Expert Systems with Applications 39 (2012) 3702–3707

Contents lists available at SciVerse ScienceDirect

Expert Systems with Applications

journal homepage: www.elsevier.com/locate/eswa

# Group decision making process for insurance company selection problem with extended VIKOR method under fuzzy environment

G. Nilay Yücenur, Nihan Çetin Demirel *

*Yıldız Technical University, Mechanical Faculty, Industrial Engineering Department, Beşiktaş, Istanbul, Turkey*

ARTICLE INFO

*Keywords:*
Multi-criteria decision making
VIKOR method
Fuzzy sets
Selection problem
Insurance sector

ABSTRACT

In recent years, because of the high potential for insurability in Turkey and the rapid improvement of insurance sector, foreign investors are interested in Turkish insurance market. Since insurability rate has reached saturation point in their countries, foreign investors tended to make investments in Turkey and start to purchase local insurance companies in Turkey. In this paper we analyze five Turkish insurance companies for a foreign investor who wants to purchase a local insurance company. For selecting the most appropriate alternative we used the extended VIKOR method which applied to determine the best feasible solution according to the selected criteria. This method was developed to solve multiple criteria decision making problems with conflicting and non-commensurable criteria, assuming that compromising is acceptable for conflict resolution. In this paper, the alternatives are evaluated according to all established criteria with the VIKOR method completely under fuzzy environment with fuzzy sets.


## 1. Introduction

Multi-criteria decision making (MCDM) refers to making preference decision (e.g., evaluation, prioritization, and selection) over the available alternatives that are characterized by multiple, usually conflicting, criteria. As decision making requires multiple perspectives of different people, most organizational decisions are made in groups (Ma, Lu, & Zhang, 2010).

Multi-criteria decision making comprises a finite set of alternatives, amongst which the decision-makers have to select, evaluate or rank according to the weights of a finite set of criteria (attributes). There are several methods for dealing with multi-criteria decision making problems, such as multiplicative exponential weighting (MEW), simple additive weighting (SAW), technique for ordering preference by similarity to ideal solution (TOPSIS), analytic hierarchy process (AHP) and so forth. It is unrealistic to assign a crisp value for a subjective judgment, especially when the information is vague or imprecise (Chang & Wang, 2009). The multi-criteria decision making models face different kinds of uncertainty, which generally could be taken into account by using stochastic analysis or fuzzy set theory. Stochastic approach suits the condition when a probabilistic data set represents the uncertainty. Fuzzy approach is appropriate when parameters are subjective and vague (Zarghami & Szidarovszky, 2009).

The VIKOR method was developed to solve multi-criteria decision making problems with conflicting and non-commensurable (different units) criteria, assuming that compromising is acceptable for conflict resolution, the decision maker wants a solution that is the closest to the ideal, and the alternatives are evaluated according to all established criteria. This method focuses on ranking and selecting from a set of alternatives in the presence of conflicting criteria, and on proposing compromise solution (one or more) (Opricovic & Tzeng, 2007).

The usage of VIKOR method has been increasing. In the literature, Liou, Tsai, Lin, and Tzeng (2010) used a modified VIKOR method for improving the domestic airlines service quality and Chang and Hsu (2009) used VIKOR method for prioritizing land-use restraint strategies in the Tseng–Wen reservoir watershed. Sayadi, Heydari, and Shahanaghi (2009) used extension VIKOR method for the solution of the decision making problem with interval numbers. On the other hand some researchers have evaluated VIKOR method under fuzzy environment. For example Kaya and Kahraman (2010) used an integrated fuzzy VIKOR and AHP methodology for multi-criteria renewable energy planning in İstanbul and also Sanayei, Mousavi, and Yazdankhah (2010) used VIKOR method for a supplier selection problem with fuzzy sets. Chen and Wang (2009) optimized partners' choice in IS/IT outsourcing projects by fuzzy VIKOR.

In this study, we applied the VIKOR method, which was developed for multi-criteria optimization for complex systems, to find a compromise priority ranking of alternatives according to the selected criteria for a selection problem. The objective of this study

* Corresponding author. Tel.: +90 212 3832868.
*E-mail addresses:* nserbest@yildiz.edu.tr (G.N. Yücenur), nihan@yildiz.edu.tr (N. Çetin Demirel).

