Application of Kim-Nelson Optimization and Simulation Algorithm for the Ranking and Selecting Supplier

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Abstract: - Selecting strategic suppliers has always played a significant role in long-term organizational plans. What is noteworthy in this process is the data on the basis of which the organization implements its supplier selection model, that is; uncertainty in the value of these data and the effect of uncontrollable factors on decision-making criteria can play a significant role in selecting a strategic supplier. In this paper, by using Kim-Nelson optimization and simulation method, the problem of ranking and selecting the suppliers has been solved. Finally, the suppliers of a software production company have been evaluated and ranked by using the criteria presented in this method and the results have been compared with Analytic Hierarchy Process (AHP) method. The results indicate that due to considering the effect of uncontrollable factors on random criteria, Kim-Nelson method has a higher efficiency and the ranking obtained from it is of higher reliability and acceptability.
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Key-Words: - Ranking and selection, supplier, Optimization and simulation, Kim-Nelson Algorithm, AHP

1 Introduction

One of the most important activities for the success of the supply chain is effective and efficient purchase. Because of factors such as globalization, increased added value in supply and rapid technological changes, the act of purchasing has attracted considerable attention in managing the supply chain. The most important purchase activity is selection of a suitable supplier, because selection of a suitable supplier can lead to significant savings for the organization [17].

Selection of the supplier is one of the most important measures taken by the client companies. This selection is a multi-criteria issue which may include both qualitative and quantitative criteria. The relationships between the supplier and the client company have always been considered among vital issues and companies use a series of evaluation criteria for comparing their suppliers. Among the major criteria, cost, quality and delivery time may be mentioned [1].

There are many methods in the literature for selection and ranking of suppliers some of which such as hierarchical analysis [2], fuzzy goal programming [16], fuzzy programming models [10], artificial intelligence models [8], fuzzy logic based approaches [4], [11], simulation optimization models[18], etc. can be mentioned.

The aim of this paper is to use the ranking and selection method by simulation optimization because in these methods besides the controllable criteria which are studied, the effects of uncontrollable factors on each of these criteria can also be identified which can eventually lead to a more reliable ranking in an uncertain environment.

2 The issue of simulation optimization

The issue of simulation optimization is not a new issue. Ever since computers began to affect scientific studies and since stochastic systems analysis by using computer programs were made possible, researchers and engineers started their efforts to optimize systems by using simulation [6], [7], [15].

In general, the advances in simulation are not entirely due to fundamental changes in the principles of system simulation, but rather because of increasing speed of the computers in the recent years. These developments have provided

simulation with many opportunities and there are many unsolved issues in this regard [6]. Besides the higher speed of the computers, vast studies have been conducted in the field of operation research and have led to development of new methods which are compatible with simulation, or in many of the studies, older methods have been modified in a way that they can be combined with simulation [7].
The purpose of simulation optimization is to examine how simulation can be sued for designing a system which provides the optimal expected function. To be specific, our assumption is that the target function is dependent on the input system parameters and our aim is to determine these parameters in a way that may lead to an optimal system. In fact, simulation is used where the system is so complex that other methods are not applicable. Our goal is to maximize the operational function which is presented as follows:

$$\max_{\theta\in\Theta} f(\theta) = E[L(\theta,\xi)] \quad (1)$$

Where $f:\Theta \to R$ is the target function, Θ the response space, and for each $\theta \in \Theta$, ξ is a random element and $L(\theta,\xi)$ is the size of the target function in the random space. Our main focus is on solving problem where in a random state we calculate the mathematical expectation of the response of simulation and try to optimize this mathematical expectation. These cases are presented as follows:

$$f(\theta) = E[Y(\theta)] \Rightarrow \hat{f}(\theta) = \sum_{i=1}^{n} \frac{y_i}{n} \quad (2)$$

3 Ranking and Selection (R & S) at simulation

Nowadays, much more attention is paid to simulation optimization issue. However, results of these simulations are random and at the end of each simulation we are provided with a huge database of search space results. Eventually, these algorithms present the system with best mean performance as best answer. However, initiative algorithms do not assure convergence toward one optimal answer. Even when it is assumed that best answer has been observed during the search phase, these is no reason that the considered system be presented as best answer due to randomness of simulation [14].
History of this discussion goes back to Bechhofer's article [3] on Indifference Zone (IZ) and also to those of Gupta [8], [9] in the years 1956 and 1965on selection of best set.

