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An Essay on Simulation and Multi Criteria Decision Making Methods in Production Enterprise

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Abstract

It's hard to make a decision about investment for enterprises because of there are too many criteria that need evaluation. The aim of this study is to apply simulation method to evaluate risk that is between investment alternatives and to apply VIKOR, is one of multi criteria decision making methods, to make the most efficient decision by using simulation results. The study was applied for a production enterprise in textile industry. It was used Monte Carlo simulation as simulation method, Analytic Hierarchy Process to determine criteria weights, VIKOR to make a decision.

Keywords: Vikor; Assessment of investment projects; Simulation.

1. Introduction

To make decision about new investment decisions in firms gets difficult for decision makers because both have many investment alternatives and to evaluate multiple criteria. Simulation is one of effective methods if past evaluations are inadequate and assessing risk for defining investment criteria is important. The aim of this study is to use simulation for assessing risk between investment alternatives and to make investment decisions effective by using Vikor, which is one of multi criteria decision making methods, with result of simulation and other criteria.

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The study was applied at new investment decisions of production firm in textile industry. It was used Monte Carlo simulation for simulation, AHP (analytic hierarchy method) to determine criteria weights and finally Vikor to make decision between new investment alternatives.

Alternatives of new investment decisions were determined by interviews at firm. It was evaluated criteria of alternatives to be selected with respect to literature of valuation investment project contained generally market analysis, technical analysis and financial analysis. Net cash flow values of alternatives were determined by using Monte Carlo simulation for comparison according to net present value at financial analysis. AHP method was used to determine criteria weights according to opinions of managers at firm. After the criteria values of all alternatives had been calculated, it was examined what investment decision could be taken by using the Vikor method.

Vikor is used as a multi-criteria decision making technique in making investment decisions in the study. In the literature review, there are studies using multi-criteria decision making techniques in investing decisions and especially the Vikor method which is applied in this study. It can be briefly evaluated some of them: A study using Vikor method in the evaluation of projects for TCDD was found in the literature [1]. In another study using the Fuzzy Vikor method, investment projects in air defense sector were evaluated with fuzzy analytic hierarchy process [2]. Project selection process was also examined using fuzzy Vikor in a study. Seven different criteria which are net present value of the project, return on investment, recycling time, risk, growth expectancy, applicability, contribution to the company success were evaluated [3]. In another study using Ahp was the subject of evaluation of construction investments projects [4]. Another study related to optimal investment strategies using Analytical Network Process and Topsis methods is included in the literature [5]. There is also a study assessing energy projects using Electre and Promethee in the literature [6]. Other studies using multi criteria decision making methods in project selection are also found in the literature. [7, 8, 9, 10, 11, 12].

The second important part of this study is simulation. Studies used simulation for investment projects is also found in the literature [13, 14, 15, 16].

Briefly, the purpose of this study is summarized as to assess the risk between investment alternatives by using simulation method and to make the most effective investment decision using Vikor method by considering these simulation results and other criteria.

2. Assessment of Investment Projects

The assessment of investment projects is one of the topics that are examined today. An investment project established for the production of goods and services can also be expressed as a fixed capital investment proposal. New investment projects can be classified under four headings as, completion-expansion investment projects, renewal investment projects, modernization investment projects. The process of preparing and assessment the project for an investment is expressed as a feasibility study. Feasibility study can be done in three stages as market analysis, technical analysis and financial analysis. [17] An investment project is the act of deciding the goods to be produced, the capacity to be used, the place of production using information and data in

order to realize a certain production at the lowest cost and obtain the highest economic and technical efficiency [18]. Two methods were used to assess the investment projects in the study.

2.1. Vikor (Vise Kriterijumska Optimizacia I Kompromisno Resenje)

Vikor means multi criteria optimization and compromise solution. The Vikor method is a multi-criteria decision making method developed by Serafim Opricovic. In a later study of same author, the Vikor method was compared with the Topsis method. The Vikor method focuses on the selection or ranking of alternatives under multiple criteria. It is a method that allows selection between alternatives in the presence of contradictory criteria. Vikor is the method that deals with the multi-criteria test index approaching the ideal solution. It is shown ideal solution (F*) and compromise solution (Fc) is a feasible solution, closest to the ideal in the Figure-1 [19, 20, 21].