0957-4174/$ - see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.eswa.2011.09.065

was to determine the priority ranking of alternative Turkish insurance companies for the evaluating of suitability of their purchasable by an international investor.

As an outline, the Turkish insurance sector and firm purchasing reasons are presented in Section 2. The definition and the background of VIKOR method and its applications are presented in Section 3. Section 4 is about a proposed solution method for selection problem under fuzzy environment. A numerical example illustrates an application of VIKOR method for selection problem in Section 5 and in the final section some conclusions are drawn for the study.

## 2. Insurance sector and firm purchasing in Turkey

Having enjoyed a spectacular growth consistently after the financial crisis in 2001 the insurance industry in Turkey experienced a slight decline at the last quarter of the 2008 and concluded the year with a growth rate below inflation as a result of the global financial crisis. Contrary to the insurance market, the individual pension system coming into force in 2003 continued to grow without its losing enthusiasm of the first years. In 2008, the number of the participants and the total amount of contributions in the system increased by 18% and 39%, respectively (http, 2010).

A major indicator of the importance of insurance industry for an economy is the total amount of coverage. There is not any industry which immunes from effects of the crisis. However, the direct impact of the crisis in Turkish insurance market has been limited. The biggest effects have been observed on the premium production. After the seven-year period of growth the trend reversed in 2008 and we witnessed a slight growth below inflation rate. However, the industry was recovered from the negative effects of the crisis shortly and entered into the period of high growth again in 2010 (http, 2010). In Table 1, premium generation by the insurance market in Turkey is shown for 20 yrs.

The high potential of insurability in Turkey and the rapid improvement of insurance and pension sector pointed Turkish insurance market to foreign investors. Since insurability rate has reached saturation point in their countries, foreign investors tended to make investments in developing countries and briskness in Turkish insurance sector that started in 2006 continued to grow to 2010 (http, 2010). That is why, in this paper we analyze five Turkish insurance companies for our foreign investor who wants to purchase a local company and be included by the Turkish economy.

## 3. VIKOR method and its applications

VIKOR was developed by Opricovic (1998) and Opricovic and Tzeng (2002) with the Serbian name: VlseKriterijumska Optimizacija I Kompromisno Resenje, means multi-criteria optimization and compromise solution. The VIKOR method was developed for multi-criteria optimization of complex systems and this method focuses on ranking and selecting from a set of alternatives, and determines compromise solutions for a problem with conflicting criteria, which can help the decision makers to reach a final decision. Here, the compromise solution is a feasible solution which is the closest to the ideal, and a compromise means an agreement established by mutual concessions. It introduces the multi-criteria ranking index based on the particular measure of "closeness" to the "ideal" solution (Sanayei et al., 2010).

According to Sayadi et al. (2009), the multi-criteria measure for compromise ranking is developed from the *P*Lp-metric used as an aggregating function in a compromise programming method. The various $m$ alternatives are denoted as $A_1, A_2, \ldots, A_m$. For alternative $A_i$, the rating of the $j$th aspect is denoted by $f_{ij}$, i.e. $f_{ij}$ is the value of $j$th criterion function for the alternative $A_i$; $n$ is the number of criteria. Development of the VIKOR method started with the following form of $L_p$-metric:

$$L_{p,j} = \left\{ \sum_{i=1}^{n} \left[ w_i (f_i^* - f_{ij}) / (f_i^* - f_i^-) \right]^p \right\}^{1/p} \quad 1 \leqslant p \leqslant \infty, \quad j = 1, 2, \ldots, J. \tag{1}$$

In the VIKOR method $L_{1,i}$ (as $S_i$) and $L_{\infty,i}$ (as $R_i$) are used to formulate ranking measure. The solution obtained by $S_i$ is with a maximum group utility ("majority" rule), and the solution obtained by min $R_i$ is with a minimum individual regret of the "opponent" (Sayadi et al., 2009).

