Moderating Risk and Vagueness in the Process of Evaluating NPV using Fuzzy Decision Making

Goran Karanovic,
Teaching Assistant at University of Rijeka,
Primorska 42, p.p. 97, 51410 Opatija, Croatia
gokarano@yahoo.com
Bisera Gjosevska,
Director of the Balkan Institute of Behavioral Research,
D. Stoparevic 21,1000 Skopje, Macedonia,
gjosevska@gmail.com

Abstract: In this paper we provide a fuzzy-based decision making for approximating NPV in the capital budgeting process. Many techniques and models are being used in this process for the purpose of determining risk and vagueness. They are not able to incorporate and value linguistic variables, however. The capital budgeting process has a couple of characteristics, such as the usual long-term cycle and the approximation of many variables, carried out by various managers and having a direct impact on the project's NPV. In order to display the usefulness of fuzzy logic and the valuation of experts expressed through qualitative opinions, i.e. linguistic variables in the process of capital budgeting, a study is presented for the prediction of the Net Present Value of one capital investment project.

Key words: Risk, Vagueness, Capital Budgeting, Fuzzy Decision, Triangular Numbers.

Introduction

Capital budgeting implies a complex process of predicting and anticipating future events that may occur, the probability of their occurrence, as well as planning for how those events will influence the capital budgeting process. A number of authors have studied the complexity of the capital budgeting process and all the risks that can have an impact on the capital investment (Merna and Smith 1996, quoted in Merna and Al-Thani 2005, 15). According to Ehsanifar, Motallebi, & Rezazad (2011), there exist "traditional methods, [that] initially, [and] may be seen as limited… when it comes to uncertainty dimension, nevertheless they are the basis for the development of sophisticated techniques which, at present time, have been used with great success". This subject has been treated by various authors who have conducted studies and examined novel techniques and methods in order to determine the variance of the probabilistic NPV, including, but not limited to Young and Contreras (1975), Zinn et al. (1977) Spahr (1982), Buck and Askin (1986), Tufecki and Young (1987) etc.

Fuzzy logic was first introduced by Lotfi Askar Zaheh (1965) by implementing fuzzy sets theory. With the application of fuzzy set theory to the capital budgeting process Chiadamrong (1999) presented a more efficient way for overcoming fixed-based variables within connected predictions and calculations. What is particularly interesting and meaningful is that fuzzy theory enables an evaluation of someone's opinion expressed through words i.e. linguistic variables. It is a bridge between modern quantitative theory and practical, real-life problem solving. McNeill and Thro contend that "many concepts are better defined by words than by mathematics, and fuzzy logic and its expression in fuzzy sets provide a discipline that can construct better models of reality" (1994, p. 11). It is precisely the valuation of someone's subjective opinion expressed through linguistic variables that may be one of the greatest contributions of fuzzy logic to modern science. As an innovative approach, it offers a new comparative advantage for qualitative variables and is on its way to being established as a standard method for moderating risk and vagueness in the capital budgeting process. The first part of this paper will therefore lay the foundations of triangular fuzzy numbers and fuzzy set theory. The second part will examine the mechanics behind implementing fuzzy decisions on the evaluation of net present value. Part three concludes.

Triangular Fuzzy Numbers and Fuzzy Set Theory

Gao, Zhang and Cao defined that "a fuzzy number is simply an ordinary number whose precise value is somewhat uncertain" (2009). In order to calculate fuzzy logic, many forms of numbers can usually be employed, but triangular fuzzy numbers and trapezoidal fuzzy numbers are the ones most often in use. A triangular fuzzy number represents a set of three possible values, i.e. points and can be presented through real numbers A (a, b, c), where each number ranges between 0 and 1. A triangular fuzzy set can be interpreted as a membership function of $\mu_A(X)$, and the more that their value is closer to unity, the higher the grade of membership of the x in A. The membership function of triangular number is interpreted as:

$$\mu_A(X)=\begin{cases}0, & x<a\\ \dfrac{x-a}{b-a}, & a\le x\le b\\ \dfrac{c-x}{c-b}, & b\le x\le c\\ 0, & x>c\end{cases} \quad 1.1$$

To get a crisp interval from an α -cut operation, it shall be obtained as $\forall\alpha\in[0,1]$ this can be written as:

$$\frac{a^{(\alpha)}-a}{b-a}=\alpha,\qquad \frac{c-c^{\alpha}}{c-b}=\alpha \quad 1.2$$

