Tourism Management 33 (2012) 456–465

Contents lists available at ScienceDirect

Tourism Management

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

Fuzzy Rasch model in TOPSIS: A new approach for generating fuzzy numbers to assess the competitiveness of the tourism industries in Asian countries

Jen-Hung Huang [a], Kua-Hsin Peng [b,*]

[a] Department of Management Science, National Chiao Tung University, 1001 University Road, Hsinchu 300, Taiwan
[b] Graduate Institute of Management Science, National Chiao Tung University, 1001 University Road, Hsinchu 300, Taiwan

A R T I C L E   I N F O

Article history:
Received 21 November 2010
Accepted 22 May 2011

Keywords:
Item response theory (IRT)
Rasch model
Fuzzy theory
Triangular fuzzy number (TFN)
TOPSIS
Tourism destination competitiveness (TDC)
Asia

A B S T R A C T

This study proposes a novel approach, the Fuzzy Rasch model, which combines Item Response Theory (IRT) and fuzzy set theory. This paper applies the Fuzzy Rasch model in Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) to analyse the Tourism Destination Competitiveness (TDC) of nine Asian countries: China, Hong Kong, Japan, Korea, Malaysia, Singapore, Taiwan, Thailand and the Philippines. The study was conducted in 2009 using 6 criteria and 15 indices. The results demonstrate the feasibility of applying the Fuzzy Rasch model in TOPSIS to analyse TDC in Asian countries. In addition, the proposed model also provides an effective means of applying the MCDM method to study TDC. Furthermore, in 2009, the Asian countries were ranked from most to least competitive as follows: China, Japan, Hong Kong, Malaysia, Thailand, Singapore, Taiwan, Korea and the Philippines.

1. Introduction

Multiple Criteria Decision Making (MCDM) is an analytical method used to evaluate a set of alternatives based on multiple criteria (Tsaur, Tzeng, & Wang., 1997; Wang & Lee, 2009). The Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) is a conventional means of solving MCDM problems (Tsou, 2008; Mahdavi, Mahdavi-Amiri, Heidarzade, & Nourifar, 2008; Wang & Lee, 2009; Singh & Benyoucef, 2011). In MCDM, the weights of the criteria are crucial for measuring the importance of the criteria (Zhang, Gu, Gu, & Zhang, 2011). The methods used to determine the weights of the criteria of the TOPSIS include the entropy method (Tsaur, Tzeng, & Wang., 1997; Singh & Benyoucef, 2011), Information Entropy Weight (IEW) (Zhang et al., 2011), Analytic Hierarchy Process (AHP) (Tsaur, Tzeng, & Wang, 1997; Dagdeviren, Yavuz, & Kılınç, 2009; Yu, Guo, Guo, & Huang, 2011), Fuzzy AHP (Wang, Cheng, & Huang, 2009; Gumus, 2009; Sun, 2010) and Rough AHP (Aydogan, 2011). Additionally, Liang and Ding (2003) depended on expert knowledge and experience to determine the weights of the criteria on a Likert rating scale. However, the inherent uncertainty and subjectivity of this method can result in weighting errors and difficulties in the criteria weight selection process. As a result, the subjectivity (i.e., the fuzzy numbers) of the criteria weight selection process varies among the experts. Mahdavi et al. (2008) and Hsieh, Lu, and Tzeng (2004) have used linguistic variables proposed by Buckley (1985) ranging from “very unimportant” to “very important” to express the fuzzy numbers. Kaufmann and Gupta (1991) and Mon, Cheng, and Lin (1994) have also used linguistic variables to express the fuzzy numbers assigned by the experts. However, using the linguistic variables defined by Buckley (1985), Kaufmann and Gupta (1991) and Mon et al. (1994) assume that different experts have the same fuzzy numbers, whereas in reality, the inherent uncertainty of the criteria weight selection process varies among the experts. Therefore, determining how to obtain accurate fuzzy numbers for the criteria weights and their subsequent evaluations of those criteria weights remain a high priority for researchers.

Item Response Theory (IRT) is a general statistical theory that analyses item (question) and scale (questionnaire) performances and the relationships between these performances and the factors measured by the items in the scale (Meads & Bentall, 2008). The simplest logistic latent trait IRT model is the Rasch One-Parameter Logistic Model (1PL) (Rasch, 1960). Georg Rasch originally developed the Rasch model to assess reading ability in 1952, and since then, this model has been widely applied for a variety of purposes. For example, Yu and Wu (2009) used the Rasch model to determine the fuzzy numbers for psychological measurements. Furthermore,

* Corresponding author. Tel.: +886 920022514.
E-mail addresses: jhh509@hotmail.com (J.-H. Huang), jenny19830514@yahoo.com.tw (K.-H. Peng).

0261-5177/$ – see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.tourman.2011.05.006

Huang and Peng (2010) used the Rasch model to generate grey weight and then adopted Grey Relation Analysis (GRA) to analyse the performances of seven Taiwanese districts containing 56 international tourist hotels in 2009. Additionally, Yu and Wu (2009) utilised IRT to generate accurate fuzzy numbers. Based on the above, this study believes that using the Rasch model to generate fuzzy numbers is not only feasible but can also rectify the inaccuracy of the fuzzy numbers assigned by the individual experts for the specific criteria. Therefore, this study proposes a new approach, the Fuzzy Rasch model, which combines the Rasch model with fuzzy theory. This new approach follows a three-step procedure. First, the Rasch model is used to generate fuzzy weights for each expert. Second, an arithmetic average is used to integrate the fuzzy weight of each expert. Third, the defuzzification weights are applied in TOPSIS.

Tourism has become the leading leisure activity of the 21st century (Claver-Cortes, Molina-Azorin, & Pereira-Moliner, 2007). In 2010, UNWTO reported that international tourist arrivals in Asia grew from 55.8 million to 181.2 million from 1990–2009 and generated US$ 204 billion in international tourism receipts in 2009 (UNWTO, 2010). Thus, the tourism industry is rapidly growing in Asia. However, the tourism industry is becoming increasingly competitive as well (Middleton & Hawkins, 1998), and consumers have developed considerable flexibility in their choice of destinations, which places the different tourism markets of Asia in competition with one another. Hovinen (2002) also indicated that the success of tourism destinations depends on their regional competitiveness. Following these developments, the recent literature has increasingly focused on measuring Tourism Destination Competitiveness (TDC) (Zhang et al., 2011; Hall, 2007; Pearce, 1997; Ruhanen, 2007; Enright & Newton, 2004; Kozak & Rimmington, 1999; Cracolici & Nijkamp, 2009). However, the role of TDC in Asian countries has received little attention to date. Additionally, according to Palmer, Sese, and Montano (2005), more advanced statistical techniques need to be used in tourism studies. Therefore, based on the Fuzzy Rasch model in TOPSIS, this study analyses the TDC of nine Asian countries (i.e., China, Hong Kong, Japan, Korea, Malaysia, Singapore, Taiwan, Thailand and the Philippines) in 2009 using 6 criteria and 15 indexes.

2. Evaluation criteria of TDC

Following a review of the pertinent literature, this study establishes the evaluation criteria and the indices for TDC. The evaluation criteria for TDC comprise the availability of attractions (Barros et al., 2011; Weaver & Oppermann, 2000), the availability of service (Weaver & Oppermann, 2000), affordability (Go & Govers, 1999; Weaver & Oppermann, 2000), positive market image (Weaver & Oppermann, 2000), peace and stability (Crouch & Ritchie, 1999; Ritchie & Crouch, 1993; Cracolici & Nijkamp, 2009; Weaver & Oppermann, 2000) and cultural links (Weaver & Oppermann, 2000).

2.1. Availability of attractions

The attractions of a destination are the main component of TDC (Crouch & Ritchie, 1999; Ritchie & Crouch, 1993). Attractions incorporate specific features (e.g., theme parks and battlefields) and generic or non-specific features (e.g., scenery and climate) (Weaver & Oppermann, 2000). Consequently, the criteria determining the availability of attractions are composed of two indices: “International tourism arrivals” (Barros et al., 2011; UNWTO, 2010) and “International tourism receipts” (Zhang et al., 2011; UNWTO, 2010).

