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Providing a New Integrated Model to Determine Investment Priorities under Risk and Uncertainty Conditions

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Abstract: Banks and financial institutions often encounter the problem of demands multiplicity and uncertainty in providing information to finance the credit required for their investments. Therefore, they seek to participate in projects with least sensitivity to variable factors during project's life. Thus, in the present study we aim to both consider the results of methods and techniques already used by banks and financial institutions and apply a new integrated model under risk as preliminary estimates which contains four tools including simulation, multiple criteria decision making models of Fuzzy Analytic Hierarchy Process (FAHP), VIKOR compensation model and a mathematical programming method. These four methods can greatly help banks and other decision makers to determine their priorities to participate or not in investments in risk circumstances.

Key words: Investment, risk, uncertainty, integrated model, Iran

INTRODUCTION

Today, since all banks financial institutions gain a large portion of their profits from loans they offer to others, so they mainly seek to participate in projects that have the lowest sensitivity to variable factors during project lifetime. In such condition, the main problem that most banks and institutions are faced with considering their limited credits is how to determine priorities in participation or not participation in investments in risky conditions. On the other hand, since analyst investigates the effects of changing basic parameters of the project on the results through the sensitivity analysis method, the less these effects are the higher confidence and hope the banks and institutions will get on implementing the project.

Engineering economy: Engineering economy is a set of mathematical techniques to simplify for economic comparison of industrial projects or to put it more simply, it is a decision making tool to choose the most economical projects. Since, making the right decision is the most important duty and the main responsibility of a manager and engineering economy techniques direct manager to adopt the correct decision, so decision nature and different types of decision making in engineering economy are examined here.

Making decision in risk is related to the time when the problem involves a number of unpredictable variables however information from the past is available and the probability of their occurrence can be predicted. There are so many documented methods in this regard that include:

- Performing all possible techniques of engineering economy
- Mathematical expectation method (expected value)
- Simulation methods
- Decision tree
- Dynamic programming

Monte Carlo simulation methods are especially useful in studying systems in which there are a large number of variables among which the fluids and amorphous materials can be named. There is not only one Monte Carlo method but the term refers to a wide range of commonly used methods (Coates and Kuhl, 2013). In engineering economy, simulation is applied to feign a real system from its appearance in order to observe and acquire information. This departure from reality has its own advantages to be able to observe a real system in the best way ever. Most recently, use of simulation to evaluate investment projects under risk and uncertainty has increased because making more reliable decision would be much easier through simulation of basic methods of project assessment (Armaneri *et al*., 2010).

Fuzzy Analytic Hierarchy Process (FAHP): This method was proposed based on analysis of human brain for complicated and fuzzy issues. This method was introduced by a researcher named Thomas L. Saaty in 1970 for which so many applications have been offered since then. There is a decision space for each decision making whether in a continuous or discrete way. It could also be a single or multiple criteria decision making process. Besides, these criteria can be qualitative, quantitative or a combination of both and decisions are made differently in each one. It is more difficult to make decision in a continuous decision space. Also, the effects of criteria on each other are required to be measured in a multiple criteria decision making.

VIKOR method: VIKOR can be defined as a method for cases with disproportionate and incompatible criteria as decision maker needs a solution that is very close to the ideal solution and all items are evaluated according to the criteria. But this method is mainly used for scenarios where a DM problem and its priorities cannot be identified and explained when designing it. This method is designed for discrete decision making issues with conflicting criteria in which multiple criteria ranking of items is performed using compromise ranking method.

Literature review: Jovanovic (1999) investigated the use of sensitivity analysis in evaluation of investment projects under risk and uncertainty. Merna and Von (2000) studied risk management of an investment in the agriculture sector using simulation. Coates and Kuhl (2013) showed how a simulation software can be used in engineering economy used examples to demonstrate that how risks should be controlled during a period of engineering economy.

Haugh (2004) used several techniques to reduce the variance of random numbers in simulation which eventually such variance will be produced and also time needed to perform the simulation will be reduced. Rebiasz (2007) assesses project risk level by converting fuzzy values into probability distributions and analyzing them through simulation techniques. Lai *et al*. (2008) showed how simulation and Analytic Hierarchy Process (AHP) are used to specify the amount of budget required for construction projects.

Iwamura and Lin (1998) and Huang (2007) optimized capital budgeting using constraints programming method based on fuzzy values. Kuchta (2000) studied capital budgeting under fuzzy condition. Huang (2007) used fuzzy parameters for capital budgeting of programming models with probability constrain. Lee and Kim (2001) used maximum likelihood models for capital budgeting with fuzzy input values and multiple conflicting objectives in which a fuzzy simulation based on genetic algorithm was used to solve these models.

