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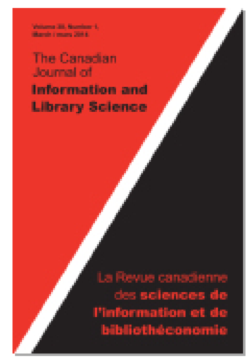

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Canadian Journal of Information and Library Science, Volume 38, Number 1, March/mars 2014, pp. 22-36 (Article)

Published by University of Toronto Press
DOI: *https://doi.org/10.1353/ils.2014.0007*

Ranking the Libraries of the University of Niš Faculties Using the VIKOR Method

Le classement des bibliothèques des facultés de l'Université de Niš par la méthode VIKOR

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Abstract: This article analyses the quality of services provided in the libraries at the University of Niš and establish a ranking by applying an exact scientific method of multi-criteria analysis (the VIKOR method—a multi-criteria compromise ranking method). The libraries are ranked according to different criteria: the time it takes to search the library holdings through available electronic databases on computers, the number of users, and the size of the library holdings. Based on the presented example, it can be concluded that the library of the Faculty of Medicine provides the highest quality of customer service.

Keywords: library, multi-criteria analysis, VIKOR method

Résumé : Cet article a pour objectif d'analyser la qualité des services fournis dans les bibliothèques de l'Université de Niš et d'établir un classement en utilisant une méthode scientifique exacte d'analyse multicritères : la méthode VIKOR, méthode de classement de compromis selon plusieurs critères. Les bibliothèques sont classées d'après différents critères : le temps nécessaire pour une recherche dans le fonds documentaire en utilisant les bases de données électroniques dans les ordinateurs, le nombre d'utilisateurs ainsi que la taille du fonds documentaire de la bibliothèque. Sur la base de l'exemple présenté, on peut conclure que c'est la bibliothèque de la Faculté de médecine qui offre aux utilisateurs la meilleure qualité de service.

Mots-clés : bibliothèque, analyse multicritères, méthode VIKOR

Introduction

"Each library is a unique place shaped by factors that include the library building, its physical location, and the community it serves" (May 2011, 356). A modern library, as a cultural institution whose operation is primarily based on the needs of its users, is characterized by a rapid and dynamic development caused by globalization, an increased efficiency and effectiveness in the field of library services, and an increased level of application of information and communication technologies.

A globalized and dynamic society shapes the needs of the users, and the quality and quantity of services provided; therefore, the operation of modern libraries in this society requires daily monitoring of trends, continuous improvement, and the acquisition of new skills. Like other institutions, a library represents an organization in the market, where only the best can survive and adapt to the changes that result from the development of innovations. “For libraries, innovation is flexible and reactive; carrying both a rhetorical force while still indicative of real-world practices” (Rubin, Gavin, and Kamal 2011).

Thus, in its operation, the library increasingly uses exact scientific methods from different fields (mathematics, economics, etc.), especially those related to management, such as teamwork, quality of service, and so on. The quality of services provided to users is a set of properties and characteristics that are in line with the capability of the library to meet the needs of its users.

The main object of this study was to determine and analyse the quality of services provided to the users of library materials, that is, the teachers, assistants, and students at the University of Niš, and to rank the university’s libraries according to different criteria by applying an exact scientific method, the VIKOR method (a multi-criteria compromise ranking method). A questionnaire was distributed to all the faculties of the university: the Faculty of Philosophy, the Faculty of Electronic Engineering, the Faculty of Medicine, the Faculty of Mechanical Engineering, the Faculty of Economics, the Faculty of Civil Engineering and Architecture, the Faculty of Sport and Physical Education, the Faculty of Technology, the Faculty of Occupational Safety, the Faculty of Science and Mathematics, the Faculty of Fine Arts, and the Faculty of Law. Based on the results of the application of the multi-criteria decision-making method, the faculties’ libraries can be ranked according to the time spent on searching through the library holdings in the available computer databases, the number of users, and the size of the available library holdings.

The methods of multi-criteria analysis

In the modern world, there are few decision-making problems in which the choice depends on only one criterion. The complexity of such decision making often leads to the application of multi-criteria models as a starting point for an objective selection and choice of alternative solutions (Radojičić and Žižović 1998).

