Todim Method For The Selection Of The Elective Courses

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Abstract

The selection of the elective courses considering the undergraduate students' abilities and interests is a crucial decision. This decision also affects their academic career and job proficiency. In this paper it is aimed to guide the students for the elective course selection via TODIM (an acronym in Portuguese of Interactive and Multi Criteria Decision Making) method. TODIM method is one of the MCDM methods which is used to order the alternatives and based on pair comparisons between them. The relative measure of dominance of one alternative over another is found and finally the global values of each alternative are computed to obtain the complete ranking.

Keywords: MCDM**,** TODIM, Elective courses selection

Introduction

The course selection that occurs in each semester is an important decision for the students. Most programs or departments in the universities have both compulsory and elective courses. In this paper elective courses are handled. Students are interested in some topics because of the different reasons so the universities offer different elective course alternatives to fulfill these requirements. Elective courses are specialized courses that students can get in addition to their compulsory courses. They allow the students to study specialized areas of their needs or interests not extensively covered in the compulsory courses. At the same time they reinforce the compulsory courses in specific skill fields that students want or need to strengthen. By this way students broaden their knowledge, follow their interests through their abilities, specialize and do something they are interested in. Also they transfer this knowledge to their careers. So the course selection for students is an essential decision for their academic careers and job proficiencies (Ersöz et al., 2011). This selection is affected by many conflicting criteria so it may be handled as multi criteria decision making (MCDM) problem and solved by MCDM methods. Dündar (2008) and Akyol et al. (2014) solved the course selection problem with the AHP method. Ersöz et al. (2011) developed a model based on ANP (Analytic Network Process) and TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) methods for choosing courses of an undergraduate program. The weights of the criteria were determined by ANP and final ranking of the courses were determined by TOPSIS. Keçek and Söylemez (2016) handled the course selection in postgraduate studies with AHP and TOPSIS methods. The literature shows that there are many studies about course selection problem in the MCDM literature but the number of studies about elective course selection problem is limited.

In this paper TODIM (an acronym in Portuguese of Interactive and Multi Criteria Decision Making) method is applied to the elective course selection problem to guide the students. TODIM method is one of MCDM methods and depends on prospect theory. It calculates dominance degrees of each alternative over the remaining alternatives and finally ranks the alternatives (Wei et al., 2015).

The rest of this paper is organized as follows. Firstly the background of TODIM method is presented. Then the application of this method is demonstrated with the elective course selection problem. Lastly the results of the application and the recommendations for future studies are given.

TODIM Method

TODIM method (an acronym in Portuguese for Iterative multi-criteria decision Making) is one of MCDM methods based on prospect theory and it was proposed by Gomes and Lima in 1992 (Krohling & Souza, 2012). The main idea of the TODIM method is measuring the dominance degree of each alternative over the remaining ones by the help of the prospect value function (Wei et al., 2015). The shape of the value function of TODIM is identical to gain and loss function of the prospect theory (Mahmoodi & Jahromi, 2014). Generally TODIM calculates the partial and overall dominance degrees of each alternative over the other alternatives and finally the ranks the alternatives (Ramooshjan et al., 2015). In the literature TODIM method has been employed to solve MCDM problems. Costa et al. (2002) integrated TODIM method with information system planning methodology to assign priorities in information systems. Gomes and Rangel (2009) used TODIM method for evaluating the residential properties and determining a reference value for their rents. Gomes et al. (2009) proposed to use TODIM method for selecting the best option for the destination of the natural gas reserves discovered in Brazil. Gomes et al. (2010) used TODIM and THOR (an acronym for Multicriteria Decision Support Hybrid

