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Procedia Economics and Finance 3 (2012) 78 – 83

Procedia Economics and Finance

www.elsevier.com/locate/procedia

Emerging Markets Queries in Finance and Business

Application of Fuzzy Logic in Determining Cost of Capital for the Capital Budgeting Process

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Abstract

The capital budgeting process is based on the technique of reducing future cash flows of the net present value which implies a process of discounting by using the discount rate. Usually, in capital budgeting process the discount rate is presented through the cost of capital. The determination of the cost of capital primarily depends on the capital structure, but since the process of capital budgeting implies a long time period, it also implies uncertainty and vagueness. Subjective perception, thinking, judgment and decision making, including a large number of predicted vague data is often expressed solely in linguistic variables by the management and this is the main characteristic of the capital budgeting process, especially in the determination of the cost of the capital through a long time period. The main intention of this paper is to present the use of fuzzy logic in the process of determining the cost of capital and providing an alternative approach in the appraisal of the cost of capital in the presence of fuzziness. The integration and implementation of linguistic variables i.e. qualitative information in the determination of the cost of capital using fuzzy numbers in the capital budgeting process will also be discussed. Through the formulation of a fuzzy system and the use of fuzzy numbers we will propose a process and methodology* for the use of fuzzy numbers in the process of the cost of capital determination. We examine the presented methods and suggest new ideas that could improve further research and implementation of fuzzy logic in the capital budgeting process.

Selection and peer review under responsibility of Emerging Markets Queries in Finance and Business local organization.

Keywords: Cost of Capital; Fuzzy Logic; Capital Budgeting; Uncertanty and Vagueness

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16/S2212-5671(12)00123-2

1. Introduction

The capital budgeting process involves long-term financial decisions by the management with the goal of maximizing the owner's wealth. The complexity of that process is manifested through all the necessary decisions that the management must make i.e. decision of the optimal investment choice, capital structure decision, acceptance of the risk and reward—profit tradeoff etc., from the long time period of investment duration, from usually high required amounts of the financial funds necessary to start and realize the investment, and risk and uncertainty that should be perceived. Since that many decisions and predictions i.e. future sales, costs, cost of capital etc. that management make in the present are related to the future profitability, it addresses the questions of accuracy, correctness and applicability of the predicted future variables that have direct or indirect impact on the profitability of the investment. One of the most important decisions that management in capital budgeting must make is defining the capital structure, because it has a direct influence on the cost of capital and profitability of the investment. Even when the management determines the capital structure it gives rise to the question of the way of calculating and determining the cost of capital. Customarily, practicing managers use the weighted average cost of capital WACC for estimating the cost of capital when the company raises capital from different sources, but when the company is financing investment only from one source, then usually the management uses other methods, depending on the financial source of the investment cost of debt-model for the coupon debt, Gordon model, CAPM etc.. But despite these universal and globally accepted methods for determining the cost of capital in the small and undeveloped markets and even in the developed markets managers sometimes cannot precisely calculate the cost of capital, and usually make estimation of the value of the cost of capital based on their subjective perception, thinking and judgment. The process of determining the cost of capital involves a significant amount of uncertainty and risk, and it is widely acknowledged that people do not perceive the same situations and environment nor do they react and behave in the same way – this is where the uniqueness and individuality of each human being emerges. "Subjectivity is a key factor in assessing risk. Whether a problem is perceived in terms of potential gains or losses will not be assessed as a simple mathematical calculation of the problem, but as a subjective fear, often linked to the consequences of outcomes." Merna & Al-Thani, 2005, p. 25-26. In many occasions, because of the vagueness and imperfect knowledge about various variables that influence on cost of capital, managers are inclined to estimate the cost of capital through linguistic variables. The fuzzy logic concept enables modeling linguistic variables and vagueness that are arising from language and it was first introduced by Lotfi Askar Zaheh 1965 within fuzzy sets theory. McNeill and Thro reviewing linguistic variable and their modeling defines 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. In fact today fuzzy logic and fuzzy numbers are perhaps one of the most useful methods for the quantification of one's opinion expressed through words i.e. through linguistic variables. The main disadvantages for the wider utilization of this alternative method in the process of the determining the cost of capital is the lack of acquaintance of experts and lack of advantages that this method provides. This main objective of this paper is to demonstrate the use of fuzzy logic in the determination of the cost of capital, and to show its possibilities for alternative decision making methods in the capital budgeting process. The secondary aim of this work is to analyze the role and importance on the process of determining the cost of capital and influence, possibilities and help that the utilization of fuzzy logic provides on it as well as to contribute to a better understanding and further application in business practice. The work is drawn on scientific and professional literature that treats cost of capital as well as capital budgeting process. The first part will address the methodological aspects of fuzzy logic, the second part will provide an in-depth analysis of it, the third part will provide analysis of fuzzy logic and capital budgeting while the fourth part will conclude this work and provide insights invaluable for the further development of this field.