2.2. Availability of service

Tourists avoid attractions if the services or facilities affiliated with the attraction are unavailable or poor in quality. Adequate tourism-related facilities include transportation, accommodation, restrooms, dining facilities and visitor bureaus. Consequently, the criteria of availability of service comprise three indices: “Number of hotel rooms” (Barros et al., 2011; Cracolici & Nijkamp, 2009; Zhang et al., 2011; WEF, 2009), “Number of operating airlines” (WEF, 2009) and “Air transportation (Number of passengers carried by main air companies)” (IMD, 2010).

2.3. Affordability

Crouch (1992) noted that travellers are sensitive to price. As a result, regions with low transportation and living costs experience increased arrivals of tourists (Weaver & Oppermann, 2000). For example, numerous tourists prefer to travel to less developed countries, such as Indonesia or Costa Rica, because of the relatively low prices of goods and services available in these countries (Weaver & Oppermann, 2000). Therefore, the criteria of affordability comprise three indices: “Transportation costs” (Dwyer & Kim, 2003; Weaver & Oppermann, 2000; WEF, 2009), “Hotel price index” (Cracolici & Nijkamp, 2009; Ritchie & Crouch, 1993) and “Cost-of-living index” (Weaver & Oppermann, 2000; Cracolici & Nijkamp, 2009; Ritchie & Crouch, 1993).

2.4. Positive market image

Image consists of a person or group’s beliefs, attitudes and impressions of a phenomenon (Weaver & Oppermann, 2000). Destination image is defined as an individual’s overall impression of a tourist site (Fakeye & Crompton, 1991) and as the person’s mental portrayal of the destination (Alhemoud & Armstrong, 1996; Seaton & Bennett, 1996). Woodside and Lysonski (1989) suggested that tourist sites with strong, positive images are more likely to be considered and selected as travel destinations. Thus, the criteria of positive market image comprise two indices: “Quality of life” (IMD, 2010) and “Quality of the natural environment” (Cracolici & Nijkamp, 2009; Inskeep, 1991; Kozak & Rimmington, 1999 and WEF, 2009).

2.5. Peace and stability

Weaver and Oppermann (2000) asserted that the tourist market is sensitive to social or political instability. Additionally, a lack of safety makes it impossible for a tourist site to successfully compete in the market because potential tourists do not want to visit a place that they perceive as unsafe (Cavlek, 2002). For example, Middle Eastern countries and the United States experienced significant reductions in total visitor numbers in the aftermath of the September 11 terrorist attacks (Dwyer & Kim, 2003). Generally, tourists prefer to travel to peaceful and stable destinations. Consequently, the criteria of peace and stability comprise three indices: “Safety and security” (Cracolici & Nijkamp, 2009; Crouch & Ritchie, 1999; Ritchie & Crouch, 1993; Kozak & Rimmington, 1999; Dwyer & Kim, 2003; IMD, 2010), “Business costs of crime and violence” (WEF, 2009) and “Business costs of terrorism” (WEF, 2009).

2.6. Cultural links

Travel is more prevalent between countries that share similar cultural elements, such as language and religion (Burton, 1995). Weaver and Oppermann (2000) noted that numerous tourists feel insecure or inconvenienced by having to cope with unfamiliar languages and social norms and, thus, prefer destinations that are similar to their home countries. Consequently, the criteria of cultural links comprise two indices: "Nation culture" (IMD, 2010) and "Discrimination (e.g., race and gender)" (IMD, 2010).

3. Method

To evaluate the role of TDC in Asian countries, this study uses the Rasch model to generate the fuzzy weights of the criteria. The defuzzification weights are then applied in TOPSIS. Finally, TOPSIS is used to rank the TDC of the Asian countries. Hence, this section is divided into four parts: (1) the Rasch model, (2) Triangular Fuzzy Numbers (TFN) and linguistic variables, (3) TOPSIS and (4) the Fuzzy Rasch model in TOPSIS.

3.1. Rasch model

The Rating Scale Model (RSM) devised by Andrich (1978) applies Rasch's model to polytomous rating scale instruments, which include the five-point Likert scale. The Rasch model is based on the concept that the probability of correctly obtaining an item is a function of a latent trait or ability (Kastrin & Peterlin, 2010). Notably, the Rasch model is also known as the One-Parameter Logistic Model (1PL). The Rasch model converts raw data from a rating scale to "an equal interval scale" measured in logits (log odd units) (Belvedere & de Morton, 2010), which reflect both the difficulty of the item and individual ability (Bond & Fox, 2007).

Since Andrich (1978) developed RSM, it has been extensively adopted by scholars to assess the values of item and person parameters, as shown in Eq. (1).

$$\log\left(\frac{P_{nij}}{P_{ni(j-1)}}\right) = \theta_n - (\delta_i + \tau_j) \tag{1}$$

In Eq. (1), P_{nij} and $P_{ni(j-1)}$ represent the probability that the item n obtains j and j-1 scores from the expert i. θ_n represents the measure score (i.e., item difficulty) of the item n, δ_i represents the measure score (i.e., individual ability) of expert i, τ_j and represents the step difficulty (i.e., threshold difficulty) of category j. The step difficulty of RSM is identical for all items (Wright & Masters, 1982). Thus, the RSM is useful if the psychological distances between categories are identical for all items (Kim & Hong, 2004), as is the case for the Likert scales.

$$\delta_{ij} = \delta_i + \tau_j \tag{2}$$

In Eq. (2), $i = 1, \ldots, E$and E represents the number of experts. $j = 1, \ldots, m$ and m represents the number of linguistic scales, which range from "very unimportant" to "very important".

3.2. TFN and linguistic variables

Fuzzy numbers are a convex fuzzy set that are characterised by a given interval of real numbers. The most common types of fuzzy numbers are triangular and trapezoidal fuzzy numbers. TFN can be denoted as $\tilde{W} = (\delta^L, \delta^M, \delta^U)$, where L and U represent the lower and upper bounds of the fuzzy number, respectively, and M represents the modal value. According to Zadeh (1975), it is extremely difficult to use conventional quantification to reasonably define situations that are overly complex or hard to define, and as a result, the linguistic variables are necessary to define such situations. A linguistic variable is a variable whose value consists of words or sentences in a natural or artificial language.

3.3. TOPSIS

Developed by Yoon, 1980, TOPSIS is based on the concept that the option selected by the user should be closest to the Positive Ideal Solution (PIS) and furthest from the Negative Ideal Solution (NIS) to resolve MCDM problems. The PIS maximises the benefits and minimises the costs, whereas the NIS maximises the costs and minimises the benefits.

3.4. Fuzzy Rasch model in TOPSIS

Fisher (1995) noted that the Rasch model endows the Fuzzy Logic Model of Perception (FLMP) with precise properties that are far superior to those of fuzzy logic. Numerous studies have used the Rasch model to generate fuzzy numbers; for example, Yu and Wu (2009) utilised the IRT to generate fuzzy numbers, and Huang and Peng (2010) used the Rasch model to generate grey weight. This study proposes a novel approach, the Fuzzy Rasch model in TOPSIS, which combines the Rasch model, fuzzy theory and TOPSIS. This novel method involves the following steps.

Step 1. Determine the evaluation criteria/indices and the alternatives.
Step 2. Determine the weights of the evaluation criteria/indices with the Fuzzy Rasch model.
Step 2–1. Determine the degree of importance for each criterion/index.
Step 2–2. Calculate the step parameters (δ_{ij}) to generate the fuzzy weight.

This study adopts the Rasch model to calculate the fuzzy weight of each expert.

$$\tilde{W}_{ij} = \left(\delta_{ij}^L, \delta_{ij}^M, \delta_{ij}^U\right) \tag{3}$$

In Eq. (3), represents the fuzzy weight of expert i for step. j.

