Fuzzy TOPSIS Method for a Tourism Destination

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Abstract

In this study, we intended to create a methodology in order to have a Multi Criteria approach for choosing a tourist destination region or place as Multi Criteria Decision Making (MCDM) is widely used to outrank, choose or cluster the alternatives with respect to multiple criteria and, in general, refers to making decisions among multi alternatives in the presence of multiple, usually conflicting criteria. Conflicting criteria often makes the problem difficult to decide and select the best alternative among the possible choices. To do this, we propose a Fuzzy TOPSIS Method to choose a Tourism destination in Portugal.

1. Introduction

Tourism destination choosing is challenging and hard among multi alternatives based on multi criteria. Multi Criteria Decision Making (MCDM) is widely used to outrank, choose or cluster the alternatives with respect to multiple criteria. MCDM, in general, refers to making decisions among multi alternatives in the presence of multiple, usually conflicting criteria. There are several MCDM methods in the literature but the main features and steps are mostly common. First, it is necessary to determine the relevant criteria and alternatives. Then, to attach numerical measures to define the relative importance of the criteria and the impacts of the alternatives on these criteria. And finally, to process the numerical values to determine a ranking of each alternative (Triantaphyllou et al., 1998).

MCDM mostly need numerical values but in real life problems, quantitative data are difficult to obtain. Instead of conventional approaches, we will apply linguistic assessments to choose a tourism destination among alternatives. In this part, we will examine a fuzzy MCDM methodology in order to have a Multi Criteria approach for choosing a tourist destination region or place. Fuzzy Technique for Order Performance by Similarity to Ideal Solution (Fuzzy TOPSIS) will be examined and applicability of Fuzzy TOPSIS will be tested over a tourism destination choosing in this part.

In Fuzzy TOPSIS method, we will use fuzzy sets of numbers. But to reach fuzzy sets of numbers, first we need the linguistic assessments about tourist destinations. As above mentioned, it is difficult to model the real life problems with crisp data. For that reason, we will take advantage of using linguistic variables. Involving a gridline scheme for selection a tourism destination, several criteria will be defined in order to create the basis for the utilization of the model for electing a destination.

Tourism destination study has been object of much research, in very different perspectives, allowing a vast debate in theory and practice. Tourism Economics gives a strong contribution in the area of tourism destination investigation contributing for the understanding of this phenomenon and for the definition of tourism policies and planning, and for management and business practices.

This study gives a contribution, through the development of a decision making methodology, for choosing a tourism destination.

2. Economy and Tourism

Taking into account the necessity of framing the developments related to this research, it is important to make some reflections around Tourism Economics, Tourism destination conceptualization and the importance of getting objective criteria for choosing a tourism destination. Considering that, after some notes around these subjects, a description of some Portuguese Regions under analysis is relevant in order to perceive the importance of such criteria.

Following these aims, some notes on Economics and Tourism Economics follow, starting by recognizing that in Economics the core question lies on the scarcity of resources, which is related to the existent inequity between the amount of available resources and people's and organizations' demand for them. Economics studies the way how limited resources are used to try to meet demands for them, which represent unlimited wants by agents.

Considering that resources are scarce, Economics constructs and models intend to get the relationship between economic variables and to describe this relationship. While microeconomics is focused on the agents themselves (individuals, companies, markets), macroeconomics is focused in the whole economy, often considered in terms of national aggregates. Besides, other concerns are growing in economics streams, as it is the case of some disciplines of Environmental Economics, or Neuroeconomics for example, or yet other perspectives related for instance with cooperative trends of agents aiming to explore new courses for the human society forms of organization.

In fact, as much as the systemic nature of tourism and the big heterogeneity of tourism activities are very central for the theoretical developments in this area, this discipline comes out modelling the tourism reality. Tourism Economics includes a set of very diversified studies focusing tourism as economic activity and as economic sector. As tourism has become a key economic strength in many countries and regions around the world, the development of tourism activities has corresponded to very significant social, cultural, economic, political and environmental transformations in societies over the past decades, with which it was possible to see considerable changes in population's work patterns, in living standards or income distribution among individuals, groups and regions.

