ICIC Express Letters
Part B: Applications
Volume **8**, Number **1**, January **2017**

ICIC International ©2017 ISSN 2185-2766
pp. **129–136**

AN INTERVAL TOPSIS FOR ASSESSING HIGHER VOCATIONAL EDUCATION DEVELOPMENT LEVELS: CONSIDERING DECISION-MAKERS' PREFERENCES

Xuefeng Li[1,2], Kai Chen[1] and Chenghua Shi[3,*]

[1]School of Business Administration
Northeastern University
No. 3-11, Wenhua Road, Heping District, Shenyang 110819, P. R. China
chenkaidbdx@126.com

[2]Heibei Construction Material Vocational and Technical College
No. 8, Wenyu Road, Haigang District, Qinhuangdao 066004, P. R. China
jcxylxf@163.com

[3]School of Economics and Management
Hebei University of Engineering
No. 199, South Guangming Avenue, Handan 056038, P. R. China
[*]Corresponding author: chenghuashi@hebeu.edu.cn

Received June 2016; accepted September 2016

Abstract. *In this work, we propose an interval TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution) for assessing the higher vocational education development level with interval information. Firstly, in order to deal with decision-makers' preferences on interval numbers, we develop a preference-based interval comparison method and then integrate it with the classic TOPSIS method to formulate an interval TOPSIS method. An application example shows the effectiveness of the work and observes the impact of decision-makers' preferences on assessment results. Several insights are also found to improve the assessment process in the real world.*
Keywords: Interval comparison, TOPSIS, Higher vocational education, Development level assessment, Decision-makers' preferences

1. **Introduction.** Education is one of the most important sources of human capital accumulation, and higher vocational education is an important part of the whole education system [1]. The differences of regional education, personnel policy and social environment often cause regional differences in the level and structure of human capital, which in turn lead to regional economic development imbalance [2]. Thus, it is important to assess the higher vocational education development level. However, the assessment is a challenging task due to the following characteristics.

- Few standards are formulated for assessing the higher vocational education development level. This is because the vocational education in one country should be in accord with the economic and social development of the country [3].
- The assessment often involves multiple factors in different dimensionalities such as population background and education structure [4]. To our knowledge, few assessment index systems are well recognized in the literature.
- The information on the assessment factors is not always precise due to the uncertainty in the real world [1]. When it is difficult or impossible to obtain precise information, decision-makers have to estimate the factors using interval or fuzzy numbers.
- Few quantitative assessment methods are reported. A few studies on assessing the teaching and training performance in vocational education were reported [4-7], but none is on assessing higher vocational education development levels.

Motivated by these observations, we focus on how to properly assess the higher vocational education development level with incomplete information. The Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) is a kind of multi-criteria decision analysis (MCDA) methods, which has been used in wide areas [8-11]. The classical TOPSIS is well recognized as one effective method for the MCDA problems when all the data are crisp values. Unfortunately, in real world situations, the assessment factor values of higher vocational education development levels often include incomplete information which can be represented by interval numbers. Meanwhile, different kinds of decision-makers often have different preferences on interval numbers, which may further impact the assessment results.

Thus, in this work, we integrate the interval comparison method with the classical TOPSIS method to assess higher vocational education development levels with interval information. In order to compare interval numbers, Ishibuchi and Tanaka [12] defined an order relation between two interval numbers. Then, Sengupta and Pal [13] defined an acceptability index. Based on the above studies, in this work we consider decision-makers' preferences on interval numbers to develop a preference-based interval comparison method, and extend the classical TOPSIS method to an interval TOPSIS for assessing higher vocational education development levels with interval information.

The contributions of this work include: (i) An index is presented for comparing interval numbers with the consideration of decision-makers' preferences; (ii) By integrating the preference-based index with the classical TOPSIS, one interval TOPSIS is proposed for assessing higher vocational education development levels with interval information; (iii) An application example is given to show the effectiveness of our work.

The remainder of this paper is organized as follows. In Section 2, we develop an interval TOPSIS for assessing higher vocational education development levels with interval information, with the consideration of decision-makers' preferences. In Section 3, we give an application example. Conclusions are finally drawn in Section 4.