Fig. 1 illustrates the step parameters (δ_{ij}) estimated by the Rasch model. This study selects a value of "very unimportant" for step

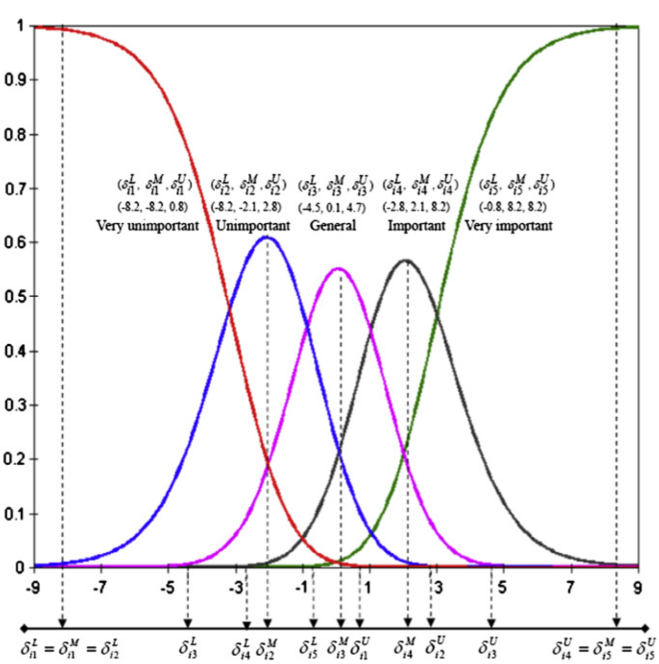

Fig. 1. Calculate "step parameters" (δ_{ij}) via the Rasch model to generate the triangular fuzzy weight.

parameter 1 (δ_{ij}). The triangular fuzzy weights of the Likert scale values are as follows: "very unimportant" is $\tilde{W}_{i1} = (\delta_{i1}^L, \delta_{i1}^M, \delta_{i1}^U)$; "unimportant" is $\tilde{W}_{i2} = (\delta_{i2}^L, \delta_{i2}^M, \delta_{i2}^U)$; "general" is $\tilde{W}_{i3} = (\delta_{i3}^L, \delta_{i3}^M, \delta_{i3}^U)$; "important" is $\tilde{W}_{i4} = (\delta_{i4}^L, \delta_{i4}^M, \delta_{i4}^U)$; and "very important" is $\tilde{W}_{i5} = (\delta_{i5}^L, \delta_{i5}^M, \delta_{i5}^U)$.

Step 2–3. Use the triangular fuzzy weight as a substitute for the values of importance calculated in Step 2–1.

$$\tilde{W}_{ijc} = \left(\delta_{ijc}^L, \delta_{ijc}^M, \delta_{ijc}^U\right) \tag{4}$$

In Eq. (4), $\tilde{W}_{ijc}$ represents the fuzzy weight of expert i to criteria/indices c for step j. This fuzzy weight is substituted for the original degree of importance calculated in Step 2–1.

Step 2–4. Use an arithmetic average to integrate the fuzzy weight of each expert.

This study uses an arithmetic average to integrate the fuzzy weight of each expert.

$$\tilde{W}_c = \frac{1}{E}\left[\sum_{j=1}^{E} \tilde{W}_{ijc}\right] = \left(\delta_c^L, \delta_c^M, \delta_c^U\right) \tag{5}$$

Step 2–5. Defuzzification.

The defuzzification values transform the fuzzy weights into crisp weights. Eq. (6) calculates the Best Non-fuzzy Performance Value (BNP).

$$BNP_c = \left[\left(\delta_c^U - \delta_c^L\right) + \left(\delta_c^M - \delta_c^L\right)\right] \Big/ 13 + \delta_c^L \tag{6}$$

Finally, this study uses the defuzzification weights as the criteria weights in TOPSIS. However, the criteria weights in TOPSIS are normalised to a sum to 1(Hwang & Yoon, 1981; Torlak, Sevkli, Sanal, & Zaim, 2011; Zhang et al., 2011; Yu et al., 2011; Tan, 2011). Based on the above, this study uses Eq. (7) to standardise the weight of the criterion.

$$W_c = SBNP_c = BNP_c / \sum_{c=1}^{C} BNP_c, \quad \sum_{c=1}^{C} SBNP_c = 1 \tag{7}$$

In Eq. (7), c represents the number of criteria/indices, as shown by the following equation:

$$0 \le W_c \le 1, \quad \forall c$$

Step 3. Data collection.

Each MCDM problem involves alternatives n and c evaluation criteria/indices. In turn, each alternative is evaluated with respect to the c criteria/indices. All of the values/ratings assigned to the alternative with respect to each criterion form a decision matrix denoted as D:

$$D = |X_{ij}|_{n \times c} \tag{8}$$

Step 4. Normalise the evaluation matrix D.

This process transforms the different scales and units among the various indexes into common measurable units that permit comparisons among the different criteria. This study normalises the decision matrix D by calculating $g_j(A_i)$, which represents the normalised value of the criteria.

$$g_j(A_i) = \frac{X_{ij}}{\sum_i X_{ij}}, \quad \forall i, j \tag{9}$$

In addition, this study uses G to represent the normalised decision matrix, as shown in Eq. (10).

$$G = |g_j(A_i)|_{n \times c} \tag{10}$$

Step 5. Calculate the weighted normalised decision matrix V.

$$V = |V_{ij}|_{n \times c} \tag{11}$$

where $V_{ij} = W_c g_j(A_i), \quad \forall i, j.$

Step 6. Determine the positive (A*) and negative (A⁻) ideal solutions.

$$A^* = \{(\max_i V_{ij} | j \in K_b), \ (\min_i V_{ij} | j \in K_d)\} = \left\{V_j^* | j = 1, 2, \ldots c\right\} \tag{12}$$

$$A^- = \{(\min_i V_{ij} | j \in K_b), \ (\max_i V_{ij} | j \in K_d)\} = \left\{V_j^- | j = 1, 2, \ldots, c\right\} \tag{13}$$

where $K_b = \{K_j | j = 1, 2, \ldots, c_1\}$and $K_d = \{K_j | j = 1, 2, \ldots, c_2\}$

Step 7. Calculate the separation measures $S_i^*$and S_i^-.

This process calculates the Euclidean distances of each alternative based on the positive and negative ideal solutions:

$$S_i^* = \sqrt{\sum_{j=1}^{m} \left(v_{ij} - v_j^*\right)^2}, \quad \forall i \tag{14}$$

$$S_i^- = \sqrt{\sum_{j=1}^{m} \left(v_{ij} - v_j^-\right)^2}, \quad \forall i \tag{15}$$

Step 8. Calculate the relative closeness (RC_i^*) to the ideal solution.

$$RC_i^* = \frac{S_i^-}{S_i^* + S_i^-}, \quad \forall i \tag{16}$$

where $0 \le RC_i^* \le 1, \quad \forall i.$

Step 9. Rank the alternatives based on their relative closeness to the ideal solution.

A larger RC_i^* implies a better alternative A_i. The best alternative is the one that is closest to the ideal solution.

$$A_i \succ A_{i'} \quad \textit{iff} \quad RC_i^* \ge RC_{i'}^*, \quad \forall i, i'; \quad i \ne i' \tag{17}$$

4. Results

This study applies the Fuzzy Rasch model in TOPSIS to analyse the TDC of nine Asian countries. The evaluation procedure used in this study comprises several steps. First, the evaluation criteria for the TDC were determined. Second, the Asian countries were

Table 1
Lists the six assessment criteria and 15 indices.

Criteria/Indices		Description
Availability of attractions	International tourism arrivals	International tourism arrivals (per thousand people)
	International tourism receipts	International tourism receipts (US$ million)
Availability of service	Hotel room	Number of hotel rooms (per 100 population)
	Number of operating airlines	Number of airlines with scheduled flights originating in the country
	Air transportation	Number of passengers carried by the main companies (per thousand people)
Affordability	Transportation costs	Relative costs of access (ticket taxes and airport charges) to international air transport services (0 = highest cost, 100 = lowest cost)
	Hotel price	Average room price (US$)
	Cost-of-living index	Cost index of goods in major cities
Positive market image	Quality of life	Quality of life in the country
	Quality of the natural environment	Quality of the natural environment in the country (1 = most polluted, 7 = least polluted)
Peace and stability	Safety and security	The degree to which personal security and private property are adequately protected
	Business costs of crime and violence	The incidence of common crime and violence in the country (1 = imposes significant costs on businesses, 7 = does not impose significant costs on businesses)
	Business costs of terrorism	The threat of terrorism in the country (1 = imposes significant costs on businesses, 7 = does not impose significant costs on businesses)
Cultural links	Nation culture	The degree to which the national culture is open to foreign ideas
	Discrimination (race, gender)	The degree of equal treatment for tourists (1 = lowest degree of equal treatment for tourists, 10 = highest degree of equal treatment for tourists)

selected as alternatives. Third, the data were collected, and the fuzzy weights of the criteria/indices were generated with the Rasch model. Finally, the TOPSIS method was used to rank the TDC of the Asian countries. These steps are detailed below:

Step 1. Determine the evaluation criteria/indices and the alternatives.