Actually, tourism assumes the robust net of relationships among economic agents in a complex system of interactions among local, regional and national levels of governmental agencies, firms, tourists and residents. In this sense, tourist products necessarily include a set of heterogeneous and complementary goods and services, supplied by firms belonging to different industries which are mainly, but not exclusively, located in the tourism destination (Filipe, 2014). The impact of tourism activities is tremendous in different areas of society's organization as it is the case of cities architecture and development, or countries governments and entities modus operandi when tourism becomes central in countries' economies.

When an economy becomes dependent of large numbers of tourists, in such circumstances tour operators, governments and many other economic interests and agents compete through advertising and image creation to attract tourism customers. In countries and regions with significantly tourism structures corresponding to highly demanded regions as tourists' destinations, with their facilities and services, the visible impact of tourists' activities is very significant (Smith and Eadington, 1992).

In Leiper (2004), cited in Filipe (2014) tourist destinations are defined as "places where travellers choose to stay a while for leisure experiences, related to one or more features or characteristics of the place – a perceived attraction of some sort". As Leiper (1990) refers, cited in Andergassen, Candela and Figini (2013), from the researcher's perspective the tourism destination embodies all the specific and problematic features of tourism, such as its systemic nature, in which, the "space" plays a fundamental role.

The rest of this part is organized as follows. Section 3 describes fuzzy sets and numbers and Section 4 covers fuzzy TOPSIS methodology and notations of the method. Section 5 explains the applicability of tourism destination choosing. In Section 6 concludes the part and discusses some future research perspectives.

3. Fuzzy Sets and Fuzzy Numbers

Fuzzy set theory, which was introduced by Zadeh (1965) to deal with problems in which a source of vagueness is involved, has been utilized for incorporating imprecise data into the decision framework. A fuzzy set $\tilde{A}$ can be defined mathematically by a membership function $\mu_{\tilde{A}}(x)$ which assigns each element x in the universe of discourse X a real number in the interval [0,1]. A triangular fuzzy number $\tilde{A}$ can be defined by a triplet (a, b, c) as illustrated in Figure 1 (Matin et al., 2011).

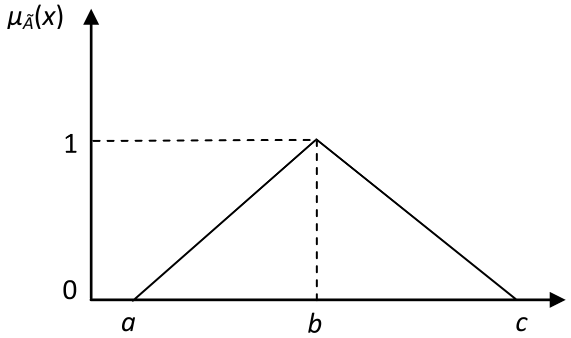

Figure 1. A Triangular Fuzzy Number $\tilde{A}$

The membership function $\mu_{\tilde{A}}(x)$ is defined as:

$$\mu_{\tilde{A}}(x) = \begin{cases} x\text{-}a/b\text{-}a & a \le x \le b \\ x\text{-}c/b\text{-}c & b \le x \le c \\ 0 & \text{otherwise} \end{cases} \qquad (1)$$

It is possible to make basic arithmetic operations on triangular fuzzy numbers like addition, subtraction, etc. Triangular fuzzy numbers are appropriate for quantifying the vague information about most decision problems. The primary reason for using triangular fuzzy numbers can be stated as their intuitive and computational-efficient representation (Karsak, 2002).