**Table 1**
Premium generation by the insurance market in Turkey (http, 2010).

| Year | Premium | | Premium per capital | | Population (million) |
|---|---|---|---|---|---|
| | Amount (million USD) | Increase (%) | Amount (million USD) | Increase (%) | |
| 1987 | 363 | 29.2 | 6.9 | 26.2 | 52.6 |
| 1988 | 401 | 10.5 | 7.5 | 8.2 | 53.7 |
| 1989 | 497 | 23.9 | 9.1 | 21.2 | 54.9 |
| 1990 | 710 | 42.9 | 12.7 | 39.8 | 56.1 |
| 1991 | 964 | 35.8 | 16.8 | 33.0 | 57.3 |
| 1992 | 1187 | 23.1 | 20.3 | 20.4 | 58.6 |
| 1993 | 1563 | 31.6 | 26.0 | 28.6 | 60.0 |
| 1994 | 1066 | −31.8 | 17.4 | −33.3 | 61.4 |
| 1995 | 1377 | 29.2 | 21.9 | 25.9 | 63.0 |
| 1996 | 1535 | 11.4 | 24.3 | 11.3 | 64.6 |
| 1997 | 1811 | 18.0 | 29.6 | 20.1 | 62.6 |
| 1998 | 2119 | 17.0 | 32.7 | 15.1 | 64.8 |
| 1999 | 2314 | 8.6 | 35.9 | 7.0 | 64.4 |
| 2000 | 2847 | 23.0 | 43.6 | 21.2 | 65.3 |
| 2001 | 2033 | −28.6 | 30.7 | −29.6 | 66.2 |
| 2002 | 2426 | 19.6 | 36.1 | 18.0 | 67.1 |
| 2003 | 3316 | 36.6 | 46.8 | 34.4 | 70.9 |
| 2004 | 4656 | 59.5 | 64.7 | 38.2 | 72.0 |
| 2005 | 5829 | 25.2 | 79.7 | 23.3 | 73.1 |
| 2006 | 6713 | 15.2 | 90.8 | 13.9 | 73.9 |
| 2007 | 8359 | 24.5 | 118.4 | 30.4 | 70.6 |

## 4. Proposed solution method for selection problem under fuzzy environment

Multi-criteria decision making problems are usually under uncertainty. One of these uncertain parameters is the decision maker (DM)'s degree of optimism, which has an important effect on the results. Fuzzy linguistic quantifiers are used to obtain the assessments of this parameter from DM and then, because of its uncertainty it is assumed to have stochastic nature (Zarghami & Szidarovszky, 2009). In this paper the problem is evaluated under fuzzy environment with fuzzy sets.

The main steps of the algorithm are taken from Sanayei et al.'s (2010) study:

**Step 1**: Identifying the objectives of the decision making process and define the problem scope. Our objective is to choosing the most suitable insurance company for the foreign investor who wants to purchase a local insurance company in Turkey.

**Step 2**: Arranging the decision making group and define and describe a finite set of relevant attributes. For our selection problem we have eight different criteria and five different alternative companies. The criteria identified and analyzed in this paper can be seen in the literature and the professional insurance life.

**Step 3**: Identifying the appropriate linguistic variables: In this step, the appropriate linguistic variables for the importance weight of criteria, and the fuzzy rating for alternatives with regard to each criterion these linguistic variables can be expressed in positive trapezoidal fuzzy numbers, as in Figs. 1 and 2 must be defined. The decision makers use the linguistic variables shown in Figs. 1 and 2 to evaluate the importance of the criteria and the ratings of alternatives with respect to qualitative criteria.

**Step 4**: Pull the decision makers' opinions to get the aggregated fuzzy weight of criteria, and aggregated fuzzy rating of alternatives and construct a fuzzy decision matrix: Let the fuzzy rating and importance weight of the $k$ th decision maker be $\tilde{x}_{ijk} = (x_{ijk1}, x_{ijk2}, x_{ijk3}, x_{ijk4})$ and $\tilde{w}_{jk} = (w_{jk1}, w_{jk2}, w_{jk3}, w_{jk4}); i = 1, 2, \ldots, m$ and $j = 1,2,\ldots,n$ respectively. Hence, the aggregated fuzzy ratings $(\tilde{x}_{ij})$ of alternatives with respect to each criterion can be calculated as:

$$\tilde{x}_{ij} = (x_{ij1}, x_{ij2}, x_{ij3}, x_{ij4}), \tag{2}$$

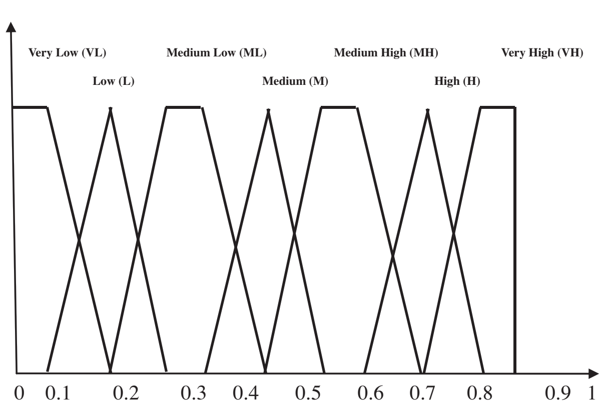


**Fig. 1**. Linguistic variables for importance weight of each criteria (Sanayei et al., 2010).

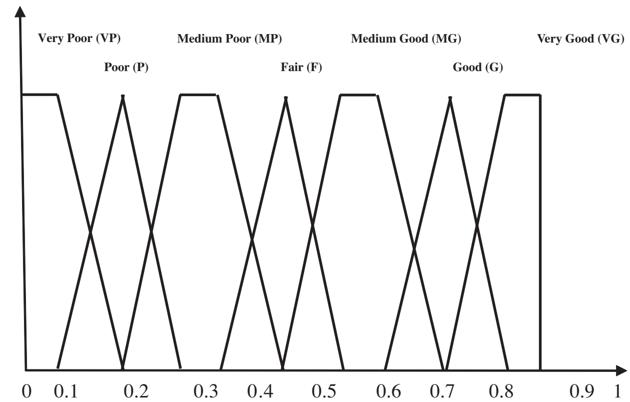


**Fig. 2**. Linguistic variables for ratings (Sanayei et al., 2010).

where

$$x_{ij1} = \min\{x_{ijk1}\}_k, \quad x_{ij2} = \frac{1}{K}\sum_{k=1}^{K} x_{ijk2}, \quad x_{ij3} = \frac{1}{K}\sum_{k=1}^{K} x_{ijk3},$$
$$x_{ij4} = \max\{x_{ijk4}\}_k$$

The aggregated fuzzy weights $(\tilde{w}_j)$ of each criterion can be calculated as:

$$\tilde{w}_j = (w_{j1}, w_{j2}, w_{j3}, w_{j4}), \tag{3}$$

where

$$w_{j1} = \min\{w_{jk1}\}_k, \quad w_{j2} = \frac{1}{K}\sum_{k=1}^{K} w_{jk2}, \quad w_{j3} = \frac{1}{K}\sum_{k=1}^{K} w_{jk3}, \quad w_{j4} = \max\{w_{jk4}\}_k.$$

A suitable insurance firm selection problem can be concisely expressed in matrix format as follows:

$$\widetilde{D} = \begin{bmatrix} \tilde{x}_{11} & \tilde{x}_{12} & \cdots & \tilde{x}_{1n} \\ \tilde{x}_{12} & \tilde{x}_{22} & \cdots & \tilde{x}_{2n} \\ \vdots & \vdots & \ldots & \vdots \\ \tilde{x}_{m1} & \tilde{x}_{m2} & \cdots & \tilde{x}_{mn} \end{bmatrix}, \quad \widetilde{W} = [\tilde{w}_1, \tilde{w}_2, \ldots, \tilde{w}_n],$$

where $\tilde{x}_{ij}$ the rating of alternative $A_i$ with respect to $C_j$, $\tilde{w}_j$ the importance weight of the $j$th criterion holds, $\tilde{x}_{ij} = (x_{ij1}, x_{ij2}, x_{ij3}, x_{ij4})$ and $\tilde{w}_j = (w_{j1}, w_{j2}, w_{j3}, w_{j4}); i = 1, 2, \ldots, m$ and $j = 1,2,\ldots,n$ are linguistic variables can be approximated by positive trapezoidal fuzzy numbers.

**Step 5**: Defuzzify the fuzzy decision matrix and fuzzy weight of each criterion into crisp values: This calculation is done by using center of area defuzzification method.