A multiple indexes evaluation method normally focuses on a set of feasible alternatives and the method used to prioritise the multiple indices. This study also examines a set of feasible alternatives composed of nine Asian countries: China, Hong Kong, Japan, Korea, Malaysia, Singapore, the Philippines, Taiwan and Thailand.

Following a literature review, this study analyses the competitiveness of the tourist industry for each of the selected Asian countries during the year 2009 using six criteria and 15 indices. Table 1 lists the six assessment criteria and 15 indices.

Step 2. Determine the weights of the evaluation criteria/indices with the Fuzzy Rasch model.
Step 2–1. Determine the degree of importance for each criterion/index.

This study assesses TDC by instructing six experts to indicate the degree of importance of six criteria and 15 indices on a Likert rating scale ranging from 1–5 (from "very unimportant" to "very important"), as listed in Table 2.

Step 2–2. Calculate the step parameters (δ_{ij}) to generate the fuzzy weight.

The step parameters of expert 1 are defined with the RSM, as shown in Fig. 2. Based on Fig. 3, this study finds that $\tilde{W}_{ij} = (\delta_{ij}^{L}, \delta_{ij}^{M}, \delta_{ij}^{U})$. This study then uses this information to define the TFN of the linguistic variables.

Table 2
Degree of importance of 15 indices (scale ranges from 1 to 5).

Criteria/Indexes		Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6
Availability of attractions	International tourism arrivals C_1	4	4	5	4	5	5
	International tourism receiptsC_2	4	5	5	5	5	4
Availability of service	Hotel roomC_3	4	4	3	4	4	3
	Number of operating airlinesC_4	5	4	3	4	3	4
	Air transportationC_5	3	2	4	5	4	4
Affordability	Transportation costsC_6	3	2	3	2	3	3
	Hotel price C_7	2	3	2	1	3	2
	Cost-of-living indexC_8	4	5	4	5	5	4
Positive market image	Quality of lifeC_9	2	4	3	2	4	3
	Quality of the natural environmentC_{10}	4	2	3	4	3	3
Peace and stability	Safety and securityC_{11}	4	5	4	4	4	5
	Business costs of crime and violenceC_{12}	2	1	3	2	3	2
	Business costs of terrorismC_{13}	2	3	2	1	3	2
Cultural links	Nation cultureC_{14}	4	3	3	3	3	3
	Discrimination (race, gender, etc) C_{15}	4	3	4	3	3	4

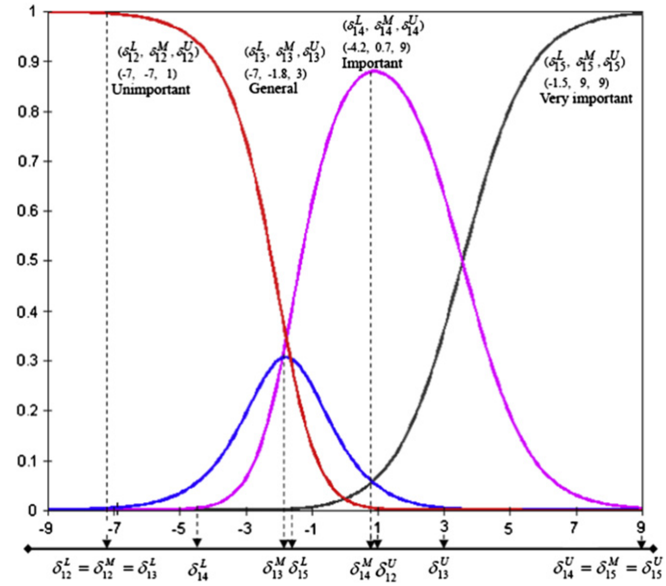

Fig. 2. Step parameters of expert 1.

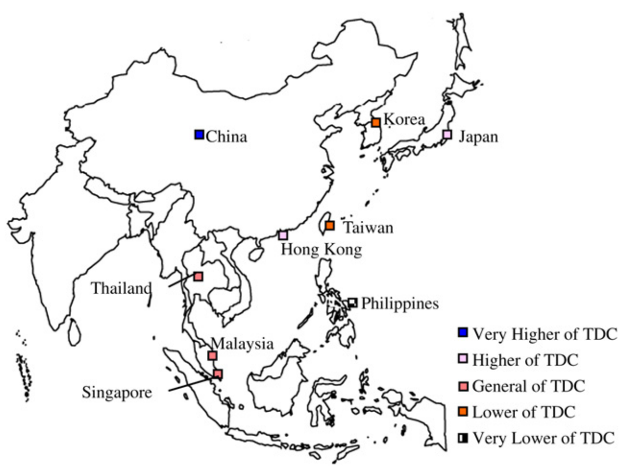

Fig. 3. The group of TDC in Asia.

$$\tilde{W}_{12} = \left(\delta^L_{12}, \delta^M_{12}, \delta^U_{12}\right) = (-7, -7, 1)$$

$$\tilde{W}_{13} = \left(\delta^L_{13}, \delta^M_{13}, \delta^U_{13}\right) = (-7, -1.8, 3)$$

$$\tilde{W}_{14} = \left(\delta^L_{14}, \delta^M_{14}, \delta^U_{14}\right) = (-4.2, -0.7, 9)$$

$$\tilde{W}_{15} = \left(\delta^L_{15}, \delta^M_{15}, \delta^U_{15}\right) = (-1.5, 9, 9)$$

Table 3 lists the linguistic variables from “very unimportant” to “very important” for the TFN obtained from the six experts.

Step 2–3. Use the triangular fuzzy weight as a substitute for the values of importance calculated in Step 2–1.

Based on the above definition of the fuzzy number, this study uses $\tilde{W}_{ijc} = (\delta^L_{ijc}, \delta^M_{ijc}, \delta^U_{ijc})$ to represent the fuzzy weights assigned by experts i to criteria/indices c. These fuzzy weights are then substituted for the original degree of importance calculated in Step 2–1, as listed in Table 4.

Step 2–4. Use an arithmetic average to integrate the fuzzy weight of each expert.

This study uses an arithmetic average (Eq. (5)) to integrate the fuzzy weight of each expert, as listed in Table 5.

Step 2–5. Defuzzification.

This study uses Eq. (6) to transform the fuzzy numbers into crisp numbers. In addition, this study uses Eq. (7) to standardise the weights of criteria/indices c, as shown in Table 5.

Step 3. Data collection.

The data mainly comes from statistical data, such as The World Competitiveness Yearbook 2010, The Travel & Tourism Competitiveness Report 2009, and the official online websites of the following government departments: Hong Kong Tourism Board, Japan National Tourism Organization, Singapore Government, National Tourism Administration of the People’s Republic of China, Department of Tourism Republic of the Philippines, Tourism Malaysia, Korea Tourism Organization and Taiwan Tourism Bureau. Table 6 lists the raw data of the TDC index for nine Asian countries in the year 2009.

Step 4. Normalise the evaluation matrix D.

This study normalises the decision matrix by calculating $g_j(A_i)$, as shown in Eq. (9). $g_j(A_i)$ represents the normalised value of the criteria.

$$\sum_{i=1}^{9} X_{ij} = 6789658 + 132924650 + \cdots + 9682700 + 3017099 + 14150000 = 231967298$$

$$g_1(A_1) = 6789658/231967298 = 0.0293$$
$$\vdots$$
$$g_1(A_9) = 14150000/231967298 = 0.0610$$

Table 3
The linguistic variables of the TFN $\tilde{W}_{ij} = (\delta^L_{ij}, \delta^M_{ij}, \delta^U_{ij})$.