Algorithm for Decision Making Processes with Discrete Alternatives) methods for selecting the best natural gas destination. Gomes and González (2012) discussed the role of TODIM method within behavioral decision theory by clarifying cumulative prospect theory and the choice of a reference point. Krohling and Souza (2012a) developed a fuzzy extension of TODIM method for solving multi criteria decision making problems under uncertainty. Krohling and Souza (2012b) used fuzzy TODIM method for rental evaluation of residential properties in Brazil. Krohling et al. (2013) extended fuzzy TODIM method for MCDM problems that contains intuitionistic fuzzy information. Lourenzutti and Krohling (2013) proposed a fuzzy TODIM method that considers intuitionistic fuzzy information and underlying random vectors that affects the performance of the alternatives. Kazancoglu and Burmaoglu (2013) selected enterprise resource planning (ERP) software by using TODIM method. Fan et al. (2013) proposed an extension of TODIM method for solving MADM (Multi-Attribute Decision Making) problems. In this proposed method, differently from classical TODIM, attribute values in terms of crisp, interval and fuzzy numbers are transformed into random variables with cumulative distribution functions. Gomes et al. (2013a) used Choquet integral to measure criteria interaction in TODIM method. By this way they decreased the amount of calculations and also enabled to use interval data. Gomes et al. (2013b) proposed an extended version of TODIM which was based on Choquet integral and applied the method to forecast property values for rent in a Brazilian city. Mahmoodi and Gelayol (2014) integrated DEMATEL and TODIM methods for determining the criteria weights of knowledge management in supply chain networks. Krohling and Pacheco (2014) extended the TODIM method for interval-valued intuitionistic fuzzy environments. Liu and Teng (2014) proposed an extension of TODIM method to handle 2-dimension uncertain linguistic information in the decision process. Uysal and Tosun (2014) used TODIM method to solve residential location choice problem by considering objective and subjective factors. Tseng et al. (2014) evaluated green supply chain practices under uncertainty with TODIM method. Passos and Gomes (2014) integrated TODIM and Fuzzy Synthetic Evaluation (FSE) approach and proposed TODIM-FSE to select the best trainee for an information technology company. Passos et al. (2014) used TODIM-FSE to help potential users to decide upon suitable contingency plans for oil spill situations. Lourenzutti and Krohling (2014) discussed using the Hellinger distance in TOPSIS and TODIM methods to assist the models for dealing with probability distributions without any transformation in the data. Zhang and Xu (2014) extended the TODIM method for the solution of MCDM problems under hesitant fuzzy environment. Wei et al. (2015) extended TODIM method for MCDM problems which include hesitant fuzzy linguistic term sets by considering the psychological behavior of the decision maker. Salomon and Rangel (2015) compared the results of TODIM method and a fuzzy expert system and they obtained better solutions with TODIM than fuzzy sets. Ramooshjan et al. (2015) used fuzzy TODIM method to select location for the branch of a bank. Sen et al. (2015) proposed TODIM method based on grey numbers and applied it to the robot selection problem. Lourenzutti and Krohling (2015) developed a new approach based on TODIM method to handle heterogeneous data. Gomes et al. (2015) used TODIM and Choquet-extended TODIM methods to determine the ranking of the suppliers in a steel industry and compared the obtained results. Li et al. (2015) proposed Intuitionistic Fuzzy TODIM (IF-TODIM) for the solution of distributer selection problem under uncertainty. Tseng et al. (2015) developed a combined approach based on fuzzy set theory, TODIM method and non-addictive Choquet integral to evaluate service innovation in the hotel industry. Ren et al. (2016) extended TODIM method for MCDM problems that contains Pythagorean fuzzy information and applied the proposed method to the governor selection of Asian Infrastructure Investment Bank. Frigolett and Gomes (2016) proposed a new method for rule extraction in a knowledge based innovation tutoring system and used TODIM method to rank the initial set of rules.

The application steps of TODIM method are presented in the following (Liu and Teng, 2014, Wei et al., 2015):

Step 1. The decision matrix is formed. It is assumed that there is a set of n feasible alternatives, A_i (i = 1,2,…,n), against to a finite set of evaluation criteria C_c (c = 1,2,…,m). Then the decision matrix X is formed. It shows the performance of different alternatives with respect to various criteria.

$$X = [x_{ic}]_{nxm} = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1m} \\ x_{21} & x_{22} & \cdots & x_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ x_{n1} & x_{n2} & \cdots & x_{nm} \end{bmatrix} \quad (i = 1,2\ldots,n;\ c = 1,2,\ldots,m) \qquad (1)$$

x_{ic} presents the performance value of *i*th alternative on *c*th criterion, n and m are the numbers of alternatives and criteria respectively.

Step 2. The decision matrix is normalized. During the normalization process maximization and minimization criteria are treated separately. Maximization and minimization criteria are normalized by Eq (2) and Eq. (3) respectively:

$$P_{ic} = \frac{x_{ic}}{\sum_{i=1}^{n} x_{ic}} \qquad (2)$$

$$P_{ic} = \frac{1/x_{ic}}{\sum_{i=1}^{n} 1/x_{ic}} \qquad (3)$$

P_{ic} is the normalized value of ith alternative on cth criterion.