3.1 Kim Nelson Algorithm

Kim Nelson is referred to a process to select best or near to best answer amongst a set of simulation systems. The process is appropriate and efficient when sampling of the relevant systems can constantly be carried out. This process is aimed at removing systems showing low performance in initial stages and consequently at reducing simulation expenses. The assumption, here, is normalcy of the community and independency of simulation data [12]. In fact, KN method assures with the $1-\alpha_{KN}$ probability to find a system of best mean where real mean of best system has the least difference of δ from that of the second best system. Indeed, δ is the parameter of indifference zone, that is, the least difference between two first and second best systems which are worth being identified? δ is determined by the user himself and differences less then δ value are not of importance for us[13], [14], [15].

4. Case study

4.1 The company

Hamkaran System started its activity in 1987 with three partners and a small capital. Although at that time, PCs were recently entered the country and they were not common like today, many efforts were made to prepare application systems needed by organizations and institutes in a way that these organizations could replace their big computers with PCs.
Financial experience of the founders on the one hand and market demand on the other hand turned main focus of Hamkaran System's operations to manufacturing financial software. After a while, these financial software gained fame and welcomed by the market. Even today, many financial managers and experts know Hamkaran System via the name of the company's efficient financial software. At the

present time, Hamkaran System Group as the biggest private software group of the country is composed of 26 specialized companies and 28 under license companies. Each of these companies located at different region of the country strengthens power of the Group to provide products and services. In fact, through keeping up its main merit among Panah Companies (companies which back up Hamkaran System's software), Hamkaran System has assigned some of its routine processes to under license companies. These companies execute software marketing, sales and establishment. Having passed establishment stage, clients enter backup stage.

4.2 Illustration

When a company outsources main part of its business, it becomes reliant on its under-license companies; as the result, any of their weak performance may lead to severe consequences. Therefore, management and evaluation of under-license companies is of great importance for an outsourcing company [5].

Ability to supply on demand high quality software deeply depends on performance of under license companies of Hamkaran System. Dependence of Hamkaran System on its under-license companies brought about some concerns about the likelihood of blemishing "Hamkaran" brand due to probable faulty relations of under-license companies with the clientele. Consequently, Hamakaran System decided to create a centralized, integrated system to monitor and evaluate its under-license companies. Since some criteria required to evaluate these companies have random nature, companies' annual performance cannot indicate abilities and potentials of the under examination companies to conduct an optimal evaluation process. As the result, to get assured of optimal ranking of under-license companies according to their performance background since their foundation date and to take into account (uncontrollable) environmental variables affecting the said criteria, simulation and optimization methods were applied to find best system in an indefinite space.

4.3 Methodology

Having received opinions of specialists and also having held several sessions with superior managers, the company came up with three criteria of sales amount, establishment amount, and percentage of under contract projects to evaluate performance of under-license companies. Next, by weighing the companies using paired comparison matrix, initial ranking was obtained according to the companies' last year performance data. Since sales process is mainly affected by variables such as economic recession, exiting sanctions, subsidies of energy carriers, customer behaviour change etc, it should be regarded as a random criterion in the study. However, since partners have much more control over this criterion compared to the other two criteria (establishment amount and percentage of under contract projects), it was considered as a definite criterion.

As previously discussed, to find an optimal system in an indefinite space, uncontrollable factors affecting sales random criterion should be taken into consideration through simulation. For this purpose, statistical data of companies' sales over the last six years were analyzed and affecting behaviour of the random factor on the considered factor was detected. Results obtained from statistical analysis of data existing (Table 1) indicated that the sales criterion enjoyed normal random distribution in most companies under examination.

Having identified random factor's behaviour on sales criterion, we were ready to apply stimulation and optimization methods to find best under-license companies. Since number of under examination systems was finite, ranking and selection methods were exploited in this study. After examining ranking and selection methods as well as conditions of under study companies, Kim Nelson method was selected as the proper method to be applied because variance of obtained samples were unknown and unequal which could lead to the increase of type 1 error. Secondly, this method was of more efficiency to compare highly populated communities. On the other hand, KN is a recently presented method with daily increasing