Multi-criteria decision making can be applied in cases involving several different criteria, some of which may even be in conflict (Čupić, Tummala, and Suknović 2001). To objectively address such situations it is necessary to rank the alternatives based on several criteria simultaneously. Multi-criteria analysis methods are easier to apply than pure mathematical optimization. Classical optimization methods use only one criterion for decision making, which in most cases ignores the reality of the particular problem under consideration.

Although the multi-criteria approach is better in that case, it does have its disadvantages. In the first place, it is necessary to use many complex mathematical models. Also, despite the large number of such models, it is still not possible to say with certainty which method of multi-criteria decision making is completely objective and produces reliable results.

Several methods of multi-criteria analysis have been applied in a variety of social and scientific fields with great practical importance. They are said to be among the best methods, the so-called outranking methods. The best known methods of multi-criteria analysis are the following:

- The ELECTRE method (ELimination Et Choice Translating REality) was first published in Benayoun, Roy, and Sussman 1966. The ELECTRE method has four versions (ELECTRE I–IV). The most commonly used method for determining the partial ordering of alternatives is ELECTRE I, whereas ELECTRE II is used to fully arrange a set of alternatives.
- The PROMETHEE method (Preference Ranking Organization METHod for Enrichment Evaluation) was developed in 1984 by J.P. Brans, B. Mareschal, and P. Vincke in four variants (Brans et al. 1984).
- The method of analytic hierarchy process is the most used procedure for multi-criteria analysis. It was developed by Thomas Saaty (1980, 2010).
- The TOPSIS method (Technique for Order Preference by Similarity to Ideal Solution) was developed by C.L. Hwang and K. Yoon (1981). It was created on the basis of the ELECTRE method and is one of its most used versions.
- The VIKOR method (a method for multi-criteria compromise ranking) has been developed based on elements from compromise programming. The method is based on the "limit" forms of the L_p metrics (Opricović 1986). It is necessary to find a solution that is closest to the ideal. It is particularly suitable for use in situations where the prevailing criteria are quantifiable.

The VIKOR method—a multi-criteria compromise ranking method

The VIKOR method (a multi-criteria compromise ranking method) is a method for multi-criteria optimization that chooses a compromise solution from a set of alternatives as the best solution (i.e., it makes a compromise ranking list) by using weight coefficients. This is a method for multi-criteria ranking that is frequently used with different decision-making problems.

A compromise solution is a possible solution that is closest to the ideal solution (figure 1), and it represents a compromise based on mutual concessions made between the alternatives (Puška 2011).

The VIKOR method was developed based on the elements of compromise programming. It builds on the "limit" forms of the L_p metrics (Opricović 1986; Kherzian et al. 2011). It is necessary to find a compromise solution that is closest to the ideal solution (figure 1).

Metrics are used as a measure of the distance from the ideal point (Liu and Wang 2011):

$$L_{pi} = \left\{ \sum_{j=1}^{n} \left[w_j \frac{f_j^* - f_{ij}}{f_j^* - f_j^-} \right]^p \right\}^{1/p} \quad 1 \leq p \leq \infty \qquad (1)$$