2. Methodological Aspects

The research methods used for conducting this research are the statistical method, mathematical method, the inductive-deductive method, quasi-experiment method Trochim & Donnelly, 2006, the method of generalization and specialization as well as other general and specific scientific methods.

3. Fuzzy logic

George Bojadziev and Maria Bojadziev described that "there is not a unique system of knowledge called fuzzy logic but a variety of methodologies proposing logical consideration of imperfect and vague knowledge" 2007, p. 43. Through the use of fuzzy logic in determining the cost of capital, company management has the possibility of utilization of an alternative methodology for handing, exploitation and implementation of expert knowledge expressed through linguistic variables concerning a problem of defining the cost of capital. Fuzzy logic has found its main utilization in technical fields such as automatic regulation, data analysis and systems of survey etc. but the intensifying use of fuzzy logic research and implementation in other fields in last ten years is can mainly be attributed as a result of the application of Japanese companies McNeill & Thro, 1994, p. 14 like Mitsubishi, Nisan, Sony of the fuzzy logic concept. The main characteristic of the fuzzy logic, in contrast with traditional logic or just true or false logic i.e. 0 or 1 logic, is that it deals with many-valued logic and probabilistic logic that emerges from the vagueness and uncertainty. Fuzzy logic variables of truth or false vary from 0 to 1, and are usually presented through fuzzy sets. In Sanches, Pamplona, and Montevechi view of point „in a fuzzy set, the transition between a member or a non-menber in a continuous ray, being a memership degree between '0' totally non-member and '1' totally member. The degree of membership 'is not probability', but a measure of compatibility between object and the concept represented by the fuzzy set" 2005, p. 3.

3.1. Fuzzy sets, numbers and linguistic variables

Since that fuzzy set involves variables between 0 and 1 it represents partial belonging or degree of the membership. Usually membership function is marked with μ. The degree of the element belonging to the given fuzzy set is called membership function, which can be written with the following expression:

$$S = \{(x, \mu_S(x))\} | x \in S, \mu_S(x) \in [0,1] \quad (1)$$

$\mu_s(x)$ represents a fuzzy set that has membership function which is associated with all the points in the interval of $[0,1]$, and as Zaheh 1965 defined the nearer the value of the $\mu_s(x)$ to unity, the higher the grade of membership of the x in S.

"Variables whose values are word or sentences in natural or artificial languages are called linguistic variables" Bojadziev & Bojadziev, 2007. Applications of the fuzzy logic and lingustic variables are numerous Uzoka, 2009; Bojadziev & Bojadziev, 2007; Ban & Bugnar, 2007; Gil-Lafuente, 2005. But with use of the fuzzy logic management especially financial management have excellent toll for analysis and determination of the various financial valuation and problems like predicting and setting optimal capital structure, cost of capital, future sales etc. and all based on the managers opinions expressed through words. Words high, middle etc. that usually managers' use for the referring and determining i.e. cost of capital or capital structure represents in total experience and knowledge of the significant number of the individuals and it cannot be accurately determined. Linguistic number can be presented through various fuzzy numbers in form of sine numbers, bell shape, triangular, trapezoid, but for the financial decisions and valuations usually the most

attractive are triangular and trapezoid fuzzy numbers etc. For that reason it will be especially observed triangular fuzzy numbers in this paper and its use in determination of the cost of capital.

Triangular fuzzy numbers are particular fuzzy sets in R represented with three points a,b,c which are real numbers, and membership function can be interpreted trough:

(2)

$$\mu_S(x)=\begin{cases} 0 & x \le a \\ \dfrac{x-a}{b-a} & a < x \le b \\ \dfrac{c-x}{c-b} & b < x \le c \\ 0 & x \ge c \end{cases}$$

and presented trough graph

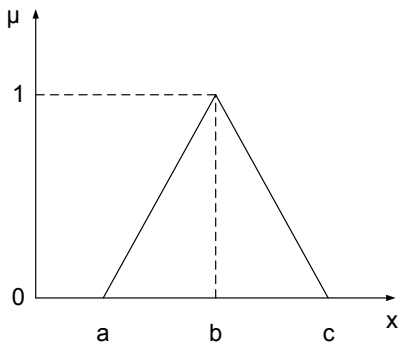

Fig. 1. Central triangular number

3.2. Capital Budgeting and Qualitative information

In the capital budgeting process management is forecasting numerous factors that are affecting the profitability of investment i.e. quantity of the sold products, cost and revenue, capital structure, number of employees and many others, cost of capital etc. Many of the forecasts usually represents managers opinions often presented trough linguistic variables, and by doing so management is in the same time determining the risk and the probability of realization of planned results. In the finance literature and in the theory it is defined that management can use quantitative—like time series, regression analysis, econometric models and qualitative methods for predicting —jury of the executive opinion, sales force estimate, Delphi forecasting etc. or just to take group or industry average. But on small and unsatisfactorily developed market such as Croatia and all Balkan markets in practice in the startup process of new investments when there is no history data or where industry average in not enough reliably for quantitative analysis many predictions of very important factors are made by management and often trough linguistic variables—i.e. Qualitative information.