A linguistic variable is defined as a variable whose values are not numbers, but words or sentences in natural or artificial language. The concept of linguistic variable appears as a useful means for providing an approximate characterization of phenomena which are too complex or ill-defined to be described in conventional quantitative terms (Zadeh, 1965). Using linguistic variables for the preference of decision makers (DMs) have been used in several MCDM methods. In this study, we will show the applicability of linguistic variables to Fuzzy TOPSIS method to evaluate the alternatives for tourism destinations. A set of pre-defined linguistic variables parameterized by triangular fuzzy numbers will be used to demonstrate preferences.

4. Fuzzy TOPSIS Method and Notations

TOPSIS, one of the most classical methods for solving MCDM problems, was first developed by Hwang and Yoon. It is based on the principle that the chosen alternative should have the longest distance from the negative-ideal solution i.e. the solution that maximizes the cost criteria and minimizes the benefits criteria; and the shortest distance from the positive-ideal solution i.e. the solution that maximizes the benefit criteria and minimizes the cost criteria. In classical TOPSIS, the rating and weight of the criteria are known precisely. However, under many real situations crisp data are inadequate to model real life situations since human judgments which are vague and cannot be estimated with exact numeric values (Hwang and Yoon, 1981). To resolve the ambiguity frequently arising in information from human judgments, fuzzy set theory has been incorporated in many MCDM methods including TOPSIS.

In fuzzy TOPSIS all the ratings and weights are defined by means of linguistic variables. A number of fuzzy TOPSIS methods and applications have been developed in recent years. Chen and Hwang (1992) first applied fuzzy numbers to establish fuzzy TOPSIS. Triantaphyllou and Lin (1996) developed a fuzzy TOPSIS method in which relative closeness for each alternative is evaluated based on fuzzy arithmetic operations.

It is often difficult for a DM to assign a precise performance rating to an alternative for the attributes under consideration. The merit of using a fuzzy approach is to assign the relative importance of attributes using fuzzy numbers instead of precise numbers. The technique called fuzzy TOPSIS can be used to evaluate multiple alternatives against the selected criteria. In the TOPSIS approach an alternative that is nearest to the Fuzzy Positive Ideal Solution (FPIS) and farthest from the Fuzzy Negative Ideal Solution (FNIS) is chosen as optimal. An FPIS is composed of the best performance values for each alternative whereas the FNIS consists of the worst performance values. We have adapted the relevant steps of fuzzy TOPSIS as presented below (Sodhi and Prabhakar, 2012).

Step 1. Determine the Weighting of Evaluation Criteria

The DMs use the linguistic variables for determining the level of importance of criteria. Linguistic variables can be defined to represent evaluations. Then each linguistic variable can be parameterized into a fuzzy set. For example, the importance weights of various criteria and the ratings of the criteria can be expressed as linguistic variables which can be modelled as triangular fuzzy numbers as shown in Table1 (Lo et al., 2010).

Table 1. Linguistic Variables for the Importance Weight of Each Criterion

Linguistic Variables	Importance Weight of Each Criterion
Very Low (VL)	(0, 0, 0.1)
Low (L)	(0, 0.1, 0.3)
Medium Low (ML)	(0.1, 0.3, 0.5)
Medium (M)	(0.3, 0.5, 0.7)
Medium High (MH)	(0.5, 0.7, 0.9)
High (H)	(0.7, 0.9, 1.0)
Very high (VH)	(0.9, 1.0, 1.0)

(Source: Chen, 2000)

Step 2. Construct the Fuzzy Decision Matrix

The fuzzy TOPSIS can be concisely expressed in matrix format as follows. DM chooses the appropriate linguistic variables for the alternatives with respect to criteria as shown in Table 2.