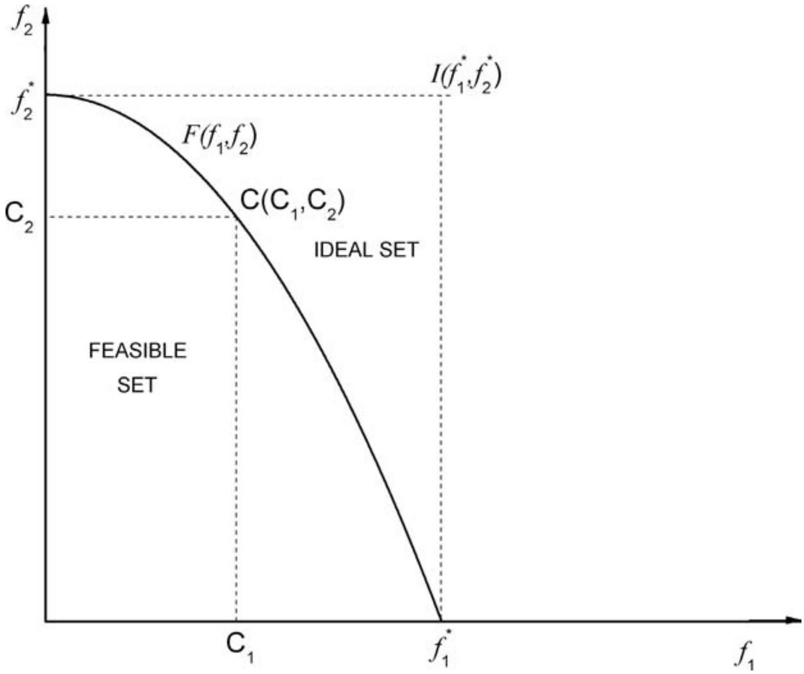

Figure 1: The ideal and compromise solution

This equation represents the distance between the ideal point $I\,(f_1{}^*, f_2{}^*)$ and the point $F\,(f_1, f_2)$ in the space of criteria functions (Opricović 1986). Its minimization determines a compromise solution C. According to Freimer and Yu (1976), p acts as the balancing factor between the total utility and the maximum of individual regret. Higher values of p increase the weight given to individual regret, while lower values of p emphasize the group utility. In the VIKOR method, the following labels are commonly used:

A – an alternative
f – a criterion
m – the number of alternatives
i – the ordinal number of an alternative; $i = 1, 2, \ldots, m$
n – the number of criteria
j – the ordinal number of a criterion; $j = 1, 2, \ldots, n$
f_{ij} – the value of the jth criterion function for the ith alternative
w_j – the weight of the jth criterion function (expresses its relative importance)
v – the weight of the satisfaction of the majority of the criteria
Q_i – the measure for multi-criteria ranking of the ith alternative

The goal of the VIKOR method is, after finding the Q_i value for each alternative separately, to choose the alternative with the lowest value (i.e., the least distance from the “ideal point”).

Table 1: Qualitative initial decision table

Library	Criteria (weights)		
	f_1 (w_1 = 0.4)	f_2 (w_2 = 0.3)	f_3 (w_3 = 0.3)
A_1	short	high	average
A_2	average	average	large
A_3	short	high	very large
A_4	average	average	very small
A_5	average	high	average
A_6	long	average	small
A_7	long	average	small
A_8	average	small	average
A_9	long	average	small
A_{10}	short	average	average
A_{11}	short	small	small
A_{12}	short	high	large

The starting point in the implementation of the VIKOR method is determining the initial decision table (table 1), which is then converted into the quantified one (table 2), in which qualitative assessments are converted into the quantitative ones. Then, the initial decision matrix is formed:

$$\begin{array}{ccc} & f_1 \quad \cdots \quad f_n \\ & w_1 \quad \cdots \quad w_n \end{array}$$

$$R = \begin{array}{c} A_1 \\ . \\ A_m \end{array} \begin{bmatrix} f_{11} & \cdots & f_{1n} \\ \vdots & \ddots & \vdots \\ f_{m1} & \cdots & f_{mn} \end{bmatrix}$$

The next step is to determine the best and worst values of f_j^* and f_j^- respectively, for each criterion separately. (For the criteria that request the minimum value, the lowest value is the best, and the highest value is the worst.)

Next, for clarity and ease of calculation, values d_{ij} are introduced and defined as

$$d_{ij} = \frac{f_j^* - f_{ij}}{f_j^* - f_j^-}.$$

They are necessary for determining the values S_i and R_i:

$$S_i = \sum_{j=1}^{n} w_j \frac{f_j^* - f_{ij}}{f_j^* - f_j^-} = \sum_{j=1}^{n} w_j d_{ij} \quad i = 1, 2, \ldots, m.$$

$$R_i = \max_j w_j d_{ij} \quad i = 1, 2, \ldots, m. \tag{2}$$

After finding these values, S^*, S^-, R^*, and R^- are calculated as

$$S^* = \min_i S_i, \quad R^* = \min_i R_i$$

$$S^- = \max_i S_i, \quad R^- = \max_i R_i. \tag{3}$$

The QS_i, QR_i, and Q_i values are then calculated for each alternative, which enables the formation of three independent ranking lists:

$$QS_i = \frac{S_i - S^*}{S^- - S^*}, \quad QR_i = \frac{R_i - R^*}{R^- - R^*},$$

$$Q_i = v \cdot QS_i + (1 - v) \cdot QR_i. \tag{4}$$

The QS_i values represent the size of a deviation, which calculates a request for the maximum group utility (the first ranking list). QR_i represents the degree of deviation, which expresses a request for minimizing the maximum distance of an alternative from the ideal (the second ranking list). The Q_i value represents the establishment of the compromise ranking that combines QS_i and QR_i (the third ranking list). Choosing a value for v (the weight for the strategy of "the majority of the criteria") may favour the influence of QS_i or QR_i in the compromise ranking list Q_i (Nikolić et al. 2010); for example, $v > 0.5$ indicates that greater relative importance is given to the satisfaction of the majority of the criteria.

