International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 1 Jan-Feb 2021, pp: 115-122 www.ijaem.net ISSN: 2395-5252

Cost of Capital and Fuzzy Logics

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Submitted: 10-01-2021 Revised: 23-01-2021 Accepted: 26-01-2021

SUMMARY: The present study objective is to conduct an improved and deep understanding of the cost of capital related to small private companies. When we talk about cost of capital, we know how necessary and fundamental it becomes to correlate the real value of the company with its partners and potential investors. It is important to tie the use of Fuzzy Logics in this research,sinceits use may provide a more focused view from the perspective of theunderstanding of the evaluation process.
The cost of capital of a smallbusiness incorporates thepossible economic risksit is exposed, and it can alter its intrinsic value.Therefore, considering that the risk isa subjective variable, it must considered that the use of fuzzy methodology summons theability to effectively deduce the determination of its solutions.The understanding related to the specifics of the cost of capital measured and testedby a firm structuredalgorithm, has the power to help decision making management to make accurate decisions to maximize the value of a company or project.
Keywords: Fuzzylogic.Cost of capital.Project evaluation.

I. PRESENTATION OF THE PROBLEM

In the business world, there is a goal, the increase in the value of the individual's wealth. Through varioustools thisis sought after. Investments, mergers, acquisitions andoptions among others. Most of the time we think about profit generated, but something so important is the discount rate that future profit will be brought to present value.

According to Amaral (2000), the evaluation of a project or a company is based on the vast majority of cases in the technique of cash flow. It consistsof bringing to the present all expectations of future cash generation. This cash flow update is based on a discount rate commonly called in the financial market "Capital Cost".
While much has been done to increase corporate revenues and profits, there are few studies that try to explain whya company's capital cost is established.
The estimation of this rate implies in an evaluation of factors that suggest uncertainty. Although this rate can be determined discreetly its explanation is very vague and uncertain. Understanding the reasons that the investor assigns a higher rate to one company in relation to another suggests an interpretation of several factors that include linguistic variables and a subjective perception of administrators and investors.
One of the main objectives of studying a company's capital cost is to determine whether an investment project will add value to the company's shareholders. The cash flow of the project (alreadyelaborated with respect to the various factors of the evaluation, such as sales forecast, direct costs, indirect costs, etc., will be discounted, missing the appropriate rate).

$$VPL = FC0 + \frac{FC1}{(1+CC)^1} + \frac{FC2}{(1+CC)^2} + \cdots . + \frac{FCn}{(1+CC)^n}$$

Where:
NPV = Net Present Value;
FCn = Cash Flow in period n
CC = Capital Cost
One of the most used tools for determining the cost of capital todayis the WACC (Weighted average cost of capital) and the main advantage of this model is the determination of the cost of capital taking into account the capital structure of the company (equity and third-party capital).
WACC ("Weighted Average Cost of Capital") is, the weighted average of the cost of capital.
This is obtained by weighting each distinct source of capital multiplied by the market value of the various sources of financing.
Whereas there are n different sources of capital used to finance the project, if M^j is the market value of the j-th source of funding, then the weighting for each j source of funding w^j is defined by;

$$W_j = \frac{M_j}{\sum_{j=1}^{n} M_j}$$

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If r^j is the marginal cost of source J, the weighted average of the capital cost $r^{c,}$ is defined by:

$$r_c = \sum_{j=1}^{N} w_j \times r_j$$

One method to estimate the cost of equity is the CAPM model. The asset pricing model establishes a relationship between the expected return of an asset and its risk, namely:

$$R_i = R_f + \beta_i (R_m - R_f)$$

where is the return of the asset, the return of a risk-free asset and the return of the entire asset market. The term , is known as the systematic risk attributed to the asset i, function of the covariance between the market return and that of the asset. In other words, beta measures how the return of the asset moves, with the return of the entire market. $R_i R_f R_m \beta_i$

The Return of risk-free assets (Rf)

The risk and return models in finance assume that there is a risk-free asset and that the expected return of it is known. This return may be that of the Savings Account or a government title. Therefore, the return of a risky asset is estimated as the return of the risk-free asset plus a premium for the risk that the investor is subjecting. Damodaran (2004) states that, in order for a security to be considered risk-free, it must meet two conditions: there is no possibility of default, and there is no uncertainty as to the re-investment rates of cash flows resulting from the security.