Fuzzy number	Very unimportance	Unimportance	General	Importance	Very importance
Expert 1	–	(−7, −7, 1)	(−7, −1.8, 3)	(−4.2, 0.7, 9)	(−1.5, 9, 9)
Expert 2	(−8.3, −8.3, 0.5)	(−8.3, −2.1, 2.2)	(−4.2, 0, 4.2)	(−2.1, 2, 8)	(−0.4, 8, 8)
Expert 3	–	(−8.6, −8.6, 1)	(−8.6, −1.3, 4.1)	(−3.4, 1.7, 7.4)	(−1, 7.4, 7.4)
Expert 4	(−7.3, −7.3, 1)	(−7.3, −1.5, 2)	(−3.8, −0.1, 3.8)	(−2.5, 1.3, 7.8)	(−1, 7.8, 7.8)
Expert 5	–	–	(−5.8, −5.8, 2.7)	(−5.8, 0, 5.8)	(−2.7, 5.8, 5.8)
Expert 6	–	(−7.8, −7.8, 1)	(−7.8, −1.4, 3.8)	(−3.8, 1.2, 7.5)	(−1, 7.5, 7.5)

Table 4
The fuzzy number of the weights assigned by the six experts to the 15 indices $\tilde{W}_{ijc}$.

Criteria/Indexes	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6
C_1	(−4.2, 0.7, 9)	(−2.1, 2, 8)	(−1, 7.4, 7.4)	(-2.5, 1.3, 7.8)	(−2.7, 5.8, 5.8)	(−1, 7.5, 7.5)
C_2	(−4.2, 0.7, 9)	(−0.4, 8, 8)	(−1, 7.4, 7.4)	(−1, 7.8, 7.8)	(−2.7, 5.8, 5.8)	(−3.8, 1.2, 7.5)
C_3	(−4.2, 0.7, 9)	(−2.1, 2, 8)	(−8.6, −1.3, 4.1)	(−2.5, 1.3, 7.8)	(−5.8, 0, 5.8)	(−7.8, −1.4, 3.8)
C_4	(−1.5, 9, 9)	(−2.1, 2, 8)	(−8.6, −1.3, 4.1)	(−2.5, 1.3, 7.8)	(−5.8, −5.8, 2.7)	(−3.8, 1.2, 7.5)
C_5	(−7, −1.8, 3)	(−8.3, −2.1, 2.2)	(−3.4, 1.7, 7.4)	(−1, 7.8, 7.8)	(−5.8, 0, 5.8)	(−3.8, 1.2, 7.5)
C_6	(−7, −1.8, 3)	(−8.3, −2.1, 2.2)	(−8.6, −1.3, 4.1)	(−7.3, −1.5, 2)	(−5.8, −5.8, 2.7)	(−7.8, −1.4, 3.8)
C_7	(−7, −7, 1)	(−4.2, 0, 4.2)	(−8.6, −8.6, 1)	(−7.3, −7.3, 1)	(−5.8, −5.8, 2.7)	(−7.8, −7.8, 1)
C_8	(−4.2, 0.7, 9)	(−0.4, 8, 8)	(−3.4, 1.7, 7.4)	(−1, 7.8, 7.8)	(−2.7, 5.8, 5.8)	(−3.8, 1.2, 7.5)
C_9	(−7, −7, 1)	(−2.1, 2, 8)	(−8.6, −1.3, 4.1)	(−7.3, −1.5, 2)	(−5.8, 0, 5.8)	(−7.8, −1.4, 3.8)
C_{10}	(−4.2, 0.7, 9)	(−8.3, −2.1, 2.2)	(−8.6, −1.3, 4.1)	(−2.5, 1.3, 7.8)	(−5.8, −5.8, 2.7)	(−7.8, −1.4, 3.8)
C_{11}	(−4.2, 0.7, 9)	(−0.4, 8, 8)	(−3.4, 1.7, 7.4)	(−2.5, 1.3, 7.8)	(−5.8, 0, 5.8)	(−1, 7.5, 7.5)
C_{12}	(−7, −7, 1)	(−8.3, −8.3, 0.5)	(−8.6, −1.3, 4.1)	(−7.3, −1.5, 2)	(−5.8, −5.8, 2.7)	(−7.8, −7.8, 1)
C_{13}	(−7, −7, 1)	(−4.2, 0, 4.2)	(−8.6, −8.6, 1)	(−7.3, −7.3, 1)	(−5.8, −5.8, 2.7)	(−7.8, −7.8, 1)
C_{14}	(−4.2, 0.7, 9)	(−4.2, 0, 4.2)	(−8.6, −1.3, 4.1)	(−3.8, −0.1, 3.8)	(−5.8, −5.8, 2.7)	(−7.8, −1.4, 3.8)
C_{15}	(−4.2, 0.7, 9)	(−4.2, 0, 4.2)	(−3.4, 1.7, 7.4)	(−3.8, −0.1, 3.8)	(−5.8, −5.8, 2.7)	(−3.8, 1.2, 7.5)

This study also uses to represent the normalised decision matrix, as shown below:

$$G = \begin{matrix} A_1 \\ A_2 \\ A_3 \\ A_4 \\ A_5 \\ A_6 \\ A_7 \\ A_8 \\ A_9 \end{matrix} \begin{bmatrix} 0.0293 & 0.0818 & \cdots & 0.0977 & 0.0929 & 0.1157 \\ 0.5730 & 0.3148 & \cdots & 0.1102 & 0.1129 & 0.1150 \\ 0.0189 & 0.0552 & \cdots & 0.1206 & 0.1077 & 0.0948 \\ 0.1276 & 0.1306 & \cdots & 0.1372 & 0.1039 & 0.1149 \\ 0.0337 & 0.0749 & \cdots & 0.1185 & 0.0782 & 0.1225 \\ 0.1017 & 0.1251 & \cdots & 0.1123 & 0.1106 & 0.0969 \\ 0.0417 & 0.0729 & \cdots & 0.1164 & 0.1238 & 0.1367 \\ 0.0130 & 0.0185 & \cdots & 0.0852 & 0.1197 & 0.0946 \\ 0.0610 & 0.12622 & \cdots & 0.1019 & 0.1233 & 0.1089 \end{bmatrix}$$

Step 5. Calculate the weighted normalised decision matrix V.

For example, $v_{i1}$is calculated to determine the availability of the attractions, as shown by the following:

$$v_{11} = W^1 g_1(A_1) = 0.0939 \times 0.0293 = 0.0027$$
$$\vdots$$
$$v_{91} = W^1 g_1(A_4) = 0.0939 \times 0.0610 = 0.0057$$

$$V = \begin{matrix} A_1 \\ A_2 \\ A_3 \\ A_4 \\ A_5 \\ A_6 \\ A_7 \\ A_8 \\ A_9 \end{matrix} \begin{bmatrix} 0.0027 & 0.0079 & \cdots & 0.0047 & 0.0034 & 0.0108 \\ 0.0538 & 0.0305 & \cdots & 0.0053 & 0.0041 & 0.0107 \\ 0.0018 & 0.0054 & \cdots & 0.0058 & 0.0039 & 0.0088 \\ 0.0120 & 0.0127 & \cdots & 0.0066 & 0.0048 & 0.0107 \\ 0.0032 & 0.0073 & \cdots & 0.0057 & 0.0028 & 0.0114 \\ 0.0096 & 0.0121 & \cdots & 0.0054 & 0.0040 & 0.0090 \\ 0.0039 & 0.0071 & \cdots & 0.0056 & 0.0045 & 0.0127 \\ 0.0012 & 0.0018 & \cdots & 0.0041 & 0.0044 & 0.0088 \\ 0.0057 & 0.0122 & \cdots & 0.0049 & 0.0045 & 0.0102 \end{bmatrix}$$

Step 6. Determine the positive (A^*) and negative (A^-) ideal solutions.

$$A^* = \left\{ \frac{\max v_{i1}}{i}, \frac{\max v_{i2}}{i}, \frac{\max v_{i3}}{i}, \frac{\max v_{i4}}{i}, \frac{\max v_{i5}}{i}, \frac{\min v_{i6}}{i}, \frac{\min v_{i7}}{i}, \frac{\min v_{i8}}{i}, \frac{\max v_{i9}}{i}, \frac{\max v_{i10}}{i}, \frac{\max v_{i11}}{i}, \frac{\max v_{i12}}{i}, \frac{\max v_{i13}}{i}, \frac{\max v_{i14}}{i}, \frac{\max v_{i15}}{i} \right\}$$
$$= \left(v_1^*, v_2^*, v_3^*, v_4^*, v_5^*, v_6^*, v_7^*, v_8^*, v_9^*, v_{10}^*, v_{11}^*, v_{12}^*, v_{13}^*, v_{14}^*, v_{15}^* \right)$$
$$= (0.054,\ 0.031,\ 0.018,\ 0.013,\ 0.032,\ 0.006,\ 0.004,\ 0.007,\ 0.005,\ 0.006,\ 0.009,\ 0.009,\ 0.007,\ 0.005,\ 0.013)$$

Table 5
The average fuzzy and defuzzification weights of the 15 indices.