In multi-criteria ranking using the VIKOR method, the alternative A_i is considered to be better than the alternative A_k (according to all criteria) if $Q_i < Q_k$, while the compromise ranking list Q_i for $v = 0.5$ is taken as the authoritative ranking list. However, if an alternative is in the first position on the ranking list, that still does not mean it is the best. In addition, it must have an acceptable advantage and a stable position; that is, it must meet the following two conditions: the $C1$ and $C2$ conditions.

The C1 condition

The alternative A', the first in the compromise list Q_i for $v = 0.5$, has an "acceptable advantage" over the following alternative, A'', if

$$Q(A'') - Q(A') \geq DQ$$

where DQ, the threshold of the "acceptable advantage," is

$$DQ = min\left(0.25; \frac{1}{m-1}\right)$$

where 0.25 stands for the size of an "acceptable advantage" threshold that limits the threshold for cases with a small number of alternatives.

The C2 condition

The alternative, which is the first on the compromise list Q_i (for $v = 0.5$), must hold the first position which is "acceptably stable" when the weight v is changed. This means that it must meet at least one of the following conditions:

- It must hold the first position in the ranking list QS_i.
- It must hold the first position in the ranking list QR_i.
- It must hold the first position in the ranking list Q_i for $v = 0.25$ and $v = 0.75$.

Therefore, if the first alternative from the ranking list does not meet one or both of the conditions $C1$ and $C2$, then it is not "acceptably" superior over the alternative in the second position and possibly other alternatives. In this case a set of compromise solutions is formed.

When the first alternative does not satisfy the $C1$ condition (or both conditions, $C1$ and $C2$), a set of compromise solutions is formed that contains the alternatives from the compromise ranking lists up to the one over which the first alternative has an "acceptable advantage" as expressed by DQ. If, however, the first alternative fails to satisfy only the condition $C2$, then the compromise set is created from the first and second alternative only.

Finally, the results of the VIKOR method are reflected in

- the ranking lists based on the QS_i, QR_i, and Q_i values; and
- a set of compromise solutions (in the case that the $C1$ and $C2$ conditions are not satisfied).

Such results are the basis for decision making and the adoption of the final solution (the multi-criteria optimal solution).

Ranking the libraries of the University of Niš faculties using the VIKOR method

In this study the VIKOR method was applied to rank the libraries at the University of Niš according to the quality of services provided and to determine which library provides the highest quality of service in terms of the given criteria.

In the following, the alternatives $A_1, \ldots, A_m$ shall represent

A_1 – the library of the Faculty of Philosophy;
A_2 – the library of the Faculty of Electronic Engineering;
A_3 – the library of the Faculty of Medicine;
A_4 – the library of the Faculty of Mechanical Engineering;
A_5 – the library of the Faculty of Economics;
A_6 – the library of the Faculty of Civil Engineering and Architecture;
A_7 – the library of the Faculty of Sport and Physical Education;
A_8 – the library of the Faculty of Technology;
A_9 – the library of the Faculty of Occupational Safety;
A_{10} – the library of the Faculty of Science and Mathematics;

A_{11} – the library of the Faculty of Fine Arts; and
A_{12} – the library of the Faculty of Law.

On the basis of a survey regarding the most significant criteria and their relative importance (weights), conducted among professors and students, the author considered the following criteria for ranking the mentioned libraries:

f_1 – the time it takes to search the library holdings through the databases available on computers: COBISS, SATIS, ISIS, WINISIS, CLIPER, and MS Access (the request for minimization).

Based on the electronic databases at the faculties in which the survey was conducted, the author, together with the respondents, estimated the time of searching through the library holdings that was necessary to satisfy the users' needs. According to the data obtained from the survey, some libraries have no electronic databases at all but use classical card catalogues (libraries A_6, A_7, and A_9); some of them possess only local electronic databases that can be browsed in the libraries (A_2 has SATIS, A_4 MS Access, A_5 ISIS, and A_8 WINISIS), and some of them, in addition to the local electronic databases, have COBISS.Net, a library-information system which enables the transparency of intellectual production and accelerates searching through the library holdings from any place outside the faculty; that is, it decreases the time it takes to provide services to the users.