We know that the cost of capital is related to the risk that the market assigns to the company.

When we study the cost of capital of a company or project we realize that it is something more connected to linguistic variables and subjective concepts leading us to try to explain this cost through fuzzy modeling.

As the risk that interests us are those we can manage, we will work more specifically with non-systematic risk.

All this together leads us to understand that a fuzzy methodology can be developed for a better explanation of the factors that lead investors to assign different rates to companies and can lead to an optimization of this rate once we come to understand what reasons led to its construction. Thus, a means to increase the value of the company without changing the expected profit.

II. FUZZY LOGIC

Aristotle, motivated by pythagoras' work, was the first scholar to begin to structure the thought process through the systematization of logical reasoning. Later, George Boolestructured mathematical logic, demonstrating that it can be manipulated algebraically and that the results of logical operations can be obtained through the use of mathematical techniques.Boole'sideas, based on binary arithmetics, were undoubtedly a major milestone in computer science, helping the implementation of the reasoning process in the machine.

In the mid-1960s, Lotfi A.Zadehnoted that the technological resources available were not able to automate activities related to ambiguous situations, which could not be processed through computational logic based on Boolean logic. Classical mathematics did not account for the modeling of the imperfections of knowledge. Thus, in 1965, Zadeh published an article on Fuzzy Sets,beginning a series of studies on fuzzy system applications.Zadehreferred to his idea as the principle of incompatibility in his article written in 1973. This principle says that because the complexity of a system exceeds a certain limit, the precise description of a system's behavior becomes impossible.

Fuzzy consists of a theory in which everything is the object of gradation, everything has elasticity. The transition between belonging or not to a set is gradual and not abrupt.

Much of our day-to-day communication is vague and ambiguous. We say that we will arrive "in a little while", we say that a person is tall or intelligent, we use adjectives that are subjective, depend on an interpretation of who is receiving that information.

This ambiguity or vague sense of information is due to adjectives being predominantly qualitative.

In formal modeling for computing we use the crisp concept, or deterministic concept. So we use information in the yes or no style in opposition to more or less. In conventional dualistic logic information is false or true, it does not fit an "approximately false".

In optimization models, a solution is feasible or not. In mathematical modeling, precision assumes that the adopted parameters express exactly our perception of modeled phenomena. Generally, precision implies an unambiguous model.

The real world, however, is very variable, in other words it is fuzzy, not in the sense of confusing, but in the sense of cloudy and imprecise.

III. THE COST OF CAPITAL IN COMPANIES OUTSIDE THEFINANCIAL MARKET

When we havenew investment projects, in companies or projectsthat we have no history or

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where industry information data is not enough for the determination of a more accurate cost of capital, we rely on the evaluationof administrators that are usually based on, qualitative information and linguistic variables.

It is common to make an analysis with different capital costs, for example ranging between 8% and 25%, and attributing this variation to optimistic or pessimistic scenarios while what should define this value would be the risk attributed by the investor to the project and all its variables.

For Mascareñas (2000) and Matos & Moura (2003), there are four factors that determine the cost of capital: These factors, when analyzed together, will make up the total risk of a company. These are:

- economic conditions,
- market conditions,
- financial and operational conditions,
- and the amount of funding to make new investments.

There are two types of risk when we analyze the corporate environment. Systematic and non-systematic risk. The first is the risk that the whole market is subject to, together and cannot be diversified. The second can be reduced through diversification and corresponds tothe specific risks of an enterprise.

Damodaran (2002) believes that the owner (or shareholder) of a privately held company concentrates most of his wealth in his own business and so he cares about the total risk of the activity and not just the market risk. Moreover, for the said author, it is implicit in the use of the beta, the premise that the investor owns a diversified portfolio. Hence, this is not the case, it suggests two ways to estimate the cost of the assets of a closed company, from the capm's perspective:

Add goodwill to the cost of equity to reflect the greater risk created by the inability to diversify it by the owner/investor;

Adjust the beta to reflect the total risk and not just the market risk.

3.1 The Company-Specific Risk

The non-systematic risk is attributed to the particularities of a project or company, involves a variety of issues that include: administrative profile, marketing strategy, company HR, economy of scale, competitiveness of products, dependence on customers or people, suppliers and the competitiveness of the market.