**Step 6**: Determine the best $f_j^*$ and the worst $f_j^-$ values of all criterion ratings, $j = 1,2,\ldots,n$

$$f_j^* = \max_i x_{ij} \tag{4}$$
$$f_j^- = \min_i x_{ij} \tag{5}$$

**Step 7**: Compute the values $S_i$ and $R_i$ by the relations

$$S_i = \sum_{j=1}^{n} w_j \left(f_j^* - f_{ij}\right) / \left(f_i^* - f_i^-\right), \tag{6}$$
$$R_i = \max_j w_j \left(f_j^* - f_{ij}\right) / \left(f_i^* - f_i^-\right). \tag{7}$$

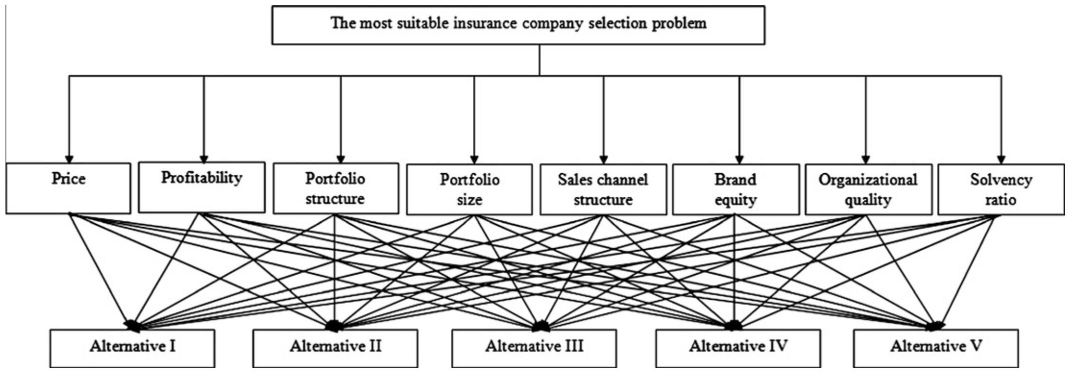


**Fig. 3**. Research model.

**Table 2**
Importance weight of criteria from three decision makers.

| Criteria | Decision makers | | |
|---|---|---|---|
| | D1 | D2 | D3 |
| C1 | H | VH | VH |
| C2 | H | H | H |
| C3 | MH | H | MH |
| C4 | MH | MH | M |
| C5 | M | MH | M |
| C6 | ML | ML | M |
| C7 | ML | ML | ML |
| C8 | M | ML | ML |

**Step 8**: Compute the values $Q_i$ by the relations

$$Q_i = v(S_i - S^*)/(S^- - S^*) + (1 - v)(R_i - R^*)/(R^- - R^*) \quad (8)$$

where $S^* = \min_i S_i$, $S^- = \max_i S_i$, $R^* = \min R_{ii}$, $R^- = \max R_{ii}$ and $v$ is introduced as a weight for the strategy of maximum group utility, whereas $1 - v$ is the weight of the individual regret.

**Step 9**: Rank the alternatives, sorting by the values $S$, $R$ and $Q$ in ascending order

**Step 10**: Propose as a compromise solution the alternative ($A^{(1)}$) which is the best ranked by the measure $Q$ (minimum) if the following two conditions are satisfied

- C1. Acceptable advantage:

$$Q(A^{(2)}) - Q(A^{(1)}) \geqslant DQ, \quad (9)$$

where $A^{(2)}$ is the alternative with second position in the ranking list by $Q$;$DQ = 1/(J - 1)$.

- C2. Acceptable stability in decision making: The alternative $A^{(1)}$ must also be the best ranked by $S$ or/and $R$. This compromise solution is stable within a decision making process, which could be the strategy of maximum group utility (when $v > 0.5$ is needed), or "by consensus" $v \approx 0.5$, or "with veto" ($v < 0.5$). Here, $v$ is the weight of decision making strategy of maximum group utility. If one of the conditions is not satisfied, then a set of compromise solutions is proposed, which consist of
  - Alternatives $A^{(1)}$ and $A^{(2)}$ if only the conditions C2 is not satisfied, or
  - Alternatives $A^{(1)}, A^{(2)}, \ldots, A^{(M)}$ if the condition C1 is not satisfied; $A^{(M)}$ is determined by the relation $Q(A^{(M)}) - Q(A^{(1)}) < DQ$ for maximum $M$ (the positions of these alternatives are "in closeness").