P value	Variance	Mean	Name of company
.143	96	799	S1
>.150	84	653	S2
>.150	67	590	S3
>.010	65	571	S4
>.150	111	564	S5
>.150	51	490	S6
>.150	76	405	S7
>.150	61	331	S8
0.097	44	326	S9
>.150	35	241	S10
>.150	50	295	S11
>.150	43	195	S12
>.150	38	180	S13
>.150	19	192	S14
>.150	17	158	S15
>.150	50	178	S16
>.150	103	191	S17
>.150	12	160	S18
>.150	13	134	S19
>.150	10	95	S20

Table 1: results of Kolmogorov–Smirnov test taken to examine normalcy of sales criterion

To rank and select the optimal under-license companies, first we calculated weights of existing criteria with the help of specialists' opinions and paired comparison matrix. Results obtained according to last year data have been presented in Table 2.

To execute KN method, programming language C#.net2008 has been applied. Results obtained from ranking process of under-license companies by means of KN method have been shown in Table 3. Every time KN method is executed, best system is selected and then removed and KN method is repeated for the systems remained. So, every stage detects and ranks its best system compared to other systems existing.

As you see, by KN method we sometimes reach to different ranking results that indicate effect of uncontrollable factors on systems' performance since this method properly identifies uncontrollable factors and the assumption of unequal and unknown variances shows its impact on ranking results. Furthermore, KN method allows superior managers of the parent company to examine performance of their under-license companies with higher degrees of confidence and to choose an appropriate strategy to treat each of these companies separately.

Ranking	Score	Sales criterion weight (0.5)	Establishment Criterion (weight 0.4)	Criterion of under contract projects percentage (weight 0.1)	Name of company
1	0.92	0.9	1	0.68	S1
2	0.77	0.73	0.9	0.47	S2
4	0.72	0.74	0.73	0.61	S3
5	0.83	0.79	0.94	0.59	S4
3	0.61	0.64	0.59	0.57	S5
6	0.62	0.68	0.58	0.56	S6
7	0.48	0.45	0.51	0.55	S7
11	0.36	0.34	0.3	0.71	S8
8	0.44	0.48	0.32	0.73	S9
9	0.32	0.32	0.25	0.55	S10
17	0.38	0.31	0.4	0.58	S11
10	0.28	0.26	0.24	0.58	S12
12	0.22	0.18	0.13	0.77	S13
14	0.27	0.22	0.26	0.54	S14
13	0.22	0.18	0.19	0.52	S15
16	0.2	0.13	0.22	0.47	S16
15	0.32	0.36	0.21	0.6	S17
18	0.21	0.2	0.14	0.48	S18

19	0.2	0.15	0.17	0.55	S19
20	0.19	0.12	0.25	0.29	S20

Table 2: Ranking results obtained from last year data of Hamkaran System Company

Raking using KN method	Initial ranking using hierarchical analysis	Name of company
1	1	S1
2	3	S2
4	4	S3
5	2	S4
3	6	S5
6	5	S6
7	7	S7
11	10	S8
8	8	S9
9	12	S10
17	9	S11
10	13	S12
12	15	S13
14	14	S14
13	16	S15
16	18	S16
15	11	S17
18	17	S18
19	19	S19
20	20	S20

Table 3: Results obtained from ranking under-license companies using two methods of hierarchical analysis and KN

5. **Conclusion**

The present study has been conducted upon Hamkaran System's need to codify a performance evaluation system so as to identify companies of the highest potential to continue business cooperation or improve relations with. The need was examined via two ranking and selection methods. First method identified criteria required to rank under-license companies using specialists' opinions and then weighed those criteria by means of paired comparison matrix. Next, using last year statistics and also hierarchical analysis the score obtained by each company was calculated. Then, considering impact of uncontrollable factors on one of under examination criteria as well as indefinite nature of information available on that criterion and the ranking result obtained, Kim Nelson selection and ranking method was applied.

Results revealed that both methods were of the same efficiency in terms of best system identification, although they ranked other under-license companies differently. This matter reveals parent company's review of initial ranking because ranking result changes while taking into account the impact of uncontrollable factors on the score of under study companies due to KN method. It can be concluded that mere reliance on last year data cannot provide an appropriate ranking to adopt managerial decisions such as selection of strategic partners, development of under-license companies or their removal from supply bed. In addition, since identifying the impact of uncontrollable factors on random variables and determining the extent of such impact on each criterion are time-consuming and costly processes, KN method can examine, evaluate and rank performance of under-license companies in a shorter period of time and higher confidence.

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