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Project Profitability Assessment with a Fuzzy Model

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Abstract: ***Planning is the first phase in the decision-making process within an organization, in the sense that planning means anticipating with a view to making a decision. So, whatever the nature or the objectives of a project, the entrepreneur proceeds to the calculation of profitability of a project before the realization of this one. He must know in advance if the project is profitable or not. The profitability of a project in the launching phase is called "projected profitability", it is the counterpart of the advantages that the investor or the entrepreneur decided to give up in order to have incomes or profits. Many factors impact the success of the investment, depending on the aspects related to each factor, such as financial, economic and internal aspects. It must be said that the analysis of the projected profitability of investments is complex insofar as it requires a continuous monitoring of the multidimensional aspects of an investment project. A regular monitoring of these indicators is very important for the project. Hence the need to implement a profitability management tool that encompasses all performance factors in a single index called "investment profitability". The tool proposed in this study is a fuzzy model based on the principle of fuzzy logic to model and calculate the index of investment profitability. To evaluate this model, we will apply it to an investment project in the mining sector.***

Keywords: Decision-making process, profitability of a project, Fuzzy logic, fuzzy model..

1. Introduction

The mining industry is the economic sector that includes prospecting and mining activities. It involves the extraction of minerals, rare earth, and metals such as copper, iron, or gold. This sector regularly experiences ups and downs. Gains can be significant, but so can lose and that determines the future of the project. Indeed, profitability depends on several factors that come into play, but with different degrees of impact, namely the budget allocated to the project, its duration, and the quantity of the insured reserve of minerals or metals. Designating a tool that takes all these factors into consideration is very complicated, so it is decided to choose certain parameters according to the degree of influence.

This paper explains the proposed approach, identifies the essential factors of profitability, then models them by membership functions, then explains how to choose the decision rules, and finally looks at the results of the simulation.

2. Literature Survey

The evaluation of the profitability of the project is a crucial step before the project realization. It requires the use of knowledge, modeling and forecasting methods, as well as appropriate mathematical techniques.

A variety of classical methods used to study the profitability based on traditional calculations. These methods do not treat profitability as a multidimensional indicator that encompasses a variety of data (certain and uncertain). Also, they do not take into account the uncertainties related to the input information.

The most commonly used methods are: The break-even point X and Y, The economic rate of return (or ROA) Z, The financial rate of return (or ROE) T, The gross margin, The gross operating surplus (EBE) N.

The objective of our work is to establish a model capable of grouping all the input parameters impacting the profitability of the project in a single index called the profitability of the project which represents the output variable by fuzzy rules, this model is based on the fuzzy logic approach that take into account the uncertainty of information via membership functions.

3. The Proposed Approach

After choosing the input parameters, The model starts with the acquisition of numerical (quantitative) data from different input factors, transforming them into linguistic (qualitative) variables via membership functions created by the data developers this operation call be “Fuzzification”. Then, these data are fed into the fuzzy inference engine which is responsible for applying the decision rules that represent human knowledge and expertise to give different commands that will merge into a single linguistic output variable that will be transformed into a numerical data such as the final decision, this operation is “Defuzzification”. Afterward, the model suggests adjustment strategies such as decision classes to the expert. The expert can approve and accept the proposed decisions or propose alternative decisions. These new suggested decisions will be added to the expertise.

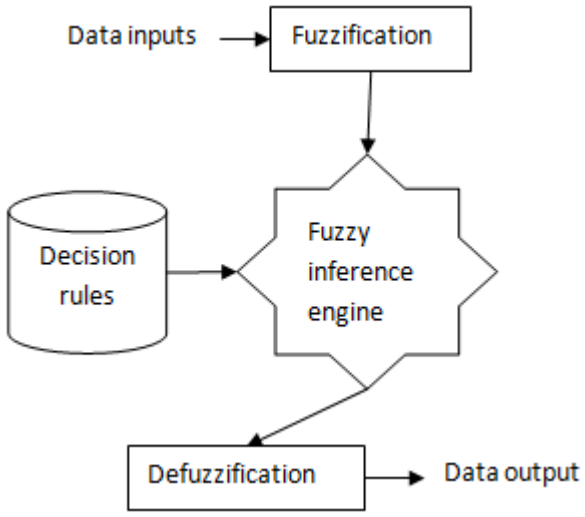


Figure 1 : Processus of fuzzy logic

Presentation of the Different Indicators

The parameters selection is relative since it depends on the nature of the investment. In our case of study it is a project in the mining sector. Therefore we have chosen the following parameters

BUDGET

Estimating the cost of a project, and therefore it's funding requirements when setting budget envelopes, is always a particularly difficult issue. The parameter "budget" plays a decisive role in the arbitration of competing projects. An underestimated project, and therefore one with too limited a budget, quickly turns out to be an inexhaustible source of problems and apparently insoluble conflicts which can lead to failure if the question of financing the project is not dealt with immediately.