## 5. Numerical example for selection problem

The proposed model has been applied to an insurance company selection problem of an international insurance firm which wants to purchase a public insurance company in Turkey.

The steps of the solution process can be defined as in follows:

- **Step 1:** The international company desires to select a suitable public insurance firm in Turkey to purchase its financial structure. After preliminary screening, five candidate Turkish insurance firms (A1, A2, A3, A4, A5) remain for further evaluation.

**Table 3**
Ratings of the five alternative insurance firms by the decision makers under the various criteria.

| | Alternatives | Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 |
| *Decision maker* | | | | | | | | | |
| D1 | A1 | MP | MP | MP | MG | G | G | F | MP |
| | A2 | MG | P | P | P | MP | MP | MP | MP |
| | A3 | MP | F | VG | F | MG | G | F | F |
| | A4 | VG | P | P | VP | P | P | P | MP |
| | A5 | VP | MG | MG | G | G | VG | F | MG |
| D2 | A1 | MP | F | MP | G | G | VG | MG | MP |
| | A2 | F | P | P | P | MP | MP | MP | MP |
| | A3 | P | MG | VG | MG | G | G | F | F |
| | A4 | VG | P | VP | VP | P | VP | P | P |
| | A5 | VP | F | MG | VG | G | VG | MG | MG |
| D3 | A1 | F | MP | P | MG | G | G | F | F |
| | A2 | MG | MP | VP | MP | P | F | MP | MP |
| | A3 | P | MG | G | MG | G | MG | F | F |
| | A4 | VG | P | VP | P | VP | P | VP | P |
| | A5 | P | G | MG | G | MG | VG | MG | MG |

**Table 4**
Aggregated fuzzy weight of criteria and aggregated fuzzy rating of alternatives.

| | Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Cl | C2 | C3 | C4 | C5 | C6 | C7 | C8 |
| Weight | (0.70,0.87,0.93,1.00) | (0.70,0.80,0.80,0.90) | (0.50,0.67,0.73, 0.90) | (0.40,0.57,0.63,0.80) | (0.40,0.53,0.57,0.80) | (0.20,0.37,0.43,0.60) | (0.20,0.30,0.40,0.50) | (0.20,0.37,0.43,0.60) |
| Al | (0.20,0.37,0.43,0.60) | (0.20,0.37,0.43,0.60) | (0.10,0.27,0.33,0.50) | (0.50,0.67,0.73,0.90) | (0.70,0.80,0.80,0.90) | (0.70,0.83,0.87,1.00) | (0. 40,0.53,0.57,0.80) | (0.20,0.37,0.43,0.60) |
| A2 | (0.40,0.57,0.63,0.80) | (0.10,0.23,0.27,0.50) | (0.00,0.13,0.17,0.30) | (0.10,0.23,0.27,0.50) | (0.10,0.27,0.33,0.50) | (0.20,0.37,0.43,0.60) | (0.20,030,0.40,0.50) | (0.20,0.30,0.40,0.50) |
| A3 | (0.10,0.23,0.27,0.50) | (0.40,0.57,0.63,0.80) | (0. 70,0.87,0.93,1.00) | (0.40,0.57,0 63,0.80) | (0.50,0.73,0.77,0.90) | (0.30,0.73,0.77,0.90) | (0.40,0.50,0.50,0.60) | (0.40,0.50,0.50,0.60) |
| A4 | (0.80,0.90,1.00,1.00) | (0.10,0.20,0.20,0.30) | (0.00,0.07,0.13,0.30) | (0.00,0.07,0.13,0.30) | (0.00,0.13,0.17,0.30) | (0.00,0.13,0.17,0.30) | (0.00,0.13,0.17,0.30) | (0.10,0.23,0 27,0.50) |
| A5 | (0.00,0.07,0.13,0.30) | (0.40,0.63,0.67,0.90) | (0.50,0 60,0.70,0 80) | (0 70,0 83,0 87,1.00) | (0.50,0.73,0.77,0.90) | (0.80,0.90,1.00,1 00) | (P 40,0 57,0 63,0.80) | (0 50,0.60,0 70,0.80) |