The respondents described the time spent on searching through the library holdings in the libraries that possess COBISS as short; the time spent on searching in the libraries that have only a local electronic database as average; and the time spent searching in those which do not have any electronic database as long (table 1).

f_2 – the number of library users (the request for maximization).

Based on the data obtained from the survey, the respondents classified the number of users into three groups: 0–999 users, 1,000–1,999 users, and more than 2,000 users; this is indicated in table 1 as small, average, and high, respectively.

f_3 – the size of the available library holdings, which includes books together with domestic and international journals (the request for maximization).

The author examined the size of the available library holdings at the University of Niš faculties and classified the obtained data into five categories: 5,000–9,999 items, 10,000–19,999 items, 20,000–49,999 items, 50,000–99,999 items, and more than 100,000 items. These are labelled in table 1 as very small, small, average, large, and very large, respectively.

Results and discussion

The qualitative evaluation of all the libraries according to all three criteria is given in the initial decision table (table 1). These qualitative assessments are converted into quantitative measures, with certain criteria weights determined by the decision makers, that is, the author, professors, and students; these quantitative results are given in the quantified initial decision table (table 2).

Table 2: Quantified initial decision table

Library	Criteria (weights)		
	f_1 ($w_1 = 0.4$)	f_2 ($w_2 = 0.3$)	f_3 ($w_3 = 0.3$)
A_1	0.3	0.7	0.5
A_2	0.5	0.5	0.7
A_3	0.3	0.7	0.9
A_4	0.5	0.5	0.1
A_5	0.5	0.7	0.5
A_6	0.7	0.5	0.3
A_7	0.7	0.5	0.3
A_8	0.5	0.3	0.5
A_9	0.7	0.5	0.3
A_{10}	0.3	0.5	0.5
A_{11}	0.3	0.3	0.3
A_{12}	0.3	0.7	0.7

The initial decision matrix R was formed on the basis of these tables:

$$
\begin{array}{ccc} f_1 & f_2 & f_3 \\ w_1 = 0.4 & w_2 = 0.3 & w_3 = 0.3 \end{array}
$$

$$
R = \begin{array}{c} A_1 \\ A_2 \\ A_3 \\ A_4 \\ A_5 \\ A_6 \\ A_7 \\ A_8 \\ A_9 \\ A_{10} \\ A_{11} \\ A_{12} \end{array}
\begin{bmatrix}
0.3 & 0.7 & 0.5 \\
0.5 & 0.5 & 0.7 \\
0.3 & 0.7 & 0.9 \\
0.5 & 0.5 & 0.1 \\
0.5 & 0.7 & 0.5 \\
0.7 & 0.5 & 0.3 \\
0.7 & 0.5 & 0.3 \\
0.5 & 0.3 & 0.5 \\
0.7 & 0.5 & 0.3 \\
0.3 & 0.5 & 0.5 \\
0.3 & 0.3 & 0.3 \\
0.3 & 0.7 & 0.7
\end{bmatrix}
$$

It is necessary to observe the minimum and maximum value in each column of the matrix R. For clarity, these values are shown in a separate table (table 3). It should be noted that for the criterion that is required to be

Table 3: The best and worst values of the libraries for the three criteria

	f_1	f_2	f_3
f_j^*	0.3	0.7	0.9
f_j^-	0.7	0.3	0.1

Table 4: Calculated values for d_{ij} and $w_j d_{ij}$ for all libraries for all criteria

Library	d_{ij}			$w_j d_{ij}$		
	f_1	f_2	f_3	f_1	f_2	f_3
A_1	0	0	0.5	0	0	0.15
A_2	0.5	0.5	0	0.2	0.15	0
A_3	0	0	0	0	0	0
A_4	0.5	0.5	1	0.2	0.15	0.3
A_5	0.5	0	0.5	0.2	0	0.15
A_6	1	0.5	0.75	0.4	0.15	0.225
A_7	1	0.5	0.75	0.4	0.15	0.225
A_8	0.5	1	0.5	0.2	0.3	0.15
A_9	1	0.5	0.75	0.4	0.15	0.225
A_{10}	0	0.5	0.5	0	0.15	0.15
A_{11}	0	1	0.75	0	0.3	0.225
A_{12}	0	0	0.25	0	0	0.075

minimized (f_1), the best value is the lowest one and the worst value is the highest one, while for the criteria f_2 and f_3, the highest value is the best and the lowest is the worst.