Reserve

The resources are the amount of mineral substance found in the deposit. These values correspond to the maximum potential of the deposit. The totality of the resources is not 100% exploitable because of their distribution and the characteristics of the mining operation envisaged..... In the calculations allows the exploitable part of the resources to be calculated: these are the reserves.

Price

The resources evaluated are valid only with current parameters and at a current level of knowledge, because if the selling price increases Some parts of the reservation deposit will become economically unprofitable, which will increase the reserves accordingly. On the other hand, if the selling price falls, then some parts of the deposit that were previously economic will no longer be economic and will be downgraded to residual resources. Thus, a reserve is only a reality in a given economic context.

Human resources

This includes all the actors working on the project. Human resources are fundamental to all projects because they are the ones doing the work, so it is normal to spend more time determining them.

The figure2 shows the model proposed structure, with 4 inputs variable (Budget, Reserve, Price, and Human resources) and 1output variable (Profitability).

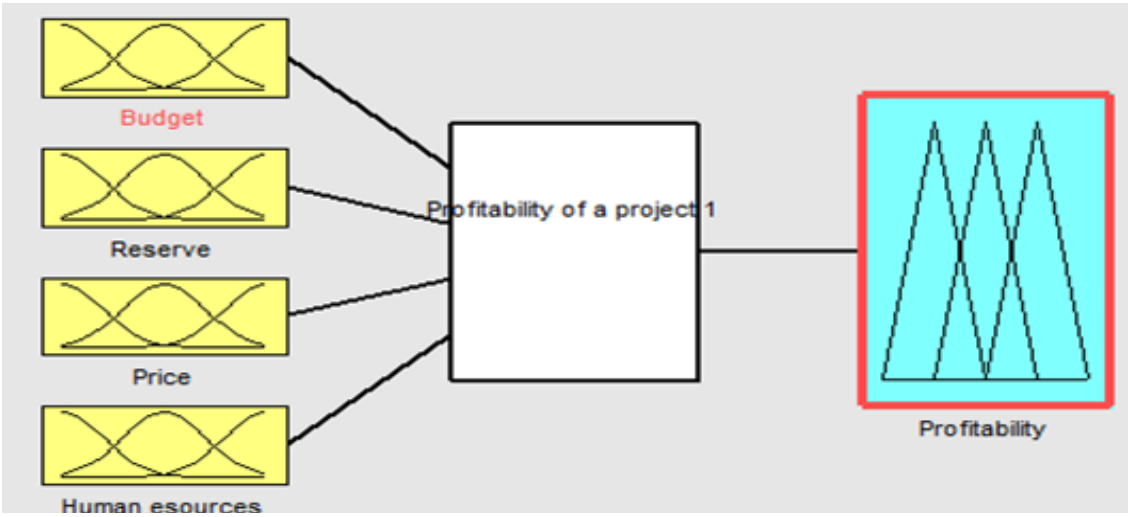


Figure 2: Model structure

Choice of Membership Functions

Once, the set of inputs and outputs have been identified, the next step is to apply a suitable Membership Function (MF) for each of the parameters. The only restriction of the membership function is that it has to satisfy values in the range of zero to one. A set of eleven in-built membership functions are present in The Fuzzy Logic Tool Box. The flexibility provided is that the same fuzzy set could be described by an innumerable number of membership functions. However, this flexibility could also result in complex decision making. On deciding the choice, the membership function can be normalized if necessary. This is to ensure that for some particular value of the input, the membership value will be one. Although, a number of membership functions are available, the designed system has used only four membership functions>