Some authors such as Matos (2003), and Pratt et al. (2000), suggest that there is no specific formula for calculating the exact number of the specific risk premium at the discount rate and the appraiser's common sense and experience should be taken into account.

Another option to determine the discount rate of equity, is through the application of the scale risk premium method developed by Schilt(1982).Based on his empirical studies, he classified the companies into five distinct categories, awarding a specific risk premium, in view of their characteristics, as shown in the following table.

Table 1: Risk Award Proposed by Schilt

Category	Company Description	Risk Award
1	Company already established in the common market to strongposition, good administration, optimal level of funding, steady past of profits, optimistic outlook of future results	6-10%
2	Company already established in a more competitive, well-funded, good administration, past stable earnings, but future results are uncertain	11 to 15%
3	Company installed in a highly competitive market, little invested capital, weak administration, despite a good history of past profits	16 to 20%
4	Small business that relies on management skills one or two persons, or large undertaking, of cyclical nature in their business. In both cases, future positive results are uncertain	21 to 25%
5	Small business, dependent on a single owner, with fairly uncertain profits	26 to 30%

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This proposal from Schilt is very interesting because it establishes a risk level ratio at a specific discount rate.

We believe that the fuzzy methodology applies here in the relationship between this risk and the cost ofcapital,for this we will specify the risks that will be analyzed that is directly related to the cost of capital.

3.2 Risks that can influence the cost of capital

A source of risk is any factor that can affect project or business performance, and risk arises when this effect is uncertain and significant in its impact on project or business performance.

There are many sources of risk that an organization must take into account before a decision is made. Therefore, it is important that these sources of risk are available, thus allowing the necessary identification, analysis and response to occur. Risks can be corporate-specific, such as political, financial, and legal risks. At the strategic business level, economic, natural and market risks may need to be evaluated before a project is sanctioned. Project risks can be project-specific, such as technical, health and safety, operational, and quality risks. At the project level, however, the project manager should be confident that the risks associated with corporate and strategic business functions are fully evaluated and managed. In many business cases, risks initially assessed at corporate and strategic business levels need to be reassessed as the project progresses, as risks can affect the ongoing project. They are divided into large groups are these:

Systematic risks
Operational risks
Revenuesrisks
Financialrisks
Administrative/Corporate risk
Strategics risks

Systematic Risks

- Political conditions: These may or may not influence a company's market, the risk related to its market should be assessed here.
- Industry growth rate: If the growth of a sector is developing constantly, the risk associated with industry is lower.
- Government Incentives: If a sector needs government incentives to maintain, additional risk should be considered, as they can be suspended at any time.

Operational risks

The operational factors that alter a company's risk are listed here:

- Percentage of fixed costs: The higher the percentage of fixed costs of a company, the greater the risk of injury in a possible decrease in sales.
- Technological Dependence: Being dependent on a specific technology increases the risk of the company since it is exposed to new emerging technologies.
- Equipment conditions: A company with older equipment increases its level of risk as it can require more maintenance increasing its operating costs.
- Productive capacity: A company to operate having some flexibility to expand and also to reduce its production without affecting its profitability or at least having an expansion plan defined in the event of increased demand.
- Production quality: A company needs to operate in the market that has proposed combining a level of quality equivalent to the market it proposes to achieve.

Revenuesrisks

There are factors about its revenuesthat can affect the company's risk:

- The higher the level of revenues, the lower the company's risk.
- The lower the variability of revenues, the lower the risk.
- Consistent revenue growth leads to a lower risk.
- The lower a customer's dependency, the greater the number of customers the lower the company's risk.

Financial Risks:

This dimension of analysis focuses on the financing conditions of the company. If a company's financial costs are high, a slight decrease in revenue can lead to a big decline in the company's return. Additionally, a company's level of risk is related to its ability to honor its financial commitments and obtain more capital if necessary. The subcriteria considered here are: ability to pay the debt service, leverage capacity (unused loans) and debt composition (rates obtained in loans).

- Financial costs – A company with high financial costs poses a greater risk to the shareholder.
- Risk of capital availability - The availability of capital, both capital and debt, is clearly an absolute requirement for successful project development. The increase in adequate debt capital and the appropriate structuring of this

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require the adoption of a detailed investment plan and cost estimation. The adequacy of funding is a critical issue, as the way funds are provided has a huge impact on project development. Merna and Al Thani (2008).