The calculated values of d_{ij} and $w_j d_{ij}$, which are the basis for the formation of the matrices S_i and R_i using formula (2), are given in table 4.

The matrices S_i and R_i are formed using formula (2):

$$S_i = \begin{array}{c} A_1 \\ A_2 \\ A_3 \\ A_4 \\ A_5 \\ A_6 \\ A_7 \\ A_8 \\ A_9 \\ A_{10} \\ A_{11} \\ A_{12} \end{array} \begin{bmatrix} 0.15 \\ 0.35 \\ 0 \\ 0.65 \\ 0.35 \\ 0.775 \\ 0.775 \\ 0.65 \\ 0.775 \\ 0.3 \\ 0.525 \\ 0.075 \end{bmatrix} \qquad R_i = \begin{array}{c} A_1 \\ A_2 \\ A_3 \\ A_4 \\ A_5 \\ A_6 \\ A_7 \\ A_8 \\ A_9 \\ A_{10} \\ A_{11} \\ A_{12} \end{array} \begin{bmatrix} 0.15 \\ 0.2 \\ 0 \\ 0.3 \\ 0.2 \\ 0.4 \\ 0.4 \\ 0.3 \\ 0.4 \\ 0.15 \\ 0.3 \\ 0.075 \end{bmatrix}$$

The values for S^*, S^-, R^*, and R^-, read from these matrices using formula (3), are:

$$S^* = 0,\ S^- = 0.775,\ R^* = 0,\ R^- = 0.4.$$

They are necessary for the further calculation of the matrices QS_i, QR_i, and Q_i (for $v = 0.5$) using formula (4).

$$QS_i = \begin{array}{c} A_1 \\ A_2 \\ A_3 \\ A_4 \\ A_5 \\ A_6 \\ A_7 \\ A_8 \\ A_9 \\ A_{10} \\ A_{11} \\ A_{12} \end{array} \begin{bmatrix} 0.194 \\ 0.452 \\ 0 \\ 0.839 \\ 0.452 \\ 1 \\ 1 \\ 0.839 \\ 1 \\ 0.387 \\ 0.677 \\ 0.097 \end{bmatrix} \quad QR_i = \begin{array}{c} A_1 \\ A_2 \\ A_3 \\ A_4 \\ A_5 \\ A_6 \\ A_7 \\ A_8 \\ A_9 \\ A_{10} \\ A_{11} \\ A_{12} \end{array} \begin{bmatrix} 0.375 \\ 0.5 \\ 0 \\ 0.75 \\ 0.5 \\ 1 \\ 1 \\ 0.75 \\ 1 \\ 0.375 \\ 0.75 \\ 0.188 \end{bmatrix} \quad Q_i(v = 0.5) = \begin{array}{c} A_1 \\ A_2 \\ A_3 \\ A_4 \\ A_5 \\ A_6 \\ A_7 \\ A_8 \\ A_9 \\ A_{10} \\ A_{11} \\ A_{12} \end{array} \begin{bmatrix} 0.2845 \\ 0.476 \\ 0 \\ 0.7945 \\ 0.476 \\ 1 \\ 1 \\ 0.7945 \\ 1 \\ 0.381 \\ 0.7135 \\ 0.1425 \end{bmatrix}$$

To test whether the conditions $C1$ and $C2$ are satisfied, it is necessary to form the matrices Q_i (v = 0.25) and Q_i (v = 0.75):

$$Q_i(v = 0.25) = \begin{array}{c} A_1 \\ A_2 \\ A_3 \\ A_4 \\ A_5 \\ A_6 \\ A_7 \\ A_8 \\ A_9 \\ A_{10} \\ A_{11} \\ A_{12} \end{array} \begin{bmatrix} 0.32975 \\ 0.488 \\ 0 \\ 0.77225 \\ 0.488 \\ 1 \\ 1 \\ 0.77225 \\ 1 \\ 0.378 \\ 0.73175 \\ 0.16525 \end{bmatrix} \quad Q_i(v = 0.75) = \begin{array}{c} A_1 \\ A_2 \\ A_3 \\ A_4 \\ A_5 \\ A_6 \\ A_7 \\ A_8 \\ A_9 \\ A_{10} \\ A_{11} \\ A_{12} \end{array} \begin{bmatrix} 0.23925 \\ 0.464 \\ 0 \\ 0.81675 \\ 0.464 \\ 1 \\ 1 \\ 0.81675 \\ 1 \\ 0.384 \\ 0.69525 \\ 0.11975 \end{bmatrix}$$