Criteria/Indexes	Fuzzy number Average of weight $\tilde{W}_c$	$\tilde{W}_c + 8$	Defuzzification of the weight BNP_c	Standardize of weight $W_c = SBNP_c$
C_1	(−2.250, 4.117, 7.583)	(5.750, 12.117, 15.583)	11.150	0.0939
C_2	(−2.183, 5.150, 7.583)	(5.817, 13.150, 15.583)	11.517	0.0970
C_3	(−5.167, 0.217, 6.417)	(2.833, 8.217, 14.417)	8.489	0.0715
C_4	(−4.05, 1.067, 6.517)	(3.950, 9.067, 14.517)	9.178	0.0773
C_5	(−4.883, 1.133, 5.617)	(3.117, 9.133, 13.617)	8.622	0.0726
C_6	(−6.433, −1.533, 4.117)	(1.567, 6.467, 12.117)	6.717	0.0566
C_7	(−6.200, −1.433, 4.933)	(1.800, 6.567, 12.933)	7.100	0.0598
C_8	(−2.883, 3.200, 7.583)	(5.117, 11.200, 15.583)	10.633	0.0895
C_9	(−7.467, −5.283, 1.883)	(0.533, 2.717, 9.883)	4.378	0.0369
C_{10}	(−6.783, −6.083, 1.817)	(1.217, 1.917, 9.817)	4.317	0.0364
C_{11}	(−5.733, −1.317, 4.600)	(2.267, 6.683, 12.600)	7.183	0.0605
C_{12}	(−4.200, −0.383, 5.767)	(3.800, 7.617, 13.767)	8.394	0.0707
C_{13}	(−7.467, −2.317, 2.833)	(0.533, 5.683, 10.833)	5.683	0.0479
C_{14}	(−6.783, −6.083, 1.817)	(1.217, 1.917, 9.817)	4.317	0.0364
C_{15}	(−2.583, 4.200, 7.583)	(5.417, 12.200, 15.583)	11.067	0.0932

Table 6
Lists the raw data of the TDC index for nine Asian countries in the year 2009.

Criteria	Availability of attractions		Availability of service			Affordability			Positive market image		Peace and stability			Cultural links	
Indexes	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}	C_{13}	C_{14}	C_{15}
Japan	6,789,658	10,305	1.20	77.50	97,022	82.60	130.20	131.45	7.05	5.00	8.52	5.00	4.70	5.89	6.63
China	132,924,650	39,675	0.10	95.50	230,000	89.90	118.10	88.44	4.84	3.20	5.95	5.10	5.30	7.16	6.59
Taiwan	4,395,004	6958	0.50	29.00	34,382	93.60	161.00	77.00	5.78	4.00	6.62	5.60	5.80	6.83	5.43
Hong Kong	29,590,654	16,463	0.80	62.00	47,139	85.70	153.00	108.70	6.25	3.40	8.29	6.40	6.60	8.30	6.58
Korea	7,817,533	9442	0.10	50.00	36,078	86.90	194.60	80.60	5.86	4.70	6.86	5.50	5.70	4.96	7.02
Malaysia	23,600,000	15,772	0.60	57.50	22,421	93.80	74.20	69.20	7.52	5.10	6.06	4.60	5.40	7.01	5.55
Singapore	9,682,700	9187	0.90	56.00	19,566	85.60	153.40	98.00	8.45	5.90	8.73	6.40	5.60	7.85	7.83
Philippines	3,017,099	2329	0.00	35.00	9508	91.20	81.00	63.80	4.62	3.30	4.21	4.30	4.10	7.59	5.42
Thailand	14,150,000	15,901	0.60	92.00	19,993	87.00	108.80	68.60	6.36	3.90	6.48	5.20	4.90	7.82	6.24

1. Institute for Management Development (IMD). The World Competitiveness Yearbook 2010.
2. World Economic Forum (WEF). The Travel & Tourism Competitiveness Report 2009.
3. Hong Kong Tourism Board. http://partnernet.hktb.com/pnweb/jsp/doc/listDoc.jsp?doc_id=129117.
4. Japan National Tourism Organization (JNTO). http://www.jnto.go.jp/.
5. Singapore Government. http://www.singstat.gov.sg/stats/keyind.html.
6. National Tourism Administration of the People's Republic of China. http://www.cnta.gov.cn/.
7. Department of Tourism, Republic of the Philippines. http://www.visitmyphilippines.com/index.php?title=VisitorStatistics&func=all&pid=39&tbl=1.
8. Tourism Malaysia. http://www.tourismmalaysia.gov.my/corporate/research.asp?page=facts_figures.
9. Korea Tourism Organization. http://kto.visitkorea.or.kr/inout.kto?func_name=search.
10. Tourism Bureau, M.O.T.C. Taiwan. http://admin.taiwan.net.tw/.

$$A^- = \left\{\underset{i}{\min} v_{i1}, \underset{i}{\min} v_{i2}, \underset{i}{\min} v_{i3}, \underset{i}{\min} v_{i4}, \underset{i}{\min} v_{i5}, \underset{i}{\max} v_{i6}, \underset{i}{\max} v_{i7}, \underset{i}{\max} v_{i8}, \underset{i}{\min} v_{i9}, \underset{i}{\min} v_{i10}, \underset{i}{\min} v_{i11}, \underset{i}{\min} v_{i12}, \underset{i}{\min} v_{i13}, \underset{i}{\min} v_{i14}, \underset{i}{\min} v_{i15}\right\}$$
$$= \left(v_1^-, v_2^-, v_3^-, v_4^-, v_5^-, v_6^-, v_7^-, v_8^-, v_9^-, v_{10}^-, v_{11}^-, v_{12}^-, v_{13}^-, v_{14}^-, v_{15}^-\right)$$
$$= (0.001,\ 0.002,\ 0.000,\ 0.004,\ 0.001,\ 0.007,\ 0.010,\ 0.015,\ 0.003,\ 0.003,\ 0.004,\ 0.006,\ 0.004,\ 0.003,\ 0.009)$$

Step 7. Calculate the separation measures S_i^* and S_i^-.

This process calculates the Euclidean distances of each alternative based on the positive and negative ideal solutions.

For example, the separation measure from the positive ideal solution of Japan is calculated as follows:

$$S_1^* = \sqrt{\sum_{j=i}^{5}\left(v_{1j} - v_j^*\right)^2} = \sqrt{(0.0027 - 0.054)^2 + \cdots + (0.0108 - 0.013)^2} = 0.060$$

The separation measure from the negative ideal solution of Japan is calculated as follows:

$$S_1^- = \sqrt{\sum_{j=i}^{5}\left(v_{1j} - v_j^-\right)^2} = \sqrt{(0.0027 - 0.001)^2 + \cdots + (0.0108 - 0.009)^2} = 0.024$$

Step 8. Calculate the relative closeness (RC_i^*) to the ideal solution.

$$RC_1^* = \frac{S_1^-}{\left(S_1^* + S_1^-\right)} = \frac{0.024}{0.060 + 0.024} = 0.291$$

Step 9. Rank the alternatives based on their relative closeness to the ideal solution.

A larger implies a better alternative. The best alternative is the one that is closest to the ideal solution, as demonstrated by the following equation:

$$RC_2^* > RC_1^* > RC_4^* > RC_6^* > RC_7^* > RC_9^* > RC_5^* > RC_3^* > RC_8^*$$

Table 7 lists the ranking of the sampled Asian countries by TDC in the year 2009. These countries are ranked from highest to lowest as follows: China, Japan, Hong Kong, Malaysia, Thailand, Singapore, Taiwan, Korea and the Philippines.