2. The Proposed Approach.

2.1. The classical TOPSIS based method. The Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) was proposed by Hwang and Yoon [14]. A brief introduction of applying the classical TOPSIS into the assessment of higher vocational education development levels is as follows.

Let m represent the number of alternative areas for attending the assessment of higher vocational education development levels and n represent the number of assessment factors. The intersection of each alternative area and criterion is given as $x_{ij},\ i = 1, 2, \ldots, m,\ j = 1, 2, \ldots, n$. Then an assessment matrix can be obtained:

$$X = \begin{bmatrix} x_{11} & \cdots & x_{1n} \\ \vdots & \cdots & \vdots \\ x_{m1} & \cdots & x_{mn} \end{bmatrix}_{m\times n} \tag{1}$$

Then, in order to reduce the impact of different dimensionalities, the above assessment matrix is normalized into the following matrix:

$$R = \begin{bmatrix} r_{11} & \cdots & r_{1n} \\ \vdots & \cdots & \vdots \\ r_{m1} & \cdots & r_{mn} \end{bmatrix}_{m\times n} \tag{2}$$

where

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}},\ i = 1, 2, \ldots, m,\ j = 1, 2, \ldots, n \tag{3}$$

After getting the normalization matrix, the positive ideal solution and the negative ideal solution can be defined as follows.

Definition 2.1. *The positive ideal solution A_b is made up of the best factor values among all the alternative areas, that is,*

$$A_b=\{\langle\max(w_j r_{ij} \mid i=1,2,\ldots,m)\,|j\in J_+\rangle, \langle\min(w_j r_{ij} \mid i=1,2,\ldots,m)\,|j\in J_-\rangle\}\equiv\{t_{bj}\} \tag{4}$$

where w_j is the weight of the jth factor, J_+ denotes the set of all the positive factors, and J_- denotes the set of all the negative factors.

Definition 2.2. *The negative ideal solution A_w is made up of the worst factor values among all the alternative areas, that is,*

$$A_w=\{\langle\min(w_j r_{ij} \mid i=1,2,\ldots,m)\,|j\in J_+\rangle, \langle\max(w_j r_{ij} \mid i=1,2,\ldots,m)\,|j\in J_-\rangle\}\equiv\{t_{wj}\} \tag{5}$$

With A_b and A_w, the assessment result of the higher vocational education development level in the ith alternative area can be obtained by:

$$s_i=\frac{d_{iw}}{d_{iw}+d_{ib}} \tag{6}$$

where d_{ib} and d_{iw} denote the distance of the ith alternative area from the positive ideal solution and negative ideal solution, respectively, that is,

$$d_{ib}=\sqrt{\sum_{j=1}^{n}(r_{ij}-t_{bj})^2},\ i=1,2,\ldots,m \tag{7}$$

$$d_{iw}=\sqrt{\sum_{j=1}^{n}(r_{ij}-t_{wj})^2},\ i=1,2,\ldots,m \tag{8}$$

According to the assessment results $\{s_i, i=1,2,\ldots,m\}$, we can rank all the alternative areas according to their higher vocational education development levels.

2.2. **A preference-based interval comparison method.** A lot of interval comparison methods have been contributed to the literature. In this work, we integrate the Sengupta and Pal's method with the classical TOPSIS to develop an interval TOPSIS for assessing the higher vocational education development level with incomplete information.

For the incomplete information of one assessment factor, we use one interval number to represent the factor value:

$$\bar{x}_{ij}=\left[x_{ij}^{low},x_{ij}^{up}\right]=\left\{x_{ij}\left|x_{ij}^{low}\le x_{ij}\le x_{ij}^{up},x_{ij}\in R\right.\right\} \tag{9}$$

where x_{ij}^{low} and x_{ij}^{up} are the lower and upper bounds of $\bar{x}_{ij}$, respectively, $x_{ij}^{low}\le x_{ij}^{up}$. According to Sengupta and Pal [13], we can compare two interval factor values $\bar{x}_{ij}$ and $\bar{x}_{jl}$ by:

$$\alpha(\bar{x}_{ij}\succ\bar{x}_{jl})=\frac{m(\bar{x}_{ij})-m(\bar{x}_{jl})}{w(\bar{x}_{ij})+w(\bar{x}_{jl})}=\frac{\frac{1}{2}\left(x_{ij}^{low}+x_{ij}^{up}\right)-\frac{1}{2}\left(x_{jl}^{low}+x_{jl}^{up}\right)}{\frac{1}{2}\left(x_{ij}^{up}-x_{ij}^{low}\right)+\frac{1}{2}\left(x_{jl}^{up}-x_{jl}^{low}\right)} \tag{10}$$

where $\alpha(\bar{x}_{ij}\succ\bar{x}_{jl})$ denotes the comparison value of $\bar{x}_{ij}$ over $\bar{x}_{jl}$, $m(\bar{x}_{ij})$ and $m(\bar{x}_{jl})$ respectively denote the mid-points of $\bar{x}_{ij}$ and $\bar{x}_{jl}$, and $w(\bar{x}_{ij})$ and $w(\bar{x}_{jl})$ respectively denote the half-widths of $\bar{x}_{ij}$ and $\bar{x}_{jl}$.

The Sengupta and Pal's method is effective to compare two interval numbers, but the method fails to reflect decision-makers' preferences. In the real world, decision-makers often have preferences on the uncertainty, such as optimistic, moderate and pessimistic. These different preferences may produce different assessment results of higher vocational education development levels with incomplete information.

In order to reflect decision-makers' preferences on interval numbers, we introduce the optimism degree γ into (10):

$$\beta(\bar{x}_{ij} \succ \bar{x}_{jl}) = \frac{o(\bar{x}_{ij}) - o(\bar{x}_{jl})}{w(\bar{x}_{ij}) + w(\bar{x}_{jl})} = \frac{\left(\gamma x_{ij}^{low} + (1-\gamma) x_{ij}^{up}\right) - \left(\gamma x_{jl}^{low} + (1-\gamma) x_{jl}^{up}\right)}{\frac{1}{2}\left(x_{ij}^{up} - x_{ij}^{low}\right) + \frac{1}{2}\left(x_{jl}^{up} - x_{jl}^{low}\right) + 1} \tag{11}$$

where γ denotes the optimism degree of decision-makers, $0 \le \gamma \le 1$, and $o(\bar{x}_{ij})$ and $o(\bar{x}_{jl})$ respectively denote the preferred mid-points of $\bar{x}_{ij}$ and $\bar{x}_{jl}$.

2.3. **The interval TOPSIS based method.** In this section, we integrate the preference-based interval comparison method in Section 2.2 with the classical TOPSIS based method in Section 2.1 to develop an interval TOPSIS based method for the assessment of higher vocational education development levels with interval information.

Under the uncertain environment, the assessment matrix is an interval matrix and is represented by

$$\bar{X} = \begin{bmatrix} \bar{x}_{11} & \cdots & \bar{x}_{1n} \\ \vdots & \cdots & \vdots \\ \bar{x}_{m1} & \cdots & \bar{x}_{mn} \end{bmatrix}_{m \times n} \tag{12}$$

where $\bar{x}_{ij} = \left[x_{ij}^{low}, x_{ij}^{up}\right],\ i = 1, 2, \ldots, m,\ j = 1, 2, \ldots, n.$

In order to deal with the interval values in (12), we use Formula (11) to develop a relative value formulation:

$$RV(\bar{x}_{ij}) = \sum_{\substack{k=1 \\ k \neq i}}^{m} \beta(\bar{x}_{ij} \succ \bar{x}_{kj}) = \sum_{\substack{k=1 \\ k \neq i}}^{m} \frac{o(\bar{x}_{ij}) - o(\bar{x}_{kj})}{w(\bar{x}_{ij}) + w(\bar{x}_{kj})} \tag{13}$$

where

$$o(\bar{x}_{ij}) = \gamma x_{ij}^{low} + (1-\gamma) x_{ij}^{up} \tag{14}$$

$$o(\bar{x}_{kj}) = \gamma x_{kj}^{low} + (1-\gamma) x_{kj}^{up} \tag{15}$$

$$w(\bar{x}_{ij}) = \frac{1}{2}\left(x_{ij}^{up} - x_{ij}^{low}\right) \tag{16}$$

$$w(\bar{x}_{kj}) = \frac{1}{2}\left(x_{kj}^{up} - x_{kj}^{low}\right) \tag{17}$$