According to the values obtained for QS_i, QR_i, and Q_i (v = 0.5), three independent ranking lists can be formed for each library (table 5).

Table 5: Ranking of the libraries according to the criteria QS_i, QR_i, and Q_i (v = 0.5)

Library	QS_i	QR_i	Q_i (v = 0.5)
A_1	3	3,4	3
A_2	5,6	5,6	5,6
A_3	1	1	1
A_4	8,9	7,8,9	8,9
A_5	5,6	5,6	5,6
A_6	10,11,12	10,11,12	10,11,12
A_7	10,11,12	10,11,12	10,11,12
A_8	8,9	7,8,9	8,9
A_9	10,11,12	10,11,12	10,11,12
A_{10}	4	3,4	4
A_{11}	7	7,8,9	7
A_{12}	2	2	2

Multiple numbers indicate that two or three libraries are tied in their ranking according to a given condition.

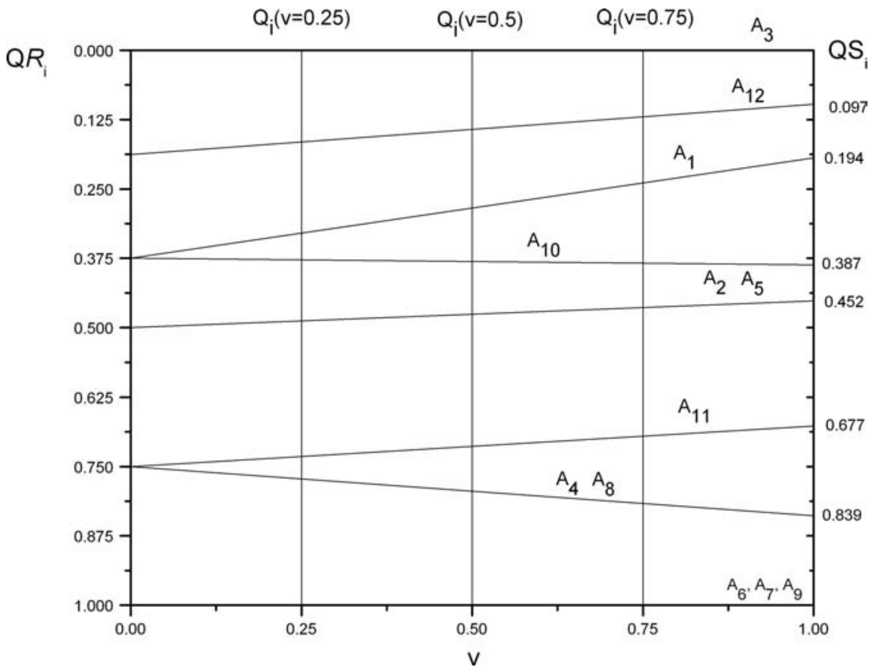

Figure 2: The ranking of the libraries depending on the criterion weight *v*

According to the criteria QS_i and QR_i, the best alternative is A_3, that is, the library of the Faculty of Medicine. In total, according to Q_j ($v = 0.5$), that library is also the best in the compromise ranking list.

It should be noted that the library A_3 is obviously better than any other (judging by the values shown in table 2) and that the libraries A_6, A_7, and A_9 are ranked the lowest. They could be eliminated immediately; however, the goal is to perform the ranking of all libraries starting from the above-mentioned criteria.

The results are presented graphically in figure 2, where the ranking of the individual libraries according to all three criteria, QS_i, QR_i, and Q_i, depending on the weight v, can easily be seen.

