scores for the capital projects.



	Project A	Project B	Project C	Project D	Project E
Score	5.2	9.3	8.8	9.1	8.5

According to the results, Project B is the best choice, and should be invested firstly. The ranking for the project's quality of investment is B, D, C, E, A. These scores are calculated using fuzzy logic which includes thr ee methods based on discounted cash flows.

IV. CONCLUSION

We have applied fuzzy logic into the investment decision making methods. Every method has some we aknesses like; NPV does not show the effectiveness of an investment project, IRR is not suitable for rating the p rojects for their profitability. New applications should be developed to decrease uncertainty and risk of the proje ct. Being first paper in this topic, we have touched only limited sides of the problem. This article presents a new way of modeling and evaluation of the projects based on the following criteria: net present value, internal rate of return, modified internal rate of return using the fuzzy sets theory, which allows solving problems that contain u ncertainty, subjectivity, and ambiguity. This model can be used by analysts to make decisions in related issues.

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