**Table 5**
Crisp values for decision matrix and weight of each criterion.

| | Criteria | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 |
| Weight | 0.87 | 0.80 | 0.70 | 0.60 | 0.57 | 0.40 | 0.35 | 0.40 |
| A1 | 0.40 | 0.40 | 0.30 | 0.70 | 0.80 | 0.85 | 0.57 | 0.40 |
| A2 | 0.60 | 0.27 | 0.15 | 0.27 | 0.30 | 0.40 | 0.35 | 0.35 |
| A3 | 0.27 | 0.60 | 0.87 | 0.60 | 0.72 | 0.72 | 0.50 | 0.50 |
| A4 | 0.92 | 0.20 | 0.12 | 0.12 | 0.15 | 0.15 | 0.15 | 0.27 |
| A5 | 0.12 | 0.65 | 0.65 | 0.85 | 0.72 | 0.92 | 0.60 | 0.65 |

**Table 6**
The values of $S$, $R$ and $Q$ for all alternative insurance firms.

| | Alternatives | | | | |
|---|---|---|---|---|---|
| | A1 | A2 | A3 | A4 | A5 |
| S | 2.96 | 5.75 | 2.24 | 7.00 | 1.41 |
| R | 0.76 | 0.96 | 0.81 | 1 | 1 |
| Q | 0.14 | 0.80 | 0.18 | 1.00 | 0.50 |

**Table 7**
The ranking of the alternative insurance firms by $S$, $R$ and $Q$ in decreasing order.

| | Ranking alternatives | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| By $S$ | A5 | A3 | A1 | A2 | A4 |
| By $R$ | A1 | A3 | A2 | A5 | A4 |
| By $Q$ | A1 | A3 | A5 | A2 | A4 |

- **Step 2:** A committee of three decision makers, D1, D2 and D3, has been formed to select the most suitable insurance firm. The following criteria have been defined:
  - Price
  - Profitability
  - Portfolio structure
  - Portfolio size
  - Sales channel structure
  - Brand equity
  - Organizational quality (Technical and social structure).
  - Solvency ratio (Solvency ratios are measures to assess a company's ability to meet its long-term obligations and thereby remain solvent and avoid bankruptcy.

  Solvency ratio = [(after tax net profit + depreciation)/ (long term liabilities + short term liabilities)] The research model is shown in Fig. 3.
- **Step 3:** Three decision makers use the linguistic weighting variables shown in Fig. 2 to assess the importance of the criteria. The importance weights of the criteria determined by these three decision makers are shown in Table 1. Also the decision makers use the linguistic rating variables shown in Fig. 2 to evaluate the ratings of candidates with respect to each criterion. The ratings of the five insurance firm alternatives by the decision makers under the various criteria are shown in Table 3.
- **Step 4:** The linguistic evaluations shown in Tables 2 and 3 are converted into trapezoidal fuzzy numbers. Then the aggregated weight of criteria and aggregated fuzzy rating of alternatives is calculated to construct the fuzzy decision matrix and determine the fuzzy weight of each criterion, as in Table 4.
- **Step 5:** The crisp values for decision matrix and weight of each criterion are computed as shown in Table 5.

- **Step 6:** The best and the worst values of all criterion ratings are determined as follows:

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| $f_1^*=0.92$ | $f_2^*=0.65$ | $f_3^*=0.87$ | $f_4^*=0.85$ | $f_5^*=0.80$ | $f_6^*=0.92$ | $f_7^*=0.60$ | $f_8^*=0.65$ |
| $f_1^-=0.12$ | $f_2^-=0.20$ | $f_3^-=0.12$ | $f_4^-=0.12$ | $f_5^-=0.15$ | $f_6^-=0.15$ | $f_7^-=0.15$ | $f_8^-=0.27$ |

- **Steps 7:** The value of $S$ is calculated for all alternative firms as Table 6.
- **Steps 8:** The value of $R$ is calculated for all alternative firms as Table 6.
- **Steps 9:** The value of $Q$ is calculated for all alternative firms as Table 6.
- **Step 10:** The ranking of the alternative firms by $S$, $R$ and $Q$ in decreasing order is shown in Table 7.