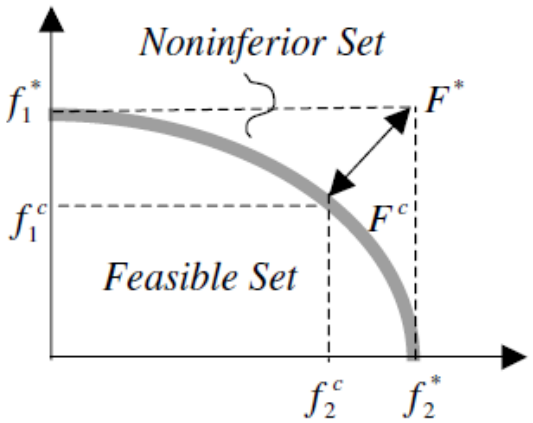

Figure 1: Ideal and compromise solutions [19]

In the Vikor method, the process starts briefly with the stage where the best (f_i^*) and worst (f_i^-) results are determined under each criterion. The process continues by calculating the values of S_j (evaluation unit) and R_j (evaluation unit) with the following formulas (1, 2). Eventually, Q_i (Score of each option) (3) values are interpreted according to certain assumptions under certain conditions. The alternative with the lowest Q value is chosen [19].

$$S_j = \sum_{j=1}^{n} \frac{wi(f_i^* - f_{ij})}{f_i^* - f_i^-} \qquad (1)$$

$$R_j = \underset{i}{^{Maks}}\left[wi(f_i^* - f_{ij})/(f_i^* - f_i^-)\right] \qquad (2)$$

$$Q_i = v\frac{S_j - S^*}{S^- - S^*} + (1-v)\frac{R_j - R^*}{R^- - R^*} \qquad (3)$$

$$S^* = min\, S_j \;;\; S^- = \max S_j \;;\; R^* = min\, R_j \;;\; R^- = \max R_j$$

The Analytical Hierarchy Process (AHP) was used to calculate the criterial weights (w) in the study. In the literature, there are studies in which Vikor and AHP technique are used together [22, 23].

2.2. Monte Carlo simulation

The solutions made by using random numbers in a model are called Monte Carlo simulations [24]. According to another definition, the Monte Carlo simulation is expressed as a technique preparing sampling experiment by creating a stochastic model of a real situation [25]. The application of the present simulation is based on the idea of sampling in the Monte Carlo method in general terms [26]. The base of Monte Carlo method is derivation of random numbers. Reference [27] Different uses of Monte Carlo simulation are found in the field of business administration [17, 28]. Using the cumulative probability distribution determined in the study, the values in the intervals corresponding to the random values derived in the uniform distribution are simulated [25].

3. Application

The study examines the investment decision related to yarn production of a company with a factory dealing with dye and finishing investment project criteria and options have been determined for the newly established yarn facility as a result of in-depth interviews with the firm's decision makers. First, it was decided which options exist to choose between. According to this, the first option of the company which has three different options is to produce yarn only for its own needs. The second option is to produce only for sale. The third option is to produce both to sell and to compensate its own needs. These three options can be considered in the feasibility study of the project. The criteria considered when assessing options were examined. According to this, capacity in terms of technical analysis, general economic expectations and demand level in the terms of market analysis, expected net present value and coefficient of variation in terms of financial analysis were determined as the five sub-criteria that are considered in the investment. Thus, the three main criteria in the feasibility analysis are divided into five sub-criteria according to result of in-depth interviews with the firm's decision makers. Application in a textile firm and using opinions of decision makers are constraints of study.