The MFs are defined mathematically with several parameters

- A triangular MF is specified by three parameters {a, b, c} as follows

$$\boldsymbol{triangle}(x;\boldsymbol{a};\boldsymbol{b};\boldsymbol{c}) = \begin{cases} \mathbf{0}, x \le a \\ \dfrac{x-\boldsymbol{a}}{\boldsymbol{b}-\boldsymbol{a}}, a \le x \le b \\ \dfrac{\boldsymbol{c}-x}{\boldsymbol{c}-\boldsymbol{b}}, b \le x \le c \\ \mathbf{0}, x \ge c \end{cases}$$

- A trapezoidal membership function is specified by four parameters as follows

$$\boldsymbol{trapezoid}(x;\boldsymbol{a};\boldsymbol{b};\boldsymbol{c};\boldsymbol{d}) = \begin{cases} \mathbf{0}, x \le a \\ \dfrac{x-\boldsymbol{a}}{\boldsymbol{b}-\boldsymbol{a}}, a \le x \le b \\ \mathbf{1}, b \le x \le c \\ \dfrac{x-\boldsymbol{a}}{\boldsymbol{b}-\boldsymbol{a}}, c \le x \le d \\ \mathbf{0}, x \ge d \end{cases}$$

- A Gaussian membership function is given by two parameters:

$$\boldsymbol{gaussian}(x;\boldsymbol{c};\Phi) = \mathbf{e}^{-\left(\frac{1}{2}\right)\left(\frac{x-c}{\Phi}\right)^2}$$

- The generalized bell membership function is specified by three parameters

$$\mathbf{bell}(\mathbf{x};\mathbf{a};\mathbf{b};\mathbf{c}) = \frac{\mathbf{1}}{\mathbf{1} + \left|\frac{\mathbf{x}-\mathbf{c}}{\mathbf{a}}\right|^{\mathbf{2b}}}$$

The figures1, 2, 3, 4, 5show the MFs ofThe inputs and the output indicators.The Budget input variable is represented with 2Mfs type Gaussian, the reserve input with 3 MFs type trapezoid, the Price input with 2MFs type Triangle, the human resources input with 2MFs type trapezoid and the Profitability output variable is represented with 2 MFs type Bell