Alternative $I$ is the most suitable insurance company for purchasing by the foreign investor and the alternative insurance companies after this are third and fifth ones according to $Q$ value.

## 6. Conclusion

The multi-criteria nature of the problem makes multi-criteria decision making methods and fuzzy logic ideal to cope with this, given that they consider many criteria at the same time, with various weights and thresholds, having the potential to reflect at a very satisfactory degree the vague – most of the times – preferences of the DMs (Kelemenis & Askounis, 2010).

In this paper extended VIKOR method is proposed to deal with the criteria and select the most suitable alternative insurance company for the foreign investor who wants to purchase a local insurance company in Turkey. The VIKOR method focuses on ranking and selecting from a set of alternatives in the presence of conflicting criteria. It determines a compromise solution that could be accepted by the decision makers. In this paper, VIKOR method is used under fuzzy environment with fuzzy sets.

According to the final score, first insurance company is the most suitable company for the foreign investor. This alternative has the minimum $Q$ value. Third and fifth alternatives are the next recommended alternative insurance companies according to criteria such as price, profitability, portfolio structure, portfolio size, sales channel structure, brand equity, organizational quality and solvency ratio.

## References

Chang, C.-L., & Hsu, C.-H. (2009). Multi-criteria analysis via the VIKOR method for prioritizing land-use restraint strategies in the Tseng–Wen reservoir watershed. *Journal of Environmental Management, 90*, 3226–3230.

Chang, T.-H., & Wang, T.-C. (2009). Using the fuzzy multi-criteria decision making approach for measuring the possibility of successful knowledge management. *Information Sciences, 179*, 355–370.

Chen, L. Y., & Wang, T.-C. (2009). Optimizing partners' choice in IS/IT outsourcing projects: The strategic decision of fuzzy VIKOR. *International Journal of Production Economics, 120*, 233–242.

<www.treasury.gov.tr>, Arrival date: 28.04.2010.

<www.turkisheconomy.org.uk>, Arrival date: 28.04.2010.

Kaya, T., Kahraman, C., (2010). Multicriteria renewable energy planning using an integrated fuzzy VIKOR & AHP methodology: The case of Istanbul. Energy, (pp. 1–11), doi:10.1016/j.energy.2010.02.051.

Kelemenis, A., & Askounis, A. (2010). A new TOPSIS-based multi-criteria approach to personnel selection. *Expert Systems with Applications, 37*, 4999–5008.

Liou, J. J. H., Tsai, C.-Y., Lin, R.-H., & Tzeng, G.-H. (2010). A modified VIKOR multiple-criteria decision method for improving domestic airlines service quality. *Journal of Air Transport Management*, 1–5. doi:10.1016/j.jairtraman.2010.03.004.

Ma, J., Lu, J., & Zhang, G. (2010). Decider: A fuzzy multi-criteria group decision support system. *Knowledge-Based Systems, 23*, 23–31.

Opricovic, S. (1998). Multicriteria optimization of civil engineering systems (in Serbian, Visekriterijumska optimizacija sistema u gradjevinarstvu). Faculty of Civil Engineering, Belgrade.

Opricovic, S., & Tzeng, G. H. (2002). Multicriteria planning of post-earthquake sustainable reconstruction. *Computer-Aided Civil and Infrastructure Engineering, 17*, 211–220.

Opricovic, S., & Tzeng, G.-H. (2007). Extended VIKOR method in comparison with outranking methods. *European Journal of Operational Research, 178*, 514–529.

Sanayei, A., Mousavi, S. F., & Yazdankhah, A. (2010). Group decision making process for supplier selection with VIKOR under fuzzy environment. *Expert Systems with Applications, 37*, 24–30.

Sayadi, M. K., Heydari, M., & Shahanaghi, K. (2009). Extension of VIKOR method for decision making problem with interval numbers. *Applied Mathematical Modelling, 33*, 2257–2262.

Zarghami, M., & Szidarovszky, F. (2009). Revising the OWA operator for multi criteria decision making problems under uncertainty. *European Journal of Operational Research, 198*, 259–265.