From where it can be shown by the following expression:

$$a^{\alpha}=(b-a)\alpha+a \qquad c^{\alpha}=-(c-b)\alpha+c \quad 1.3$$

Finally arriving at:

$$X_{\alpha}=\left[a^{\alpha},c^{\alpha}\right] \qquad X_{\alpha}=\left[(b-a)\alpha+a,-(c-b)\alpha+c\right] \quad 1.4$$

The fuzzy set from above represents a collection of related items which belong to the set $\mu_A(X)$ of different degrees. In contrast to traditional set theory, moderate fuzzy set theory allows a partial, i.e. graded belonging to related item, and function values of relation are represented between intervals $[0,1]$ as shown in the following figure:

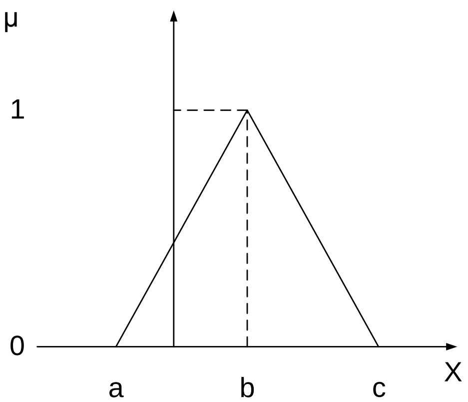

Figure1 Triangular fuzzy number X = (a, b, c)

The comparative advantage for the use of fuzzy logic in the capital budgeting process lies in that fuzzy sets can be described and operated as linguistic variables, i.e. terms used in fuzzy rules. Fuzzy rules are word like tall, high, large, good medium etc. that are fuzzy, i.e. qualitative and not precisely determined. Fuzzy variables can be described as human opinions that are fuzzy or other linguistic opinions and statements which are not precise or exactly measured.

Implementing Fuzzy Decisions in the Evaluation of Net Present Value

The vast majority of scientific research conducted on the matter of capital budgeting and determining the most widely acknowledged methods in the decision-making process of accepting or refusing an investment, emphasizes the importance of net present value and fuzzy logic as one of, if not the most, popular new methods for the decision-making process. The level of net present value depends on various factors, and only excellent cooperation within all division managers inside the company under the direction of the project manager can bring out a successful investment. These various variables that can influence the success of the capital investment have different origins:

- Sale; quantity and type of products sold,
- Price sale; depends on competition, period of year, purchase power, etc.,
- Variable and fixed cost; depends on level of sale and production,
- Cost of capital; it is directly connected to financial leverage, to the state on market, etc.,
- Risks; economic, political, ecological, etc.

Sometimes the financial experts can give different, and every so often, even totally opposite opinions (with great differences—they can move from positive to negative) on the net present value. Thus when a certain financial expert expresses an opinion given by means of a confidence interval, because all calculated NPV contains a certain amount of uncertainty. It should not be forgotten either, that all decisions and calculations are made under great subjective perception, thinking and judgment. According to the Merna and Al-Thani paper, “Subjectivity is a key factor in assessing risk. Whether a problem is perceived in terms of potential gains or losses [it] will not be assessed as a simple mathematical calculation of the problem, but as a subjective fear, often linked to the consequences of outcomes.“ (25-26). To reduce the uncertinty of predicted net present value a company can hire counter experts to reduce risk od just one opinion.

Table 1 Probabilities of the NPV

α	Minimum and maximum presumptions
0	Minimum 200.000
0.1	Low-low
0.2	Medium-low
0.3	Hi-low
0.4	Low-medium
0.5	Medium-medium
0.6	Hi-medium
0.7	Low-high
0.8	Medium-high
0.9	High-high
1	Very high 1.000.000

Table 2 Experts’ Triples

1		,3	,4
2	,6	,9	
3	,3	,5	,7
4	,7	,8	
5	,8	,9	
6		,2	,3
7	,5	,5	,5
8	,3	,6	,9

9	,4	,8	,9
10			,2

In the following case study, a company has proposed the net present value expressed in monetary units from a minimum (200.000) to a maximum (1.000.000). To reduce individual subjectivity, the company has engaged 10 experts, who have expressed their opinion in linguistic form by triples means of confidence with the range $[0,1]$, as shown in Table 2. Afterwards, it is possible to draw up the confidence triples gathering $\underset{\sim}{x}$ for every level $\alpha \in [0,1]$ the number of times that each presumption is repeated. Calculations of presumptions are presented in Table 3:

Table 3 Number of times of presumptions

α	Wors t	Most likely	Best
0	1	1	1
0,1	0,7	1	1
0,2	0,7	1	1
0,3	0,7	0,9	0,9
0,4	0,5	0,6	0,8
0,5	0,4	0,6	0,7
0,6	0,3	0,6	0,6
0,7	0,2	0,5	0,6
0,8	0,1	0,5	0,5
0,9	0	0,3	0,5
1	0	0,1	0,3