$$
\tilde{D} = \begin{array}{c} \\ A_1 \\ A_2 \\ A_3 \\ \vdots \\ A_m \end{array}
\begin{array}{c}
\begin{array}{ccccc} C_1 & C_2 & C_3 & \dots & C_n \end{array} \\
\begin{bmatrix}
\tilde{x}_{11} & \tilde{x}_{12} & \tilde{x}_{13} & \dots & \tilde{x}_{1n} \\
\tilde{x}_{21} & \tilde{x}_{22} & \tilde{x}_{23} & \dots & \tilde{x}_{2n} \\
\tilde{x}_{31} & \tilde{x}_{32} & \tilde{x}_{33} & \dots & \tilde{x}_{3n} \\
\vdots & \vdots & \vdots & \vdots & \vdots \\
\tilde{x}_{m1} & \tilde{x}_{m2} & \tilde{x}_{m3} & \dots & \tilde{x}_{mn}
\end{bmatrix}
\end{array}
$$

$$\tilde{x}_{ij} = \frac{1}{k}(\tilde{x}_{ij}^1 + \tilde{x}_{ij}^2 + \dots + \tilde{x}_{ij}^k) \qquad (2)$$

where $\tilde{x}_{ij}$ is the rating of alternative A_i with respect to criterion C_j evaluated by K expert and $\tilde{x}_{ij} = (\tilde{a}_{ij}^k, \tilde{b}_{ij}^k, \tilde{c}_{ij}^k)$

Table 2. Linguistic Variables for the Ratings

Linguistic Variables	Ratings of Alternatives
Very Poor (VP)	(0, 0, 1)
Poor (P)	(0, 1, 3)
Medium Poor (MP)	(1, 3, 5)
Fair (F)	(3, 5, 7)
Medium Good (MG)	(5, 7, 9)
Good (G)	(7, 9, 10)
Very Good (VG)	(9, 10, 10)

(Source: Chen, 2000)

Step 3. Normalize the Fuzzy Decision Matrix

The raw data are normalized to eliminate anomalies with different measurement units and scales in several MCDM problems. However, the purpose of linear scales transform normalization function used in this study is to preserve the property that the ranges of normalized triangular fuzzy numbers to be included in [0,1] (Aref et al., 2012). Suppose $\tilde{R}$ denotes normalized fuzzy decision matrix, then;

$$\tilde{R} = [\tilde{r}_{ij}],\ i=1,2,\dots,m,\ j=1,2,\dots,n \qquad (3)$$

$$\tilde{r}_{ij} = \left(\frac{a_{ij}}{c_j^*}, \frac{b_{ij}}{c_j^*}, \frac{c_{ij}}{c_j^*}\right) \text{ and } c_j^* = \max c_{ij} \text{ (benefit criteria)} \qquad (4)$$

$\sim \quad a^-_i \quad a^-_i \quad a^-_i$

$$r_{ij} = \left(\frac{\quad}{c_{ij}} , \frac{\quad}{b_{ij}} , \frac{\quad}{a_{ij}} \right) \quad \text{and} \quad a^{-}_{j} = \min a_{ij} \text{ (cost criteria)} \tag{5}$$

Step 4. Compute the Weighted Normalized Matrix

The weighted normalized matrix $\tilde{V}$ for criteria is computed by multiplying the weights (w) of evaluation criteria with the normalized fuzzy decision matrix $\tilde{r}_{ij}$.

$$\tilde{V}_{ij} = \tilde{r}_{ij} \times \tilde{w}_j \tag{6}$$

Step 5. Determine the Fuzzy Positive-Ideal Solution (FPIS) and Fuzzy Negative-Ideal Solution (FNIS)

The fuzzy positive-ideal solution (FPIS, A^*) and the fuzzy negative-ideal solution (FNIS, A^-) are demonstrated in the following equations:

$$A^+ = (\tilde{V}_1^+ , \tilde{V}_2^+ , \ldots \tilde{V}_n^+) \text{ where, } \tilde{V}_j^+ = (1, 1, 1) \quad j=1,2,\ldots,n \tag{7}$$

$$A^- = (\tilde{V}_1^- , \tilde{V}_2^- , \ldots \tilde{V}_n^-) \text{ where, } \tilde{V}_j^- = (0, 0, 0) \quad j=1,2,\ldots,n \tag{8}$$