Administrative/corporate risk
This criterion refers to the ability of the company's management to generate value for it.
In this subdivision of factors we can relate:

- Investor confidence (capital providers) in the management of the company.
- Dependence of specific people for the good management of the company. A company dependent on a strong executive or even a very important partner raises the level of risk of it.
- HR relevance in the Company: Companies with a greater concern with training and level of employee satisfaction tend to require a lower level of risk for shareholders.
- Confidence in the ability of managers to carry out the company's business plan.
- Organizational Experience

Strategics risks :

The consideration here is how the competitiveness of the company is seen in relation to its impacts on the risk of it. The company's position in the market and whether the company has the capacity to generate and maintain a strong identity in the market.

The sub-criteria for strategic analysis are derived from the 5 competition forces that impact the organization and industry (Porter 1980, 1985). These forces are (1) bargaining power with suppliers, (2)bargaining power of buyers, (3) threat of new entrants, (4) threat of substitutes, and (5)rivalry between participants.

Examining the impact of each of these forces on the company provides significant additional information regarding the ability to create value on today's bases. For example, "How the threat of new entrants can affect the company's ability to meet investor expectations." If it is weak in its reaction to the new entrants this may indicate a higher risk in the issue of meeting the expectations generated by the company.

IV. FUZZY MODELING

The proposed model is based on the Coppe Cosenza Model, Souza and Cosenza (2019), which consists of confronting the risk demand situations that investors attribute to a projecttype with the factors offered by a specific project.

Given an matrices$A = (a_{ij})$ and $B = (b_{jk})$ representing the demand by the investors of the risk situation of a company (A) and the risk supply in relation to a specific company(B).
Demand has 4 levels of requirement: critical, conditioning, mildly conditioning and irrelevant. And the offer has 4 levels of service: excellent, good, reducedand non-existent

Each risk factor has a supply to meet the demand required by aninvestor. For example, is considered critical the Investor Confidence (capital providers) in the management of the company (management efficiency).The company itself meets the investor demand in a certain way. Investor confidence in the management of the company varies from excellent to non-existent.

The following table shows us the possible combinations of supply and demand for an specificrisk, it also shows in which situations there are penalties that are the cases where the demand for a risk is not met by the company's offfers.

Penalties are called X, Y and Z and will be explained later.

Relevancia\Attendance	Excellent	Good	reduced	Non-existent
Critical	0.0	X	Y	Z
Conditioning	0.0	0.0	X	Y
Mildlyconditioning	0.0	0.0	0.0	X
Irrelevant	0.0	0.0	0.0	0.0

It is important to highlight that the demand in relation to an specific given risk can change from industry to industry. For example: The age of equipment may be more relevant to the telecommunications industry to the to the oil industry. It is important that the risk requirements in each sector studied be defined by industry experts.

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To determine how much risk should be added to each company we will use the following methodology:

An estimate of the cost of capital will be made by experts foran specific company. The same will determine from a risk list for companies in the technology sector what are the requirements of the industry to minimize its risk.

They will also estimate the capital cost of a company considered ideal for investment in the sector, or in others words, a company with the minimum cost of capitalpossible . The difference between the ideal company and the evaluated company will be the sum of the individual contributions of the combinations of demand and supply of the risk factors of the same.

R_s-R_{min} =Sum of the individual contribution of each risk that does not meet the specific demand. Where Rs is the specific risk of the company andRmin is the minimal risk for anideal company in the sector.

Definition of the individual contribution of each risk.

1st We establish the relationship between a possible requirement in relation to a risk item of a company and its service. We'll call this relationship Yi.

Relevancia\Attendance	Excellent	Good	reduced	Nonexistent
Critical	0	1	2	3
Conditioning	0	0	1	2
Mildlyconditioning	0	0	0	1
Irrelevant	0	0	0	0

Yi can receive the values from 0 to 3 depending on the fulfillment of the item demand.

We see from the table that if the project has an excellent service for a risk that we classify as crucial, the same does not add anything to the cost of capital. If the project does not meet the risk that is considered critical to the project it is penalized. The penalty takes place at 3 different levels and the further you get away from what was desired the higher the penalty.