MATERIALS AND METHODS

In the present study, an integrated model under risk condition is applied which contains four tools including simulation, multiple criteria decision making models of Fuzzy Analytic Hierarchy Process (FAHP), VIKOR Compensation Model and mathematical programming. Using these four tools can help banks and decision makers to determine the priorities of participating or not participating in investments under risk and uncertainty. To collect data, questionnaire, interviews and bank database were used.

In this study, a decision support system has been used to evaluate the projects under risk which is a combination of four methods including simulation, multiple criteria decision making models which consist of hierarchical analysis and TOPSIS methods and linear mathematical programming model to prioritize items available.

RESULTS AND DISCUSSION

Financial indicators selection and screening: According to various information sources and expert's opinions, a series of financial indices were determined that are effective in evaluation and selection of projects. The list provided is as follows.

In order to perform the screening process and final selection of financial indicators we did as follows. Since, a number of indicators such as sales percentage in breakeven point, sales rate in breakeven point and production rate in breakeven point all represented one concept, only the indicator on row 1 by expert's opinions was kept and two other were eliminated. Now, every indicator is briefly described.

Selection and screening of non financial indices: Just like financial indices, here to select and screen non-financial indices, at first a list of all the indicators was provided and then some of them were retained according to expert's opinions to determine the weights.

Among indicators presented in Table 1 and 2, project location was discarded according to expert's idea because most projects are implemented in industrial towns that have all features including infrastructure, etc., while to be able to run a project in agriculture sector, availability of facilities and infrastructure and partly good climatic conditions and some other factors should be provided. If these requirements are not available, the project will be rejected in the very beginning. Thus, since these indices are not taken into account before the project gets started, it won't be necessary to include separately them in agricultural projects. Indicators on rows 1, 2 and 6 are also eliminated due to the lack of comprehensive information in this study as well as expert's opinions. Now in this study, we explain each of them in summary.

Table 1: Indicators of financial decision making

Row	Name of decision making indicator	Type of decision making indicator	Sources
1	Percentage of sales in breakeven point	Financial	Bank expert's opinions
2	Sales rate in breakeven point	Financial	Bank expert's opinions
3	Production rate in breakeven point	Financial	Bank expert's opinions
4	Ratio of total facilities to total investment required	Financial	Bank expert's opinions
5	Internal rate of return on investment with financing	Financial	Bank expert's opinions
6	Return of capital with financing	Financial	Bank expert's opinions
7	Net present value of investment with financing	Financial	Bank expert's opinions
8	Return on sales	Financial	Bank expert's opinions
9	Measuring the usefulness of loans	Financial	Bank expert's opinions
10	Investment volume	Financial	Bank expert's opinions
11	Economic value added	Financial	Bank expert's opinions
12	Profitability index	Financial	
13	Ratio of total debt	Financial	Bank expert's opinions
14	Investment growth rate	Financial	Shu Ling Lin
15	Ratio of current assets	Financial	Bank expert's opinions

Table 2: Indicators of financial decision making

Row	Name of decision making indicator	Type of decision making indicator	Sources
1	Size of the existing market	Non financial	Henig and Katz
2	Competition in the existing market	Non financial	Henig and Katz
3	Project location	Non financial	Industries locating methodology, Journal of Rah Shahr Consulting Engineers Group
1-3	Geographical and climatic factors		
1-1-3	Ecology		
2-1-3	Soil		
3-1-3	Temperature		
4-1-3	Humidity		
5-1-3	Earthquake		
2-3	Infrastructure facilities		
1-2-3	Transport networks		
2-2-3	Fuel, water, electricity and gas		
3-3	Human factor (specialized manpower)		
4-3	The possibility of access to raw materials and primary centers		
5-3	Health and environmental factors		
1-5-3	Its effects on soil		
2-5-3	Its effects on water resources		
3-5-3	Its effects on natural biological resources		
4-5-3	Its effects on water quality		
6-3	Access to market		
4	Qualifications of the applicant	Non financial	Non financial
1-4	Trustworthiness and reliability		
2-4	Technical competence		
3-4	Financial strength		
4-4	Collateral		
5-4	Personality		
5	Per capita job creation	Non financial	Non financial
6	Effect of technology or service studied on business	Non financial	Topco 2010
1-6	Its effect on market share		
2-6	New market potential		

Scoring the items on each indicator: Scoring the remaining items in each indicator was conducted in two ways:

- First the means of all values of financial and non financial indicators of job creation per capita were quantitatively calculated and then the values obtained were included in the decision making matrix
- Non financial indicators of applicant's qualification whose values are qualitative were specified using expert's opinions andthen performance ratings of this index in projects 1, 2, 7 and 10 were set

To convert the qualitative values into quantitative, the following Table 3 was used.