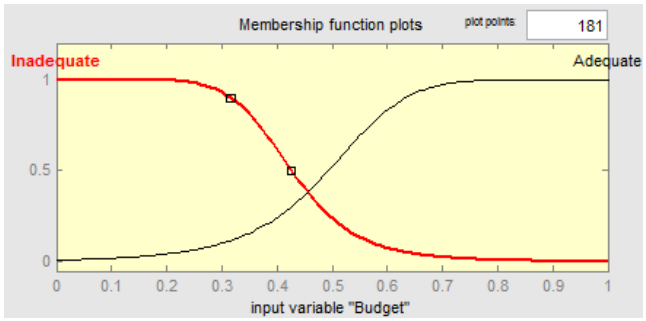


Figure 3: MF for Budget

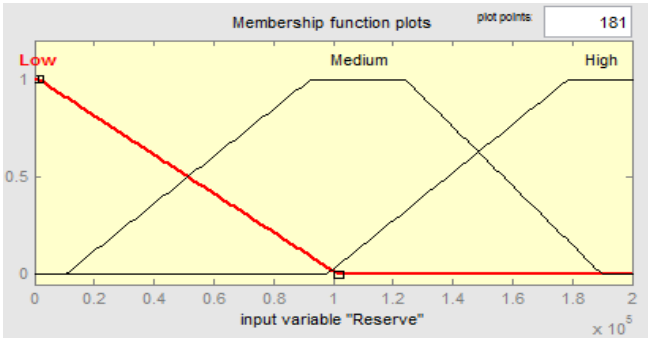


Figure 4: MF for Reserve

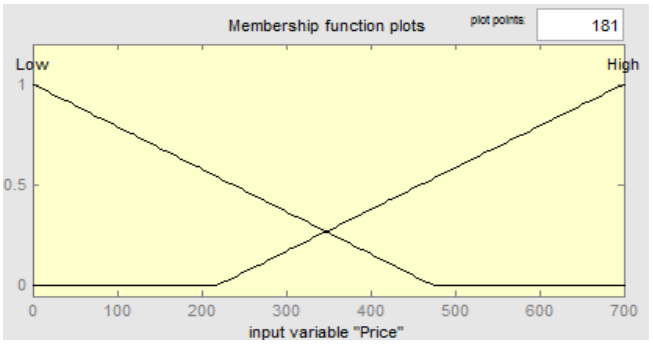


Figure 5: MF for Price

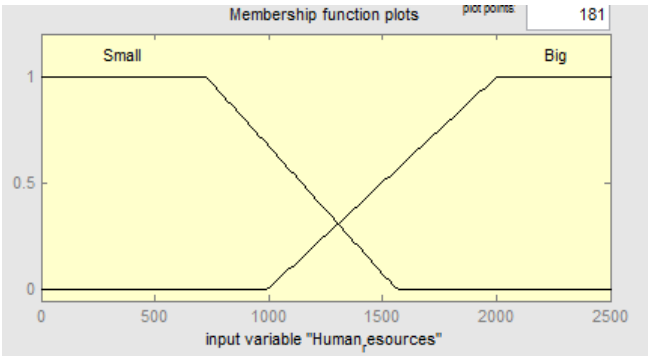


Figure 6: MF for Human resources

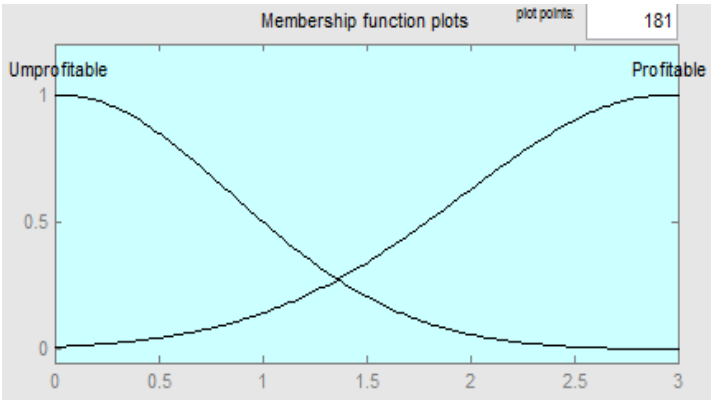


Figure 7: MF for Profitability

For example
Price=300€

$$f(300€) = \begin{cases} \text{Low with Membership value} = 0.25 \\ \text{High with Membership value} = 0.35 \end{cases}$$

The Fuzzy inference

Fuzzy Inference System (FIS) is a way of mapping an input space to an output space using fuzzy logic. A FIS tries to formalize the reasoning process of human language by means of fuzzy logic (that is, by building fuzzy IF-THEN rules), by using fuzzy connectors "OR" 'AND"

In this research, the total number of decision rules is 24 rules (= 2×3×2×2) as shown in Figure-6. The rules are based on the "Mamdani Inference Method" with the fuzzy connector "AND".

Table 1: Decision rules

Budget	Reserve	Price	Human resources	Profitability
Inadequate	Low	Low	Small	unprofitable
			Big	unprofitable
		High	Small	Profitable
			Big	Profitable
	Medium	Low	Small	Unprofitable
			Bib	unprofitable
		High	Small	Profitable
			Big	Unprofitable
	High	Low	Small	Unprofitable
			Big	Unprofitable
		High	Small	Profitable
			Big	Unprofitable
Adequate	Low	Low	Small	Profitable
			Big	Unprofitable
		High	Small	Profitable
			Big	Profitable
	Medium	Low	Small	Profitable
			Big	Profitable
		High	Small	Profitable
			Big	Profitable
	High	Low	Small	Profitable
			Big	Unprofitable
		High	Small	Profitable
			Big	Profitable

Aggregation and defuzzification

After applying decision rules, the outputs obtained for each rule will be combined together into a single fuzzy by using aggregation. This single will be mapped to a quantifiable result in Crisp logic.

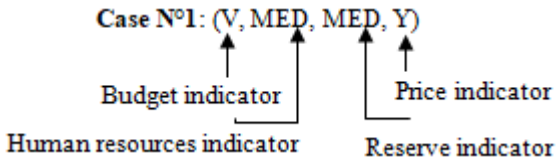
The method used here is the center of gravity method $Z^*= \frac{\int_{zi}^{zk} \mathbf{Z}\times\mu(\mathbf{z})\mathbf{dz}}{\int_{zi}^{zk} \mu(\mathbf{z})\mathrm{dz}}$

The aggregation processes is schematized in figure 6

Figure 8: Aggregated output

4. Results and Discussion

Several important special cases will be treated, giving the Profitability according to the Budget, Reserve, Price and human resources.