Then, we use Formulas (2) and (3) to normalize the relative values into:

$$\hat{\bar{R}} = \begin{bmatrix} \frac{RV(\bar{x}_{11})}{\sqrt{\sum_{i=1}^{m} RV(\bar{x}_{i1})^2}} & \cdots & \frac{RV(\bar{x}_{1n})}{\sqrt{\sum_{i=1}^{m} RV(\bar{x}_{in})^2}} \\ \vdots & \cdots & \vdots \\ \frac{RV(\bar{x}_{m1})}{\sqrt{\sum_{i=1}^{m} RV(\bar{x}_{i1})^2}} & \cdots & \frac{RV(\bar{x}_{mn})}{\sqrt{\sum_{i=1}^{m} RV(\bar{x}_{in})^2}} \end{bmatrix}_{m \times n} \tag{18}$$

Based on Definition 2.1 and Definition 2.2, the positive ideal solution and negative ideal solution with interval information (respectively denoted by $\hat{\bar{A}}_b$ and $\hat{\bar{A}}_w$) can be obtained by:

$$\begin{aligned} \hat{\bar{A}}_b \ = \ & \left\{ \left\langle \max \left(w_j \frac{RV(\bar{x}_{ij})}{\sqrt{\sum_{i=1}^{m} RV(\bar{x}_{ij})^2}} \middle| i = 1, 2, \ldots, m \right) \middle| j \in J_+ \right\rangle, \right. \\ & \left. \left\langle \min \left(w_j \frac{RV(\bar{x}_{ij})}{\sqrt{\sum_{i=1}^{m} RV(\bar{x}_{ij})^2}} \middle| i = 1, 2, \ldots, m \right) \middle| j \in J_- \right\rangle \right\} \equiv \left\{ \hat{\bar{t}}_{bj} \right\} \end{aligned} \tag{19}$$

$$\begin{aligned}\hat{\hat{A}}_w &= \left\{ \left\langle \min\left(w_j \frac{RV(\bar{x}_{ij})}{\sqrt{\sum_{i=1}^{m} RV(\bar{x}_{ij})^2}} \middle| i = 1, 2, \ldots, m \right) \middle| j \in J_+ \right\rangle, \right. \\ &\quad \left. \left\langle \max\left(w_j \frac{RV(\bar{x}_{ij})}{\sqrt{\sum_{i=1}^{m} RV(\bar{x}_{ij})^2}} \middle| i = 1, 2, \ldots, m \right) \middle| j \in J_- \right\rangle \right\} \equiv \left\{ \hat{\hat{t}}_{wj} \right\}\end{aligned} \tag{20}$$

With $\hat{\hat{A}}_b$ and $\hat{\hat{A}}_w$, the assessment result of the higher vocational education development level in the ith alternative area with interval information can be obtained by:

$$\hat{\hat{s}}_i = \frac{\sqrt{\sum_{j=1}^{n} \left(w_j \frac{RV(\bar{x}_{ij})}{\sqrt{\sum_{i=1}^{m} RV(\bar{x}_{ij})^2}} - \hat{\hat{t}}_{wj} \right)^2}}{\sqrt{\sum_{j=1}^{n} \left(w_j \frac{RV(\bar{x}_{ij})}{\sqrt{\sum_{i=1}^{m} RV(\bar{x}_{ij})^2}} - \hat{\hat{t}}_{wj} \right)^2} + \sqrt{\sum_{j=1}^{n} \left(w_j \frac{RV(\bar{x}_{ij})}{\sqrt{\sum_{i=1}^{m} RV(\bar{x}_{ij})^2}} - \hat{\hat{t}}_{bj} \right)^2}} \tag{21}$$

According to the assessment results $\left\{\hat{\hat{s}}_i, i = 1, 2, \ldots, m\right\}$, we can rank all the alternative areas according to their higher vocational education development levels with interval information.

3. **An Application Example.**

3.1. **Assessment data.** A province in China wants to make the assessment of higher vocational education development levels in its 11 cities $C_1, C_2, \ldots, C_{11}$. Four assessment factors are recognized as the main indicators: the average number of higher vocational graduates (denoted as F_1), average education years (denoted as F_2), the average number of higher vocational teachers (denoted as F_3) and average educational funds per year (denoted as F_4). Based on the situations in these 11 cities, the original assessment data (that is, the interval assessment matrix $\bar{X}$) are obtained, as Table 1 shows.