4. Application of Fuzzy Logic in the Process of Determining the Cost of Capital

Financial management has determine that cost of capital of the new project will be from 15,10% up to 18,25%, and for the more acurrate predicting they hired four financial experts from the field of capital budgeting and capital sturcture to predict cost of capital trought best, worst and most likely scenario—triplets. The experts agreed that cost of the capital of the new project will bee some where from 15,10% and 18,25%, but it is necessary to know that uncertanty and vaguness has major imapct on the subjectivity of the experts and on their results. First management must interview experts and offer them probability, what is presented in tables 1 and 2.

Table 1. Probabilities of the cost of capital

α	Minimum and maximum presumptions
0	Minimum 15,10%
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 18,25%

Table 2. Experts presumptions

Experts	Triplets
1	(0; 0,3; 0,4)
2	(0,6; 0,9; 1)
3	(0,3; 0,5; 0,7)
4	(0,7; 0,8; 1)

Than trought matematical precedure it is possible to calculate ε(S) using means of the expected experts triplets presumtions—x what can be written in modified formulae Gil-Lafuente, 2005

$$\varepsilon(S) = S_x + \left(S^x - S_x\right) \cdot \varepsilon(\chi) \qquad (3)$$

After the experts gave their opinions it is possible to create table of the triplet confidence for the all levels of $\alpha \in [0,1]$ for the worst, most likely and worst case and to calculate $\varepsilon(S)$ shown in table 3, 4 and 5. Calculated triplet from table 5. 16,53%; 17,18%; 17,61% can be used as average estimations of the experts for the cost of capital.

Table 3. Sum of the α interval presumptions in fraction

α	Worst	Most likely	Best
0	4/4	4/4	4/4
0,1	3/4	4/4	4/4
0,2	3/4	4/4	4/4
0,3	3/4	4/4	4/4

Table 4. Sum of the α interval presumptions in decimal

α	Worst	Most likely	Best
0	1	1	1
0,1	0,75	1	1
0,2	0,75	1	1
0,3	0,75	1	1

Table 5. Calculated ε(S)

α	Worst	Most likely	Best
0	18,25	18,25	18,25
0,1	17,46	18,25	18,25
0,2	17,46	18,25	18,25
0,3	17,46	18,25	18,25

0,4	2/4	3/4	4/4		0,4	0,5	0,75	1		0,4	16,68	17,46	18,25
0,5	2/4	3/4	3/4	→	0,5	0,5	0,75	0,75	→	0,5	16,68	17,46	17,46
0,6	2/4	2/4	3/4		0,6	0,5	0,5	0,75		0,6	16,68	16,68	17,46
0,7	1/4	2/4	3/4		0,7	0,25	0,5	0,75		0,7	15,89	16,68	17,46
0,8	0/4	2/4	2/4		0,8	0	0,5	0,5		0,8	15,10	16,68	16,68
0,9	0/4	1/4	2/4		0,9	0	0,25	0,5		0,9	15,10	15,89	16,68
1	0/4	0/4	2/4		1	0	0	0,5		1	15,10	15,10	16,68
										$\bar{x}$	16,53	17,18	17,61

5. Conclusion

As it is shown in this paper vagueness and uncertainty are main characteristic of capital budgeting process and also of the associated process of the determination of cost of capital. Comparing the most commonly used methods for determining cost of capital, it can be concluded that fuzzy logic and triangular fuzzy numbers should be recommended, or even yet and obligatory tool for estimating cost of capital in small and undeveloped markets for determining cost of capital. Since that with using fuzzy logic and triangular fuzzy numbers it is possible to apply qualitative information as linguistic variables and used them for quantitative process of determining the cost of capital.

Application of the fuzzy logic and especially triangular fuzzy numbers in finance especially capital budgeting process can and should have greater share, especially regarding the possibility of valuation someone's opinion expressed through linguistic variables and possibility of displaying results in quantitative form. The main implication of this paper is to bring closer to the scientific and professional auditorium the advantages of fuzzy logic in business practice.

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