Step 6. Calculate the Distance of Each Alternative from A^+ and A^-

The distance (d^+ and d^-) of each weighted alternative i =1, 2,...,m from the FPIS and the FNIS is computed as follows:

$$d_i^+ = \sum_{j=1}^{n} d_v (\tilde{v}_{ij} , \tilde{v}_j^+), \; i =1, 2,...,m \quad j =1, 2,...,n \tag{9}$$

$$d_i^- = \sum_{j=1}^{n} d_v (\tilde{v}_{ij} , \tilde{v}_j^-), \; i =1, 2,...,m \quad j =1, 2,...,n \tag{10}$$

d^+ and d^- values are the total distance of the alternatives from FPIS and FNIS respectively.

Step 7. Evaluate the Closeness Coefficient

A closeness coefficient (CC_i) is defined to determine the ranking order of all possible alternatives once d^+ and d^- of each alternative has been calculated. CC_i represents the distances to the fuzzy positive-ideal solution (A^+) and the fuzzy negative-ideal solution (A^-) simultaneously by taking the relative closeness to the fuzzy positive-ideal solution. CC_i of each alternative is calculated as:

$$CC_i = \frac{d_i^-}{d_i^+ + d_i^-} , \; i =1, 2,...,m \tag{11}$$

It is clear that $CC_i = 1$ if $A_i = A^+$ and $CC_i = 0$ if $A_i = A^-$. In other words, alternative A_i is closer to the FPIS and farther from FNIS as CC_i approaches to 1. According to the descending order of CC_i, we can determine the ranking order of all alternatives and select the best one from among a set of feasible alternatives (Chen et al., 2006).

Fuzzy TOPSIS method has been used in several areas in the recent years. Most of the areas are in selecting problems like, personnel selection, (Chen, 2000; Saghafian and Hejazi, 2005; Mahdavi et al., 2008; Matin et al., 2011; Wimatsari et al., 2013), supplier selection (Onut et al., 2009; Chen et al., 2006; Aref et al., 2012; Kazemi et al., 2014;) and other selection problems (Mahmoodzadeh et al., 2007; Ashrafzadeh et al., 2012; Chang and Tseng, 2008; Madi and Tap, 2011; Momeni et al., 2011; Lo et al., 2010; Gupta et al, 2012; Datta et al., 2013; Azadeh et al., 2014). Fuzzy TOPSIS method is widely used in ranking different alternatives like software companies (Wang et al., 2007), customers (Santos and Camargo, 2010), e-commerce websites (Yu et al., 2011), travel websites (Kabir and Hasin, 2012) and different alternatives (Aktan and Tosun, 2013; Sodhi and Prabhakar, 2012; Ding, 2011; Jahanshahloo et al., 2006; Falsafi, 2011; Keshavarz et al., 2014)

5. Applicability of Fuzzy TOPSIS Method

The mathematical notation of Fuzzy TOPSIS Method was explained above and in this part, we will demonstrate how we can apply it to a tourism destination problem. Starting point for determining of the MCDM methods are the alternatives and the criteria. Then, we need to determine the criteria as they are maximization or minimization like in Table 3.

Table 3. Criteria and Orientations

Criteria	**Orientations**
C_1	Maximization
C_2	Minimization
C_3	Maximization
C_4	Minimization
C_5	Maximization

The questionnaire should be prepared with linguistic variables for the importance weight of each criterion and linguistic variables for the ratings. An example table is shown Table 4.

Table 4. Example of Linguistic Assessments for Each Criterion.

Linguistic Assessments	VL	L	ML	M	MH	H	VH
C_1				X			
C_2					X		
C_3						X	
C_4					X		
C_5						X	

After collecting the needed information, we convert the linguistic assessments to fuzzy number sets to use them in Fuzzy TOPSIS method. You can see the fuzzy number sets in Table 4, given as example.

Table 5. Example of Fuzzy Number Sets for Each Criteria.