3.2. **Results with $\gamma = 0.6$.** As analyzed in Section 2.2, decision-makers' optimism degree γ has impact on the interval comparison results, which may further impact the assessment results. Here we first give the results with $\gamma = 0.6$. Using Formulas (13)-(17)

Table 1. The original assessment data

Cities	F_1 (Person)	F_2 (Year)	F_3 (Person)	F_4 (Ten thousand yuan)
C_1	$[23000, 25000]$	$[1.8, 2.2]$	$[3000, 3500]$	$[350, 400]$
C_2	$[12000, 14000]$	$[2.1, 2.5]$	$[1200, 1600]$	$[110, 120]$
C_3	$[11000, 15000]$	$[1.6, 1.9]$	$[1400, 1600]$	$[150, 180]$
C_4	$[35000, 38000]$	$[2.5, 3.1]$	$[3200, 3500]$	$[260, 280]$
C_5	$[9000, 10000]$	$[1.5, 1.6]$	$[820, 900]$	$[80, 120]$
C_6	$[5000, 6000]$	$[1.2, 1.5]$	$[400, 450]$	$[120, 150]$
C_7	$[20000, 22000]$	$[2.2, 2.6]$	$[1100, 1300]$	$[400, 450]$
C_8	$[13000, 15000]$	$[1.8, 2.1]$	$[300, 500]$	$[240, 260]$
C_9	$[6000, 7000]$	$[1.5, 1.8]$	$[500, 600]$	$[120, 150]$
C_{10}	$[11000, 13000]$	$[2.1, 2.5]$	$[480, 520]$	$[220, 240]$
C_{11}	$[21000, 23000]$	$[2.5, 2.8]$	$[1200, 1300]$	$[320, 350]$

TABLE 2. The normalized relative values with $\gamma = 0.6$

Cities	F_1	F_2	F_3	F_4
C_1	0.3189	−0.0384	0.3951	0.3419
C_2	−0.0736	0.1654	0.0462	−0.4747
C_3	−0.0612	−0.2088	0.1435	−0.1727
C_4	0.5938	0.4575	0.6204	0.1922
C_5	−0.2486	−0.3625	−0.0898	−0.3234
C_6	−0.4453	−0.4909	−0.3919	−0.2649
C_7	0.2118	0.2334	0.0327	0.4562
C_8	−0.0379	−0.0677	−0.2626	0.1176
C_9	−0.3961	−0.2793	−0.2606	−0.2649
C_{10}	−0.1093	0.1654	−0.3506	0.0431
C_{11}	0.2475	0.4259	0.1176	0.3497

in Section 2.3, we can get the relative values of the original assessment data. Then, using Formula (18), we can normalize the relative values, as Table 2 shows.

With the normalized relative values, using Formulas (19) and (20), we can determine the positive ideal solution and negative ideal solution (The weight of each assessment factor is recognized as equivalent):

$$\hat{\hat{A}}_b = \{0.1485, 0.1144, 0.1551, 0.1140\}$$

$$\hat{\hat{A}}_w = \{-0.1113, -0.1227, -0.0980, -0.1187\}$$

Finally, using Formula (21), we can obtain the assessment results:

$$\begin{aligned} & \{\hat{\hat{s}}_i, i = 1, 2, \ldots, 11\} \\ = & \{0.6988, 0.3989, 0.3887, 0.8755, 0.2067, 0.1005, 0.6579, 0.4026, 0.1640, 0.4094, 0.7078\} \end{aligned}$$

As we can see, when $\gamma = 0.6$, the higher vocational education development of city C_4 is in the highest level in the province, and city C_6 is in the lowest level.

3.3. **Results with different optimism degrees.** Using the similar process in Section 3.2, we can obtain the assessment values with different optimism degrees, as Table 3 shows. Figure 1 shows the variation analysis of the assessment results.

From the results in Table 3 and Figure 1, we can get the following observations.