Fig. 3 shows that the nine Asian countries considered in this study could be divided into five groups based on their TDC values. China is ranked much higher than the other eight countries and, thus, is the sole member of the first group (Very High TDC). Japan and Hong Kong are both ranked highly and, thus, belong to the second group (High TDC). Malaysia, Singapore and Thailand are ranked near the middle and belong to the third group (General TDC). Korea and Taiwan are ranked low and belong to the fourth group (Low TDC). Finally, the Philippines is ranked very low and, thus, belongs to the fifth group (Very Low TDC).

Table 7
Ranking of each destination's competitiveness in Asia.

	S_i^*	S_i^-	RC_i^*	Rank
Japan	0.060	0.024	0.29061	2
China	0.018	0.068	0.79531	1
Taiwan	0.066	0.012	0.15058	7
Hong Kong	0.053	0.022	0.29057	3
Korea	0.065	0.011	0.14129	8
Malaysia	0.057	0.019	0.25283	4
Singapore	0.063	0.018	0.21846	6
Philippines	0.071	0.010	0.12157	9
Thailand	0.060	0.019	0.24276	5

Table 8
Ranked order of nine countries in six criteria respectively.

	Availability of attractions	Availability of service	Affordability	Positive market image	Peace and stability	Cultural links
Japan	0.102 (5)	0.546 (2)	0.291 (9)	0.651 (3)	0.610 (3)	0.460 (5)
China	1.000 (1)	0.664 (1)	0.633 (4)	0.040 (8)	0.401 (7)	0.518 (4)
Taiwan	0.059 (8)	0.211 (7)	0.576 (5)	0.300 (6)	0.581 (5)	0.212 (9)
Hong Kong	0.252 (2)	0.340 (3)	0.343 (8)	0.281 (7)	0.929 (1)	0.569 (2)
Korea	0.094 (7)	0.133 (8)	0.475 (6)	0.445 (4)	0.591 (4)	0.528 (3)
Malaysia	0.217 (3)	0.243 (6)	0.903 (2)	0.729 (2)	0.367 (8)	0.240 (8)
Singapore	0.097 (6)	0.315 (4)	0.439 (7)	1.000 (1)	0.849 (2)	0.943 (1)
Philippines	***0.0000 (9)***	***0.022 (9)***	***0.932 (1)***	***0.026 (9)***	***0.000 (9)***	***0.277 (7)***
Thailand	0.181 (4)	0.290 (5)	0.818 (3)	0.360 (5)	0.451 (6)	0.448 (6)

Table 8 indicates that China is ranked first in terms of the availability of its attractions, whereas the Philippines, Taiwan and Korea are ranked the lowest. China is also ranked first for service availability, whereas the Philippines, Korea and Taiwan occupy the last three places. The top three countries for affordability are the Philippines, Malaysia, and Thailand, whereas the last three are Japan, Hong Kong, and Singapore. The top three countries for positive market image are Singapore, Malaysia and Japan, whereas the Philippines, China and Hong Kong occupy the last three places. In terms of peace and stability, Hong Kong, Singapore and Japan occupy the top three rankings, whereas the Philippines, Malaysia, and China are ranked at the bottom. Finally, the top-ranked countries for cultural links are Singapore, Hong Kong and Korea, whereas Taiwan, Malaysia and the Philippines take the last three places.

5. Conclusions

This study successfully combines TOPSIS with the Fuzzy Rasch model to evaluate TDC in nine Asian countries: China, Hong Kong, Japan, Korea, Malaysia, Singapore, Taiwan, Thailand and the Philippines. This study was conducted during the year 2009 using six criteria and 15 indexes. Determining the weight of the evaluation criteria with the Fuzzy Rasch model appears to be a feasible task. Doing so can rectify the inaccuracy of the real fuzzy numbers assigned by the individual experts for the specific criteria. Additionally, this study's methodology represents not only an innovative attempt to evaluate TDC but also a practical application of the MCDM method to studying TDC.

The analytical results presented in this study demonstrate that China significantly outscored the other countries in terms of TDC (Very High TDC) because it outperforms the other countries in terms of the availability of its attractions and services. However, China did not outperform the other countries in positive market image as well as peace and stability. According to the world competitiveness yearbook published by the IMD, tourist intention to travel to a country increases for countries with more secure environments. These findings suggest that China should focus on improving its peace and stability as well as its market image.

Additionally, Japan and Hong Kong belonged to the High TDC group. Thus, Japan and Hong Kong should endeavour to reduce the costs of living, the costs of transportation and the hotel prices (affordability) because tourists pre-plan their travel costs before travelling to a country. As a result, the cost-of-living index of a destination country affects the tourist travel intention for that country. Hong Kong should also improve the quality of its natural environment to achieve a more positive market image; the poor natural environment of Hong Kong contributes to its negative image, and most travellers avoid travelling to destinations with a negative market image.

Malaysia, Singapore and Thailand belong to the General TDC group. Hence, Malaysia and Thailand should work on improving their peace and stability as well as their cultural links, whereas Singapore should focus on improving its costs of living, costs of transportation and hotel prices (affordability).

Korea and Taiwan belong to the low TDC group. Thus, Taiwan and Korea should focus on enhancing the availability of their attractions and services. TDC increases the number of tourist arrivals in a country. According to the World Tourism Organization's statistics, most tourists fly to Asian destinations, and as a result, Taiwan and Korea should increase both the number of service local routes to their airlines and the number of passengers carried per plane. Taiwan and Korea should also increase the number of hotel rooms, as this factor represents another area that requires improvement for both countries.

Finally, the Philippines exhibit weak TDC. The Philippines enjoys an advantage in affordability, but in the other criteria, this country is far less competitive than the other countries. Thus, the Philippines should strive to improve in all of the criteria.

Acknowledgements

The authors would like to thank two anonymous reviewers and the editor for their useful comments and suggestions.

References

Alhemoud, A. M., & Armstrong, E. G. (1996). Image of tourism attractions in Kuwait. *Journal of Travel Research, 34*(4), 76–80.
Andrich, D. (1978). A rating formulation for ordered response categories. *Psychometrika, 43*(4), 561–573.
Aydogan, E. K. (2011). Performance measurement model for Turkish aviation firms using the rough-AHP and TOPSIS methods under fuzzy environment. *Expert Systems with Applications, 38*(4), 3992–3998.
Belvedere, S. L., & de Morton, N. A. (2010). Application of Rasch analysis in health care is increasing and is applied for variable reasons in mobility instruments. *Journal of Clinical Epidemiology, 63*(12), 1287–1297.
Bond, T. G., & Fox, C. M. (2007). *Applying the Rasch model. Fundamental measurement in the human sciences* (2nd ed.). New Jersey: Lawrence Erlbaum Associates, Inc., Publishers.
Barros, C. P., Botti, L., Peypoch, N., Robinot, E., Solonandrasana, B., & Assaf, G. A. (2011). Performance of French destinations: tourism attraction perspectives. *Tourism Management, 32*(1), 141–146.
Buckley, J. J. (1985). Fuzzy hierarchical analysis. *Fuzzy Sets and Systems, 17*(3), 233–247.
Burton, R. (1995). *Travel geography* (2nd ed.). London: Pitman.
Cavlek, N. (2002). Tour operators and destination safety. *Annals of Tourism Research, 29*(2), 478–496.
Claver-Cortes, E., Molina-Azorin, J. F., & Pereira-Moliner, J. (2007). Competitiveness in mass tourism. *Annals of Tourism Research, 34*(3), 727–745.
Cracolici, M. F., & Nijkamp, P. (2009). The attractiveness and competitiveness of tourist destinations: a study of Southern Italian regions. *Tourism Management, 30*(3), 336–344.
Crouch, G. I., & Ritchie, J. R. B. (1999). Tourism, competitiveness, and societal prosperity. *Journal of Business Research, 44*(3), 137–152.
Crouch, G. I. (1992). Effects of income and price on international tourism. *Annual of Tourism Research, 19*(4), 643–664.
Dagdeviren, M., Yavuz, S., & Kılınç, N. (2009). Weapon selection using the AHP and TOPSIS methods under fuzzy environment. *Expert Systems with Applications, 36*(4), 8143–8151.