Then through a formal matematical precedure it is possible to calculate ε(A) using means of the expected experts' triplets presumtions—x what can be written in modified formulae presented by Gil-Lafuente (2005)

$$\varepsilon(\underset{\sim}{A}) = A_x + (A^x - A_x) \cdot \varepsilon(\underset{\sim}{x})$$

Table 4 Construction of triangular fuzzy numbers on opinions of the experts

α	Worst	Most likely	Best
0	1.000.000,00	1.000.000,00	1.000.000,00
0,1	760.000,00	1.000.000,00	1.000.000,00
0,2	760.000,00	1.000.000,00	1.000.000,00
0,3	760.000,00	920.000,00	920.000,00
0,4	600.000,00	680.000,00	840.000,00
0,5	520.000,00	680.000,00	760.000,00
0,6	440.000,00	680.000,00	680.000,00
0,7	360.000,00	600.000,00	680.000,00
0,8	280.000,00	600.000,00	600.000,00
0,9	200.000,00	440.000,00	600.000,00
1	200.000,00	280.000,00	440.000,00
	534.545,45	716.363,64	774.545,45

In this way, the following triples (534,555; 716.364; 774.546) of the predicted net present value of the observed capital investment should be accepted as the aggregate estimation of the experts' opinions on NPV.

Conclusion

The modern business environment, which thrives on uncertainty and vagueness, needs a new set of financial modeling tools in order to anticipate and control the complexity of the decision-making process. Fuzzy logic offers a solution to the exigencies of the added complexity and subjectivity as it is a byproduct of the inability of classical logic to deal with behavioral biases and conventional rule-of-thumb heuristics present in managerial boardrooms.

The case study presented in this paper offers one more argument in favor of fuzzy logic, as it presents an ideal set of mathematical and logical tools for the calculating and determining of net present value in the capital budgeting process. By using the opinions of financial experts, it reduces imprecision and applies a formal decision-making method to real-life situations. In addition, the vagueness and risk that arise from individual subjectivity responsible for predicting, planning, calculating and decision-making in capital budgeting can be much better understood when using the presented method. Having examined the most commonly used methods for determining net present value by applying fuzzy logic concepts, it can be concluded that implementing capital budgeting decisions in the perpetually changing business world of today should be approached from a completely different angle. Fuzzy logic concepts and triangular fuzzy numbers should be recommended in the decision-making process of management, as they can not only complement, but single-handedly determine the net present value and profitability of a certain investment project.

References:

1. Buck, James R., and Ronald G. Askin. Partial means in the economic risk analysis of projects. Engineering Economics, 31(3) 189-212, 1986.
2. Chiadamrong, Navee. An integrated fuzzy multi-criteria decision making method for manufacturing strategies selection. Computers & Industrial Engineering, 37 (1), 433-436, 1999.
3. Ehsanifar, Mohammad, Farshad Motallebi, and Abbas Rezazad. Classification of Investment Projects Using Fuzzy IF-THEN Rules. American Journal of Scientific Research, July, 95-99, 2011.
4. Gil-Lafuente, Anna Maria. Fuzzy Logic in Financial Analysis. 175, Berlin: Springer-Verlag, 2005.
5. Merna, A., and N.J. Smith. Projects Procured by Privately Financed Concession Contracts. Asia Law & Practice (1-2), 1996. Quoted in Merna, Tony, and Faisal F. Al-Thani. Corporate Risk Management: An Organisational Perspective. Chichester: John Wiley & Sons Ltd, 2005.
6. Merna, Tony, and Faisal F. Al-Thani. Corporate Risk Management: An Organisational Perspective. Chichester, John Wiley & Sons Ltd, 2005.
7. Spahr, Ronald W. Basic uncertainty in capital budgeting: Stochastic reinvestment rate. Engineering Economics 27(4), 275-289, 1982.
8. Tufekci, Suleyman, and D. B. Young. Moments of the present worths of general probabilistic cash ows under random timing. Engineering Economics 32 (4), 303-336, (1987).
9. Young, Donovan, and Luis E. Contreras. Expected present worths of cash ows under uncertain timing. Engineering Economics 20 (49, 257-268, 1975.
10. Zadeh, Lofti Askar. Fuzzy Sets. Information and Control, 8, 338-353, 1965.
11. Zinn, C. D., W. G. Lesso, and B. Motazed. A probabilistic approach to risk analysis in capital investment projects. Engineering Economics 22 (4), 239-260, 1977.