Example: The Reserve and the Price indicators are fixed in advance: Medium.

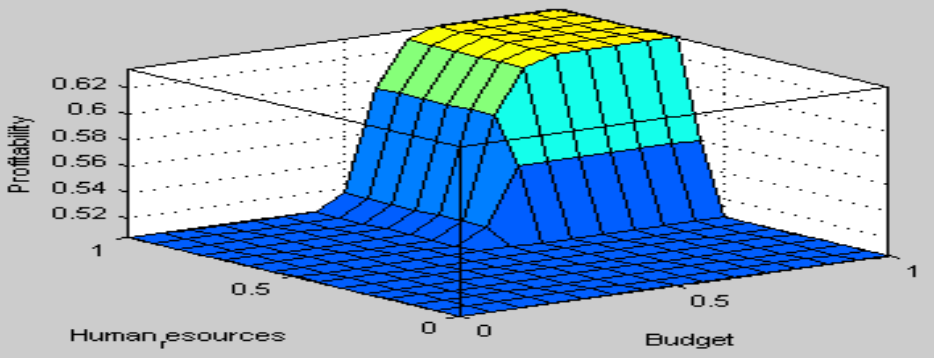


Figure 9: The curve of the case N°1 (V, MED, MED, Y) result

The interpretation of the above curve reveals that the Profitability can vary conforming to the inference rules. The Demand is null when one of the indicators (Residual and seasonal) is null. However, it is medium when the budget is high and the human resources indicator is medium. It's high when both of them are high. The expert can manage the result according to the knowledge and importance of different indicators. Indeed, the management of the result is founded on the use of decision rules.

- **Case N°2**: The Budget and Human resources indicators are fixed in advance: Medium

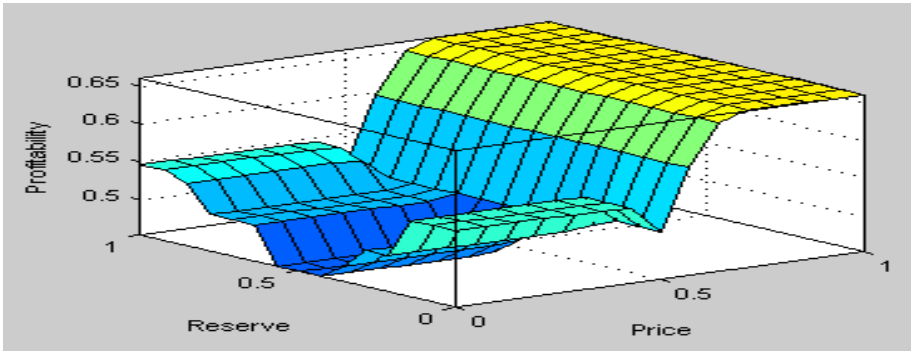


Figure 10: The curve of the case N°2 (MED, W, X, MED) result

The interpretation of the above curve reveals that the Profitability indicator can vary conforming to the inference rules. Profitability is high when the Price is high. However, it is null when the price is Low and the Reserve is medium. This result is impossible in the binary logic. Here we find the difference between fuzzy logic and binary logic. In the binary logic when one of the indicators is null the project profitability is null.

The principal purpose of this approach is to utilize the tolerance for incertitude and impreciseness to attain flexibility, lustiness.

By using fuzzy logic, modeling the indicators allow us to highlight the dependency and interaction between indicators. Thus, experts can pilot the results by editing and re-establishing decision rules which are based on the importance of each input indicator. This is the usefulness of fuzzy logic, it allows us to solve systems and obtain results which can't be found by using classic logic.

5. Conclusion

The paper presented shows the feasibility of setting up an expert system that is used to properly monitor the profitability of an investment project in the mining sector through the use of fuzzy logic techniques to help investors to know the situation where the project is beneficial or not. The results of the simulation are shown in different cases.

The proposed technique assumes that the experts have made a difficult choice to develop the rules that govern decision-making through the exploitation of historical data obtained over time.

The main objective is to demonstrate the usefulness of an expert system model based on the simultaneous interpretation of several graphical records in order to have a view of the profitability; the implementation of adequate decision rules gives the proposed approach some robustness. The prospects are to adapt this approach to properly monitor the profitability of the project.

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