If an item is conditional on a project, we will only penalize it if the service is reduced or non-existent.

If an item is not very conditionable we will only penalize the same if the service is non-existent.

If an item is irrelevant to the project it will not be penalized regardless of theservice.

The company's risk beyond the minimum risk is the sum of the risks of each factor (i) and the risk contribution of each factor will be given by:

$$\text{Risk contribuction by the factor} = e^{y_i}. (c)$$

It was considered that the penalty occurred is exponential due to natural aversion to risk. Other hypotheses may be considered in future studies.

C is a constant that equalsthe equation:

R_s-R_{min}= C x$\sum_{i=1}^{n} e^{y_i}$

V. APPLICATION OF THE METHODOLOGY IN A REAL CASE

Company description.

The company considered is a real company, but we will not mention its name for confidentiality purposes. We'll call it RC.

The company operatesin the IT sector and while it can offer various services it specialized in the cyber defense industry, being one of the few in the world market that provides this expertise.

It is a small company with less than 20 employees and sales below R$ 3MM.

The RC was presented to two experts and according to them they would apply a discount rate on the company evaluation between 25% and 35%.

We consider that a small private company in this sector has a minimumdiscount ratepossible (R_{min}) of 10% even considering that all the risk factors of the company are controlledandtherefore the risk factors of the company SC are responsible for the remainder of the risk attributed by the experts.

So, our risk list for a project would look like this:
(For the purposes of this study we will present the risk itens that generated a penalty for the company)

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Risks	Expectation	Service	Y
Systematic Risks			
Economic political conditions	Critical	Good	1
Operational Risks			
Technology dependency	MildlyConditioning	Nonexistent	1
Revenuesrisks			
Revenue level	Conditioning	Reduced	1
Revenue growth.	Conditioning	Reduced	1
Dependency on a client. (with higher percentage of demand)	Conditioning	Reduced	1
Financial Factors :			
Financial costs	Conditioning	Reduced	1
Capital Availability	Conditioning	Nonexistent	2
Administrative/corporate factors			
Investor confidence (capital providers) in the management of the company (management efficiency).	Critical	Good	1
Confidence in the ability of managers to carry out the company's business plan.	Critical	Good	1
Strategic Factors:			
Cournot reaction model (suppliers' bargaining power x buyers bargain)	Conditioning	Reduced	1
Market Size	Critical	Good	1

It has then:

$27.5\%-10\%= C \times \sum_{i=1}^{n} e^{y_i}$

Applying the risk demand and supply matrix the company has as the result:

$\sum_{i=1}^{n} e^{y_i} = 34.6$

E C=0.506

VI. CONCLUSION

The individual contribution of each risk can be observed in the following table:

Risks	Y
Economic political conditions	1,38%
Technology dependency	1,38%

Revenuelevel	1,38%
Revenue growth.	1,38%
Dependency on a client. (with higher percentage of demand)	1,38%
Financial costs	1,38%
Capital Availability	3,74%
Investor confidence (capital providers) in the management of the company (management efficiency).	1,38%
Confidence in the ability of managers to carry out the company's business plan.	1,38%
Suppliers' bargain poder x buyers bargain	1,38%
Market Size	1,38%
Sub Total	17,50%

One benefit of this methodology is that we can specify which points of the company are generating an increase in the cost of capital of the company and actions can be taken to mitigate this risk.

An example of this was the availability of capital, which because it was not adequate added a cost of 3.74% to the cost of capital of the company a factor well relevant to be mitigated.

A cost-benefit ratio can be made of which points should be taken care of in order to optimize the cost of capital of the company.

The modeling used to define the cost of capital to later is a good estimate for what was established by the experts, several tests can be done to deepen the model, such as increasing the number of specialists, hierarchizing them andchange the consideration from exponential to linear of the cost of capital among others.

The constant Cis another item that needs more studies. Its evaluation in a study for a set of companies brings many benefits to the understandingofthe issue.

The gain in value is considerable for the company's shareholders. Targeted strategy changes or investments can be used to increase the value of the company more efficiently.

The more this methodology is used to define the cost of capital, the more we can improve the model and use it to bring more efficiency and understanding to project management.

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International Journal of Advances in Engineering and Management
ISSN: 2395-5252

IJAEM

Volume: 03 Issue: 01 DOI: 10.35629/5252

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