Step 3: The importance weight of each criterion (w_c) is determined. In this paper the AHP (Analytic Hierarchy Process) method is used because of its simplicity. It was developed by Saaty (1980) and it depends on pairwise comparison of criteria. More detailed information about the procedure of the AHP method is provided in the paper of Saaty (1980). After obtaining the weight of each criterion, the normalized decision matrix is formed. Then the relative weight (w_{cr}) of the criterion C_c (c = 1,2,…,m) to the reference criterion C_r is determined by Eq. (4):

$$w_{cr} = w_c \,/\, w_r \qquad (4)$$

In this formula w_r is the weight of reference criterion. Reference criterion may be selected as the criterion that the decision maker considers as the most important criterion. In this paper weight of reference criterion is selected as the maximum weights of the all criteria as $w_r = \max \{w_c \mid c = 1,2, . . . ,m\}$

Step 4: The dominance degree of alternative A_i over alternative A_j, $\delta(A_i, A_j)$, is determined by Eq. (5):

$$\delta(A_i, A_j) = \sum_{c=1}^{m} \Phi_c(A_i, A_j) \qquad \forall (i, j) \qquad (5)$$

In this formula the dominance degree of alternative A_i over alternative A_j, $\Phi_c(A_i, A_j)$, concerning criteria C_c (c = 1,2,…,m) is determined by Eq. (6):

$$\Phi_c(A_i, A_j) = \begin{cases} \sqrt{\dfrac{w_{cr}(P_{ic} - P_{jc})}{\sum_{c=1}^{m} w_{cr}}} & if \quad (P_{ic} - P_{jc}) > 0 \\ 0 & if \quad (P_{ic} - P_{jc}) = 0 \\ \dfrac{-1}{\theta} \sqrt{\dfrac{(\sum_{c=1}^{m} w_{cr})(P_{ic} - P_{jc})}{w_{cr}}} & if \quad (P_{ic} - P_{jc}) < 0 \end{cases} \qquad (6)$$

(P_{ic} - P_{jc}) > 0 and (P_{ic} - P_{jc}) < 0 denote the gain and the loss of the ith alternative over the jth alternative respectively. θ represents the attenuation factor of the losses. Different choices of θ lead to different shapes of the prospect theoretical value function in the negative quadrant (Gomes & Rangel, 2009). Namely the greater θ is, the lower the degree of loss aversion is.

Step 5: Overall dominance degree of alternative A_i (ζ_i) is determined by Eq. (7):

$$\zeta_i = \frac{\sum_{j=1}^{n} \delta(A_i, A_j) - \min \sum_{j=1}^{n} \delta(A_i, A_j)}{max \sum_{j=1}^{n} \delta(A_i, A_j) - \min \sum_{j=1}^{n} \delta(A_i, A_j)} \quad (7)$$

Finally alternatives are ranked in descending order according to their overall values (ζ_i) and the alternative with the greatest overall dominance degree is selected as the best one.

Application

Course selection is important for students because it can help them to focus on their interests and learn more about a field that they are interested in studying. In this section, an elective course selection problem is performed to demonstrate the applicability of TODIM method. Firstly, the supervisor has identified five evaluation criteria as suitability of the course to the personal interest or ability (C_1), scheduling time of the course (C_2), lecturer of the course (C_3), applicability of the course content for their future career (C_4) and feedbacks (C_5). The data for all criteria are qualitative. 5 point scale (5: Excellent, 4: Very good, 3: Good, 2: Fair, 1: Poor) is used while evaluating the alternatives with respect to all criteria. Considering these criteria the student has determined 6 different elective courses (A_1, A_2,…,A_6) from the elective course catalogue. These elective courses have the same ECTS value. The student has evaluated the alternatives by considering 5 criteria and these evaluations form a decision matrix shown in Table 1. Then decision matrix is normalized by Eq. (2) and shown in Table 2. In this paper all criteria are beneficial criteria where higher values are desirable.

Table 1. Decision matrix

	C_1	C_2	C_3	C_4	C_5
A_1	5	3	4	2	3
A_2	5	4	4	4	2
A_3	5	2	4	3	3
A_4	4	5	4	5	3
A_5	2	5	3	4	4
A_6	3	4	5	3	5

Table 2. Normalized decision matrix

	C_1	C_2	C_3	C_4	C_5
A_1	0,208	0,130	0,167	0,095	0,150
A_2	0,208	0,174	0,167	0,190	0,100
A_3	0,208	0,087	0,167	0,143	0,150
A_4	0,167	0,217	0,167	0,238	0,150
A_5	0,083	0,217	0,125	0,190	0,200
A_6	0,125	0,174	0,208	0,143	0,250

Then weight of each criterion is calculated by the AHP method. While comparing the criteria, Saaty's nine-point scale shown in Table 3 is adopted. The Consistency Ratio (CR) is calculated as 0,015. As a result of AHP method, the criteria weights (w_c) are found as in Table 4. The criterion with the highest weight is regarded as the reference criterion and the relative weight (w_{cr}) of each criterion to the reference criterion is calculated by using Eq. (4) and shown in the last column of Table 4.