Verifying the C*1 condition for library* A₃

The first library, the alternative A_3, obviously satisfies the $C1$ condition because

$$Q_{12} - Q_3 = 0.1425 - 0 = 0.1425 > DQ = 0.0909$$

$$\left(DQ = min\left(0.25; \frac{1}{12-1}\right) = 0.0909\right)$$

It can be concluded that the library has an acceptable advantage over the second-ranked alternative, A_{12} (the library of the Faculty of Law).

Verifying the C2 condition for library A_3

The $C2$ condition is fulfilled because the library A_3 holds the first position in the ranking list for QS_i and in the ranking list for QR_i, as well as in the lists for Q_i for the values $v = 0.25$ and $v = 0.75$. This means that all three subconditions are fulfilled, whereas the condition requires only that at least one is met. It can be concluded that the library of the Faculty of Medicine has an acceptably stable first position according to all criteria.

Verifying the C1 condition for library A_{12}

The analysis of the $C1$ condition for following library, the alternative A_{12}, the second in the ranking list Q_i gives:

$$Q_1 - Q_{12} = 0.2845 - 0.1425 = 0.142 > 0.0909$$

which means that the library of the Faculty of Law, the alternative A_{12}, has an acceptable advantage over the following alternative, A_1, the library of the Faculty of Philosophy.

Verifying the C2 condition for library A_{12}

The library A_{12} has an acceptable stability because it has a lower value on the ranking list for QS_i compared to the library A_1, that is, a better position in the ranking list QS_i.

It can be concluded that both conditions $C1$ and $C2$ are fulfilled, and that the second-ranked library on the compromise list, A_{12}, the library of the Faculty of Law, has an acceptable advantage over the following alternative, A_1, the library of the Faculty of Philosophy, as well as an acceptably stable position.

It should be noted that when $R_i = R^-$ (which can be seen in the matrix R_i in our case) is obtained for more i indexes, then the so-called modified measure R_i is introduced: R_i (mod) = $R_i + [(S_i - R^-) / 100]$. However, this modification can be omitted, because not all values are equal (Nikolić et al. 2010).

Conclusion

Based on all that is stated above, it can be concluded that the multi-criteria analysis can be successfully applied to rank the faculty libraries according the quality of customer service they offer. The application of the VIKOR method has proven that the library of the Faculty of Medicine is undoubtedly the best, because it holds the first position in all three ranking lists. This was to be expected based on the values given in the quantified initial decision table (table 2). However, this is the exceptional case when the values of all the criteria are the best for one alternative. Of the remaining libraries, the library of the Faculty of Law, which meets both conditions $C1$ and $C2$, is the second best, and it has an acceptable advantage over the next library (that of the Faculty of Philosophy), together with acceptably stable position. The last three positions in all ranking lists in table 5 are shared by the libraries of the Faculty of Civil Engineering and Architecture, the Faculty of Sport and Physical Education, and the Faculty of Occupational Safety. This can also be concluded on the basis of the given criteria values shown in table 2.

It was shown in this study that the application of the method of multi-criteria ranking as a basis for the objective selection of a library that provides the highest quality of customer service is justified, as it is in other cases dealing with the distribution of different values over different criteria. Therefore, using the VIKOR method produced an objective ranking of the given libraries according to different criteria simultaneously.

Acknowledgements

I kindly thank the Faculty of Science and Mathematics and its Dean, Prof. Dr Dragan Djordjević, for the financial support necessary for the completion of this work. I am also very grateful to my colleagues, the academic librarians of the faculty libraries in Niš and Leskovac, for their cooperation and participation in the questionnaire, as well as to everyone who in any way contributed to the realization of this article.

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Appendix. Review of the questionnaire—criteria for determining the service quality level

Library	Faculty	Criteria	
		Number of users	Size of holdings
A_1	Faculty of Philosophy	2,997	35,500
A_2	Faculty of Electronic Engineering	1,559	77,700
A_3	Faculty of Medicine	4,146	138,083
A_4	Faculty of Mechanical Engineering	1,344	5,300
A_5	Faculty of Economics	3,201	41,000
A_6	Faculty of Civil Engineering and Architecture	1,584	15,600
A_7	Faculty of Sport and Physical Education	1,022	10,708
A_8	Faculty of Technology	466	45,667
A_9	Faculty of Occupational Safety	1,461	12,358
A_{10}	Faculty of Science and Mathematics	1,284	40,000
A_{11}	Faculty of Fine Arts	504	16,091
A_{12}	Faculty of Law	4,178	81,000