Technical requirements, production capacity is determined in tons per year. The evaluation on the title of market analysis is determined by the following question: What are your ratings on 1 to 5 scales? General economic expectations are determined by the scores given to the options. Demand was also assessed with the same question. Simulation was used for net present value in financial assessment section. The duration of the project is 10 years. The reason for using simulation is lack of historical data and calculation considering the scenario probabilities in the future. In the simulation, firstly, the values that the annual net cash flows for each option were assigned probability by the decision makers. The values, probabilities, cumulative probabilities, and random number ranges for the net cash flows for each option are shown in Table 1. There are 500 simulations for each option and for each period. In the simulations, net cash flows were determined with values obtained random from 0-1 uniform distribution.

The risk-free discount rate is fixed at 0.07. The expected net present values and the coefficients of variation, to calculate risk, for each option were calculated as a result of the simulation. The matrix of the results of the five

criteria is shown in Table 2.

Table 1: Probabilities of Net Cash Flows

Probabilities	Cumulative Probabilities	Random Number Ranges	Net Cash Flows		
			A Option	B Option	C Option
0,2	0-0,2	0-0,1999	3000000	3200000	6250000
0,3	0,2-0,5	0,2-0,4999	3250000	3450000	6500000
0,35	0,5-0,85	0,5-0,8499	3500000	3700000	6750000
0,15	0,85-1	0,85-1	3750000	3950000	7000000

Table 2: Values of Options According to Criteria

	Technical	Market		Finance	
Options /Criteria	Capacity	Economic Evaluation	Demand	E(NBD)	Coefficients of Variation
A (Needs)	350	5	5	4264403,196	0,134008
B (Sale)	350	3	2	5601149,754	0,098465
C (Needs+ sale)	1000	3	3	7696114,569	0,073115

The analytical hierarchy process (AHP) was used to determine the criterion weights the comparison matrix formed by the values given in the scale of 1-9 and the criteria weights are shown in Table-3. Consistency ratio (CR) is 0,033.

Table 3: Comparison Matrix of AHP Results and Criteria Weights for Criteria

	Capacity	Economic Evaluation	Demand	E(NBD)	Coefficients of Variation	Criteria Weights
Capacity	1	0,125	0,111111	0,25	0,25	0,032634
Economic Evaluation	8	1	0,142857	3	2	0,180538
Demand	9	7	1	8	6	0,573473
E(NBD	4	0,333333333	0,125	1	4	0,130763
Coefficients of Variation	4	0,5	0,166667	0,25	1	0,082592

After the Criterion Weights were obtained, the processes of the Vikor were applied. The result values S, R and Q in Table 4 are calculated. According to the relevant assumptions, the best option is A (Needs), has the lowest Q value.

Table 4: Results of Vikor S_i R_i and Q_i Values

Options	Si	Ri	Qi
A (Needs)	0,213356	0,130763033	0
B (Sale)	0,868221	0,573472539	1
C (Needs+ sale)	0,595487	0,382315026	0,575868154

4. Conclusions and recommendations

A firm's investment project, which plans to invest in a yarn production facility, has been evaluated in the study. The minimum number of criteria was used, and the Vikor method was applied, in which the criterial weights are determined by the analytic hierarchy process. Microsoft Excel was used in the study.

Simulation has been applied for net present value calculations in order to add risk to investment decisions. The expected net present value and the coefficient of variation are calculated by the simulation. These results have been used for Vikor method to make decision. This study contributes to the literature: using simulation to calculate risk and using the Vikor method on the basis of the analytical hierarchy process on investment decision for the yarn production.

According to these results, Firm should establish a yarn production plant that will produce only for its needs. Later on, the firm should produce both needs of the firm and sale. In the application, the criteria determined by the feasibility studies were designed for the firm. Other firms may apply different decision methods by setting their own criteria. Different criteria may be appropriate for investment projects. In order to shed light on future research, it is possible to design studies in which different multi-criteria decision making techniques can be used or even fuzzy versions can be added. From a simulation point of view, studies can be made in which not only net cash flows but also other elements (production amount, sales volume, interest rate, etc.) can be used. Simulation can also be applied to areas where continuous values exist.

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