Fuzzy Number Sets	*DM₁*	*DM₂*	*DM₂*	...	*DMₙ*
C_1	(0.3,0.5,0,7)	(0.5,0.7,0,9)	(0.9,1.0,1.0)		(0.5,0.7,0,9)
C_2	(0.3,0.5,0,7)	(0.3,0.5,0,7)	(0.3,0.5,0,7)		(0.5,0.7,0,9)
C_3	(0.7,0.9,1.0)	(0.7,0.9,1.0)	(0.9,1.0,1.0)		(0.3,0.5,0,7)
C_4	(0.9,1.0,1.0)	(0.5,0.7,0,9)	(0.3,0.5,0,7)		(0.5,0.7,0,9)
C_5	(0.5,0.7,0,9)	(0.9,1.0,1.0)	(0.3,0.5,0,7)		(0.3,0.5,0,7)

Then we can normalize the Fuzzy Decision Matrix by using the equations (4) and (5). With the help of the equation (6), we reach the Weighted Normalized Matrix. After that, we can calculate the distance of each alternative from FPIS and FNIS with respect to each criterion by using equation (9) and (10). d^+ values of each alternative are the total distances from FPIS while d^- values of each alternative are the total distances from FNIS. You can see an example of FPIS and FNIS distances for alternatives in Table 5.

Table 5. The Distances of Each Alternative from FPIS and FNIS.

Criteria	Alternative 1		Alternative 2		Alternative 3		Alternative 4	
	$d(A_1, A^+)$	$d(A_1, A^-)$	$d(A_2, A^+)$	$D(A_2, A^-)$	$d(A_3, A^+)$	$d(A_3, A^-)$	$d(A_4, A^+)$	$d(A_4, A^-)$
C_1	0.48	0.58	0.48	0.58	0.57	0.50	0.52	0.54
C_2	0.46	0,61	0.26	0,81	0.34	0,74	0.28	0,79
C_3	0.72	0.31	0.68	0.37	0.71	0.32	0.68	0.36
C_4	0.42	0,64	0.36	0,71	0.28	0,78	0.61	0,45
C_5	0.72	0.31	0.73	0.30	0.66	0.39	0.76	0.26
d^+	2,79	-	2.50	-	2.55	-	2,84	-
d^-	-	2.45	-	2.77	-	2.73	-	2.41

We can calculate the closeness coefficients by using equation (11) to rank the alternatives. It is possible to see the closeness coefficients and final ranking of each alternative in Table 6.

Table 6. The Closeness Coefficients and Final Ranking of Alternatives

	Alternative 1	Alternative 2	Alternative 3	Alternative 4
CC_i	0.36	0.49	0.47	0.32
Ranking	3	1	2	4

These tables show us that we can outrank tourism destinations with the linguistic assessments. With Fuzzy TOPSIS method, we can use the advantage of linguistic assessments because; we believe that linguistic assessments are easier to collect than quantitative crisp data. We can convert the linguistic assessments to fuzzy number sets to process in Fuzzy TOPSIS method.

6. Conclusions

In economy, industry and daily life, most of the problems that have been encountered in are mostly multi criteria decision problems. In our daily lives or in professional settings, there are typically multiple conflicting criteria that need to be evaluated in making decisions (Genc, 2014). In this study, we examined the applicability of a Fuzzy MCDM method over a daily problem. Tourism destination choosing is a challenging topic in most cases. To overcome this difficulty, we propose a quantitative approach for a decision making question including multi alternatives and multi criteria.

We examined a fuzzy MCDM methodology in order to have a Multi Criteria approach for choosing a tourist destination. We explained the notations of the method first to be familiar with process and then we described how to apply it over a tourism destination choosing. We preferred to apply a fuzzy method because we consider that it is difficult to model real life problems with crisp data.

This chapter can be used to as a methodology for any business and management problem, if the DM would collect the preferences over alternatives. Mathematical approaches are better than discernment methods because these methods systematically process the data and reach a conclusion. On the contrary, conventional approaches are mostly depending on the DM's past experiences and knowledge.

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