Dwyer, L., & Kim, C. (2003). Destination competitiveness: determinants and indicators. *Current Issues in Tourism, 6*(5), 369–414.
Enright, M. J., & Newton, J. (2004). Tourism destination competitiveness: a quantitative approach. *Tourism Management, 25*(6), 777–788.
Fakeye, P. C., & Crompton, J. L. (1991). Images differences between prospective, first-time and repeat visitors to the Lower Rio Grande valley. *Journal of Travel Research, 30*(2), 10–16.
Fisher, W. P., Jr. (1995). Fuzzy truth and the Rasch model. *Rasch Measurement Transactions, 9*(3), 442.
Go, F. M., & Govers, R. (1999). The Asian perspective: which international conference destinations in Asia are the most competitive? *Journal of Convention & Exhibition Management, 1*(4), 37–50.
Gumus, A. T. (2009). Evaluation of hazardous waste transportation firms by using a two step fuzzy-AHP and TOPSIS methodology. *Expert Systems with Applications, 36*(2), 4067–4074.
Hall, C. M. (2007). Tourism & regional competitiveness. In J. Tribe, & D. Airey (Eds.), *Developments in tourism research* (pp. 217–230). Oxford: Elsevier Science, (Chapter in Book).
Hovinen, G. (2002). Revising the destination lifecycle model. *Annals of Tourism Research, 29*(1), 209–230.
Hsieh, T. Y., Lu, S. T., & Tzeng, G. H. (2004). Fuzzy MCDM approach for planning and design tenders selection in public office buildings. *International Journal of Project Management, 22*(7), 573–584.
Huang, J. H., & Peng, K. H. (2010). Using the Rasch in grey model to assess international tourist hotel industry performance. *Journal of Grey System*, (Accept).
Hwang, C. L., & Yoon, K. (1981). *Multiple attribute decision making: Method and application*. New York: Spring-Verlag.
Inskeep, E. (1991). *Tourism planning: An integrated and sustainable development approach*. New York: Van Nostrand Reinhold.
Institute for Management Development. (2010). *The world competitiveness yearbook*. Lausanne: Institute for Management Development (IMD).
Kastrin, A., & Peterlin, B. (2010). Rasch-based high-dimensionality data reduction and class prediction with applications to microarray gene expression data. *Expert Systems with Applications, 37*(7), 5178–5185.
Kaufmann, A., & Gupta, M. M. (1991). *Introduction to fuzzy arithmetic: theory and applications*. New York: VanNostrand-Reinhold.
Kim, B. S. K., & Hong, S. (2004). A psychometric revision of the Asian values scale using the Rasch model. *Measurement and Evaluation in Counseling and Development, 37*(1), 15–27.
Kozak, M., & Rimmington, M. (1999). Measuring tourist destination competitiveness: conceptual considerations and empirical findings. *International Journal of Hospitality Management, 18*(3), 273–283.
Liang, G. S., & Ding, J. F. (2003). Fuzzy MCDM based on the concept of α-cut. *Journal of Multi-Criteria Decision Analysis, 12*(6), 299–310.
Mahdavi, I., Mahdavi-Amiri, N., Heidarzade, A., & Nourifar, R. (2008). Designing a model of fuzzy TOPSIS in multiple criteria decision making. *Applied Mathematics and Computation, 206*(2), 607–617.
Meads, D. M., & Bentall, R. P. (2008). Rasch analysis and item reduction of the hypomanic personality scale. *Personality and Individual Differences, 44*(8), 1772–1783.
Middleton, V. T. C., & Hawkins, R. (1998). *Sustainable tourism: A marketing perspective*. Oxford: Butterworth-Heinemann.
Mon, D. L., Cheng, C. H., & Lin, J. C. (1994). Evaluating weapon system using fuzzy analytic hierarchy process based on entropy weight. *Fuzzy Sets and System, 62*(2), 127–134.
Palmer, A. L., Sese, A., & Montano, J. J. (2005). Tourism and statistics bibliometric study 1998–2002. *Annals of Tourism Research, 32*(1), 167–178.
Pearce, D. G. (1997). Competitive destination analysis in Southeast Asia. *Journal of Travel Research, 35*(4), 16–24.
Rasch, G. (1960). *Probabilistic models for some intelligence and attainment tests*. Copenhagen: Danish Institute for Educational Research.
Ritchie, J.R.B., & Crouch, G.I. Competitiveness in international tourism: A framework for understanding and analysis. Proceedings of the 43rd Congress of the Association Internationale d'Experts Scientifique due Tourisme on Competitiveness of Long-Haul Tourist Destinations, San Carlos de Bariloche, Argentina. October 17–23, 1993. pp. 23–71.
Ruhanen, L. (2007). Destination competitiveness. In A. Matias, P. Nijkamp, & P. Neto (Eds.), *Advances in modern tourism research* (pp. 133–152). Heidelberg: Physika-Verlag.
Seaton, A., & Bennett, M. (1996). *Marketing tourism Products – Concepts, Issues and Cases*. London: International Thompson Business Press.
Singh, R. K., & Benyoucef, L. (2011). A fuzzy TOPSIS based approach for e-sourcing. *Engineering Applications of Artificial Intelligence, 24*(3), 437–448.
Sun, C. C. (2010). A performance evaluation model by integrating fuzzy AHP and fuzzy TOPSIS methods. *Expert Systems with Applications, 37*(12), 7745–7754.
Tan, C. (2011). A multi-criteria interval-valued intuitionistic fuzzy group decision making with Choquet integral-based TOPSIS. *Expert Systems with Applications, 38*(4), 3023–3033.
Torlak, G., Sevkli, M., Sanal, M., & Zaim, S. (2011). Analyzing business competition by using fuzzy TOPSIS method: an example of Turkish domestic airline industry. *Expert Systems with Applications, 38*(4), 3396–3406.
Tsaur, S. H., Tzeng, G. H., & Wang, K. C. (1997). Evaluating tourist risks from fuzzy perspectives. *Annals of Tourism Research, 24*(4), 796–812.
Tsou, C. S. (2008). Multi-objective inventory planning using MOPSO and TOPSIS. *Expert Systems with Applications, 35*(1–2), 136–142.
Wang, J. W., Cheng, C. H., & Huang, K. C. (2009). Fuzzy hierarchical TOPSIS for supplier selection. *Applied Soft Computing, 9*(1), 377–386.
Wang, T. C., & Lee, H. D. (2009). Developing a fuzzy TOPSIS approach based on subjective weights and objective weights. *Expert Systems with Applications, 36*(5), 8980–8985.
Weaver, D., & Oppermann, M. (2000). *Tourism management*. New York: Wiley.
Woodside, A. G., & Lysonski, S. (1989). A general model of traveler destination choice. *Journal of Travel Research, 27*(4), 8–14.
World Economic Forum (WEF). (2009). *The travel & tourism competitiveness report*. Retrieved from http://www.weforum.org/issues/travel-and-tourism-competitiveness/.
World Tourism Organization (UNWTO). (2010). *Tourism highlights*. Retrieved from http://www.unwto.org/facts/eng/highlights.htm.
Wright, B. D., & Masters, G. N. (1982). *Rating scale analysis*. Chicago: MESA Press.
Yoon, K. Systems selection by multiple attributes decision making (1980). PhD Dissertation, Kansas State University, Manhattan, Kansas.
Yu, S. C., & Wu, B. (2009). Fuzzy item response model: a new approach to generate membership function to score psychological measurement. *Quality and Quantity, 43*(3), 381–390.
Yu, X., Guo, S., Guo, J., & Huang, X. (2011). Rank B2C e-commerce websites in e-alliance based on AHP and fuzzy TOPSIS. *Expert Systems with Applications, 38*(4), 3550–3557.
Zadeh, L. A. (1975). The concept of a linguistic variable and its application to approximate reasoning. *Information Science, 8*(3), 199–249.
Zhang, H., Gu, C. L., Gu, L. W., & Zhang, Y. (2011). The evaluation of tourism destination competitiveness by TOPSIS and information entropy-A case in the Yangtze River Delta of China. *Tourism Management, 32*(2), 443–451.