Ranking items using TOPSIS method: After the incompatibility of pairwise comparison matrices is determined using AHP method and by expert choice software, now it's time to use TOPSIS method to the remaining projects. According to the explanations given on how to determine the rating of each item in every indicator, decision matrix of remaining items will be as follows (Table 4).

Table 3: Rating of applicant's qualification (a qualitative indicator)

Scales used to rate trustworthiness and reliability	Scales used to rate technical competence	Scales used to rate financial strength	Scales used to rate collateral	Scales used to rate personality
Very much (9)	Excellent (9)	Excellent (9)	Excellent (9)	Excellent (9)
Very (7)	Good (7)	Good (7)	Good (7)	Good (7)
Average (5)	Average (5)	Average (5)	Average (5)	Average (5)
A little (3)	Poor (3)	Poor (3)	Poor (3)	Poor (3)
Very little (1)	Bad (1)	Bad (1)	Bad (1)	Bad (1)

Table 4: Decision matrix of remaining items

Variables	Indictor type (profit, costs)	Absolute weight of indicator	Project 1	Project 2	Project 7	Project 10
Percentage of sales in breakeven point	Cost	0.03937	0.3427	0.3935	0.3747	0.4343
Ratio of total facilities to total debt	Cost	0.01225	0.297	0.242	0.513	0.2686
Internal rate of return	Profit	0.03237	0.31	0.25	0.17	0.25
Return of capital	Cost	0.147	3.7163	3.8773	5.1973	3.8586
Net present value	Profit	0.14787	6903520	46332115	808735	4137546
Return on sales	Profit	0.01487	0.1534	0.0978	0.2711	0.1455
Index of measuring usefulness of loan	Profit	0.01575	1.9459	3.3405	2.8037	2.0061
Initial investment volume	Cost	0.02625	6995632	110063244	15577218	9440616
Economic value added	Profit	0.08925	2320292	18761660	1488014	1509822
Profitability	Profit	0.2695	1.9868	1.4209	1.0519	1.4382
Ratio of total debt	Cost	0.04025	2.078	3.3405	2.8037	2.0061
Ratio of current assets	Profit	0.04025	0.7658	0.7339	0.6796	0.7049
Trustworthiness and reliability	Profit	0.0387	7	7	7	7
Technical competence	Profit	0.0063	5	5	5	5
Financial strength	Profit	0.03892	5	5	5	5
Collateral	Profit	0.01608	7	7	7	7
Personality	Profit	0.01248	9	9	9	9
Job creation per capita	Profit	0.0125	269062	516728	537145	629374

Table 5: Ranking the items using TOPSIS method

Project name	Scores obtained	Ranking
Project 1	0.3909	2
Project 2	0.7465	1
Project 7	0.1149	4
Project 10	0.2384	3

After decision matrix is completed to rank projects using TOPSIS as stated in the second chapter, the item selected should have the least distance from the ideal solution and ate the same time be in the farthest distance from the negative ideal solution. In order to rank the remaining items, TOPSSIS 2005 application was used and the following results were obtained (Table 5).

Mathematical modeling of the projects considering the constraints in the model: As you can see, project 2 and 7 gained, respectively the highest and lowest scores among all. Regarding the rankings obtained for projects as well as the constraints of the model, the final model is as follows:

$$\begin{bmatrix} \text{Max} = 0.3909\times X_1 + 0.7465\times X_2 + 0.1149\times X_3 + \\ \quad 0.2384\times X_4 + 6995632\times X_1 + 110063244\times \\ \quad X_2 + 15577218\times X_3 + 9440616\times \\ \quad X_4 \leq 126499492 \\ X_4 = 1 \\ X_i = 0 \text{ or } 1,\ i = 1, 2, ..., 4 \end{bmatrix}$$

Model 1: The estimated model considering the constraints of project selection process. To solve the above model, LINGO v.8 Software was used upon which projects 1, 2 and 10 were eliminated due to their limitations.

CONCLUSION

As observed, a Decision Support System (DSS) was used in this work to evaluate the projects under risk which is a combination of four techniques including simulation, MADM Models consisting of AHP and TOPSIS and mathematical programming method. Given the advantages of each method mentioned, they can remarkably help decision makers especially bank experts when all the four methods are combined with each other because risk factors are never taken into consideration when investigating about investment projects in banks. On the other hand, some indicators (financial and non financial) are included in decision making processes but since these scholars and experts have never given the right weights to these indices, they've never been able to properly choose the best project for investment and make an economic decision. Hence, by applying this decision making system, the risk level involved in investing in projects by banks can be largely reduced.

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