Table 3. Saaty's nine-point scale

Degree preferences	Verbal judgment of preference
1	Equal importance
3	Weak importance of one over another
5	Essential or strong importance
7	Demonstrated importance
9	Absolute importance
2, 4, 6, 8	Intermediate preferences between the two judgments

Table 4. Pairwise comparison matrix for criteria

	C_1	C_2	C_3	C_4	C_5	w_c	w_{cr}
C_1	1	2	3	1/2	4	0,26	0,63
C_2	1/2	1	2	1/3	3	0,16	0,38
C_3	1/3	1/2	1	1/4	2	0,10	0,23
C_4	2	3	4	1	5	0,42	1,00
C_5	1/4	1/3	1/2	1/5	1	0,06	0,15
CR = 0,015					*Total:*	1	2,39

The dominance degrees of the each alternative $\Phi_c(A_i, A_j)$ over the alternatives considering each criterion are calculated by Eq. (6). In this paper θ is taken as 1, which means that the losses will contribute with their real value to the global value (Gomes & Rangel, 2009). Then the dominance degree of alternative A_i over alternative A_j, $\delta(A_i, A_j)$, is determined by Eq. (5). In this part dominance degrees of the first alternative over the others considering each criterion are given in Table 5 because of the page constraints. The same procedure is repeated for all alternatives and overall dominance degrees of the each alternative over the others are computed by Eq. (7).

Table 5. Dominance degrees of the first alternative over the others considering each criterion

	$\boldsymbol{\Phi_1(A_i, A_j)}$	$\boldsymbol{\Phi_2(A_i, A_j)}$	$\boldsymbol{\Phi_3(A_i, A_j)}$	$\boldsymbol{\Phi_4(A_i, A_j)}$	$\boldsymbol{\Phi_5(A_i, A_j)}$	$\delta(A_i, A_j)$
(A_1,A_2)	0,000	-0,522	0,000	-0,477	0,056	-0,943
(A_1,A_3)	0,000	0,083	0,000	-0,337	0,000	-0,254
(A_1,A_4)	0,105	-0,738	0,000	-0,584	0,000	-1,217
(A_1,A_5)	0,181	-0,738	0,064	-0,477	-0,898	-1,868
(A_1,A_6)	0,148	-0,522	-0,656	-0,337	-1,271	-2,637
				$\sum_{j=2}^{n} \delta(A_1, A_j) = -6{,}919$		

Table 6. Overall dominance degrees of the each alternative over the others

	$\sum_{j=1}^{n} \delta(A_i, A_j)$	ζ_i
A_1	-6,919	0,000
A_2	-4,455	0,400
A_3	-4,570	0,381
A_4	-0,754	1,000
A_5	-4,661	0,366
A_6	-3,103	0,619

According to Table 6 the ranking of the elective courses is A_4 - A_6 - A_2 - A_3 - A_5 - A_1. So A_4 is selected as the best elective course by the TODIM method.

Conclusion

The elective course selection is an important part of students' future careers in terms of improving their knowledge associated with their fields of interests. In this paper choosing the most appropriate elective course of a student is handled and this selection problem is solved by TODIM method which is one of the MCDM methods. In this manner firstly the elective course selection problem of the student is structured by defining the evaluation criteria and elective course alternatives. Then the student provides the necessary data namely decision matrix of the problem and the weight of the criteria. The measure of the dominance degree of one elective course over the other elective courses is determined for each pair of elective courses. Finally elective courses are ranked according to their overall degrees of dominance. A_4 is selected as the best elective course for this problem.

TODIM method is suitable for the problems including qualitative and quantitative criteria. It incorporates the expressions of the losses and gains to the multi criteria function (Ramooshjan et al., 2015). It captures the decision maker's psychological behavior (Wei et al., 2015). In this paper TODIM method is applied considering only one student. The same procedure may be repeated for the other students. If the number of criteria and alternatives in the problem increase, the time requiring for the solution may be long. This situation may be overcome by developing a software which performs TODIM method steps.

In future studies, the number of criteria and alternatives may be changed for the same selection problem. The weights of the criteria may be derived from different weighting methods. The ranking of the alternatives may be performed with other MCDM methods and the obtained results may be compared. Also fuzzy extension of the method may be applied to the same problem or other selection problems.

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