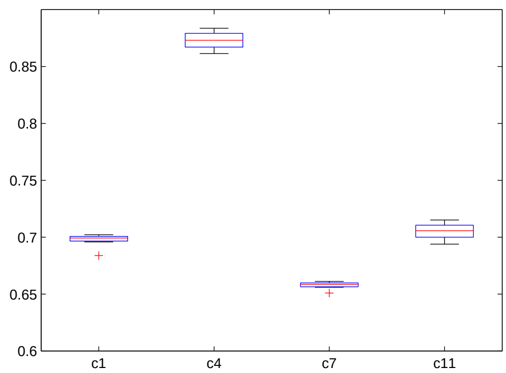
(1) Based on the assessment results, the higher vocational education development levels of the 11 cities can be divided into three categories: The assessment values of cities C_1, C_4, C_7 and C_{11} are bigger than 0.6, so the higher vocational education development of these four cities, especially C_4, is relatively in good level; The assessment values of cities C_2, C_3, C_8 and C_{10} are between 0.3 and 0.6, so these four cities are in average level; The assessment values of cities C_5, C_6 and C_9 are below 0.3, so these cities are in low level.

(2) The decision-makers' optimism degree indeed impacts the assessment values, which even changes the assessment orders. For example, city C_1 is in better level than city C_{11} when $\gamma = 0$ and $\gamma = 0.2$, but the former is in worse level than the latter when $\gamma \geq 0.4$; similarly, city C_3 is in better level than city C_2 when $\gamma = 0$, but the former is in worse level than the latter when $\gamma \geq 0.2$. This observation shows the reasonability of integrating the preference-based interval comparison method with the classical TOPSIS.

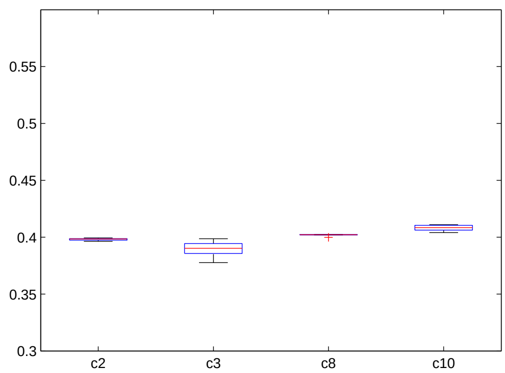
(3) The impact of decision-makers' optimism degree on the assessment results varies as the uncertainty degree in the assessment data. As Figure 1 shows, the assessment values of cities C_4, C_{11}, C_3, C_5 and C_6 bear bigger impact by the decision-makers' optimism degree, and the assessment values of other cities bear smaller impact, especially for C_2 and C_8.

TABLE 3. The assessment results with different optimism degrees

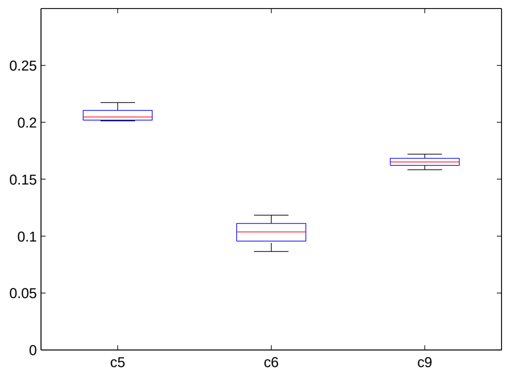
Cities	The optimism degrees (γs)						
	0	0.2	0.4	0.5	0.6	0.8	1
C_1	0.7022	0.7010	0.6999	0.6993	0.6988	0.6959	0.6839
C_2	0.3965	0.3973	0.3981	0.3985	0.3989	0.3994	0.3985
C_3	0.3987	0.3953	0.3919	0.3903	0.3887	0.3848	0.3777
C_4	0.8614	0.8660	0.8707	0.8731	0.8755	0.8805	0.8837
C_5	0.2013	0.2015	0.2032	0.2047	0.2067	0.2118	0.2173
C_6	0.1184	0.1127	0.1067	0.1036	0.1005	0.0940	0.0865
C_7	0.6612	0.6602	0.6591	0.6585	0.6579	0.6560	0.6510
C_8	0.4020	0.4021	0.4022	0.4024	0.4026	0.4025	0.3999
C_9	0.1720	0.1691	0.1664	0.1651	0.1640	0.1616	0.1583
C_{10}	0.4041	0.4058	0.4076	0.4085	0.4094	0.4109	0.4110
C_{11}	0.6940	0.6988	0.7035	0.7057	0.7078	0.7116	0.7152



(a) $\hat{\hat{s}}_i \geq 0.6$



(b) $0.6 > \hat{\hat{s}}_i \geq 0.3$



(c) $0.3 > \hat{\hat{s}}_i \geq 0$

FIGURE 1. Variation analysis of the assessment results

4. **Conclusions.** In this work, we proposed an interval TOPSIS method by integrating the interval comparison method with the classical TOPSIS method. In the integrated method, a preference-based interval comparison method was presented in order to consider decision-makers' preferences into the comparison process. Then, the classical TOPSIS method was extended to the interval TOPSIS by introducing the preference-based interval

comparison method. However, some issues remain to be resolved, such as the construction of a systematic assessment index system and the determination of index weights.

Acknowledgements. This research is supported by Hebei High-Level Personnel Funded Project (No. A201500112) and Hebei Province Outstanding Experts Overseas Training Project.

REFERENCES

[1] L. Cao and L. T. Tran, Pathway from vocational education and associate degree to higher education: Chinese international students in Australia, *Asia Pacific Journal of Education*, vol.35, no.2, pp.274-289, 2015.

[2] L. Wantchekon, M. Klašnja and N. Novta, Education and human capital externalities: Evidence from colonial benin, *The Quarterly Journal of Economics*, vol.130, no.2, pp.703-757, 2016.

[3] E. R. Khairullina et al., Features of the programs applied bachelor degree in secondary and higher vocational education, *Asian Social Science*, vol.11, no.4, pp.213-217, 2015.

[4] A. Hoekstra and J. R. Crocker, Design, implementation, and evaluation of an ePortfolio approach to support faculty development in vocational education, *Studies in Educational Evaluation*, vol.46, pp.61-73, 2015.

[5] R. Saunders, Assessment of professional development for teachers in the vocational education and training sector: An examination of the concerns based adoption model, *Australian Journal of Education*, vol.56 no.2, pp.182-204, 2012.

[6] S. Cervai, L. Cian, A. Berlanga, M. Borelli and T. Kekäle, Assessing the quality of the learning outcome in vocational education: The Expero model, *Journal of Workplace Learning*, vol.25, no.3, pp.198-210, 2013.

[7] A. C. John, Reliability and validity: A sine qua non for fair assessment of undergraduate technical and vocational education projects in Nigerian universities, *Journal of Education and Practice*, vol.6, no.34, pp.68-75, 2015.

[8] J. Ignatius, A. Mustafa and M. Goh, Modeling funding allocation problems via AHP-fuzzy TOPSIS, *International Journal of Innovative Computing, Information and Control*, vol.8, no.5(A), pp.3329-3340, 2012.

[9] R.-C. Chen, Y.-W. Lo and H. Jiang, The application of TOPSIS algorithm to diabetic diet recommendation, *ICIC Express Letters, Part B: Applications*, vol.6, no.4, pp.1105-1111, 2015.

[10] M. Tavana, Z. Li, M. Mobin, M. Komaki and E. Teymourian, Multi-objective control chart design optimization using NSGA-III and MOPSO enhanced with DEA and TOPSIS, *Expert Systems with Applications*, vol.50, pp.17-39, 2016.

[11] P. Wang, Z. Zhu and Y. Wang, A novel hybrid MCDM model combining the SAW, TOPSIS and GRA methods based on experimental design, *Information Sciences*, vol.345, pp.27-45, 2016.

[12] H. Ishibuchi and H. Tanaka, Multiobjective programming in optimization of the interval objective function, *European Journal of Operational Research*, vol.48, no.2, pp.219-225, 1990.

[13] A. Sengupta and T. K. Pal, On comparing interval numbers, *European Journal of Operational Research*, vol.127, no.1, pp.28-43, 2000.

[14] C. L. Hwang and K. Yoon, *Multiple Attribute Decision Making: Methods and Applications*, Springer-Verlag, New York, 1981.